SHAPES OF FORMS

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From Gestalt Psychology and Phenomenology to Ontology and Mathematics

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The Editor

LILIANA ALBERTAZZI

FORM AESTHETICS: INTRODUCTION

1 WHAT IS A FORM?

The concept of form has been of central importance in philosophical and scientific reflection since its beginnings. One thinks, for example, of the Ionian physicists and their hypothesis that many aspects of the world depend on the form of atoms. Similarly, innumerable variations on Plato's world of ideas/forms and Aristotle's dialectic of matter/form have characterized Western thought throughout its history. Of universal currency is Galileo's thesis that the book of nature is written in the language of the geometric forms, and that it is only necessary to learn how to read it. The various theories of form that have been developed in the twenty-five centuries of Western civilization instruct us that there is no single or fundamental theory of forms. The problem thus becomes one of those theoretical cruxes that enable us to understand the meaning and deeper-lying characteristics of a theory. A book about form, therefore, may pursue the purely theoretical purpose of developing an *aesthetics of knowledge*, in the sense of analysis of the *forms that emerge qualitatively from the physical level*.

Moreover, the development of research connected with artificial intelligence and the cognitive sciences obliges us to confront further components of the traditional problem of form and to ask ourselves once again: 'What is a form?' Among the answers now forthcoming to this question, some seem irritatingly traditional: for example, that there exists a world of experience which displays the features of an *intuitive physics*, more Aristotelian than Galilean, and that the procedures of *semantic categorization* employed by natural language are more closely connected to perception than we would have been willing to admit even only a few years ago.

These answers refer to concepts of form which assume a *perceptive and phenomenological* nature, and they thus recover the original meaning of scientific traditions that had grown outmoded or had been radically distorted. Indeed, it was Gardner himself, when tracing the history of cognitivism, who asked whether we have truly moved forward from Gestalt psychology and the Würzburg school, or whether in fact we are merely rediscovering what they already knew.[1]

I shall examine two cognitive theories that are today generally assumed to be irreconcilable: that of Gibson and that of Gregory.

L. Albertazzi (ed.), Shapes of Forms, 1–17.

The supporters of an *ecological theory of perception* maintain that the same laws of organization operate in both thought and perception, an example being the Gestalt law of field, which would exclude the *perception of phases*. By contrast, the proponents of a *constructivist theory* claim that perceptive processes and the processes of thought follow the same *inferential logic*.

In brief, Gibson's theory rejects the constructivist point of view and affirms that *perception is a direct organization* of the available information.[2] Conversely, Gregory argues that *perception* is the result of our brain's processing data about a world and that it can be explained in terms of stored mental representations.[3] For Gregory, *perception is hypothesis*, with the correlated idea that the mind must translate sensory information into a *language of the mind*.[4]

Both conceptions share the idea that *perception proceeds in a single direction* from stimuli to meaning, and that massive transformations in sequence are required to break these structures down for analysis. Nevertheless, although the two positions have a large amount of experimental evidence in common, they are apparently incompatible.

And yet, at least in part, the polemic that divides the two theories on the cognitive processes involved in the phases between distal and proximal stimulation could profitably draw on theories developed prior to the 1930s. The *theory of production* developed by the Graz school, for example, assumed that perceptive aspects and cognitive integrations are connected in the various *phases* of the presentation. In modern terms, this suggests that the difference between '*bottom up*' and '*top down*' in cognitive processes is more a difference of degree than of kind internally to a *form* – that is, a *structure* consisting several layers. At issue are the differences between a theory of perception founded on *eventualities of presentation* and one founded on *eventualities of judgement*, or in modern terms, between theories of representation that place more or less emphasis on its 'inner' or 'outer' aspects, as well as the directions taken by information input and output. Moreover, between the presentation and the hypothesis lies the assumption (*Annahme*), which is a type of act which is not yet a judgement – in the sense of a comparison among several and successive presentations (hypotheses) – but contains a form of immediate conviction deriving from the *apprehension of the mode of being* (*So-sein*) of a physical object.[5] This is an aspect of Meinongian theory which sank into oblivion but which in the last fifteen years has been revived only with regard to logico-linguistic aspects of Meinong's semantics, whereas it would be much more relevant to the theory of perception in which it originated. An assumption, in simple terms, is a type of intermediate act between presentation and judgement which enables apprehension of an object through awareness of its *existence* or *presence* (*Vorgegebenheit*) and its ordering or structuring into an 'objective'.[6] The 'hypotheses' referred to by Gregory's theory, and of which it is accused by the Gibsonians – this in effect being the term most frequently used by Gregory himself – are not always hypotheses; on occasion they are outright 'assumptions' in Meinong's sense of the term. For example, in the case of Penrose's impossible triangle, after *apprehension of the perceptively given mode of being* of that 'object', the visual system assumes that all three sides touch on all three sides, whereas this happens on only one side. In fact, the sides touch *only optically*, because they are separate in depth. In Meinong's words, Penrose's triangle has been inserted in an 'objective', or in what we would today call a "cognitive schema".

Re-examination of the Graz school's theory, as said, sheds light on several problems concerning the theory of perception, and, as Luccio points out in his contribution to this book, it helps to eliminate a number of over-simplistic commonplaces, such as the identification of the cognitivist notion of 'top down' with Wertheimer's 'von oben unten', and of 'bottom up' with his 'von unten nach oben'. In fact, neither Hochberg's and Gregory's 'concept-driven' perception nor Gibson's 'data-driven' perception coincide with the original conception of the Gestalt.

In a Gestaltist configuration, in fact, 'top down' and 'bottom up' processes act simultaneously, because perception is viewed as a set of numerous processes with differing degrees of complexity. However, as Zimmer's article in this book shows, these processes are not hierarchically ordered but interact as *forces of a field* which tend towards stability according to a 'principle of minimum'. Necker's cube is a paradigmatic example of this phenomenon. Since competing processes are at work, constantly new spatial structurings and restructurings are generated. Other examples are provided by the phenomenon of spatial multi-stability, the perception of space from two-dimensional displays, and the role of symmetry in the history of science.

A categorization of this kind – which broadly speaking we may call *phenomenological* – has nothing to do with hermeneutic phenomenology. Nor does it belong to the mainstream of analytic philosophy, although it shares a certain expository simplicity and a number of themes with the latter, as evidenced by several similarities between Husserl and Wittgenstein.[7] Moreover, since its original formulation by the School of Brentano, phenomenological inquiry has always had an *experimental* aspect to it, as a discipline whose *experimental variables are mental contents of direct experience* rather than physical stimuli or physiological processes.[8] *Experimental phenomenology*, then, is not only a *theory of consciousness*, it is also a *science* which could be called a *descriptive psychology* of perception.[9] This type of inquiry, which lies midway between metaphysics and psychology, and which draws on laboratory experiments, displays a number of *variations* in its base conception. By way of simplification, it was more 'cognitivist' among the Meinongians and more 'realist' in various branches of Husserlian phenomenology. Nevertheless, it invariably addressed issues that are still central to ongoing debate in the cognitive sciences – from the perception of form to the transfer of a modified image over another. Frequently, moreover, it obtained results that are today in the process of being re-discovered, as Gardner observes, and to do so used refined conceptual tools which enabled the integration of these results into a more general theory.

An intuitive example is provided by research into perceptive illusions, distortions, ambiguous objects like Rubin's vase, and paradoxical objects like Penrose's already-mentioned impossible triangle. Such inquiry had already been amply developed by Brentanist psychologists, both experimentally and theoretically, given that the theory available to them (in this particular case Meinong's *theory of objects*) was able to ascribe an ontological status even to entities of this kind. One thinks, in fact, of the polemic between Benussi and Koffka on ideal objects, and the dispute concerning *presentations of a-sensory provenance* that set Graz and Berlin against each other – with Meinong, Ameseder, Höfler and Benussi on one side, and Koffka and Bühler on the other, to cite only the best-known names.[10] This, however, is an ontological problem that has broader implications than a mere dispute between schools. As shown by Grattan-Guinness's article in this volume on the objects of algebra, or by Jadacki's contribution on the objects of logic, it traverses the whole of mathematics, starting from discussion on the nature of the complex, irrational or negative numbers variously defined false, impossible or chimerical.

As for phenomena of temporal inversion, like the acoustic tunnel, or those involved in the perception of causality that Michotte analysed, these are entirely coherent with Brentano's metaphysical analyses of the velocity and direction of perceptive continua. Indeed, many of these phenomena were already being investigated by experimental psychology at the beginning of this century. Curiously, current debate in the cognitive sciences displays the same conflict over the theoretical interpretation of experimental debate that split the exponents of descriptive psychology: I refer in particular to the conflict between Graz and Berlin.

All these themes centred, and still centre today, on the *concept of representation* (or better, the *inner stratification of the morphogenesis of the representative modules*), beginning with the first stages of concrete presentations, visual and auditory presentations in particular.

One of the starting-points of the contemporary cognitive sciences is, in fact, the assumption that knowledge essentially consists of the *manipulation of inner representations* variously defined as *neurophysiological states*, *mental images* or *symbolic codifications*. From these premises, also on the promptings of researchers working in the field of artificial intelligence, various theories have been developed, for example Fodor's connectionism, Johnson-Laird's mental models, and Fauconnier's mental spaces.[11]

In general, therefore, a Brentanian or phenomenological programme is required not only in philosophy but also in various areas of psychophysical research, examples being the theory of vision and the temporary structure of spatial representation; the recognition of form: the analysis of the structure and formation of mental images and experimental studies of memory; the ecology of perception, phenomenologically-based structuralism and naïve physics; and finally cognitive semantics as a natural approach to semantics on a representational basis.[12]

The phenomenon is evident in specific research areas, like auditory stream or studies on imagery, which could certainly benefit from the conceptual tools of an experimental phenomenology. For example, it would be profitable to combine certain phenomena of stream segregation studied by Michotte with analyses conducted in Würzburg and Graz, ongoing inquiries in artificial intelligence into spatio-temporal reasoning with Brentano's theories of perceptive continua, or the analysis by contemporary American naïve physics of the structures and axioms of natural language with the 'psychognostic' inquiries of Marty and Bühler. The results would be better and in many respects more cogent.

After decades of intolerable conceptual confusion, scientific phenomenology has been recodified by Thinès, Vicario and Bozzi, following earlier research by the Leipzig school (Sander, Krueger and Volkelt in particular), by the Louvain school (Michotte), and by Fraisse into the temporal apprehension of intervals.[13]

The key concepts of a scientific and experimental phenomenology are the notion of *observable* – namely, whatever lies within the range of the eye and the hand and is amenable to manipulation in the actual duration – the notion of *event* which in general states that the objects of perceptive fields have duration, and that the perception of events is therefore tied to the perception of temporal structures,[14] and the notion of *invariant*, which concerns the essential features of observables.[15]

All three of these concepts, which are fundamental just as much for science as for phenomenological metaphysics, relate to a conception of *form* as *structure*.

2. FORM AS STRUCTURE

The concept of form as structure is founded on the relative independence of form from local stimuli, and it can be analysed by starting with one of its essential components, namely duration.

Other essential components are the *modes of appearance* of the form, such as the epiphanic colours studied by Katz,[16] the dynamic *force* possessed by the spatial configurations analysed by Lipps and Lewin[17] – features which take account of the *modalities* of the objects of experience[18] – and the *fusion* of their formative particulars, as examined in Stumpf's studies of consonance[19]. A conception of this kind regards the *sensible qualities* as *intensive magnitudes* which possess a certain *degree* and *purity* (*Prägnanz*) and are distinguished by *continuity* and *discontinuity*. Fusion in forms corresponds to a *continuous variation* in the degree of quality, whereas distinction corresponds to a *discontinuous variation*. This conceptualization – which is present in diverse forms in the work of von Ehrenfels, Selz and Musatti – is essentially qualitative and has numerous features in common with *phenophysics*.[20]

In effect, the field of the perceptive duration provides a laboratory for analysis of the concept of *form*. In this case, forms are *events* more than *objects*, or better they are not yet objects in the descriptive sense. Rather, they are percepts or *forms* which manifest an *essentially temporal* givenness. The principal area of temporal analysis of duration, therefore, is constituted by sounds; but also lights, colours and even their particular states (like transparency or the perception of whiteness) offer countless examples of the fact that form is a *structure dependent* on the entity, dimensions and order of the '*perceived*' *temporal intervals*. It is this intuition that underlies stroboscopic movement, for example, which is the principal Gestalt phenomenon.[21]

In fact, the time of the duration is largely reducible to the time of a *qualitative change*. This is perception of a change in the *position*, *direction*, *velocity*, *pureness* and *degree* of the forms perceived, which varyingly depend on the phenomenal salience, texture, clarity, and so on, of the events of a duration, and which affect the perception of a sequence of stimuli. One cannot say that the time of the duration is composed of a series of *quanta* (Stroud's perceptive moments[22]) because, as Vicario has shown, according to the pitch, timbre and qualitative similarity of the sounds in a triplet which fall within one of these moments, these sounds may be perceived – and are thereby *recombined* by the perceptive processes – in *a manner different* from their sensory *order*.[23]

The phenomenon is apparent not only in sounds but in other perceptive materials like colours as well. In fact, corresponding to the phenomenon of temporal inversion in the auditory field are the phenomena of inversion in the visual field, as demonstrated by Legrenzi's experiment,[24] and likewise the phenomena of transparency analysed by Kanizsa and by Gerbino, when the colour dissolves and the colour of the surface beneath is seen *through* that superimposed on it.[25] Involved in this case, too, is the *double-face* structure of the duration, because on the one hand there is *a single* linear chain of stimuli, while on the other there are two events separated in space but coincident in time.

In short, the problem of the duration (or of the *time of presentness*, to use a term from the exact sciences) highlights how there are always *two connected aspects* in the temporal continuum of the perception of forms: an *internal boundary* and an *external boundary* of the continuum. These two aspects cannot be made to coincide, although the *process of information* is given by their form of *tuning*.

Analysis of the genesis of forms shows that the form is stabilized in the duration. It is topologically extended and flattened in a field of forces created by the perceptive contours. The visual or auditory form thus produced is therefore the outcome of an equilibrium of primitives or of *formative factors* in the complexity. The form of an object is the *resultant* of forces – in the sense of Lipps' aesthetic mechanics – in which there operate spatial primitives consisting of the points, surface lines, directions, angles and parallelograms of a space which still does not possess the features of a Euclidean space but comprises tactile and kinaesthetic qualities, movement, velocity, and tension towards a form. It is therefore an essentially dynamic structure of the phenomena of vision. In fact, there arise *temporal structures mapped on to a space of qualities.*[26]

The distortions and reconstructions of this dynamic process are *phenomenologically objective* in that they restore the morphogenesis of the particulars. Innumerable examples of this sort of aesthetic mechanism are provided by the history of art.

The borderline aspect of the time of presentness was very clear in its early formulation by Wertheimer. Subsequently, however, in Gestalt, the internal border was increasingly neglected in favour of an 'ecological' analysis of the percept. Only Benussi continued to work on both aspects for most of his lifetime, earning himself the accusation of being a 'psychophysicist' from the Berlin gestaltists.

Consider, too, what happens in stroboscopic movement, a *visual form of movement* with a highly sophisticated structure. Vicario shows in his contribution to this book that the movement of a luminous point from A to B is only seen if B is lit up. Thus the *cause* of the *present* movement is situated in the *future* of A – only a few milliseconds later but nevertheless in the future.[27] In this situation the distinction between the categories of 'before' and 'after' as regards temporal continua disappears, and it consequently becomes of great importance to understand the structure of the time of presentness and of the perception of forms in general.

These findings as regards the structure of the duration also highlight a number of features of perceptive causality analysed by Michotte. Let us return for a moment to stroboscopic movement, and specifically to the case of a light which moves from A to B when B lights up. This means that that the representation of the beginning of the movement of A arrives much later than when A lights up, and precisely when B lights up. This strange effect can only be explained by assuming, with Benussi, that the *representation of the movement* is realized with the formation of the *simultaneous content A–B* in the actual genesis of the duration (or genesis of the form) in the time of presentness.

The case of *objective phenomena* analysed in the laboratory, like those of temporal dislocation in the auditory or visual field, or stroboscopic movement itself, shows that events occur in the time of presentness which are at least *partially independent* of events in the time of the objective sequences. Subjective time and objective time *do not flow in unison*, and the continuum of the physical sequences has *modalities of existence* which differ from those of the continuum of the perceptive sequences.

The difference inheres in the *unit of representation* of the perceived forms: both are measured in milliseconds, but for objective time the unit of representation is the *instant*, while for subjective time it is the *elastic temporal moment* of variable duration (ranging from 50/100 milliseconds to some seconds), according to the phenomenon in question – whether, for example, it is stroboscopic movement, the tunnel effect, or the perception of causality.[28]

This said, one may enquire as to the usefulness of the results obtained by analyses of temporal structure for science or metaphysics.

For example, they may prove useful for analysis of an intuitive mechanics and dynamics, where one opts for a *metaphysics of events* (or processes) as the primitive phenomena of *change* internal to an actual duration.[29] From the point of view of perception, in fact, change is a *primitive phenomenon* with respect to simultaneity and succession. Other fleeting phenomena, like a flash in the dark or the beat of a kettledrum in music, constitute a change for perceptive consciousness. Bonaventura showed this very clearly in experiments conducted in the 1930s, and most of the laws of pregnancy – as both a scalar property and a zone of points of discontinuity in a qualitative series – arise from the sensitivity to change typical of our perceptive system and evidenced by the nature of perceptive singularities.[30]

As regards science, therefore, the contribution by analyses of form to *knowledge engineering* is their specification of moments *internal to the presenting*. These are *objectual moments* which differ from the objects of experience relative to a *time of the development of form* corresponding to the construction of the scene by means of various profiles.[31] As Luccio points out in his article in this book, at least *two* levels can be distinguished in the perceptive process: one which can be defined, following Neisser, as *pre-attentive*, and one which is more *cognitive* and involves the identification and categorization of the objects in the field.[32] This is the difference that Kanizsa summed up in 'seeing' and 'thinking' and which, as Peruzzi points out in his article, from the point of view of kinaesthetic perception appears as a set of gestaltic patterns intrinsic to bodily movements.

A feature shared by the results of these researches is their emphasis on the non-linguistic nature of the schemes of perception, and therefore their affirmation of natural constraints on the original categorization – a finding already operative in robotic engineering. A second feature concerns the convergence of these lines of inquiry on a *constructivism of the scene* based on an entirely specific form of *proprioception* which combines the 'cubist' view of Meinong's ontology with Brentano's theory of intentional reference.[33]

From this point of view, the enormous quantity of experimental data produced by the cognitive sciences and which apparently cannot find cogent theoretical classification, may be assimilated into a broader philosophical theory, namely that of an experimental phenomenology.[34]

3. FORM AS WHOLE

One of the fundamental assumptions of the classical theory of the Gestalt is that a whole it is greater than its parts. This is an essentially phenomenologically theory: in fact, despite the shortcomings of his *Third Logical Investigation*, Husserl's achievement was to elaborate a theory of wholes and of their parts.[35] Subsequent mereological analyses, however, have underestimated or indeed neglected certain fundamental features of the original theory, from the point of view of both wholes and parts.

Firstly, classical extensional mereology especially, as developed by Leonard and Goodman,[36] has under-estimated the role of wholes, concentrating instead on parts. Secondly, later mereological inquiry, like the formalization of the *Third Logical Investigation* by Null and Fine,[37] has neglected the fact that the phenomenological theory of wholes is rooted in the relationship between act, object and content. Or in modern terms, it implicitly comprises the problem of cognitive integrations in the formation of wholes. In other words, implicitly involved is an unresolved problem of Kantianism which, as Jadacki and Poli show in their contributions to this book, renders the relationship between ontology and epistemology extremely complex, if not downright negative. Moreover, the problem of Kantianism traverses the whole of contemporary research in knowledge engineering, as well as being evident in the revival of Peirce's conceptual graphs by computer scientists like Sowa and the search for a lattice of categories which accounts for the complexity and development of the categorization starting from pre-categorial aspects.

Nowadays, the development of topologically-based mereologies (the so-called mereo-topologies) has been stimulated by research in naive physics and, more generally, by attempts to provide a formal reconstruction of the commonsense world. Indeed, Husserl's work, by virtue of the mathematical structure underlying his thought of *dependence*, can be interpreted topologically as an intuitive topology. More in general, every phenomenology can be considered a morphology and therefore a doctrine which is topological in nature, for consciousness is always consciousness of *something located in space and time*, even if this is a non-Euclidean (or not yet Euclidean) space.[38]

The experimental phenomenology inherited the *mereological theory* from Husserlian phenomenology and from Gestalt psychology, but apparently comprises, at least in some of its branches, both the problem of *cognitive completion* by perceptive and mental acts and that of the *morphogenesis* (as well as the description) of wholes; aspects which are of great topicality in current experimental research in the cognitive sciences.[39]

The difference between emphasis on a theory of wholes and emphasis on a theory of parts, however complementary the two theories may be, relates to the following problem. If phenomenal wholes (whether perceptive or mental) are considered from a *descriptive* point of view, besides being *transposable* they display *suprasummativity*, in the sense that the *form* is considered to be a whole which takes priority over its constitutive parts. This was one of the factors that induced Gestalt to concentrate on *object-forms* rather than on *event-forms* or *action-forms*.

James discussed the *ubiquitous relations* of consciousness or, in contemporary terms, the ubiquity of cognitive schemata, and Wertheimer stressed the *constitutive role of the parts* in the formation of wholes, for example in the phenomenon of 'grouping'.[40] Other currents of thought connected more or less directly with phenomenology and Gestalt – like the *Ganzheitspsychologie* of Leipzig and the already-mentioned Graz *theory of production* – have paid close attention to the problem of the dynamics of parts. Finally, similar concepts are developed in Whitehead's *Process and Reality* and in many of Peirce's essays.[41]

The predominance of the parts in the *genesis* of the form is an assumption also shared by Benussi, Musatti and the later Kanizsa, and it is also apparent in Marr's research on the *phase structure* of vision. Analysis of the *actual genesis* of the form in the time of presentness has evidenced the constitutive role played by *pre-Gestalten* as non-independent parts of the whole. Together with the *functional dominance* of the formal quality of the *whole* over individual givens, therefore, there is a *genetic primacy* of the formal qualities of the *parts* in the onset of a form at *a certain temporal point of consciousness*. The only 'formal components' of perception, in fact, are the *contours*. In particular, it is the $2\frac{1}{2}$ D level that best expresses the *inner representation* of objective reality prior to the decomposition of the visual scene into distinct objects.

The pre-Gestalten tend to combine into a particular configuration which assumes certain features and not others *internally to a particular perceptive field* and according to the prevalence of some *qualitative factors* over others. Depending on the circumstances, these factors may be the phenomenal salience of one colour brighter than another, the chromatic contrast between two surfaces, the prevalence of tonal distance over the distance between the silent pauses in melodies, and so on.[42] The pre-Gestalten, in sum, are the *partial contents* of the act of presentation which merge together to determine (or modify) the overall perceptive whole as it develops in the time of presentness. Given the velocity of their development, the genesis of the Gestalten can be observed in the laboratory by reducing the stimulus conditions (use of the tachistoscope for optical figures, increased lighting in darkness, and so on). The distinctive feature of the qualities of pre-Gestalten is that they are *diffuse* – angled, acute, round, etc., like the atoms of Democritus. Further features are their marked lability of connection, their tension to a form, and their emotional colouring.

A second assumption of Gestalt, again linked with the problem of a mereological theory of wholes, concerns the *complementarity of figure and ground*, and especially the fact that determination of figure/ground relations precedes recognition of form.

Recent experimental analyses have gone so far as to claim that the form is *independent* of the ground, in the sense that the *processes of form recognition* can help with the 'computation' involved in the directing relations between figure and ground.[43] Finally, there is the principle that the *directions* of the form (*bottom up* or *top down*, for example) only concern the *figural region*, as also pointed out by Lipps.[44] From a linguistic point of view, this is expressed as the primary role of *verticality* with respect to *horizontality*. The correlation between figural symmetry and equilibrium, in particular, is examined by Peruzzi in this book.

One of the distinctive differences between figure and ground is the *one-sided limit function of contours*. As demonstrated by Metzger's studies conducted in the 1970s, and which today are one of the most advanced areas of research in the cognitive sciences,[45] this feature confers some sort of limitlessness on the ground.

Metzger's experimental results are of great importance from a philosophical point of view. They confirm Brentano's hypothesis that perceptive continua, and the spatial continuum in particular, exist (are present) only *in their boundaries*. They also show that the perceptive boundaries or *contours* of figures create *force fields* which are responsible for the displacement of other contours.[46]

Secondly, and this is very evident in ambiguous figures like Rubin's vase, *meaning* (vase or profiles) seems to be a *quality of the line as a whole* and of the *area* delimited by it. Thus, as the articles in this book by Luccio and by Stadler, Pfaff and Kruse point out, meaning becomes a *determinant* of the *limit function* of the contour.

The formative power of the contours in creating force fields is even more evident in *mechanical aesthetics*, by which term is meant an aesthetics of the *formative particulars* or, descriptively, of the parts. A mechanical aesthetics highlights the role of points, lines and angles in the perception of singularity, as well as the tendency to orthogonality and rectangularity of figures in the visual field, as evidenced by optical-geometric illusions and discussed by Luccio in his analysis of *Prägnanz* in this book. Moreover, as shown by the studies of Stadler, Pfaff and Kruse on the 'wandering point phenomenon', not even a plain sheet of paper is homogeneous but has a *hidden structure* which represents a potential landscape of stable and unstable areas, of attractors and repellers, which specify the phenomenological qualities of the 'substrate space', to use an expression from phenophysics. *Corners* operate as strong attractors; indeed the four corners of a sheet of paper are equally powerful attractors in the case of circular shapes, thus confirming Segall's '*carpenter world hypothesis*'.[47]

The outcomes of an experimental phenomenology, as already pointed out, lead to a specific form of *proprioception*. This is not, or not entirely, a constructivist conception akin to the autopoiesis of Maturana and Varela.[48] In the latter case, in fact, there reappears what I called a problem of unresolved Kantianism. Involved here is not *solely* a 'top-down' process but one which is both 'bottom-up' and 'top-down', and in which *self-reference* does not create a world separate from the reality of transphenomenal things, a world beyond the *mind's* capacities of apprehension. Self-reference, in fact, involves not only the mind but also the *psyche* in the Aristotelian sense of a *complex and internally stratified form* able to apprehend the entities of various irreducible but ontologically connected layers of reality. The *aesthetics of forms*, understood in the Kantian sense as a theory of sense-based knowledge, is a dynamic phenomenology which works on the *boundary* between internal and external psychophysics from Fechner's direct factors' to mental contents to ideal objects. Given its premises, the aesthetics of forms cannot give rise to an identical or single concept of form, only to a *theory of forms of experimentally-based theories.*

4. FORM AS SCHEMA

As already observed, cognitivism is still concerned with the problem of unresolved Kantianism. At issue is the ontological commitment of the cognitive integrations in the identification of objects. This feature is evident in the opposing conceptions of perception mentioned earlier, but above all in the so-called 'ontologies' of computer science which confront the problem in knowledge engineering of devising a classification of objects that can be used in machines by means of algorithms. Sowa's paper is an example of this situation.

Researchers in artificial intelligence and cognitivists share the assumption that knowledge essentially consists of the manipulation of inner representations. And they have also for long subscribed to a particular semantically-oriented view of *representation*, whether in connectionist modularism or in Newell and Simon's logicist approach to computer science.

This is a legacy from the 'linguistic revolution' of the 1900s which gave rise to the use of a concept of *representation* (*Darstellung*) shorn of its psychological connotations – shorn, that is, of its original features as *cognitive presentation* (*Vorstellung*). In other words, for decades the theory of representation examined the cognitive aspects most closely connected with either *formal expression* or *linguistic communication*, rather than aspects of the *inner mental representation*. The difference is a subtle one and can be exemplified by citing the differing uses made of the terms *expression* (*Ausdruck*) and *notification* (*Kundgabe*) in the theory of representation; terms which refer respectively to the 'incoming' and 'outgoing' aspects of the representation itself. The concept of representation was therefore long considered to be the analogue of the concept of *Bild* employed by the theoreticians of physics, which was founded on the relationship between *signs*, *objects* and *states of affairs* where the object was identified by formal definition in a model. Consequently, and for an equally long period of time, *perceptive forms* had no role to play in scientific descriptions of the world, and ignored as obsolete were most of the problems relative to a *schematism of experience*.

One of the surprising aspects of the problem is that, without wishing to minimize other influences, the dominance of the concept of representation as opposed to presentation – from the outset and in the two areas associated with (i) the *theory of knowledge* and (ii) *semantics* – was largely due to Bühler's critique of the a-sensory provenance of the act of presentation and his advocacy of an immediately *content-based* Gestalt theory.[49]

This is an interpretation that has gained widespread currency. Indeed, the assumption that it is not possible to achieve a *conscious construction of forms* starting from the original primitive elements – and in general that analysis of both *Gestalten* and *meanings* must begin with *mental contents* (*Inhalte*) rather than information about sense impressions (*Gehalte*) – has passed with various contaminations into analytic phenomenology. It is to be found, for example, in Føllesdal's interpretation of the Husserlian concept of *noema*, a highly defective 'mentalistic' interpretation.[50] For decades, the same assumption has been used to liquidate a series of theoretical and experimental findings, whether of Helmholtzian or Hartmanian derivation, concerning the *original structural aspects* of perception as unconscious. And the same shift is to be found in Husserl.[51]

The crucial theoretical feature of the choice of a particular 'format' of representation – for example, the choice of 'externally' directed aspects rather than 'internally' directed ones – consists in *which primitives* of the description are selected. Since the 1930s, definitional primitives have usually been chosen, in the manner of Goodman or Carnap, thereby relegating the (objective) experience of perceptive or mental forms to the realm of (subjective) 'living'. Understanding the *dynamics of forms*, therefore, is also to shed light on the *linguistic description* and *scientific depiction* of the world.

Today, however, the cognitive sciences are once again confronted by the problem of schemata of experience because of the difficulties raised by analysis of visual or auditory perception, or of mental rotation, and this restores importance to the original presentational aspects. In various ways, Biedermann's geons, Marr's sketches, and Palmer's studies on the segmentation of figures – the examples abound – revive an approach current before the 'linguistic revolution' in epistemology and which distinguishes between *low-level* features (coterminations like T, Y and Arrow conjunctions, continuation) and *high-level* (symmetry, parallelism, grouping) features (or primitives or non-accidental properties) in perception and imagery.[52] In other words, this is a return to conceptions such as those developed by Lipps, Bühler, Allesch, Benussi, and others, and a revival of the problem of the whole and parts in perceptive wholes.

A further example of this change of perspective, one which directly concerns language, is provided by cognitive linguistics, which, in line with cognitive psychology and in opposition to formal and syntactic semantics, has taken up the idea of a representational semantics based on the *schemata of perception*. The distinctive feature of this type of semantics is not so much the concept of 'cognitive', which could for example be adapted from Chomskian generative grammar; instead, cognitive semantics are distinguished by the *phenomenological* rather than mental or 'mentalist' character of cognition, relatively to the perceptive processes and structural factors that underlie it, and which can be summed up in the laws of Gestalt. Finally, cognitive semantics more or less expressly envisage the existence of a *continuum* which traverses all the aspects of the human categorization of the world, from its perception to its linguistic description.

In short, cognitive semantics develop a concept of *natural grammar* that still does not exhibit a separation between syntax and grammar and which comprises *categorial structures or invariants.* In particular, an approach of this kind resembles Talmy's linguistic analyses of the temporal structure of the spatial representation and the force fields that operate in language. These are themes that, at the foundational level, were already evident at the beginning of this century in Brentano's theory of intentional reference, in Lipps' mechanics and their configurations of non-Euclidean space, and in Bühler's theory of language. An example of this type of approach to language is provided by Massironi and Levorato's contribution to this book, which analyses the relationship between perception and language at the level of the *representations that they have in common,* and on the basis of experiments conducted on the primitive or 'innermost' aspects of the spatial representation.

In conclusion, this book on form sets out a theoretical proposal for identification of a *schematism of experience* so that unitary organization can be given to the enormous mass of experimental data now available to us. Such a schematism, however, still fails to qualify as a general *theory of experience.*

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NOTES

[1] Gardner 1985.
[2] Gibson 1979.
[3] Gregory 1980.
[4] Fodor 1968; Pylyshin 1981.
[5] On the modes of being see Metzger 1941, ch. 2.
[6] Meinong 1910.
[7] Hintikka 1997.
[8] Vicario 1993.
[9] Brentano 1874.
[10] Lipps 1897; Bühler 1913.
[11] Fodor 1979.
[12] Talmy 1985; Langacker 1987;Lakoff 1987.
[13] Thinès 1991; Vicario 1993; Bozzi 1989.
[14] Albertazzi 1994.
[15] On the concept of invariant see Koffka 1935, ch. 6; Zimmer 1989. On the distinction between formal and material invariants see *infra.*
[16] Katz 1911.
[17] Lipps 1897; Lewin 1936
[18] Talmy 1985.
[19] Stumpf 1883.
[20] Petitot 1985.
[21] Wertheimer 1923.
[22] Stroud 1949.
[23] Vicario 1973.
[24] Legrenzi 1971.
[25] Gerbino 1988.
[26] Thom 1980.

[27] Vicario 1997.
[28] Albertazzi 1996.
[29] Eilan, McCarthy 1993.
[30] Bonaventura 1929.
[31] See, for example, the 'rediscovery' of *Zeitverschiebung* phenomena by the cognitivists, as in Michon, Jackson 1985.
[32] Neisser 1987.
[33] Brentano 1974; Varela et al. 1992; Maturana 1978.
[34] Michon, Jackson 1985.
[35] Husserl 1900–1.
[36] Goodman 1951.
[37] Null 1983; Fine 1995.
[38] Thom 1980.
[39] According to Brentano, descriptive psychology sets itself the following tasks: distinguishing and classifying the *elements* of psychic phenomena; clarifying the nature of psychic phenomena and the *laws of their dependence* on the whole of consciousness; elaborating the *connections among the parts* of the whole of consciousness; and justifying a grammar of *linguistically expressible* psychic experiences. Consequently, implicit in the theory of intentionality and its applications is a *theory of language* based on the structural laws that govern the formation of wholes of consciousness or psychic phenomena. Cf. Brentano 1928; Husserl 1900–1, *Third Investigation*; Marty 1950; Koffka 1935; Baumgartner, Simons 1992/3.
[40] Wertheimer 1922–23.
[41] Whitehead 1929; Peirce 1931–35.
[42] Bozzi 1989; Albertazzi, forthcoming.
[43] Peterson et al. 1991.
[44] Peterson, Bradley 1993; Luccio 1997.
[45] Smith, Petitot 1996.
[46] Brentano 1976.
[47] Segall et al. 1969.
[48] Maturana 1978; Varela et al. 1992.
[49] Bühler 1913, especially part II, ch. 1.
[50] Føllesdal 1969. For the contrary view see Gurwitch 1964.
[51] Husserl 1966.
[52] Palmer 1975; Marr 1982; Biedermann 1985.

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EXPERIMENTAL PHENOMENOLOGY: A HISTORICAL PROFILE

I

Those authors who have attempted to trace the evolution of Gestalt theory, or those who have had occasion to examine its origins, are unanimous in indicating an experimental study by Max Wertheimer (1880–1943) as marking its beginnings.[1] The subject-matter and approach of Wertheimer's study had none of the features typical of a manifesto for a new line of thought, such as those displayed, for example, by the article 'Psychology as the Behaviourists View It' published by John B. Watson (1878–1958) just one year later than Wertheimer's and which inaugurated the behaviourist movement.

Instead of setting out an epistemological programme, Wertheimer conducted wide-ranging and complex experimental inquiry into a specific type of apparent motion: stroboscopic movement. This was a phenomenon of which scientists had been aware for almost a century, and it was the basis of perception of cinematographic images. Wertheimer's experiments demolished almost all of scientific psychology's previously-held tenets. Admittedly, he attacked only theories of perception, which were then based on the two pivotal ideas of 'sensation' (the atom or minimum unit of sensory perception) and 'association' (the associative intervention of thought, memory or imagination on the material of the sensations). It is also true, however, that he thus struck at the roots of the general ideas sustained by any form of elementarism or summativism and, indeed, at the metodological assumption – which at the time encompassed almost every area of psychology – that it was possible to break every complex event of human experience down into simple parts without thereby losing what today is called information on its inner laws.

Was this a novel idea? In the 1930s, a number of scholars compared the Gestalt revolution to that accomplished by Einstein in physics. Others, however, and among them the most outstanding historian of psychology, Edwin G. Boring, did not regard it as anything particularly new. Nevertheless, following Wertheimer's study, an extraordinary quantity of empirical research – and an unprecedented amount of experimentation in controlled conditions – converged on his theory. And it was a theory which, in its turn, generated a very large number indeed of new discoveries, mainly in the field of perception but also as regards other cognitive activities and in social psychology. Still

L. Albertazzi (ed.), Shapes of Forms, 19–50.

today, Wertheimer's approach has great heuristic potential in psychological research.

In Boring's view, some aspects of Gestalt theory had roots that penetrated deeply into the history of Western culture. Several psychological theories of the nineteenth century had already modelled concepts that resembled those that would subsequently be utilized by the Gestaltists, and Gestalt theory itself comprised a philosophy of knowledge well aware of its philosophical, epistemological and scientific antecedents. Accordingly, it is necessary at the outset to mention certain ideas which, in the history of Western culture, anticipated some of the central notions formulated by the Gestalt movement.

2

For the sake of brevity, I shall restrict my discussion to two themes. First I shall examine the whole/part relationship, which plays a crucial role in Gestalt theory both in its studies of perception and in those on memory and thought, and which the Gestaltists also used as an interpretative tool in their numerous experiments conducted in the area of social psychology. The whole possesses inner properties which are no longer apparent in the parts into which it is subsequently broken down, and which cannot be inferred from item-by-item inspection of these parts (the slogan 'The whole is something more than the sum of the parts' inadequately conveys the idea). The whole is not the totality of consciousness but the structure often possessed by specific events in ongoing experience.

Second, I shall discuss the primacy of the phenomenological method in experimental design and in the construction of explanatory models: that is, the Gestaltists' constant appeal to the forms of immediate experience, to the qualitative structure of the events of everyday experience, accompanied by the temporary 'bracketing' of what we know – or believe we know – from the other scientific disciplines or from psychology itself and which might hamper our capacity to conduct ingenuous observation of phenomena.

These are themes already to be found in Plato and Aristotle. In the *Theaetetus* (204 a), Plato poses the question: "Or do you wish to say that also the whole is made up of parts, although it is a single idea and differs from all its parts?" – a question which implies the answer 'no' – after having shown that "the syllable is not the letters, but rather some sort of single idea born from them, with a form unique to itself and different from the letters" (203 o).

In various passages in *Metaphysics*, Aristotle addresses the theme of the inner cohesion of the units of experience, arguing that the strongest unit is characterized by 'continuity'. There may, however, be increasingly weaker units, such as the bundle of wood lashed together with a cord, pieces of wood simply in contact with each other, and so on.

As far as phenomenological evidence is concerned, Plato's endeavour to "save phenomena" is well known, and so too is Aristotle's dictum that "to touch with the hand and describe, this is truth".

Interesting examples of phenomenological analysis and observations on the relationship between the whole and the parts are to be found in Descartes, Malebranche and Condillac, and also in the English empiricists (notably in Locke, who distinguishes sharply between summative aggregates and structures in which the organization of the parts gives rise to a coherent whole) – their programmatic sensism and elementarism notwithstanding. Nicholas Pastore's book *Selective History of Theories of Visual Perception*[2] provides an excellent account of these matters.

However, the history of the ideas relevant to understanding of Gestalt theory, understood as a twentieth-century scientific and philosophical programme (and, in this sense, still operating in certain cultural areas of Europe, Japan and the United States) began with Kant.

I shall devote the first part of my exposition (until Section 5) to certain aspects of the philosophical thought and specifically psychological theory which, from Kant until the early years of the twentieth century, highlighted the shortcomings of the method which broke facts analytically down into elements – although it was a method that led to numerous advances in the natural sciences (chemistry, for example) – and which instead emphasised the organic character, the objective structurality, of many mental experiences and of the experience itself of the outside world.

The second part of the essay (sections 6 and 7) will examine the foundation of the Gestalt movement, its falsificatory and polemical phase, followed by the open-minded research and theoretical enthusiasm which culminated in the systemization set out in Koffka's *Principles*[3].

The third part will conduct a survey of the works which, once the philosphical debate on the foundations of the theory had died away, extended Gestalt principles to broader areas of psychological research, as far indeed as psychopathology and aesthetics.

As said, the most systematic anticipation of Gestalt theory is to be found in Kant. His restoration of the entire problem of knowledge to the realm of phenomena; his theorizing of an organizing function of subjectivity in the constitution of objects (*realitas phaenomenon*) without thereby overly emphasizing the relativity of the particular subjects; and finally – at variance with these premises – his constant assertion of a noumenon lying beyond phenomena to which none of the characteristics constitutive of the world of experience can be attributed without committing a gross theoretical error: all these made Kant one of the philosophers most frequently cited by Gestaltist texts. There is, of course, a fundamental difference between the two positions: the noumenon, or transcendent thing-in-itself, was for certain Gestaltists (Köhler, Metzger) the world treated by physics, while the only interpretation of mathematical physics was, for Kant, the world of phenomena. However, this difference may be not so much a divergence as a semantic shift due to the profound changes that physics has undergone in the last two centuries.

Kant's *oeuvre*, moreover, abounds with extremely subtle phenomenological analyses. By way of example we may take the following: if I observe a house before me, I explore it with acts of observation which follow each other in time and are dislocated in space; if the house were nothing but these sensations, its parts would be phenomenically successive in time. But the house *qua* phenomenon is the object of this exploration; it is simultaneous in its parts, it exists previously to the acts of observation and it is independent of them. This is said not of the house as a thing-in-itself but of the house as a phenomenon-in-itself. The perceptive structure possesses an autonomy pre-established with respect to the observer, and it is extraneous to the flux of momentary sensations. This passage from the *Critique of Pure Reason* already draws a sharp distinction between the phenomenal objects 'encountered' and the momentary properties of the visual field; a distinction which is crucial to understanding of the Gestalt phenomenology of visual perception.

In the *Critique of Judgment*, the whole/part relationship is treated thus: "we may also conceive of an intellect which, not being discursive like ours, but intuitive, moves [...] from intuition of a whole as such to the particular, that is, from the whole to the parts".[4] Consequently we must admit "the possibility of the parts (according to their nature and their connection) as dependent on a whole [...] so that the representation of a whole contains the principles of the possibility of its form and of the connection thereto of the parts"[5].

Some lines from this paragraph are quoted by Goethe in a posthumously published philosophical fragment. Goethe was, if one may say so, highly Gestaltist both in his experimental research on colours and in his philosophical-scientific speculations. Although less systematic than Kant, obviously, he was nevertheless an empirical researcher of considerable imagination and talent. The cornerstone of Goethe's epistemology is the immediacy of the outside world as given by perception: "It is not the senses that deceive but the judgment [...] man in himself, insofar as he makes use of his healthy senses, is the greatest and most exact physical instrument that there can be".[6] Another key idea in Goethe's investigation of chromatic phenomena is that it is extremely difficult to see phenomena in their authentic nature, in their true constitution, because our eyes are clouded by theories, by the abuse of mathematical schematizations, by language itself. A third central component of Goethe's theory is the notion that there is continuity between laboratory research and the world observed in its free state, because it is possible to find ever richer situations starting from simple experiments, and to construct a factual continuum which comprises every level of complexity without omitting the "original phenomenon" (the law identified by means of experiments).

A striking feature of Goethe's theory of colour – although it is one both widely criticised and criticizable – is his insistence that colours are not pure chromatic shades but aspects of material structures endowed, besides chroma, with coarseness or brightness, hardness or softness (a theory which would be later experimentally corroborated by David Katz (1884–1943)): indeed, he once wrote: "might it not be that colour does not belong to the sight?"[7] A part of *Farbenlehre* is devoted to study of the expressiveness of colour, which Goethe calls "sensible and moral action". Although this component of his research was not conducted using experimental method, it is rich with subtle insight, especially as regards the combinations of colours capable of generating impressions and affective states.

3

As we know, to Goethe's detriment is the fact that he waged a tenacious and (in terms of physics) baseless polemic against Newton's optics. But there was another factor that undoubtedly helped to prevent the philosophical framework of his theory and the fecundity of his empirical findings from entering the mainstream of scientific research in the decades that followed publication of *Farbenlehre* in 1810: this factor was the birth of psychophysics.

In psychology, psychophysics was the exact opposite of the assumption that the unit of analysis – that is, the subject-matter – of scientific inquiry is the complex organizations of experience. Psychophysics was based on the principle that every complex structure of visual, acoustic, tactile, kinesthetic, and so on, experience had to be broken down into its elementary parts or minimal components (a sound, a colour, a weight), and that empirical research began once this decomposition into isolated elements had been accomplished. It was thus possible to have a sensation of sound insulated against the influence of other possible factors, and given that the sound can vary in pitch, timbre and intensity, these three sensory parameters could be applied with great precision to variations – measured by physical instruments – in the frequency, in the spectral make-up of the wave, and in the amplitude of the oscillations of a vibrating body (stimulus). Those wishing to study colours had first to dismantle the ingenious juxtapositions that interested Goethe and to draw a map of all possible variations in each individual colour observed. This map had borders which merged into nothingness because there are stimuli too weak to be noticed, physical impressions on the sense organs incapable of producing sensations. These borders represented the absolute threshold of the perceptible.

If we conceive the world of experience as an infinite collection of sensations, according to the fine description by David Hume, and the surrounding physical world as an infinite galaxy of stimuli, and if moreover we conceive of every sensation as standing in a univocal relation with a specific stimulus and varying in accordance with it, then the study of experience becomes just an analysis of the relations between stimuli and sensations. These relations were formalized in Weber-Fechner's law, which is the basis of psychophysics. Of course, if this scientific programme was to achieve the results it desired, it had to accept *in toto* the chapter in J. S. Mill's *Logic* (1843) which recommended the decomposition of complex phenomena into their elements. It was no coincidence that psychophysics was born in the very same years that British philosophy was codifying the rules of a new associationistic empiricism.

The founders of scientific psychology worked for decades on this programme. The vast corpus of analysis produced by Hermann von Helmholtz[8] was entirely based on these presuppositions; to the extent that, with impeccable consistency, whenever Helmholtz came across sensations in his experiments which did not fit the straitjacket of psychophysical laws – that is, sensations which could not be explained in terms of stimulation – he accounted for these facts by resorting to an "unconscious judgment" involving an unwitting memory of past experience or tacit forms of mental calculation able to modify sensations and render them more functional to identification of external physical objects.

However, these facts proved to be so numerous that the sensations of psychophysics came to be the exception rather than the rule, and the intervention of the higher faculties, or of Helmholtz's "unconscious judgment", was invariably cited in explanation when the segments of sensory experience being considered, like the objects of everyday experience or routinely occurring events, possessed a certain degree of complexity. If an object moved away in space, it was the mind that calculated its motion on the basis of the progressive reduction of its retinal projection; if a white sheet of paper was still white at sunset, it was again the mind that remembered its colour at midday and attributed this colour to the paper; and so on.

The deviant behaviour of complex objects with respect to the dictates of psychophysical laws compelled the theory to set off in a fresh direction; and it was this exigency that guided the efforts of the precursors of Gestalt theory.

4

From the 1880s onwards, numerous mainly German authors carried out experimental research in specific areas or conducted thorough revision of their philosophical postulates, or worked on both of these tasks simultaneously. They thus developed a viewpoint (or a range of viewpoints) in sharp contrast with the tenets of psychophysics, and they indeed contemplated recasting the discipline on a more convincing basis.

Not coincidentally, the first of them, Ewald Hering (1834–1918), drew directly on the theory of colours developed by Goethe, who had been the first to attempt a classification of chromatic hues based on the oppositions 'yellow/blue', 'red/green', etc. Like Goethe, Hering did not attempt to formulate a physical theory of the genesis of colours (following Helmholtz); he instead started from the phenomenon of complementarity, that is, from the fact that prolonged fixation on red generates the after-image of green, and vice versa, and that blue likewise generated yellow, and vice versa, as well as the fact that when set against the background of a small grey field each of these colours induces its complementary colour within it. Hering was also interested in the interactions among chromatic areas and in the chromatic changes brought about, not by stimuli, but by the perceptive setting of a particular area. His book *Zur Lehre vom Lichtsinne* (1872) describes numerous strictly phenomenological experiments conducted on complex chromatic structures without the use of psychophysical methods. A distinction is proposed between the colour of things and the ambient light which, from a strictly sensationalist point of view, is nonsensical. Moreover, Hering argued in several of his writings that phenomenological inquiry is physiological in nature because the law of a mental state is the law of a physiological process; which was one way of enunciating what W. Köhler would later call the "postulate of isomorphism".

While Hering was constructing his phenomenological physiology, Franz Brentano (1829–1917) published his book that would be so influential, in various ways, on twentieth-century culture: *Psychologie vom empirischen Standpunkte* (1874). Brentano was not an experimentalist, although he was well versed in the psychophysical literature and in the works of Helmholtz and Wundt. Brentano's "empirical point of view" was founded on direct observation of phenomena, insofar as they are immediately given in experience and ostensible to other observers. His criticism of psychophysics was based on the fact that sensations do not depend solely on the intensity of the stimulus; they also depend on at least the attitude of the subject and on the context in which they are observed. To ascertain this fact it is not necessary to conduct experiments, since mere observation suffices, bearing in mind that the phenomena of perception are "true in themselves". Brentano pushed this argument so far as to contend that perceptive facts, and colours especially, are not psychic facts but immediately physical ones to which the consciousness is directed via intentional acts. *Psychophysical measurements are in reality 'physical-physical'.* The subject-matter of an empirical psychology is intentionality and the act, and the dynamics of this act can be grasped by introspection. He had no misgivings concerning introspective methods because in the act every psychic state is exactly as it appears. Brentano borrowed from Hamilton – who in the mid-years of the century had already advanced an number of interesting phenomenological ideas in British philosophy – the expression "subjectively subjective" in order to describe this aspect of experience *ex parte subjecti*. This sphere comprises, besides sentiments, memories, intentions or will, also sensations; but the object of all of them are the complex things denoted by the term 'physical phenomena': "As examples of physical phenomena we may cite: a colour, a shape, a landscape that I see; a chord that I hear; the heat, the cold that I feel; the odour that I smell". It is the task of phenomenology to identify the border or 'watershed' between these two realms. The object does not lie beyond the subject but at its limit.

Even more radical were the views set out by Ernst Mach (1838–1916) in his book *Beiträge zur Analyse der Empfindungen* of 1886 and subsequently developed in *Erkenntnis und Irrtum* (1905). What I have called the 'watershed' between the subject and the object becomes the ambit of the only reality amenable to scientific inquiry: the order of the sensations on the basis of which, by means of two complex networks of logical relations both coupled to this same empirical material (i.e. sensory experience), it is possible to construct physics on the one hand, and psychology on the other. Physics is constructed – and this is the relatively easier task – by positing systems of relations among sensations which empirically manifest themselves independently of the presence of an observer endowed with a body and mental states. Psychology was born as an attempt to take account also of these latter complexes of sensations, which constitute approximately the 'self'. The 'self' does not have substantial reality, nor does it have clearcut boundaries; it is instead constituted moment by moment in the overall field of experience as a special portion of it, an aggregate of sensations endowed with specific relationships with those that form the world of physics. We shall see below the extent to which this conception of the self was absorbed into the theory of the Gestalt.

To be sure, Mach was the originator of the concept of 'structure' (although this term was not part of his normal vocabulary) in the sense with which it came to play a fundamental role in the Gestaltists' system. Chapter 6 of *Analyse* examines two cases decisive in the formulation of this concept. Consider a letter of the alphabet drawn in black on a white background, and the same letter drawn in white on a black background (but the letter could equally be blue on a red background, green on a yellow background, and so on). The identity of the form is immediately recognized, even though all the colour sensations have changed. The form is independent of the matter of the local sensations; it is a structure, precisely, although Mach calls it a 'sensation of space'. Take these two shapes:

These are geometrically congruent but optically entirely different shapes. The first is a square, the second is what later authors called a 'diamantoid'. The abstract geometric relations are the same in the two cases, but the structure changes with variation in the concrete relations (optical, physiological) between the figure and the surrounding space. Two different distributions of sensations may have the same structure; and two similar distributions of sensations may have different structures. The structure, therefore, is something independent of sensations. Although Mach treats it as a special case of sensation, the theoretical leap has been made: terminology apart, there are objects of the vision which are not reducible to sensations as the psychophysicists defined them.

In Chapter 10, Mach states that sensations are so closely interwoven in the complex objects of direct experience that only by intentional analytical effort can we separate them and consider them in themselves. But the analysis of music that Mach conducts in Chapter 13 gives concrete demonstration that this analytical effort is constrained by very narrow limits: it is the structure, that is to say the system of relations, which governs the parts.

A brief digression is necessary at this point. A history of the theoretical antecedents of Gestalt psychology should contain a chapter devoted to the development of musical theory, especially in the eighteenth-century treatises. The progressive codification of the rules of composition, and of contrapuntal composition especially, led musicians to the discovery of numerous laws of the structuring of sound material; laws based on the shared and unmentioned (because obvious) assumption that the 'whole' has properties which are not present in the 'parts', the individual sounds.

The vertical structures of sounds – that is, of chords – plainly possess perceptive and expressive properties which are not present in the notes that form them; and every note, while remaining materially the same, changes function as the notes of the chord to which it belongs change. As the succession of chords proceeds horizontally, it must be constructed according to the principle of the 'good conduct of the parts', which enables the individual voices to be kept separate. This 'good conduct' is based on the Gestalt law of 'proximity', which we shall meet later when discussing Wertheimer. All the most significant psychologists in the Gestalt school were, moreover, good or excellent musicians who were genuinely interested in musical theory.

Returning to Mach: he demonstrated the existence of a sensation of equality of rhythm with the same technique that he had used previously in analysis of visual shapes: the presentation of two sequences of entirely different notes but possessing the same rhythmic structure. It is therefore not sound sensations that constitute rhythm. Similar considerations concerning simultaneous combinations of sounds enabled Mach to enunciate what later became better known as the 'von Ehrenfels principle': a melody is the same melody if it is executed starting from any note but respecting the order of the intervals and the duration of the sounds. The example is absolutely decisive and it falsifies *a priori* any attempt to relate the properties of the whole to the qualities of the elements into which it can be analysed. In fact, the same melody can be executed – and be recognized as the same melody – in two different tonalities chosen so that no note present in the first appears in the second.

A wide-ranging discussion of these sensation-independent forms – which starts from the case of the transposability of melodies – was conducted in 1890 by Christian von Ehrenfels (1859–1932) in his essay 'Über Gestaltqualitäten' (1890), which gave currency to the term 'Gestalt' in scientific psychology. Von Ehrenfels work was substantially a logical analysis of facts such as those used by Mach which distinguished between sensory ingredients (*Fundamente, Grundlagen*) and the qualities of the whole irreducible to them (*Gestalten*), the latter being classified into temporal structures (for example, melodies) and non-temporal ones (for example, chords or patterns). Von Ehrenfels's essay opened the way for the distinction between structures in the strict sense and expressive properties founded on structures, while it chided Mach for continuing to call such complex objects 'sensations'.

Von Ehrenfels was a pupil of Alexius Meinong (1853–1920) at Graz. Meinong developed the topic of the formal qualities in two important works: *Zur Psychologie der Komplexionen und Relationen* (1891) and *Über Gegenstände höherer Ordnung und deren Verhältnis zur inneren Wahrnehmung* (1899). Experience consists of *inferiora* and *superiora*, founding objects and founded objects – that is, sensations and structures. The latter are tied to the former by logical necessity, in the sense that they cannot exist without their relative *inferiora*. Accordingly, in Meinong's view, the whole depends on the parts; but it should be added that the joint presence of the *inferiora* in consciousness is not sufficient to give rise to *superiora*; there must simultaneously be a consciousness of their joint presence. Meinong did not accept von Ehrenfels's thesis of the sensory nature of complex forms: relations subsist, sensations exist. However, they both appear in full simultaneity and concreteness. This point becomes clearer if one bears in mind that Meinong's aim was to construct a theory of all the objects that can be experienced and thought, both real and unreal, possible and impossible, and all of them hierarchized by foundational relationships. In some way the formal qualities, based on sensations, are the first step towards ideas. Meinong developed this theory between 1904 and 1910, the year in which *Gegenstandtheorie* was published.

The superior intervention of the subject who organizes the material of the senses into higher-order objects, and thereby contaminates the sensations of ideality, was investigated empirically by Vittorio Benussi (1878–1927) and Stephan Witasek (1870–1915). Benussi sought to define the act of production which generates what he called the "a-sensory" (*aussinnliche*) structure founded on the *inferiora* by studying configurations in which a change in the observer's stance modifies the organization of the parts. Of course, this does not happen in melodies, but it may occur in certain cases of structural ambiguities, in the subjective grouping of dots, and even in the reduction of the intensity of certain optical illusions through practice, although Witasek, using very simple melodies, tried to demonstrate their non-sensory nature.

Between 1883 and 1890 two volumes of Carl Stumpf's (1848–1936) *Tonpsychologie* (1883; 1890) were published. A pupil of Brentano and Lotze, Stumpf had already made his mark with an essay in which he argued that extension and colour are properties intrinsic to the perceptive system and able to organize themselves independently of experience. He was an accomplished musician, and it was on musical grounds that he launched an forthright attack against classical psychophysics. He derived a rigorous and productive phenomenological framework from Brentano which enabled him to replace the fragile physicalist theory developed by Helmholtz to explain the consonance and dissonance between musical notes. Stumpf's crucial discovery was that people without musical educations, and therefore not trained in the analysis of sounds, hear pairs of consonant notes presented together as if they were one single sound, whereas on listening to dissonant bichords they are entirely aware that the simultaneously present sounds are two in number. It is very difficult for an octave to be recognized as two simultaneous sounds, and a fifth or a fourth is often taken to be a single sound. But a seventh or a second is readily apprehended as an aggregate of two notes, while a third – in Stumpf's statistics – occupies an intermediate position. The explanation of consonance thus shifts from a physical cause (the beats for Helmholtz) to a phenomenological condition (the 'fusion' or indiscernability of sounds tied by numerically simple frequency relationships).

The influence of Brentano's teaching is certainly apparent in Stumpf's musical psychology, but it is strikingly evident in his two works published in 1907, *Erscheinungen und psychische Funktionen* (1907) and *Zur Einteilung der Wissenschaften* (1907), which addressed themes drawn from Brentano under almost identical titles. The objects of psychology are psychic functions analysed introspectively, but psychology has its necessary propaedeutic in phenomenology – a science no more psychological than physical – whose subject-matter is the world of the things of immediate experience, the condition and outcome of the aggregative functions. Stumpf placed great emphasis on the independence of the properly psychic functions from phenomenal objects by citing cases of empirical evidence in which the function changes without the phenomenon undergoing alterations, or the phenomenon changes without involving the function. The independence of the external world from the subject accordingly finds its phenomenlogical foundation.

5

The first years of the twentieth century saw publication of the *Logische Untersuchungen* (1900–01) by Edmund Husserl (1859–1938).

The work was dedicated to Carl Stumpf, and one of the authors cited in it was Brentano, under whom Husserl had studied. Husserl's aim in the *Logische Untersuchungen* was to give an anti-psychologistic foundation of logic and the theory of knowledge. It should therefore fall outside the line of historical development from Locke to Gestalt theory expounded here. However, experimental psychology in general is anti-psychologistic, although Husserl himself was largely unaware of the fact.

Husserl tended to identify psychology with the theories of Wundt, who, after setting up the first laboratory of psychology, dominated the academic scene of the time. Following J. S. Mill, Wundt recommended the breakdown of every experience into elementary sensations or, more broadly, "mental elements". Husserl's notion of 'psychologism' may be applied directly only to this manner of proceeding. It should be borne in mind, however, that much of European and American psychology at the turn of the century was of Wundtian derivation. Husserl therefore had a very broad target to attack.

It is impossible here to dwell at length on the analyses of the structure of experience that abound in the *Logische Untersuchungen.* Already in *Philosophie der Arithmetik* (1891), Husserl had based the apprehension of multiplicity on a concept similar to that of *Gestaltqualität* formulated by Mach and von Ehrenfels. In a commentary on Stumpf in *Logische Untersuchungen*, he analysed the functional dependency among the qualities constitutive of an object as evidenced, for example, by the fact that the colour of an object may change with its shape, or the timbre of a sound with variation in its intensity, although cases might arise in which this dependency did not occur. The entire work is traversed by a covert discussion with Stumpf and Brentano that surfaces in the appendix to the second volume: whether or not we call the objects of the intentional acts 'physical', they have the same evidence that Brentano attributed to our inner states. Thus: "inner perception and outer perception, to the extent that these terms are used in their natural sense, have exactly the same character from the gnoseological point of view";[9] and "I perceive that anguish squeezes my throat, a tooth causes me pain, sorrow torments my heart in the same sense that I perceive that the wind shakes the trees or that this box is square and is dark in colour".[10] Husserl's subsequent works – although they seem to have exerted very little influence on the Gestaltists' theoretical work – are extremely rich in observations that might belong to a scientific and experimental psychology inspired by Wertheimer, although Husserl's prose style grew increasingly impenetrable, and the philosophical implications of his new language tended more towards a noumenology than towards an empirically verifiable phenomenology.

It is worth pointing out that a phenomenology of immediate experience was also outlined by Charles Sanders Peirce (1839–1914) in numerous notes written between 1895 and 1910. Peirce repeatedly recommended that logical constructs or natural prejudices should not rely on the observation of objects. His *phaneron* was the "complete set of everything that is in some way and in some sense present to the mind, irrespectively of whether it corresponds to some reality or not",[11] but mention of the word 'mind' does not imply any form of mentalism, despite the fact that it normally carries "a psychological connotation which I intend carefully to exclude".[12] Phenomenology, according to Peirce, "examines direct experience by combining the minutest accuracy with the most broad generalization" and it pits itself "against the reasoning according to which facts *should* be such and such", because its task is the "simple and honest observation of appearance".[13]

Although Peirce's theories were not taken up, in those same years – that is, the first decade of this century – numerous scholars more or less consciously adopted phenomenological methods in their inquiries into perception and thought processes: most notably Georg Elias Müller and Friedrich Schumann, who identified the problem of unity in the visual field and indicated spatial proximity as an organizing factor (besides proximity, Müller listed similarity, e.g. identity of colour, and continuity of direction, which we shall meet later when discussing Wertheimer). David Katz resumed one of Goethe's favourite themes and conducted numerous experiments to demonstrate that colours have various modes of appearance:[14] for example the epiphanic colours, which are perceived as surfaces; the diaphanic colours, which appear penetrable to the gaze (fog); the volumetric colours (a turbid liquid), which are perceived as properties internal to the substance of a three-dimensional body; colours which admit to transparency; and so on. These are phenomenological structures which cannot be explained in terms of the physical properties of the light that strikes the eyes – which is subject to only three variables (frequency, amplitude and spectral composition) – but only in terms of the context in which a given colour is present.

At Würzburg, throughout the whole of the first decade of the century, under the supervision of Oswald Külpe (1862–1915) and later Karl Bühler (1879–1963) numerous researchers conducted phenomenological analysis of thought processes which took the form of controlled introspection.

The method – which consisted in the minute description of events occurring in the mind some instances before the subject answered a detailed question, or solved a simple logical problem – was fiercely criticised by Wundt as non-scientific. Nevertheless, replication of these experiments in the conditions described by the original researchers yields very similar results, showing that it is indeed possible to observe thought in its act of genesis and development, and to capture its emotive concomitants (uncertainty, stress, sudden lapses), as well as, sometimes, the images that accompany it (although, according to the Würzburg school, these do not perform an important role). Moreover, the fundamentally important work on thought that Wertheimer wrote some decades later invited its readers to perform the same sort of experiment in order to test the reliability of his theory empirically.

6

The essay that Wertheimer published in 1912, and which I mentioned at the outset, is not only an exhaustive account of the conditions and forms of stroboscopic movement, it is also the text which from an epistemological point of view inaugurated the first phase of Gestalt theory, which I shall call 'falsificatory'. In 1910 Wertheimer met Wolfgang Köhler (1887–1967) and Kurt Koffka (1886–1941) at Schumann's laboratory in Frankfurt: Köhler had been a pupil of Stumpf, while Koffka was from Würzburg. They were the first to see Wertheimer's experiments and to act as his experimental subjects. From their discussions was born the theoretical framework of Gestalt psychology. Enthusiasm for the new theory inevitably bred controversy, and falsificationism was the epistemological guise assumed by the polemic. One year after publication of Wertheimer's research Köhler's theoretical work *Über unbe-*

merkte Empfindungen und Urteilstäuschungen (1913) appeared as the first explicit and rigorous theorization of the principle of falsifiability.

Wertheimer's main observations can be summarized as follows: if two lights are projected onto a screen, with a short distance between them, with a temporal interval of varying magnitude between the moment when the first light is switched off (a) and the second is switched on (b), we may see different things: if the interval of darkness is less than 30 msecs we see the two lights as switching on and off almost simultaneously; if the interval is longer than approximately 60 msecs, we see a single light moving from one position to the other, like an object travelling along a highly visible path; if the interval is extended even further, we again perceive two distinct lights, each of them briefly moving towards the position of the other. But with any further extension of the time interval, *a* and *b* alternately occupy each other's positions, while movement in the pure state occurs between them: a movement without an object in motion, the clear and distinct perception of motion in itself, what Wertheimer called movement ϕ. Only when the time interval is longer than 200 msecs, or more, will *a* and *b* appear consecutively in their positions, with no trace of motion in the space between them. Thus, merely by adjusting the time interval, we obtain two facts which are phenomenologically irrefutable ("*esse est percipi*" taught the Brentano-Stumpf-Husserl tradition, with the external support of Peirce) and of exceptional theoretical importance: two objects in a *static* position become *one* object in *movement*; and the movement may detach itself from the object and present itself as pure phenomenon. It is extremely difficult to go beyond a phenomenon such as this in search of the elementary sensations of which it is constituted. The movement is *a primum* non-analysable, and it may provide the point of departure for analysis of further problems.

Movement in perception is an axiom to be posited in order to yield further logical developments. But the psychology of sensations had contended that stroboscopic movement is seen because the subject unwittingly moves his or her eyes from one spot to another when light *a* is switched off and light *b* appears. Wertheimer placed *a* to the right and *b* to the left, but just below them a' to the left and b' to the right, and then switched the lights simultaneously on and off. Thus, while *a* moved towards the right, a' moved towards the left; but the eye cannot move in two directions at once. Therefore the thesis was false.

The psychology of sensations had also claimed that stroboscopic movement was not really seen; it was thought, or imagined so vividly that it seemed almost real. Wertheimer arranged for an optimal stroboscopic movement (with 60 msec of interval) to be projected over the real movement of a light source. The apparent movement was more real than the real one. The phenomenological method thus confounded the most profoundly-held tenets of the doctrine of the sensations.

When Wertheimer's essay was published, Köhler was at work on his article on the unnoticed sensations and errors of judgment. The article waged a somewhat acrimonious polemic against his master Stumpf and whatever of the sensationalistic his theory of perception still preserved. The current interpretation of perceptive facts, Köhler argued, ran as follows: the physical stiimuli that affect the peripheral sense organs generate sensations which vary with the stimulus according to psychophysical laws: as soon as the sensations are formed (and before they are felt; that is, before they become true sensations), judgments in the unconscious sphere of the mind re-order them and transform them in accordance with what we know of the outside world, or in accordance with certain "schemes of calculation" (Helmholtz). This operation of the unconscious judgments on the unnoticed sensations means that we see true objects before us, rather than patches of colour; but a certain inertia or blindness of the mechanisms of judgment means that we also see deceptive things like optical illusions.

Köhler's arguments against this thesis ran as follows:

(a) To be sure, there exist examples of sensations connected univocally to stimuli, and they vary with variations in them. These examples are constructed in the laboratory so that every action on sensations not reducible to variation in the stimuli is rigorously excluded. By restricting the field of facts to experiments of this kind the psychophysical hypothesis of the constancy of the stimulus/sensation ratio can never be refuted.

(b) Let us take a case in which matters do not add up from a psychophysical point of view: an optical illusion in which two psychophysical lengths appear to be different. With effort and a great deal of practice we may finally see them as equal – that is, 'as they really are' – except that when our effort ceases they revert to what they were before. Why do we not say, at this second moment, that we see them 'as they really are'? Because from the beginning we have accepted the hypothesis of stimulus/sensation constancy as a general theory of the sensations.

(c) When we encounter cases which contradict the hypothesis of this constancy, we say that they stem from an 'illusion due to the judgment'. But this explanation is advanced only when the constancy hypothesis is contradicted by the facts; and moreover we are by no means aware of having this judgment in mind. An effectively thought judgment able to modify the sensations would offer at least a foothold for research, but unconscious judgment cannot give it any concrete indications.

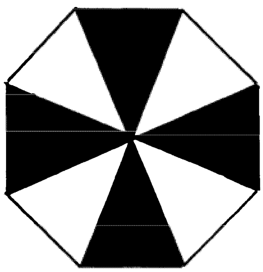
The conclusions are evident and immediate: the classical theory of the sensations-perceptions is not falsifiable. There is no fact, not even an entirely imaginary one, that it cannot explain. In every imaginable case, indeed, either the perception matches the stimulus and the explanation is psychophysical, or the perception is at variance with the stimulus and the auxiliary hypothesis of the unconscious judgment intervenes. "The auxiliary hypotheses, precisely because of their logical nature, bury faith in observation: specifically, faith in the facts that are the object of psychology, and the pleasure of observation, the taste for progress".[15]

In this way the new phenomenology no longer took the form of the descriptive recognition of immediacy (Brentano, Stumpf) but of recognition of the facts of direct experience which by virtue of their structure falsify general theses and explanations comprising mechanisms irreducible to experience itself. For a theory to be true it must foresee which facts should not come about. That is to say, it is not a theory if it explains every possible and imaginable fact. Only in 1934 would Karl Popper write that "an empirical system should be confutable by experience",[16] thereby familiarizing philosophers by compelling analysis with this basic principle of scientific inquiry.

If viewed in the light of Köhler's epistemological proposal, Wertheimer's study of apparent movement marked the beginning of a new experimental psychology. The dismantling of theories by citing facts imcompatible with whatever can be deduced from them became the preeminent style of researchers with Gestaltist training.

In the same years, moreover, and outside the Wertheimer-Köhler-Koffka group, Edgar Rubin working in Göttingen discovered the first phenomenological laws of the figure/background articulation. The perceptive field is made up of objects detached from their background because of the shape of chromatically differentiated areas, not because of the individual sensations of colour into which the field can be decomposed. The entire organization of experience rests on this structure.

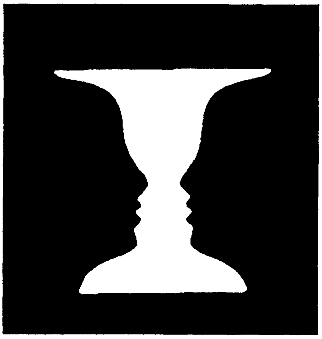
If a loop is drawn on a homogeneous surface, one sees that the area within the loop has a visibly different character from the area lying outside it: its colour and grain make it a 'thing' (*Dingcharakter*), while the remaining area does not stop at its boundaries but passes behind it. If a piece of paper is divided into two equal parts, one black and one white, with a straight border between them, it appears to be the juxtaposition of two surfaces. But if the border is curved to make, for example, the white part convex, it becomes a figure against a black background. In a figure like the following:



it is possible to see a black cross with horizontal and vertical arms, or a white cross set at 45°. Prolonged fixation on the figure enables the eye to pass from one perceptive pattern to the other. In this passage, all the roles of the parts are reversed. Whereas at first the black cross was figure, with the white between its arms as the background which also extended behind the cross, and the character of 'thing' concentrated in the black areas, now it is the black that appears as background and the white becomes more compact.

At the moment of the inversion, the margins dividing the white from the black change their function. They at first limit the black, leaving the white free to expand behind the cross; then they limit the white, with a black octagon lying behind. Therefore, where there are figures, the margins perform a unilateral function.

The shift in the unilateral function may give rise to different figures, as in the following example:



All this happens while the sensations – defined as the close correlates of the stimulus – remain the same. Indeed, the concept of sensation has no role to play in this analysis.

Moreover, the figures are remembered more readily than the backgrounds, and they arouse richer associations of ideas.

These results were published in 1915 in Danish, in 1921 in German, in a book entitled *Visuell wahrgenommene Figuren.*

In the year 1915, Köhler was living in Tenerife, where he had been trapped by the outbreak of the First World War. During this period he devoted himself to the study of intelligence in anthropoid apes. In his work with chimpanzees he conducted lengthy analysis of their behaviour in learning and problem-solving situations. Although the chimpanzees were caged, their movements were unimpeded (the animals were therefore not confined by laboratory equipment which restrained them according to the researcher's experimental design), and the problems set them involved various ways of obtaining a banana. In these conditions the animals revealed themselves to be highly ingenious. They were able to pile boxes on top of each other when the banana was hanging from the roof, or to find a thread tied to a banana outside the cage but with one end just inside it, or to fit two sticks together and make a longer one when the banana was too far away to be reached with only one stick.

But the real theme of the inquiry was the following: already evidenced by animal behaviour is the fact that the solution to a problem consists in the improvised restructuring of the individual parts of the perceptive field. Thought has something in common with perception. Just as the eye suddenly sees the two profiles in the above illustration after first having seen the goblet, so in representation of the objects present in the surrounding field the intuition may abruptly arise of the relationship between the two short sticks which can be made into long one, on the one hand, and the goal to be achieved on the other. Even more so when solving the problem is made easier by arranging the sticks in line, thereby perceptively prompting the subject to fit them together.

The act of grasping the relations among facts and thus solving the problem was called *Einsicht* – 'insight' (intuition, restructuring act) in English – and it became the cornerstone of Gestalt psychology of thought. This body of research was published in 1917 under the title *The Mentality of Apes*. In that same year, Wertheimer was probably already making notes for a study of the psychology of logic, in which the notion of insight was to throw new light on the problem of syllogistic proof. He had in fact promised the study for Stumpf's seventieth birthday. Although from a formal point of view the syllogism is a concealed deduction, as J. S. Mill had pointed out, there are cases in which the conclusion takes the form of a discovery – that is, cases in which the restructuring of the meaning of the premises produces the 'insight' of the conclusion, the evidence for its necessity.

The years of First World War, the period in which the foundations of Gestalt theory were laid, saw another theoretical contribution of major importance: Koffka's polemic against Benussi, and in general against the Graz school. The aim of Koffka's arguments was to demolish the idea of 'production' which, as we have seen, took the elements of sensory origin (sensations) and shaped them into experiences of a-sensory origin, true Gestalten, structures in which the whole is more than the sum of the parts. Koffka's clarification – which is a model of the logical analysis of a theory – gave a new and definitive form to the Gestaltist idea of Gestalten. These do not arise from a combination of sense data, since they exist as objects of immediate experience from the outset. Hence the problem of their genesis is a false problem. Nor does the question of their correspondence or non-correspondence with the stimulus arise: given a constellation of stimuli, the structure of the object emerges just as it is, without being mediated by the sensations. The sensations of the psychophysics laboratories are simply what is obtained by decomposing the object. And it is this that should form the basis of a new physiology of the brain.

These theoretical assumptions gave rise to a substantial body of empirical research conducted both by the three founders of the school and by the various researchers who joined them.

Thus 1921 saw publication of the first fascicle of *Psychologische Forschung* (Psychological Research), a journal which gathered and published the research and debate generated by the new theory.

7

During the life of *Psychologische Forschung*, which ceased publication in 1938 as a result of Nazi persecution, Gestalt psychology extended the bounds of its inquiry beyond the phenomonology of perception to encompass the problems of thought, memory, emotional dynamics, social psychology and even psychopathology.

However, before considering these matters, mention should be made of an essay on natural philosophy which Köhler published in 1920. Entitled *Die Physische Gestalten in Ruhe und im stationären Zustand*, this essay won Köhler appointment to the professorial chair vacated by Stumpf. His discussion centred on the properties of suitably selected physical systems, and on their theoretical applicability in interpretation of certain classes of perceptive facts. The dynamic self-distribution of electrical charges on a semi-conductor, and more in general the properties of electrical and magnetic fields, illustrate in physics the peculiarities of the perceptive forms that Koffka had demonstrated to Benussi: once the appropriate conditions obtain, the structure is instantly realized, and it is the whole of this structure that determines the local properties of the field. If from a semiconductor of a particular shape, and with a certain distribution of electrostatic charges on its surface, some of these charges are eliminated, those that remain redistribute themselves immediately and re-establish the overall pattern of the field.

Besides these examples, Köhler lists numerous others taken from the mechanics of liquids and rigid bodies. Different physical patterns can be placed in relationship to the same perceptive structure. The permanence of a stable configuration in the visual and auditory field can be likened to the behaviour of an isolated physical system in stable equilibrium, but also to a stationary system in which a dynamic process takes place continuously over time (like the constant flow of a liquid in a cylindrical tube); or to an oscillating stationary process in which the dynamic properties of the system recur cyclically over time (like vibrating chords or pendulums).

The relationship between figure and background, for example, can be interpreted as a surge of potential in a homogeneous conductor. Assuming the region of the conductor, which here represents the *figure* (in Rubin's sense), to be considerably smaller than that of the *background*, there will be an average density of energy internally to the region of the figure that is proportionally greater than the energy distributed across the remaining region. In fact, the same quantity of energy is concentrated into a smaller space in the *figure*. It is not difficult, writes Köhler, to set this fact in relation to the salience possessed phenomenologically by the *figure* with respect to the background.

As his discussion proceeds, Köhler devotes four pages[17] to an attack on universal interactionism. This attack should be mentioned because it rests on an entirely distorted interpretation of Gestalt theory.

A straightforward philosophical adjustment to the arguments set out so far yields the idea that 'everything depends on everything' and that, in psychology, only the totality of consciousness is able to explain individual events. From a Gestalt point of view this is an entirely erroneous assumption. The field of experience is made up of a myriad isolated systems, each of which is Gestalt in the sense explained above, but all of of which are independent of all the others, just as "the world of physics is sharply divided into physical systems, to which alone natural laws apply".[18] If universal interactionism were true, research would be in principle impossible: it would be impossible to control the variables of a phenomenon if the entire universe changed whenever one of them was altered. Experience is made up of definite things, and research investigates finite objects: it is precisely for this reason that it achieves results. With this specification Köhler rejects both the psychologistic holism of Felix Krueger – which is often erroneously cited as an example of Gestaltism – and the thesis of 'ubiquitous relations' (omnipresent functional dependencies) propounded by William James.

The appearance of *Psychologische Forschung* coincided with an essay by Koffka on the basic concepts of Gestalt theory[19] aimed at the American scientific community, which was at that time almost entirely dominated by behaviourism. The origins of the theory in Brentano and Stumpf is evident from the outset in Koffka's definition of the world of perception by negation. The world of perception is not what we represent to ourselves, nor is it what we think of objects, nor is it a content of the imagination; when these psychic activities have been removed, it is the objective residue of direct experience. "When I speak of perception [...] my intention is not to speak of a specific psychic function ... and I wish to use the term 'perception' in a sense which excludes any theoretical prejudice",[20] in particular the prejudice that contraposes perceptions to sensations as a more refined product of the mind.

A year later, *Psychologische Forschung* published Wertheimer's study of the formation of units in the perceptive field.[21] The figure/background category had already been absorbed into phenomenological inquiry from the researches of Rubin. But on the basis of what cohesion factors do objects, already segregated by the background, aggregate themselves into units? A number of dots against a background are not simply dots; instead they form patterns. They aggregate themselves spontaneously and naturally, although with effort it is possible to see them as connected in different patterns. These latter, however, are short-lived and, as soon as our effort slackens, they yield to the rules of spontaneous aggregation. Consider this simple fact:

This is a ‘row’ of dots. The distance between them is now altered as follows:

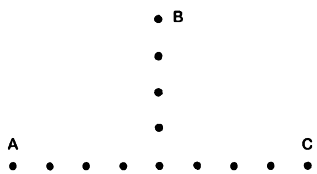
This is a ‘row of pairs’ of dots. The space visible between one point and the next is the factor that organizes them into units (a pair is in its fashion a unit).

But distance is not the only unifying factor. This can be shown by arranging a certain number of objects at regular intervals, but so that two similar objects stand next to each other, in the following order:

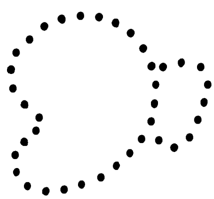
Here too we have a pattern of pairs, but this time it is one based on a relationship of similarity. The observer is able to form his or her own pattern at will when the two factors conflict with each other:

Here we can see either pairs based on proximity or pairs based on similarity. But this subjective structuring by the observer is momentary, for the objective factors are always stronger.

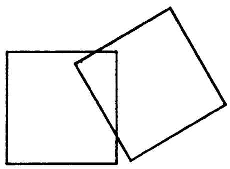
The factor of the continuity of direction prevails over that of proximity. In the following figure all the dots of segment C are more distant from the dots of segment A than those of segment B. And yet A and C form a single line while B maintains its independence.



The factor of closure is even stronger than that of continuity in certain conditions, as shown by this example:

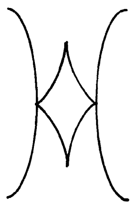


There is also a factor of 'good form'. In the following example we may, in theory, see three enclosed and somehow coordinated areas. Instead, however, we see the overlapping of two squares: two symmetrical objects rather than three irregular polygons.



Past experience may also be influential, albeit relatively rarely, in the organization of perceptive material into units.

For instance, experience of the Roman alphabet greatly helps one to see the letters M and W superimposed in the following pattern, because continuity of direction and closure are factors which prevail over the weak action of past experience:



As already mentioned, some of these factors had been identified years earlier by G. E. Müller, the teacher of Katz and Rubin. However, it was Wertheimer's achievement to realize that the factors of unitary organization (i) have differing force, (ii) can be made to conflict and give rise to weak units, (iii) can be made to act in synergy to produce strong units, and (iv) allow a conceptual distinction to be drawn between the 'natural parts' and the 'arbitrary parts' of a given whole or Gestalt.

Every object of experience can be segmented in scores of different ways. If we make a hole in a piece of black cardboard, we can view the world through it piece by piece just as it, the world, really is. This device and others like it were called 'reduction screens', and they were used to obtain true sensations without interference by the context. But objects in their entirety really possess parts, which are the elements discernable in their constitution, hierarchized in some manner and tied together by relationships which depend on the configuration of the whole. Using only the laws of 'figure/background' configuration and Wertheimer's factors it is possible to explain most of perceptive experience, or in any case to conceive of it in a problematically new manner.

Again in 1922, Freidrich Wulf applied the concept of 'good form' to memory in a series of experiments which demonstrated the mnesic evolution of less regular patterns into more regular ones. Between 1918 and 1922 Adhamar Gold, Kurt Goldstein and Wilhelm Fuchs tested new ideas in the pathology of the vision, finding that the structural (or Gestaltic) aspects of perceptive phenomena tend to emerge with specific forms in cases of both brain damage and retinal trauma, sometimes with the effect of compensating for the functions lost.

1922 was also the year in which Kurt Lewin (1890–1947) joined the Gestalt school and published a wide-ranging study, from the point of view of the philosophy of science, on the concept of 'genesis' in physics, biology and the theory of evolution which, in certain respects, was apparently an extension of Köhler's theory of physical forms to the biological sphere. Thanks to these contributions (and to a study by Lewin of the concepts of scientific law and experimentation in psychology), Köhler and Lewin came into contact with members of the Berlin neo-positivist circle – officially constituted in 1928 but which had already been in operation for a number of years on the initiative in particular of Hans Reiehenbach and Carl Gustav Hempel. They were active members of the circle until it was dissolved in 1933 when the Nazis came to power. In that year Lewin was in America, where he would remain.

Lewin had contributed studies on acoustic perception to *Psychologische Forschung* since 1922. In 1926 the journal published two essays of fundamental importance: 'Vorbemerkungen über seelischen Kräfte und die Sruktur der Seele' and 'Vorsatz, Wille und Bedürfnis', two chapters of a single essay on theoretical psychology. Lewin began by developing a theme already treated by Köhler in *Die Physische Gestalten*: the proposition "every thing is connected with every other" is generally false, and it is so in the case of the mind as well. Recognition of this, however, is not prejudicial to a unitary concept of the mind itself. In reality, the mind is a set of more or less independent, and sometimes entirely independent, systems. Not in the sense that the mind comprises diverse and simultaneous psychic faculties, like memory, thought or perception – whose forms of interaction and collaboration should indeed be studied – but in the sense that it is the diverse psychic experiences, in the act in which they originate and in their simultaneity, that constitute autonomous and closely integrated blocks: complex indivisible 'Gestalten', like thinking about the solution to a problem, suddenly remembering something, noticing that it is too hot, realizing that there are books and a picture before our eyes. Two psychological events influence each other if they belong to the same system, but they will not influence each other at all, or only weakly, if they belong to different systems. Should this latter happen, however, it will generate a new system. The unity of the mind is simply the entire field of the coexistence of such systems and of the forces that dynamically regulate them. Performing a coordinated and non-chaotic activity presupposes the independence of systems and the possibility of excluding most of the other psychic tensions simultaneously present. In developing this theme, Lewin introduced the concept of tendency towards equilibrium, of vector (the directed thrust which often occurs in locomotion through the environment), and of "boundary among psychic systems". These conceptual tools made it possible to devise a research programme on the psychology of affective states that was pursued in the following nine years by numerous collaborators. Above all, however, taken together they formed the theoretical basis for a new experimental social psychology which was perhaps the most enduring contribution of Gestalt psychology to the human sciences.

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Just as the psychic factors (memories, representations, sensations, etc.) disappear in Lewin's theory to be replaced by the plurality of the systems of experience into which the field of direct experience is segmented, so in a work by Erich von Hornbostel,[22] the prejudice of the 'five senses' is eliminated, in this case to be replaced by the objects of experience in their complex intersensory integration: "movement can be seen, heard, touched";[23] sounds can be coloured; the same adjective can be used for tactile, visual and acoustic qualities. The five senses are an abstraction; facts are sensorially multidimensional. Similar views were expressed in a book by Cesare Musatti.[24] By radicalizing some of the theses propounded by the school of Meinong – Musatti had studied with Benussi – he took the world of the objects of experience as his starting point for the conceptual elaboration of various structurings of reality: on the one hand towards the outside, i.e. towards physics and the natural sciences, and on the other towards the interior, i.e. towards phenomenology and psychology. At the basis of a system of fictions lies the 'objectuality' of the immediate datum.

In 1929, Köhler published a book[25] which imposed some sort of order on the by now broad debate on the principles of Gestalt theory. Experimental research had accumulated in *Psychologische Forschung* and in other more traditional journals, while critical reactions came mainly from American behaviourist circles (Koffka had been appointed to a professorship at Smith College in 1927). Much of European psychology was still working on associationist and Wundtian presuppositions, not without resentment at a certain arrogance that had typified the Gestaltist style from the outset. Köhler's book is characterized by its highly systematic organization and polemical thrust. It is still the finest exposition of Gestaltism ever written. Köhler begins by showing that there is a close affinity between associationism and behaviourism: in both, the method of empirical inquiry presupposes fragmentation of the situations of experience into their presumed elementary components, which in both theories take the form of simple mechanical relationships: stimulus/sensation, stimulus/response. He then shows that the sphere of reality from which behaviourism draws its 'facts' – facts which in his philosophy must be objective and non-mental, because the mind is private and whatever is private cannot be the subject-matter of science – is the same sphere as that in which phenomenal events occur. If behaviourism were consistent in its rejection of the phenomenal world, it would lose all its empirical data and all the areas in which its measurements are made. Köhler's third step is to show with examples how premature measurement distorts the structure of the facts, which should be taken in their qualitative immediacy because this generates problems – just as happened at the beginning of physics and astronomy, when the most fundamental problems of those sciences arose precisely from the qualitative analysis of phenomena.

Having eliminated the mechanistic interpretation of psychological facts, Köhler proposes a dynamic theory which no longer comprises chains of cause and effect but, instead, conditions which assume various combinations according to the complex phenomenon assumed as the object of inquiry. Experimental analysis of the conditions of the phenomenon (almost always) leads to the discovery that it can be interpreted as a field phenomenon. That is to say, a logic is used which displays close similarities with the logic that describes electromagnetic fields, the gravitational field, and so on. Accordingly, the association itself is a structure and not a simple connection. If we try to memorize a pair of semantically very different words, their mechanical repetition is less help to us than an overall image which incorporates both of them, even if it is somewhat odd (lake/sugar: a sugar cube melting in a lake; railway/elephant: an elephant walking along a railway track).

Of course, the psychophysical relationship plays an important role in the theory. But it is recast in totally new terms. Although there is a space-time of physics, it is not that of phenomenology, that is, of direct experience. We never have direct dealings with the objects of physics, which exist in their own space-time. The objects of physics include that particularly complex system that is the central nervous system. Our every dealing with something is the result of the activity of the brain; therefore the brain is extraneous to every experience. The link between the totality of our experiences and the brain is constituted by the fact that they coincide with *one part* of the brain's activity (which is a physical-chemical and electrical activity) and by the further fact that the form assumed by the laws of our phenomenological experiences is that form assumed by the logic of the concomitant cerebral processes (isomorphism). If, when experimenting on phenomena, we find that a given fact depends on three variables combined in a certain way, then there is a process within the brain – perhaps one of those that Köhler described in *Die Physische Gestalten* (1920) – whose realization depends on at least three conditions, each of which representing, at the level of nervous activity, the variable as manipulated in the ongoing experience. The 'postulate of isomorphism' assumes isomorphism between the logical form of the experiential organization and the logical form of the physical process (biochemical, electrical, etc.) taking place in the central nervous system.

The fact that there are independent systems in experience shows there are independent systems in the brain; the fact that there are functional dependencies in experience shows that there are functional dependencies in the brain. The reality of the functional dependencies that knit the subject and the environment together demonstrate the falsity of the theories derived from Hume's empiricism, for phenomenal causality exists and indeed guides our behaviour as regards the external environment. The 'insight' or immediate intuition of dependency relationships is pre-categorial because it is a given which determines behaviour even before the mind becomes aware of the structure of a situation; but it is also a logical category of explanatory thought imposed on the description of states of affairs.

Memory is based on the understanding of relationships; the problem of other minds can be dealt with by eliminating every metaphysical prejudice and analysing the field of experience in terms of expressiveness: tone of voice, facial or gestural mimicry, the environmental and cognitive context, together constitute the phenomenological conditions of the act of comprehension. Köhler argues that the universe of common sense and natural language contains not only all problems but also many of the productive and rigorous conceptual tools of psychology.

As said, Koffka moved to the United States in 1927. The headlong rush of events combined with racial persecution also forced Wertheimer to New York in 1933. After wavering between Germany and America, Lewin too emigrated to the United States in 1935, followed by Köhler, who took up an appointment at Swarthmore College after he had made his life in Germany unbearable by launching public attacks against the regime. The entire leadership of the Gestalt movement thus found itself in a cultural environment very distant from the tormented theoretical premises in Europe from which they had drawn their problems, ideas and intellectual style. One of Wertheimer and Köhler's pupils, Karl Duncker, certainly one of the most outstanding minds in the school, was unable to cope with such a radical transplant and committed suicide at the age of thirty-seven. Duncker was the author of the study *Zur Psychologie des produktiver Denkens* (1935). Much of his book is devoted to analysis of the thought processes which lead to solution of mathematical problems. Duncker's description of ongoing thought enables him to distinguish between nonsensical errors and productive errors, which are amenable to correction, and to isolate those particular cases of 'insight' which tie the consequences to the premises, both logically and factually. Duncker highlights the affinity that ties the causal relationship to the logical implication, and he identifies the conditions under which thought passes from partial understanding to 'total insight' or evidence. This is therefore analysis of the logical force that gives ineluctability to every salient step in a proof. Duncker himself stresses the continuity of his investigations with the line of thought developed by Hume, Kant, Husserl and Wertheimer.

In 1935 Koffka's great treatise *Principles of Gestalt Psychology* was published. The 'Bible' of all the work thus far accomplished by the Gestaltists, this is a book in which Koffka's theoretical discussion and innovative ideas interweave with minute description of a myriad experiments conducted by the Gestaltists and with reinterpretations of experiments in the classical tradition. The first part of the book deals with perception, but an unusually large amount of space is devoted to analysis of the memory, of the self and of action. Central to Koffka's theory is the distinction between the geographical environment and the behavioural environment. The former is the set of properties of the external world describable using the language of physics and the natural sciences; the latter is the phenomenological universe in which the subject operates as s/he moves, reflects, remembers, recognizes, values and constructs sensate knowledge; the universe, that is, in which facts are not simply facts but elements of an overall conceptual organization which confers meaning on its substructures from above (the distinctive feature of *Principles* is its avowedly anti-positivist epistemological stance). However, rather than create a dualism, this distinction is used to sustain a physicalist monism in which the central nervous system performs a role of total mediation, on the one hand identifying itself – in strictest accordance with Köhler's postulate of isomorphism – with a subject's field of experience at a given moment, and, on the other, ensuring interpretation of the macroscopic properties of the surrounding physical world in their biologically important aspects. One of the most interesting features of Koffka's physicalism is his theory of mnesic traces, by which are meant those states of the brain which guarantee our contacts with the past. This is a theory which satisfies the requirements of a physical interpretation of the permanence of states over time simultaneously with those of compatibility with the psychological facts that emerge from studies of the evolution and transformations of memory. Despite the marked unevenness and occasional obscurity of Koffka's treatise, it can nevertheless be regarded as the most outstanding effort to systematize the psychological content of Gestalt philosophy.

Another form of physicalist monism – one perhaps even more influential in America than Koffka's *Principles* – was that developed by Egon Brunswik, an unorthodox Gestaltist who reintroduced sensations into the theory of perception. In a celebrated article written for the *Encyclopaedia of Unified Science*,[26] Brunswik envisaged the unification of physics and psychology and proposed a probabilistic interpretation of the laws of perception.

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However, Gestalt theory's most profound influence on American scientific culture was exerted by the work of Kurt Lewin – not so much in the field of general psychology as in the social sciences, especially in microsociology. Lewin's theories had been well known in the United States since the early 1930s. One year after Koffka's *Principles*, he published a book[27] in which his project of 1926 was developed into a system. Unfortunately, Lewin's reference to the topology of mathematics is highly debatable, if not downright erroneous.

One should read the book bearing in mind that what Lewin calls topology is in fact a graphic language of his own invention able to represent the experience of a given person at a given moment (or by means of more complex depictions, in several successive instants of a 'story') and articulated into specific relationships with the phenomenally external environment and specific internal states (affective, cognitive, etc.) hierarchized into systems and subsystems. Inner states and external events are represented by areas. These areas are separated by barriers of greater or lesser permeability, and they are connected by vectors which represent forces with varying degrees of intensity. Areas may carry positive or negative valencies which indicate sources of attraction or repulsion.

Koffka's 'environment of behaviour' can be thus represented in a language of its own whose terms can be written so that some sort of calculation can be made. A diagram by Lewin represents the life-space of a person P in an environment A at a given moment. Behaviour (i.e. change in the relations internal to the diagram) is a function of the structure of P and A. Since the field – the state of affairs depicted by the diagram – is always considered in a given instant, it must be conceived as a sort of absolute present, in which the past is the presence of the past in the present (e.g. memories) and the future is the set of projects and possibilities currently imagined, here and now. This principle obliges Lewin to distinguish between historical causality and systematic causality. Every behaviour is subject to systematic causality, that is, the pattern of forces present in the field at a given moment, but the structure of the field can only be explained by the factors that have led events, therefore forces, to assume that particular pattern. Dynamic psychology, especially as social psychology and the psychology of small groups, should therefore be framed as the in-depth analysis of the individual case, and not as the statistical balance-sheet of a collection of cases reduced to quantitative data. The method of psychology should therefore be Galilean, Lewin stressed in a celebrated essay, not Aristotelian and therefore classificatory.

Lewin's theory produced a large quantity of research. Mention should be made in particular of *Psychology and the Social Order* (1936) by John F. Brown, which extended Lewin's topological interpretation to macrosociological and mass phenomena. The Marxist slant of Brown's work prevented it from achieving the success that it warranted, but it contains still extremely topical analysis of power relationships in the liberal democracies, and of fascist and communist dictatorships. In 1940 Brown published another book, *The Psychodynamics of Abnormal Behavior*, in which he applied Lewin's concepts and logic to psychoanalysis, psychopathology and psychiatry with rare skill of systematization.

Of the few Gestaltists who remained in Germany mention should be made of Edwin Rausch and Wolfgang Metzger (1899–1979). Most notable of Rausch's many works is *Über Summativität und Nichtsummativität* (1937), the first mathematical treatise on the concept of Gestalt as a structure which does not result from the sum of its parts. Of Metzger's output worth citing is his book

Psychologie, published in 1941. Just as Koffka's *Principles* had been an encyclopaedia of Gestaltist experimental research prior to 1935, so *Psychologie* was the encyclopaedia of the phlosophical problems connected with those researches and theories. Metzger was probably the most Kantian of the Gestaltists: the key chapters in his book are those on the appearance of 'reality' and on causality. Metzger proposed a stratification of various realities in experience, ranging from the inescapable reality of the material objects that populate our life-space to the reality of the imagination, of the void and of nothingness, each of them founded on its own conditions and capable of exerting specific effects. He analysed causality with a wealth of examples taken from everyday experience which, in a sharply anti-Humean conceptualization, he regarded as prefiguring the formal structures of epistemology. Metzger assumed the dificult task of keeping the Gestaltist tradition alive in Hitler's Germany, first at Frankfurt and then, from 1942 onwards, at Münster.

Another important book of 1940 was *Organizing and Memorizing* by George Katona (who had studied with Müller at Göttingen, where he changed from associationism to Gestaltism), in which a series of ingenious experiments showed that, as Aristotle had said, "the memories that come to depend on a principle produce themselves in a readier and more beautiful manner". According to Katona, there are in fact two memories: one for the learning of random items (syllables or telephone numbers) and one, which functions Gestaltically, based on structural understanding of the material (theorems, logical games, connections among facts) and which enables the transfer of what has been learnt to other materials.

The end of the Second World War meant that publication of three outstanding works was now possible: *Productive Thinking* by Wertheimer (posthumously), *La perception de la causalité* by Albert Michotte, and *Phénoménologie de la perception* by Maurice Merleau-Ponty.[28]

It was Wertheimer's intention that his book should introduce a project for a new logic that took account of the real progress of thought from the problem to its solution via successive restructurings of the cognitive material, and therefore of its logical form. Wertheimer's fundamental category was 'good sense', the ability to see into (in-sight, *ein-sicht*) structures and grasp their inner architecture. It is one thing to find the sum of 1+2+3+4+5+6+7+8+9 by adding up all the numbers (a blind and necessarily summative procedure to the structure); it is quite another to see – almost visually – that the first number plus the last number in the series makes ten, and that also the second number plus the penultimate one, the third plus the antepenultimate one, and so on, make ten, which is always the double of the central number in the series. Adding up the numbers in this case means taking the central term in the series and multiplying it by the number of terms: the result is immediate and the procedure is elegant. This happens because our eye has 'X-rayed' the logical structure of the problem and seen through to its skeleton. Wertheimer's book contains numerous examples of this kind, all of them discussed in detail.

Michotte's book showed, by means of scores of experiments, that there is a direct perception of mechanical causality and that this obeys laws. The perceptual analysis of a structure (an object A moves until it reaches an object B already present in the field, object B immediately moves in its turn, less rapidly than A but along the same trajectory: what one sees is A striking B and pushing it onwards; from this paradigmatic situation numerous variations, causal and otherwise, can be obtained) reveals that certain elementary concepts of mechanics, like those of 'force', 'impact', 'mass', are already present in perception of the physical environment.

Merleau-Ponty's book sought to achieve a philosophical synthesis between Husserl's later reflections and the theoretical and empirical matters investigated by the Gestaltists, thereby amalgamating two perspectives – after they had followed very different routes – which had shared a great deal in common at the beginning of the century.

The most important works written by Gestaltist psychologists in the 1950s were concerned less with perception than with other areas of psychology. Although a considerable amount of good quality research into visual perception was still being conducted in Germany, Italy, Japan and Sweden (Uppsala), no attempt was made at theoretical innovation and there was no enthusiasm for the daring conceptions that had characterized the decades between the wars. Truly innovative works were written by Fritz Heider on interpersonal relations,[29] a book long in gestation which attempted to provide a logical formalization of the sympathy and repulsion relationships between two people who share, or do not, a liking for a particular object; a book by Solomon Asch[30] which summarized numerous experiments in social psychology, some of them carried out by Asch himself, designed to illustrate the effects of group pressure on an individual or a minority, or to show that the prestige of the source of a message affects its interpretation; a book by Rudolf Arnheim which applied the knowledge on perception accumulated by the Gestalt psychologists during almost half a century of research to painting and the visual arts, opening new avenues for art criticism and general aesthetics.

The bulky volume by Wolfgang Metzger, *Gesetze des Sehens* (1975), was the last significant work written in the spirit of Wertheimer. Metzger's book was an encyclopaedia on visual perception running to almost seven hundred pages; its first edition of 1936 contained less than two hundred. The theoretical framework remained the same, but experimental research had proliferated during the forty years between the two dates. This state of affairs is perhaps the deep-lying cause of the declining fortunes of Gestalt theory in contemporary psychology.

Since 1979 a new German journal, *Gestalt Psychology*, has reopened debate on the fundamental themes of the Gestalt tradition, attracting the interest of a good number of scholars in Europe and America.

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NOTES

[1] Wertheimer 1912.
[2] Pastore 1971.
[3] Koffka 1935.
[4] Kant 1913, Part Two, II, § 77
[5] Ibid.
[6] Goethe 1830, *Aphorisms*, 59, 367.
[7] Goethe 1830, *Aphorisms*, 168.
[8] Cf. Helmholtz 1867; 1863.
[9] Husserl 1900–01, 231.
[10] Husserl 1900–01, 232.
[11] Buchler 1956, 75.
[12] Buchler 1956, 74–5.
[13] Buchler 1956, 75.
[14] Katz 1911.
[15] Köhler 1913, 80.
[16] Popper 1935.
[17] Köhler 1920, 157–60.
[18] Köhler 1920, 158.
[19] Koffka 1922.
[20] Koffka 1922, 532.
[21] Wertheimer 1923.
[22] Von Hornbostel 1925.
[23] Von Hornbostel 1925, 82.
[24] Musatti 1926.
[25] Kohler 1929.
[26] Brunswik 1925.
[27] Lewin 1936
[28] Wertheimer 1959; Michotte 1954; Merleau-Ponty 1945.
[29] Heider 1950.
[30] Asch 1952.
[31] Arnheim 1954.

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ALF ZIMMER

WHAT IS FORM?

The contributions of psychology to an old epistemological problem

Let chaos storm!
Let cloud shapes swarm!
I wait for form.

Alexander Pope

1. INTRODUCTION: THE INTRICACIES OF THE FORM VERSUS MATTER DEBATE

One of the central topics of discussion in Western philosophy has been the precedence of form over matter, or vice versa. For this reason the question 'What is form?' has a strong traditional flavour and I have to admit that also my tentative answer from the vantage point of psychology, or to be more precise: from that of perceptual processes, is deeply rooted in philosophy. Democritus (fragment 13) distinguishes between genuine qualities in nature, like weight and size, and those which only emerge if nature is perceived, like colour and taste. In modern parlance,[1] this is the distinction between objects as they *are* and objects as they are *seen* from a specific point of view. In my opinion, the discussion about the primacy of either form or matter, especially in the Aristotelian tradition of thought, misses one important point: in perception neither objects are seen as isolated in space nor as spatial arrangements or geometrical projections unrelated to the projected objects. What is perceived are objects in situations or events which, except for very specific situations, are phenomenologically unique. Two examples can serve to illustrate this point. In Figure 1 an erratic line (A) is shown in two different contexts: while in (B) the oscillations are accidental and what is seen is a free-hand drawing of a brick, in (C) these same oscillations determine the meaning, namely, an undulating plane with one vanishing point – in a way, what is accidental in (B) is substantial in (C), but in both cases the percept is unique.

The degree to which a frame of reference determines the perception of an object is shown in Figure 2: the 'true' motion of the two points is given by two perpendicular vectors meeting in one point; however, what is perceived are two points colliding head-on while the scene is shifted orthogonally to the collision course. Actually, from the viewpoint of vector algebra (and from that of classical mechanics) both descriptions are equivalent but the perceived event corresponds only to the second – and that is phenomenologically unique.

L. Albertazzi (ed.), Shapes of Forms, 51–88.

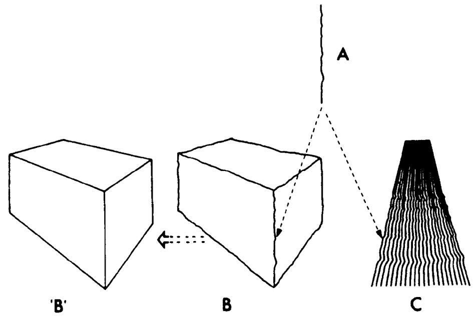


Figure 1. Context dependency of what serves as information and what as noise

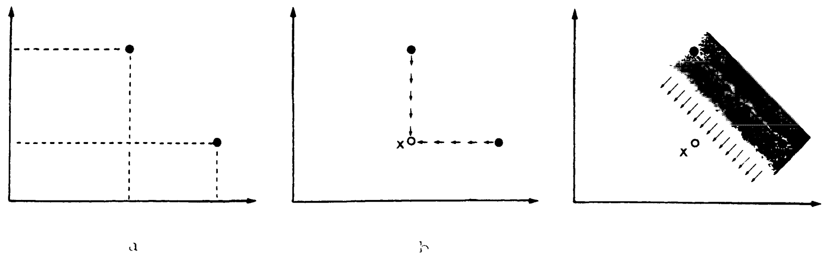


Figure 2. The emergence of a frame of reference for moving points

The question 'What is form?' and the concomitant matter-versus-form debate can also be regarded as a classic case of preventing insight by dissolving a complementarity into two mutually exclusive alternatives. In what follows, perceptual processes will be presented which show the intricate interaction and interdependence of objects 'as they are', corresponding to the Aristotelian 'substance', and 'as they are seen', that is, 'accidental' in his terminology. One could argue against equating these concepts, saying that it is misleading because everything that is perceived is only represented in what Democritus termed 'matter of opinion' as opposed to the 'matter of objects'. However, this would imply a Radical Constructivist point of view[2] which disregards the fact that perceptual processes have evolved subject to the constraints of the 'matter of objects'. Without going into too many details of this evolutionary process[3], I want to mention two examples for the naturalness of perceptual processes. One concerns sensory processes while the other concerns 'higher' perceptual processes. The sensitivity of the eyes of nearly all animals corresponds to the energetic maximum of electromagnetic waves on the surface of the earth;[4] if the sensitivity were different, higher levels of energy would be needed for a comparable discrimination. Moreover, the spectral sensitivity curves of the eyes in different species closely mirror the distributions of reflectances in the respective niches.[5] However, basic sensory processes are not the only ones that depend directly on what is materially given. Starting with the analyses of D'Arcy Thompson,[6] it has been demonstrated[7] that even beauty is not primarily 'in the eye of the beholder', as Hume assumed, but well founded upon material constraints. This becomes evident if one analyses the growth of plants, where a maximum of stability must be obtained with a minimal expenditure of mass. What one observes in branching sequences follows very closely the Fibonacci series (see Figure 3): 1,2,3,5,8,13,21 with the underlying construction rule $x_{n-2} + x_{n-1} = x_n$

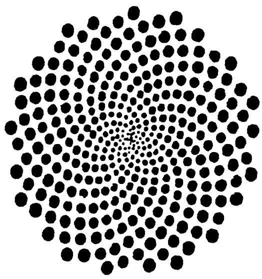


Figure 3. A sunflower

where the limit for $n \to \infty$ of the proportion $x_{n-1} : x_{n-2}$ is the Golden Section (approximately 1.618; see Figure 4);

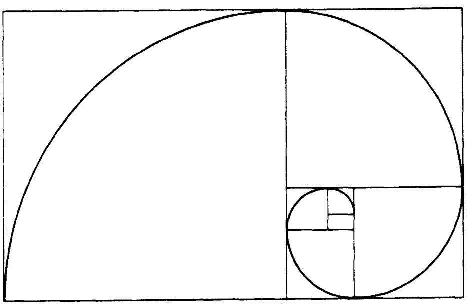
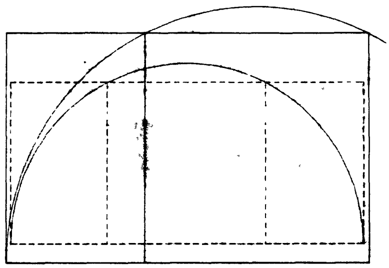


Figure 4. The generation of a sequence of Golden Sections

The Golden Section of this evolutionary process has in turn been the dominant generative rule in architecture and generally in visual art since the classical Egyptian age. For the ancient Greeks, the golden section together with the circle and the square constituted what was termed 'sacred geometry' (see Figure 5a and 5b).



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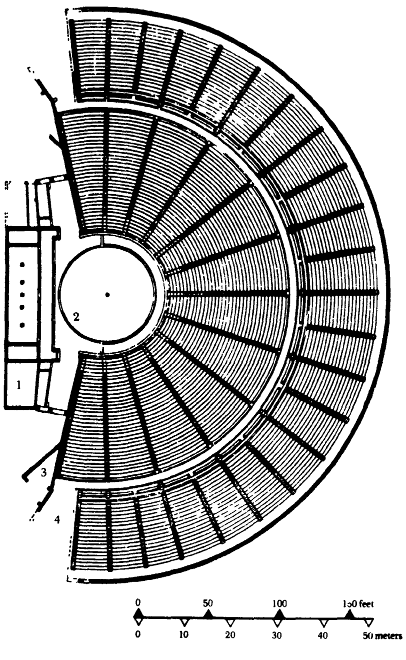

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Figure 5. (a) Front of the Parthenon with Golden Proportions. (b) The theatre of Epidauros (1. skene, 2. orchestra, 3. diazoma, 4. upper cavea); the numerical relations between the part approximate the Golden Section

The use of the Golden Section is documented for most cultures and styles. Even today it is pervasive in decorative art, in fashion and in the design of everyday objects. It is especially dominant in styles which refer explicitly to the organic, for instance Art Deco. The common denominator of all these variations of the Golden Section is the production of an impression of equilibrium in complexity. To this extent, beauty – at least partially – is an indicator of stability and therefore of evolutionary optimality.

D'Arcy Thompson made the point[8] that the interplay of forces is mirrored in form:

The form, then, of any portion of matter, whether it be living or dead, and the changes of form which are apparent in its movements and its growth, may in all cases alike be described as due to the action of force. In short, the form of an object is a 'diagram of forces', in this sense, at least, that from it we can judge of or deduce the forces that are acting or have been acted upon it: in this strict and particular sense, it is a diagram – in the case of a solid, of the forces which have been impressed upon it when its conformation was produced, together with those which enable it to retain its conformation; in the case of a liquid (or of a gas), of the forces which are for the moment acting on it to restrain or balance its own inherent mobility. In an organizm, great or small, it is not rarely the nature of the motions of the living substance which we must interpret in terms of force (according to kinetics), but also the conformation of the organizm itself whose permanence or equilibrium is explained by the interaction or balance of forces, as described in statics.

This position was taken up by Köhler, who proposed[9] a variant of Gestalt theory founded on the conception of a generalized field theory. His treatise on forces in equilibrium expands on D'Arcy Thompson's approach to the mathematics of biological forms by describing the interaction of forces in a field, which gives rise to spontaneously self-organizing processes. Koffka, finally, has argued that due to this dependence of the perceptual processes on evolutionary constraints, perceived order and form are 'real' entities, not mentalistic Figments:

[...] we see that without our principles of organization the objects could not be objects, and that therefore the phenomenal changes produced by these changes of stimulation would be as disorderly as the changes of stimulation themselves. Thus we accept order as a real characteristic, but we need no special agent to produce it, since order is a consequence of organization, and organization the result of natural forces.[10]

Thus the perception of order is not an interpretative act, but rather mirrors what is given in the world in reference to the perceiver. This is what Gibson describes as 'affordances'.[11]

That these perceptual processes really are phylogenetial in nature and do not result from experience becomes apparent in experiments with neonates[12] which reveal that objects and not features are the building blocks of neonate perception. Object and size constancy, together with the classification of objects according to their common fate, characterize infants' reactions towards objects prior to perceptual learning. In other words, sensitivity to invariants seems to precede sensitivity to isolated features; infant perception is the perception of forms (Gestalten). It should be noted, however, that not all Gestalt principles of perceptual organization seem to be independent of the influences of perceptual learning; for instance, the factors of symmetry and similarity – central to the concept of invariance in physics – appear relatively late in perceptual development. This is plausible because at least the perception of rotational and glide symmetry is strongly influenced by cognitive processes, as has been shown experimentally.[13] Further, what is perceived as similar depends not only on frames of reference but also on what might be called the perceptual attitude – that is, whether it is the global structure that is primarily taken into account or whether details are attended to with scrutiny.[14]

2. PERCEPTION: TOP-DOWN, BOTTOM-UP, OR BOTH AT THE SAME TIME?

Many theories of perception – for instance, all those originating from Helmholtz's theoretical point of view – postulate that the proper object of perception is constructed by starting with the raw material of sensory perceptions and going through a sequence of unconscious and later conscious cognitive operations. David Marr[15] postulates a sequence of filters and constructive processes which leads from sensory data to perceived objects. Gestalt theory, understood as a top-down theory, is often contrasted with these bottom-up theories; in such a top-down theory the form, termed 'Gestalt', determines the meaning of every detail, or a frame of reference makes a complex scene meaningful. If understood thus, a hierarchy of operations in perception can be found in Gestalt theory, too. If, however, Wolfgang Köhler's notion of perceptual fields[16] is taken to be the essence of the Gestalt theory of perception, the notion of a hierarchical organization of perception becomes questionable. I shall therefore posit the following hypothesis: perception consists of many processes of differing complexity. However, these are not hierarchically ordered but interact like forces in a field, and this interaction can be cooperative as well as complementary or competitive.[17]

In this respect, I agree. A network model of the multistable Necker cube can serve as an example for an interaction of processes in perception. Feldman has proposed such a model[18] which was subsequently refined by Zimmer.[19] The model starts from the notion that a Necker cube can be economically represented as an ordered set of 'forks' and 'arrows' (as favoured in 'Computer Vision'[20]) which induce a spatial impression if the following conditions are given[21]:

(i) A fork juncture is perceived as the vertex of a cube if and only if the measure of each of the three angles is equal to or greater than 90°.

(ii) An arrow juncture is perceived as the vertex of a cube if and only if the measure of each of the two angles is less than 90° and the sum of their measures is equal to or greater than 90°.

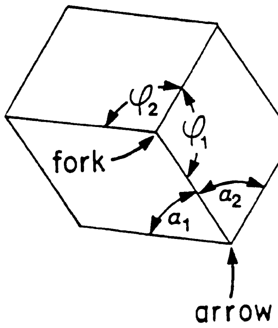


Figure 6. A cube with arrows and forks (Perkins 1973)

The constellations of arrow- or fork-like vertices of the Necker cube may have two different orientations, namely convex or concave. If one takes these vertices as the constituents of the Necker cube and connects them with excitatory or inhibitory arcs, as well as with autoinhibition, in order to model the saturation effect, the result is the following net (see Figure 7).

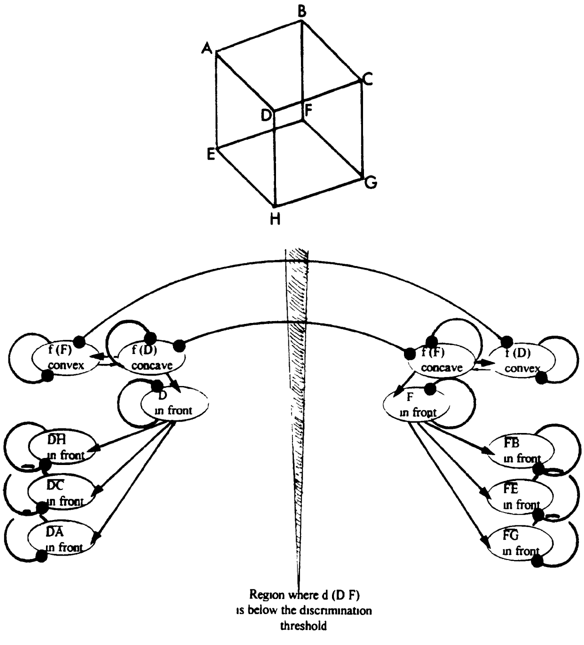


Figure 7. A network model of the Necker cube (Zimmer 1989). f(x) means fork at vertex X

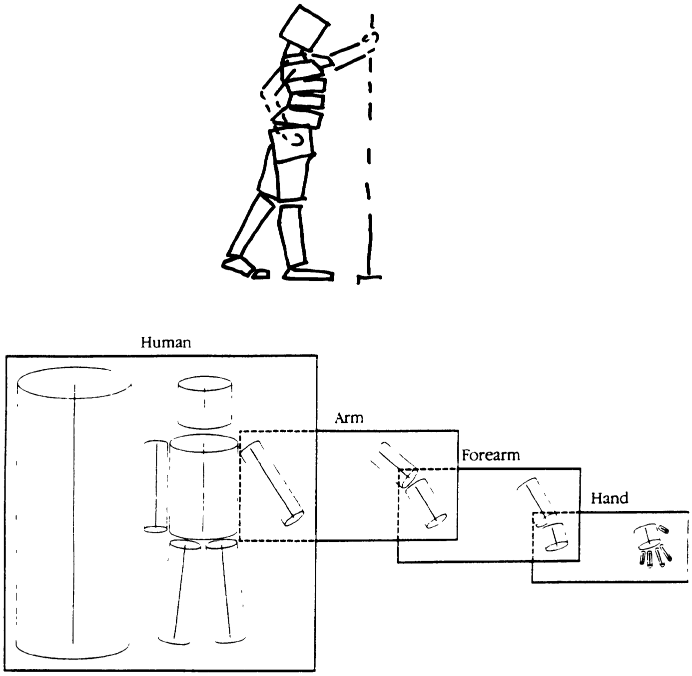
The vertices with positive excitation are perceived as convex, and those with negative excitation as concave. Together with autoinhibition this results in a switching between two different percepts and hence in the bi-stability of the Necker cube. The three processes of excitation, inhibition and autoinhibition are competitive; since they are not hierarchically ordered, the phenomenon of spatial structuring, as well as of sudden re-structuring, is generated spontaneously and continually.

It should be noted that the network approach just demonstrated is not the only non-hierarchical interpretation for the effect of multistability. For instance, Ditzinger and Haken have suggested[22] a synergetic model for ambiguous or reversible Figures. In their model, multistability develops if there are two or more order parameters of about the same strength, in which case the enslaving of all but one order parameter is not stable because the perturbations due to attentional shifts are of the same order as the difference in the strength of the order parameters. Both models result in a behaviour very similar to that noted in human observers. However, it is difficult to decide which of these non-hierarchical theoretical accounts is preferable in regard to parsimony, because it is impossible to determine the relative complexities of these accounts.

Phenomena in real life are, without doubt, significantly more complex, and the perception of space is not only determined by rules like Perkin's laws but depends on many more conditions. Nevertheless, this introductory example illustrates the chain of arguments which will show that traditional hierarchical approaches are not sufficient for the interpretation of perceptual phenomenon.

Bottom-up models of human perception involve the notion of hierarchical processing or different levels of perception that David Marr developed in his seminal text.[23] This theory starts from the notion that a picture exists 'outside' in the physical world or, in the case of binocular vision, that two pictures exist in correspondence to the two eyes; these two pictures must be integrated into a unitary percept. By means of a sequence of filtering processes, features of different complexity, including spatial interpretations, are extracted until there finally evolves an invariant description of the objects which carries meaning. Usually, the object is assumed to consist of generalized cones,[24] which is a technique of pictorial design already present in Dürer's work. In 1500, Dürer composed complex objects out of generalized geometric bodies, usually cubes. The similarity of these techniques is obvious if one compares Figure 8a with Figure 8b.

In spite of differences in detail, Marr's model and its reliance on Hubel and Wiesel's results[25] conceptually parallel the classical Helmholtzian assumption concerning the neurophysiological processes in perception: namely, the assumption that receptive fields with complex and hypercomplex cells, up to gnostic cells,[26] act as analysers at different levels up to the cells which represent 'meaning': For example, according to Gross monkeys have a cell which fires only if there is a monkey's claw.[27]



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b

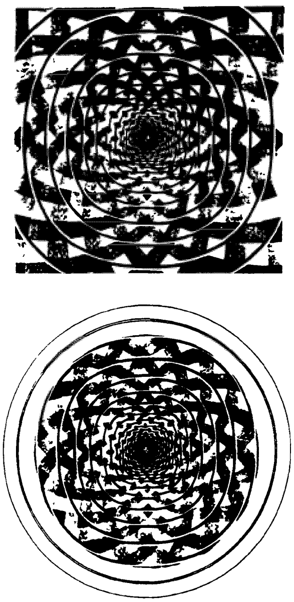
Figure 8. (a) Dürer's drawing of a body consisting of cubes. (b) the corresponding construction of a body out of generalized cones (Marr 1982)

The most radical theoretical alternative to this approach is 'Radical Constructivism').[28] According to this position, complex processes of construction, in particular self-reference, create *actuality* (the world that we can *act* upon) and which must be both theoretically and practically separate from *reality* (the world of transphenomenal things: *res)*, which is beyond the mind's grasp. The Constructivist approach is the most clear-cut case of a top-down theory of perception based on the idea that 'the mind tells the eye what to see'; an idea which derives from the results set out in the classic paper 'What the frog's eye tells the frog's brain'[29] that started the Constructivist movement.

The bottom-up and top-down models share the idea that perception is a kind of one-way road between pictorial stimuli and meaning. Moreover, both models assume that on each level massive transformations of the existing information take place in a sequence so that later or higher levels of perception never influence the activities of earlier or lower ones. This assumption has the important practical consequence that such structures are decomposable.[30] Without any doubt this is a highly desirable feature for theory building because it allows one to analyse and to model local processes without concern about the global structure in which they are embedded. However, investigations by Trevarthen showed[31] that even in his simplistic model the one-way characteristic of cortical processing is only true for one of the ascending pathways of visual information. That is, the pathway which leads from the retina through the *corpus geniculatum laterale* to the visual cortex (area 17) is linear, but for the other ascending pathway to the tectum the one-way characteristic no longer applies already in the *colliculus superior*. Here, eye movements are influenced by incoming information, so that the information that is 'picked up' now determines what will be 'picked up' as information next. Still, if one concentrates only on the former – that is, the purely ascending visual pathway in Trevarthen's model – a further and theoretically more serious deviation of the one-way characteristic is observed in the information processing behind area 17, where the pathway is forked. One pathway leads to the *cortex temporalis* inferior and anterior, where visual discrimination takes place (in the inferior part) and features (i.e., size, colour, texture, and form) are extracted (in the anterior part); these processes are necessary for the identification and recognition of objects. The other pathway leads in parallel to the anterior parietal regions where the localization of objects occurs, including auditory and tactile information about them.[32] Since the experiments by Mishkin and Ungerleider, the nature of higher-order cortical processes has been investigated further, with the result[33] that even in anatomically well-separated regions multiple functions can be found. In these seperated regions, the analyses of spatial relations, of object identification, and of feature discrimination, happen in parallel: "the inferior parietal lobule, in close conjunction with areas in the premotor and prefrontal cortex, provides a specialized set of semi-independent modules for the on-line visual control of action in primates".

The examples, demonstrations, and analyses discussed so far yield a picture which seems perturbing or contradictory only as long as one clings to the notion that the mind has to *translate* the sensory information into the mind's *language*. This implies, that '*Erkenntnis*' (attribution of meaning) does not refer to objects as they are but entirely to mental representations, as suggested by Fodor and by Pylyshyn.[34] If this position is correct, then these 'contradictions' of the visual perception should give rise to effects similar to those of meaningless sentences or paradoxes in language; that is, to a state in which understanding is no longer possible. However, in perception this is patently not the case: 'contradictions' abound, especially in the perception of space from two-dimensional displays. But instead of leaving the perceiving mind perplexed, they induce a strong spatial percept where only scrutiny[35] reveals that it relies on contradictory information. For examples, in the tower of S. Sidone in Turin, the architecture plays with constancy effects (of form as well as of size) in order to enhance the impression of height. Similar effects can be seen in S. Ignazio or the Palazzo Spada, both in Rome. The artful combination of local 'contradictions' results in an seemingly well-ordered perceptual world consisting of invariant objects and unique spatial relations. Projective geometry shows that both of these features cannot be realized at the same time; that is, an invariant object cannot be uniquely localizable and vice versa. However, if in perception both features are present at the same time, an interesting consequence for art results: the picture best representing what is perceived must be an impossible picture from the point of view of perspective geometry.[36]

Even if one regards the constraints of projective geometry on spatial perception as culturally imposed[37] or if one assumes that spatial knowledge is an amalgamation of tactual as well as visual information,[38] the intriguing question remains how local and global processes interact in space perception. Bottom-up theories require that the information obtained by early local processing must influence the final meaning of the perceived stimuli; by contrast, top-down theories assume that the constructive processes of the human mind start from something like Platonic ideals and impose their constraints on local analyses, thereby overriding contradictions in details, according to Goethe's dictum that "one only sees what one knows". Stimuli of the kind constructed by Frazer in 1908 can be used to test these contradicting assumptions. Figure 9a shows a compromise between a circle and a square; however, the details in Figure 9b reveal that in reality we have perfect cycles consisting of low level details which distort the global form of a circle to a square.



a

b

Figure 9. (a) Frazer's illusion. (b) Demonstration that the underlying form in (a) really is a circle

From the point of view of Gestalt theory, it is especially puzzling that the resulting perception contradicts the tendency towards good form because the circle is without any doubt a singular (*prägnant*) form,[39] and the form of a circle is present in the stimulus, whereas the alternative singular form of a square is not. However, what is perceived is none of these singular forms. Instead, a derived form prevails, a compromise between them. In such a case of two equally strong attractors, Gestalt theory would predict an alternation between these two forms. The top-down position predicts that the higher-order influences either unequivocally determine the percept of the circle or give rise to a perceptual paradox, namely, a bistability between two forms (cycle and square). As devastating as this result is for pure top-down models may be, the result of a visual demonstration by Ramachandran[40] is equally damaging for bottom-up models. If a subject is asked to decide in which of the two stimuli (Figure 10a or Figure 10b) a symmetrical form is imbedded, a) is always chosen despite the fact that here only a 'perceived object symmetry' is given, whereas in a pixel-wise fashion stimulus b) is horizontally as well as vertically symmetric but is not perceived as such.

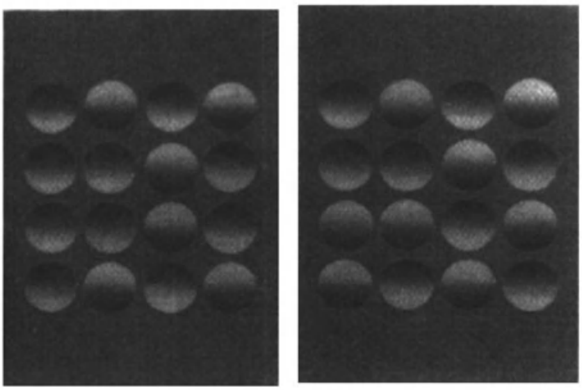
a  b

Figure 10. Ramachandran's stimuli for the perception of symmetry

The reason for this puzzling result seems to be that in this case the identification of form, apparently three-dimensional half-spheres, prevails over the directly detectable low-level symmetries. Here we have a case where what is seen is only what has been known before, and this is a clearcut case of top-down perception.

Joint consideration of these two examples reveals that not only has there been a contest between different perceptual mechanisms[41] in the phylogenetic process of evolution but also that every actual situation of perception involves some sort of contest between local and global analyses. In these examples the contest is competitive but it can also be complementary or cooperative.

In what follows, I shall demonstrate in three different areas of perception the thesis that it is not a hierarchical processing (top-down or bottom-up) which results in a world perceived as stable but a permanent interaction of processes or mechanisms on different levels of complexity. The examples are:

(i) The *phenomenon of spatial multistability* reveals that the strongest spatial effects do not occur if the parameters of basal features like symmetry, complexity or closure are simultaneously maximized or minimized, but only if the parameters are set at an intermediate level where no single feature is able to dominate the others.

(ii) The *perception of space from two-dimensional displays* which induce the strongest three-dimensional effect only if the invariant characteristics of perceived objects and the perspective distortions are equally strongly supported by the two-dimensional picture, resulting in a convincing spatial impression. This impression uniquely defines the position of the observer in relation to the depicted objects.

(iii) *The role of symmetry in the history of science* demonstrates how problematic the factor of 'symmetry' is for the adequate modelling of physical phenomena, at least as long as symmetry is understood as based upon perception and not as an abstract concept.[42]

3. MULTISTABILITY AS AN INDICATOR OF THE AUTOMATIC NATURE OF 3-D PERCEPTION

The Case of the Necker Cube

In Figure 11 six skeleton cubes are presented which differ to the extent that they induce 3-dimensionality (apparent depth) and in their degree of multistability. In both features, 11b induces the strongest effect because it has two equally strong semi-stable views which correspond to alternative spatial organizations.

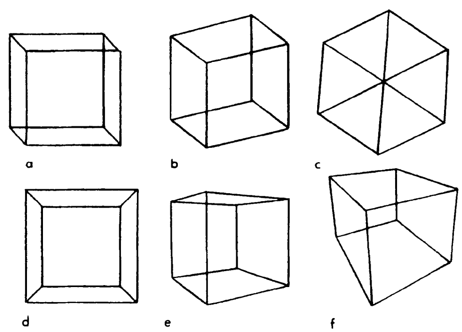


Figure 11. Six views of a skeleton or wire cube

Only slighly weaker is the effect in 11a, weaker because here a third transient state can be observed in which a 2-D pattern with a 45° axis of symmetry appears. This effect can be enhanced by rotating the axis of symmetry into a vertical position).[43] From an empirical point of view, only Figures 11d through f should give the impression of depth because only they correspond to real perspective projections with one, two or three vanishing points. By contrast, 11a is a perspectively impossible view of a wire cube, while 11b and 11c are parallel projections either without a vanishing point or with one that is infinitely far off; they are therefore not possible in a finite environment. On the other hand, because of their unique perspective specifications, 11d, e and f should induce a strong spatial effect but no multistability. As it turns out, they induce a weaker effect regarding apparent depth than do 11a and b, which is apparent from the fact that minor perturbations, namely removal of the vertices, destroy the 3D effect but nevertheless give rise to bistability, albeit with a bias towards the cube.

These results seem to defy the minimum principle of Gestalt theory[44] according to which deformations of forms exhibiting 'Prägnanz' (singularity) are avoided by perceptual mechanisms.[45] However, practically none of the closed geometrical forms in 11e or f displays the high degree of symmetry typical of stable 2-D forms.[46] The cube is a three-dimensional form with multiple axes of symmetry, and is therefore highly stable, but none of these characteristic features is preserved in the perspective drawings. The lines are not parallel, nor are they of equal length, and the angles are not orthogonal. These features are at least partially preserved in 11a, b, c and d, where this preservation plus the breaking of symmetry induces the strong three-dimensional effect, especially in 11a and b. If, by contrast, a two-dimensional projection of a cube exhibits maximal symmetry (6 axes of symmetry as in 11c and 8 in 11d), only a weak and transient depth effect, if any, is induced.

There still remains one puzzling example among the wire cubes of Figure 11, namely 11d. This preserves many features of the cube and it is a possible projection; nevertheless it appears to be flat, like a picture frame, not a cube. Perkins has used this instance[47] to derive his above-mentioned laws of the induction of 3-dimensionality in pictures.

These laws correctly predict that Figure 11d will be seen as flat. However, if the symmetries are broken, as in Figure 12, forms are generated which defy Perkins' laws, especially a and c.

Not only do the wire cubes in Figure 12 induce a depth effect, they also exhibit multistability. They can be seen as a cube from the inside or as a cut-off pyramid from the outside. There is no clear-cut preference for either of these perspective orientations. In experiments, the initial frequency of judgments made by subjects are about evenly split between a cube and a pyramid; afterwards subjects tend to stick to their initial percept. This is probably due to the fact that biases for the convex form (pyramid) and for the most regular form (cube) are about equally as strong, and a concept preserving transforma-

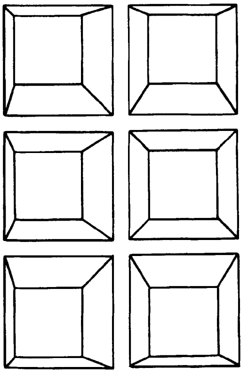


Figure 12. Breaking the symmetries in 11d

tion between these percepts is not possible. A similar 'real-world' example is provided by the view of the cupola of S. Giovanni degli Eremiti in Palermo, where the cupola is usually seen as concave but the pendentives tend to induce a convex orientation, despite our knowledge about the constructive rules for building cupolas over square groundplans (see Figure 13).

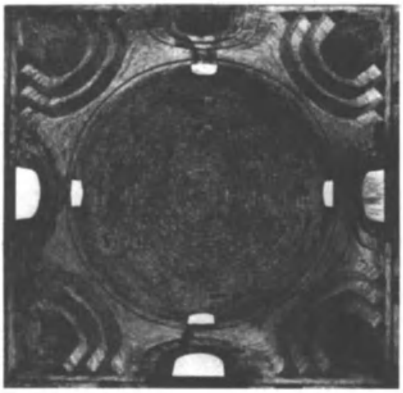


Figure 13. View of the cupola of S. Giovanni degli Eremiti in Palermo

There are several lessons about multistability and its role in depth perception to be learnt from this analysis of different projections of wire cubes:

(i) If the necessary conditions for perceiving a wire cube are given, namely 8 vertices with 3 connections each, plus convexity, apparent depth is induced if, and only if, the symmetry of the display is broken; an orientation of 30° relative to the fronto-parallel plane seems to be optimal.

(ii) The depth effect, as well as the frequency of perceptual switches, are strongest if as many features of the cube as possible are preserved in its projection.

(iii) Prior experience with such stimuli seems to play a negligible role, either in the sense that the subjects might have seen such a projection or in the sense that the rules of projective geometry are known and applied.

These results only partially agree with the results of a factor analytic study of "reversible-perspective drawings of spatial objects" carried out by Hochberg and Brooks. According to that study,[48] the apparent depth of a drawing depends on three factors: (i) simplicity versus complexity (measured by the number of angles); (ii) good continuation versus segmentation (measured by the number of line segments); and (iii) symmetry versus asymmetry (measured by the relative number of different angles). What this factor-analytic approach implies, however, is the additivity of these components: "the greater the complexity, the asymmetry, and the discontinuity of the projection of a given tridimensional object in two-dimensions, the more three-dimensional it will appear. We may, in reality, be dealing with only one dimension – 'figural goodness'".[49] This runs counter to the comparison of the induced depth effects in the cube drawings in Figure 11. The views of the cube in a and b have a much stronger effect than those in e and f, which implies that the interaction between the components identified by Hochberg and Brooks is not additive but that they must be modelled as competing processes producing the maximum joint effect if they all are of comparable magnitude. That this interpretation is not restricted to Figures 11c and b can be shown by analysis of generalizations of wire-cube drawings. For example, (i) repetitions and glide symmetries can be used to produce tilings with the Necker cube as constituting elements (Figure 14); (ii) the dimensionality of the generating spatial object can be increased from 3 to 4; a 4-dimensional hyper-cube is defined as consisting of 32 edges and 16 fourfold vertices (see Figures 15 and16); or (iii) the cube as one exemplar of the Platonic bodies can be exchanged for a more complex one, the dodecahedron (Figure 17).

In all cases, the factor-analytic criteria plus the convexity criterion of a generalized soap bubble[50] would predict that the spatial effect is even stronger than in Figure 11b. Inspection shows that this is not the case, and experimental results concerning the depth effect after an occlusion of the vertices support this finding.

In regard to the tilings in Figure 14, one may argue that, due to multistability, different perspective orientations cancel the overall depth effect but these different perspective orientations do not occur simultaneously. If one

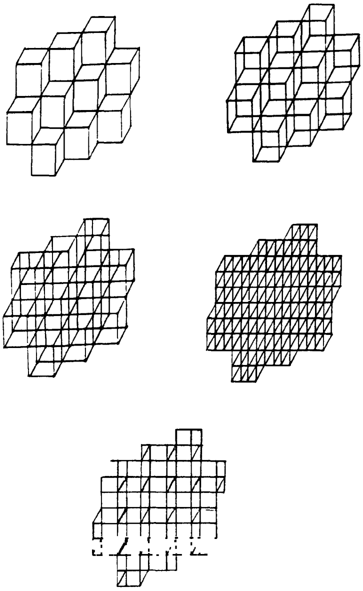
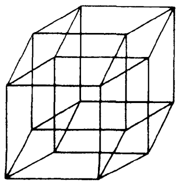
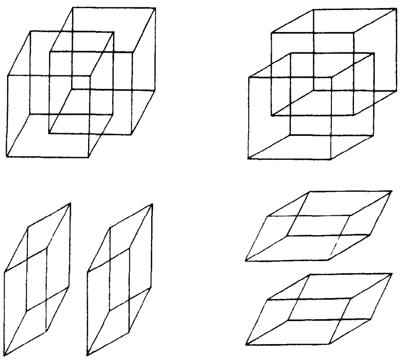


Figure 14. Tilings consisting of partial or complete Necker cubes



a



b

Figure 15. (a) A 2-D projection of a four-dimensional Necker cube. (b) 2-D projections of three-dimensional partitions of Fig. 15a

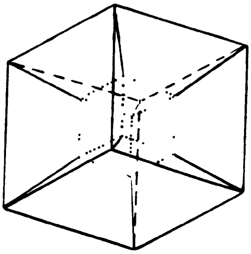


Figure 16. An alternative for Figure 15

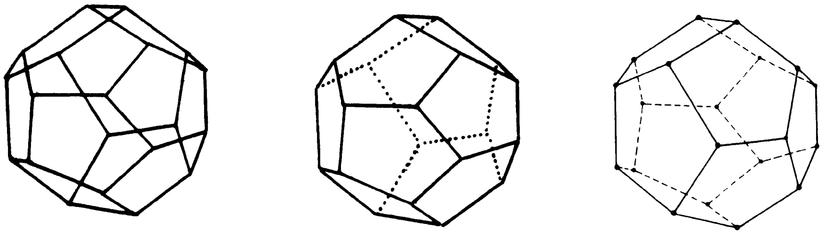


Figure 17. A skeleton dodecahedron

segment switches, all other segments become enslaved at such a speed that self-observation cannot determine the exact and detailed time course of the process or the subprocesses of enslavement. However, the theory of tilings offers one further alternative interpretation, which is that the patterns in Figure 14 are all periodic. In other words, there exists a subpattern which is repeated over and over again, resulting in glide symmetries; if the rhythm is broken, as in the non-periodic tiling of Figure 18, multistability is produced despite the complexity in the pattern. My conjecture is that non-periodicity, convexity, and symmetry breaking[51] are the decisive factors for the depth effect in drawings.

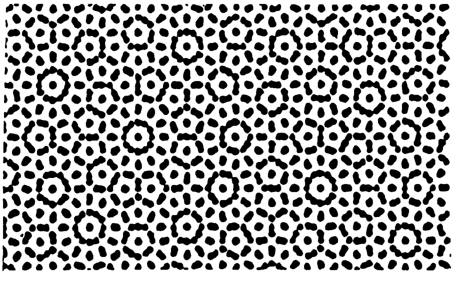


Figure 18. A non-periodic tilıng (Stadler, Seeger, Raeithel, 1977)

In the following section, I shall show how artists have made use of these factors to produce strikingly realistic pictures which on closer inspection deviate from the directly projected transformation implied by the devices for perspective drawing invented by Alberti and Dürer. These deviations accentuate the factors of symmetry breaking and convexity, whereas non-periodicity is usually already given by the choice of the subject.

4. HOW TO INDUCE A COMPELLING 3D-EFFECT IN PICTURES

The bifurcation between the object as it is and the object as it is seen from a specific vantage point in a defined situation (or as Gibson put it,[52] the bifurcation between "no change" and "change") uniquely specifies the position of the observer in relation to the perceived object. However, this is only the case if the object and its environment comply with the experiences of the observer and are not at odds with the fundamental and time-independent features of objects. These features are three-dimensionality, partial convexity, rigidity, regularity (that is, showing a tendency towards good form), and closure of the surface. If all these features are present, a spatial orientation is possible, even with unknown objects. These benefits must be set against the implicit costs of these perceptual "hypotheses"[53] costs which consist in the tendency to succumb to spatial illusions, especially if a distorted environment induces a re-scaling of objects and thereby renders the entire scene a perceptual paradox, as in the case of the Ames room.

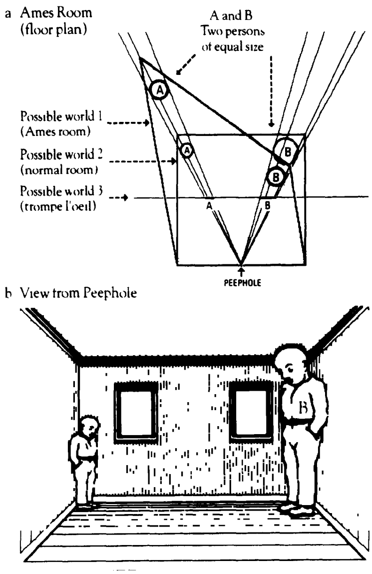


Figure 19. The Ames room

Panofsky claims that only the social and philosophical re-orientations caused by the emancipation of Italian cities allowed the emergence of a new iconographic schema in which objects were no longer depicted as they were 'known', or – in scholastic terms – according to their 'form', but as they were 'seen by a specific observer from his or her vantage point: the 'intuitus'.[54] In a later analysis,[55] Panofsky points out that there is an irreducible contradiction between the geometric construction and the subjective percept. In what follows, it will become apparent that this contradiction is in essence due to the multiple parallel processing of visual information, and that artists skilfully distort perspective to capture exactly these processes of perception and thereby make their spatial effects most compelling.

In his classic text, *De pictura* of 1435, Alberti explains the importance of his approach to perspective as follows:

> The instructions are such that anyone will grasp their utility, if they understand them and the [underlying] doctrine of pictorial expression. One should never assume that anyone can be a good artist who does not understand clearly what he is going to do (my translation).

It is apparent from this quotation that Alberti sets a standard for the evaluation of visual art, and specifically that expertise in perspective drawing is the necessary precondition for the production of genuine works of art. Alberti, however, does not confine himself to the theoretical aspects of perspective geometry, for he also gives practical advice on how to produce a drawing which is perspectively correct: "On the surface on which I intend to paint, I draw a rectangle of the size I want, this is regarded as an open window through which the object of my painting is viewed" (my translation). This is the definition of the 'Alberti window', which is sometimes called the 'da Vinci window' in the literature. In his treatise on architecture, Antonio di Piero Averlino gives closer specification to Alberti's technical instructions and develops the central perspective as the one which fits the human eye. His success explains – at least partially – why the central perspective played such an important role in the paintings of Raphael and other Renaissance painters. Leonardo da Vinci followed up these ideas and speculated about the physiology of the human eye, making the central perspective the only one suited to the human eye: " [. . .] in this way objects directly opposed to the eye impinge more strongly on the senses if they are in line with the respective nerves". Moreover, in manuscript A of 1492, Leonardo sets out rules on how to apply Alberti's rules correctly, the so-called '*Construzione legittima*'. In parallel with these theoretical elaborations and specific instructions, a number of technical instruments were developed for the drawing of perspective. The earliest of these was Brunelleschi's (1377–1446) apparatus, which consisted of a system of mirrors and a peephole; a device which became generally known as the 'camera obscura' about one hundred years later (see Figure 20). Finally, Dürer in his *Underweysung der Messung* (first published in 1524, but the third edition of 1538 is of special importance for the development of perspective) summed up what was then known about perspective, theoretically as well as practically. He also proposed the 'Dürer window', which became the standard instrument for perspective drawing until the advent of modern art. As regards the importance of form, it is thus interesting to note that perspective geometry originated in the intent of artists to protray objects as they are seen from a specific point of view. The implicit physical presuppositions, as well as the implications for mathematics, were analysed much later. For instance, in 1619 Schreiner showed experimentally that rays of light propagate linearly and that they cross in the camera obscura (see Figure 21).

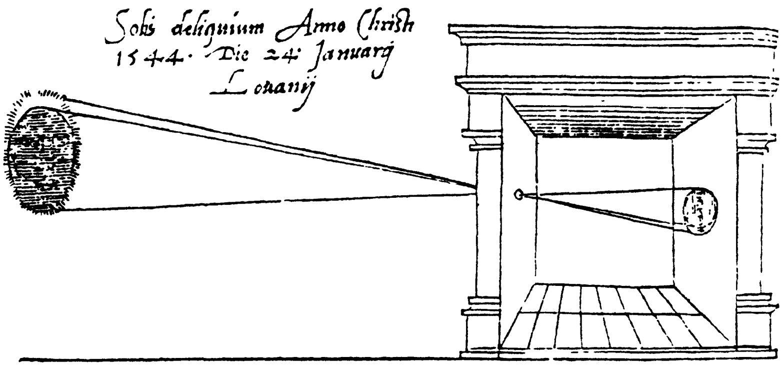


Figure 20. The camera obscura

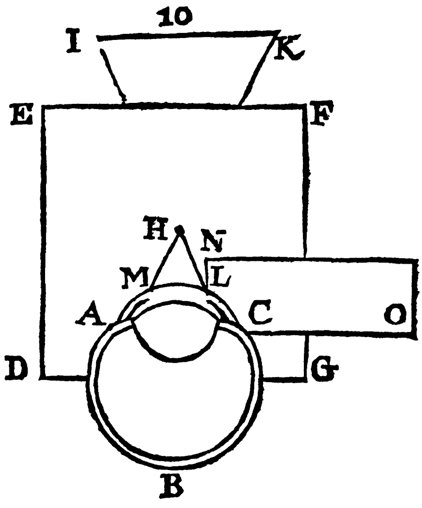


Figure 21. Schreiner's apparatus for the analysis of how the light travels in the camera obscura

It took even longer for mathematics to realize the implications of perspective drawing for geometry. As late as the second half of the eighteenth century, J. H. Lambert in his *Theorie der Parallellinien* (written in 1766 and published in 1786) finally concluded that any hypotheses on spatial relations which do not lead to contradictions offer a possible geometry; insofar as Renaissance perspective constituted one possible geometry.

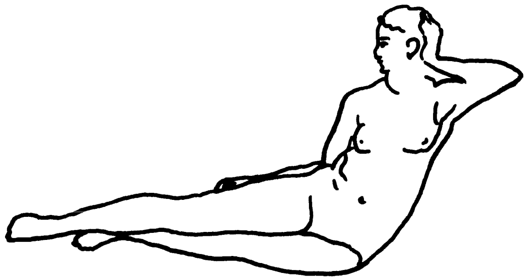
One reason for this delay in basic research into the propagation of rays and of linear perspective may be that artists themselves systematically deviated from their own precepts. The third edition of Dürer's *Underweysung* (1538) contains a picture of an artist using the 'Dürer window' to draw a reclining women (see Figure 22a). However, if one uses this drawing to reconstruct how the artist really saw the reclining nude from his point of view, what results is shown in Figure 22b.

a

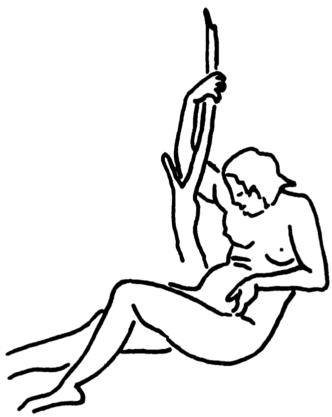
b

Figure 22. (a) Illustration of the Dürer window from the 'Underweysung' of 1538. (b) Approximation of the projection on the screen of the Dürer window

Nowhere in Dürer's *oeuvre* can one find such a view of a reclining woman. His drawings that most closely resemble the view of the artist in Figure 22 are the 'Reclining Nude' of 1509 (see Figure 22c) and the woman in the 'Family of the Satyr' of 1505 (see Figure 22d).



c



d

Figure 22. (c) 'Reclining Nude' by A. Dürer (1509). (d) Woman from the 'Family of Satyrs' by A. Dürer (1505) redrawn for reasons of comparability

When these Figures are compared, it becomes apparent that Dürer solves the problem of showing the objects as they are, and as they are seen from the artist's point of view, by rotating the reclining women of Figure 22c into a canonical position; from this perspective the distortions are minimal. In Figure 22d he uses an alternative approach which stretches or shortens the limbs towards their natural proportions: that is, he does not produce a real projective view but joins different views together in such a way that a global impression is formed. This impression takes account of the invariant proportions of the human body but at the same time gives the impression of a specific point of view. Dürer thus integrates what Penrose called the two opposite views of art:[56] showing what one sees, or showing what one knows.

Although the integration of these two opposing views can be regarded as convincing, in art criticism[57] these deviations from the geometrically correct projections are sometimes regarded as ‘primitive’. Stadler makes this point when analysing Dürer’s watercolour of the ‘Castle of Arco’ (see Figure 23a).

a

b

c

Figure 23. (a) The ‘Castle of Arco’ by A. Dürer (watercolour 1494). (b) A photograph of the castle of Arco (Leber, 1988). (c) The different vantage points of Figure 23a

The watercolour in Figure 23a shows marked differences with respect to the photograph in Figure 23b. Figure 23c shows from which points of view the different segments of the watercolour have been taken and how they have been integrated. Only the buildings on the top of the mountain (hedged) correspond exactly to the view in the photograph; a view which is nevertheless implied in the watercolour. This is in spite of the fact that most parts of the *aquarelle* are not seen from this point of view. If one compares the details and the proportions of the photograph with those of the watercolour, systematic differences appear in addition to the integration of different perspectives:

(i) the size of those objects serving as points of orientation for the observer have been enhanced;

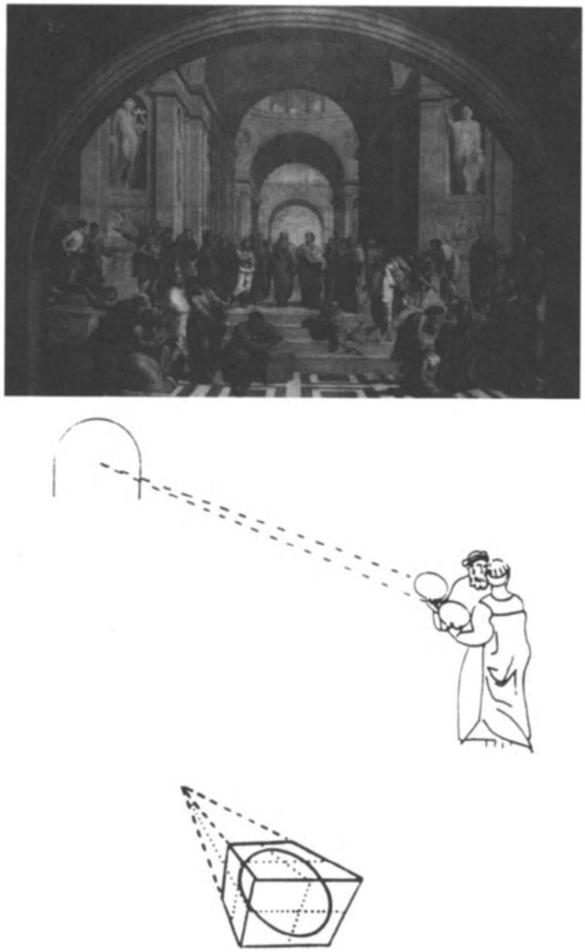
(ii) the position as well as the orientation of objects have been adjusted for a maximal spatial effect, and

(iii) the relation of height to width has been massively distorted.

More detailed analysis is conducted by Leber, who also provides further illustrations and examples.[58] In the eighteenth century, Piranesi used these systematic distortions in his *Vedute di Roma* to produce the spatial effect that corresponds most closely to the subjective view.[59] A series of experiments[60] have shown that the proportions in 'distorted pictures' are regarded as more realistic than those that correspond to 'perspectively correct' photographs. Therefore, contrary to what Stadler claims,[61] these are the results not of a 'primitive level of construction' but of an optimal synthesis of the 'no change' and 'change' in Gibson's terminology.

One further example of this synthesis is provided by Raphael's 'School of Athens' (see Figure 24a). The assembly of Greek philosophers in a central perspective view immediately produces the impression of a natural spatial constellation. However, if one compares the rendering of the people and geometric bodies in the picture with what a camera obscura would produce, systematic distortions become apparent. The most striking instance is the perfectly circular spheres held by Euclid and an accompanying person in the right part of picture. LaGournerie was the first to point out[62] that the spheres should appear as ellipses (see Figure 24b). The reason for this is demonstrated in Figure 24c. However, LaGournerie discovered that such a perspectively correct representation strikes the observer not only as uncommon but also as patently wrong.

It should be noted that what applies to the spheres also applies to the other objects, and especially to the people depicted as if they were in the centre of the frontal-parallel plane. Thus, the seemingly correct global pictorial representation is in fact an assembly of many separate representations. Pirenne comments[63] that this result contradicts an empiricist view of perception because such an assembly does not correspond to any possible real scene.



a

b

c

Figure 24. (a) 'The School of Athens' by Raphael (in the Stanze della Seguatura 1508–1511). (b) The correct perspective distortions of the sphere held by Euclid and an accompanying man. (c) The constructive principle for the ellipses in (b)

Thus it appears that the spectator looking at Raphael's picture of the spheres must make a complicated intuitive compensation. On account of natural perspective, the circles appear foreshortened to him. They do not form in his eyes the retinal images which would be formed by actual spheres. But, on the basis of his knowledge of the shape and position of the surface of the painting, he recognizes them as circles drawn on a flat surface. Since real spheres always look circular, he concludes that these circles represent spheres. It will be noted that all this, which must somehow occur unconsciously, can be done as well when the spectator uses both eyes, and is in the wrong position. To most spectators, the *School of Athens*, in which the perspective is in parts inaccurate, appears as an outstanding example of the use of perspective.

Contrary to Pirenne, I would argue that the 'complicated intuitive compensation' performed by the observer is not at all complicated. It is automatic and does not involve any information processing.[64] This result contradicts the modularity assumptions made by Fodor,[65] because the 'correct' ellipses must be processed *analytically* in order to prove that they represent reality correctly. By contrast, the 'distorted' views of circles immediately yield a unique spatial representation which portrays the world as it really seems to be. A parallel top-down and bottom-up processing of information takes place here. Another consequence is that, whereas the constituents of the complex scene are processed in parallel, so that each constituent can have its own stable frame of reference in which orthogonality and linearity are given, the total scene is processed serially, with the result that the incongruity between the different frames of reference and vanishing points does not become apparent. This corresponds to Hochberg's view[66] that the perception of a complex scene is the result of an integration of separate glances at the constituents of this scene. Global contradictions, as in Escher's paradoxical etchings, consequently do not 'pop out' but must be searched for analytically.

Comparing perspective pictures of Renaissance art with those of the Baroque period yields further insights into the mechanisms of spatial perception. Symmetry prevails in Renaissance art, resulting in the preference for a central perspective, whereas in Baroque and later art these symmetries are intentionally broken. The view of the interior of Regensburg cathedral and Blechen's romanticist rendering of a ruined church (see Figures 25a and b) may serve as examples. Apparently, the importance of breaking symmetries in order to induce a spatial effect is not confined to simple situations like the Necker cube. In more complex scenes, symmetry breaking has the side-effect of resulting in more occlusions, thus adding to the impression of a 3-D space because of their importance for 'direct information pick-up'.[67]

According to Gibson,[68] spatial orientation relies on the perception of the flow field and on identification of the invariants within it – this cannot be mimicked in 2-D paintings – although equally important is the structure of perceived occlusions. It has been demonstrated experimentally that these alone, under appropriate conditions, can result in a unique spatial specification.[69]

If one tries to condense the message from the techniques of spatial representations in visual art, the main result is that the pictures are neither constructed nor perceived analytically in a sequence of hierarchical levels. They are instead perceived in a parallel fashion where not the global consistency of projective geometry but the saliency of local processes in interaction is decisive for the subjective impression of a 3-D scene represented in a 2-D picture.

Besides this general result for the architecture of perception, also of importance is a specific finding concerning the role of symmetry. Symmetries play a major role in science: not only are the laws of Newtonian physics characterized by symmetries but so too are those of modern physics. Chemistry

a

b

Figure 25. (a) Interior of the cathedral of Regensburg (about 1600). (b) Ruin of a gothic church by Blechen (about 1840)

and a special christallography abound in intricate symmetries (at least seventeen can be described analytically). Finally, practically all animate objects display one or more axes of symmetry or hierarchies of bilateral symmetries.[70] In the light of the pervasiveness of symmetries in the world around us, it is surprising that on one hand Bower was unable to find a symmetry effect in the object perception of neonates,[71] while on the other hand the perception of 3-D bodies as spatial in 2-D pictures relies on the breaking of symmetry. My conjecture is that because the *forms of the objects* are symmetric, they have to be *represented* from an angle which allows them to separate 'change' and 'no change'. It is precisely the tension produced by this separation that gives rise to a perception which is realistic in the sense of Scholastic philosophy (*res* = objects as seen) as well as in that of everyday language, because it results in an optimal fit between the world as it is and the world as perceived.

In order to demonstrate that this role of symmetry is not confined to the inspection of simple forms or the pictorial representations of spatial scenes, I will use a case study from the history of science to show how important the symmetry breaking is for any veridical representation of the world of objects.

5. SCIENTIFIC MODELS AS REPRESENTATIONS OF THE WORLD OF OBJECTS: THE CRUCIAL IMPORTANCE OF SYMMETRY BREAKING

The extent to which the Aristotelian notion of an invariant form underlying variable and transient phenomena has determined the formation of theories about the world becomes especially apparent in theories about the solar system. In 1660, Athanasius Kirchner classified and systematized different theories from Ptolemy to Copernicus (see Figure 26). However, he excluded the then already accepted Keplerian system, because this ellipsoidal system was at odds with the presupposition that invariant forms ought to be simple (see Figure 27).

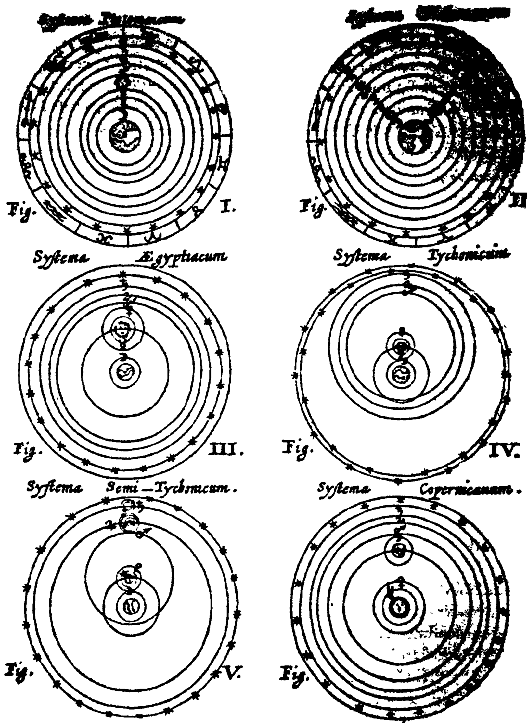


Figure 26. Six different models of the world according to Kircher (1660)

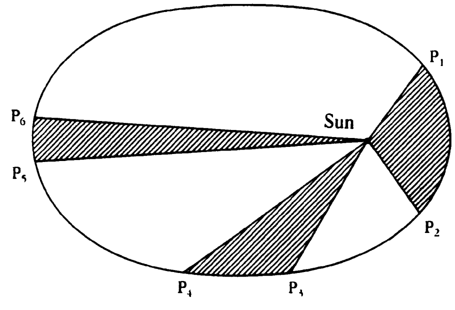


Figure 27. Illustration of Kepler's second law

Kepler himself was impeded in his scientific progress by this presupposition (see for instance his *Mysterium Cosmographicum* of 1597; Figure 28). Here he postulates that the diameters of the circular trajectories of the planets are determined by the sequence of Platonic bodies. This theory was so attractive because, in essence, it constituted a 'theory of everything' which tied the Platonic theory of elements (Figures 29a and b) to the Copernican model of the solar system.

However, its especial attractiveness lay in the perfect symmetry of the macrocosmic and microcosmic world thus envisaged. Plato's identification of the elements with what came to be known as the Platonic solids (*Timaeus* 53–56) and Kepler's celestial model were regarded as a proof that the world had been by a rational being.

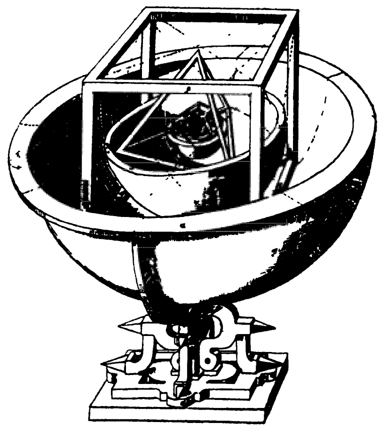
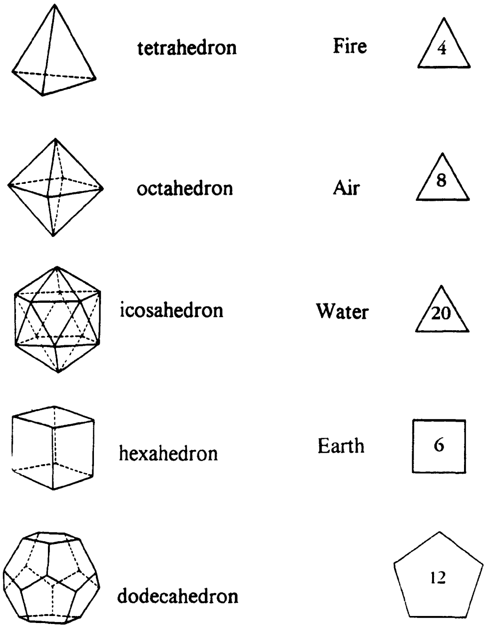
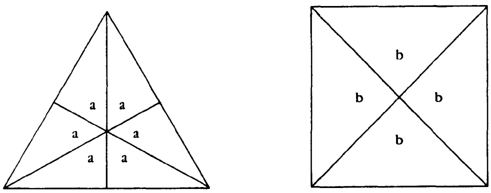


Figure 28. Kepler's model of the world as consisting of involuted Platonic bodies





Fire	Tetraeder	=	4 · 6 a	=	24 a	(1)
Air	Oktaeder	=	8 · 6 a	=	48 a	(2)
Water	Ikosaeder	=	20 · 6 a	=	120 a	(5)
Earth	Hexaeder	=	6 · 4 b	=	24 b	

Figure 29. Plato's correspondence of ideal bodies and elements

It is my intention, Reader, to demonstrate that the Highest and Most Good Creator in the creation of this mobile world and the arrangement of the heavens had his eye on those five regular bodies which have been celebrated from the time of Pythagoras and Plato down to our own day; and that to their nature He accommodated the number of the heavenly spheres, their proportions, and the system of their motions.[72]

Although this approach hampered the advent of the correct elliptoidal model for some years, it opened the way for the physical analysis of celestial phenomena and resulted in Newton's model. This in turn motivated Bohr's model of the atom, which is again a seemingly perfect correspondence between macrocosm and microcosm.

From my point of view, these two tendencies – towards the most perfect form and towards a correspondence between different levels of analysis – do not reflect primarily cognitive processes, which are biased by conservatism or cognitive heuristics. Rather, they indicate perceptual processes which involve the bifurcation between perceiving an object as it is and as it is seen in perspective from a specific point of view.

Kepler's work shows that he emancipated himself from the error-inducing influence of 'ideal forms' by developing the elliptoidal model of planetary motion. However, he himself did not reflect on the psychological processes which first led him astray but finally allowed him to find the correct solution. As far as I know, Christiaan Huygens was the first to conduct a phenomenological analysis of the perceptual and conceptual influences on the scientific process of representing the world of objects in analytical terms. He chose a problem which had haunted astronomy since the invention of the telescope: what is the real form of the planet Saturn?

Huygens analysed the relationship between observation and conceptual structure in science in his book *Systema saturnium* (1659, here quoted after volume XV of his *opera omnia*). In one illustration he shows thirteen different views of the planet Saturn as reported by astronomers since the beginning of the seventeenth century. Most of these views exhibit perfect bilateral symmetry, horizontally as well as vertically (see Figure 30).

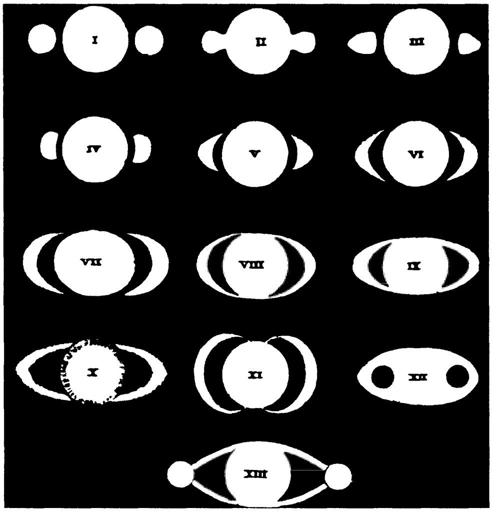


Figure 30. 13 different views of Saturn as reported up to Huygens' analysis

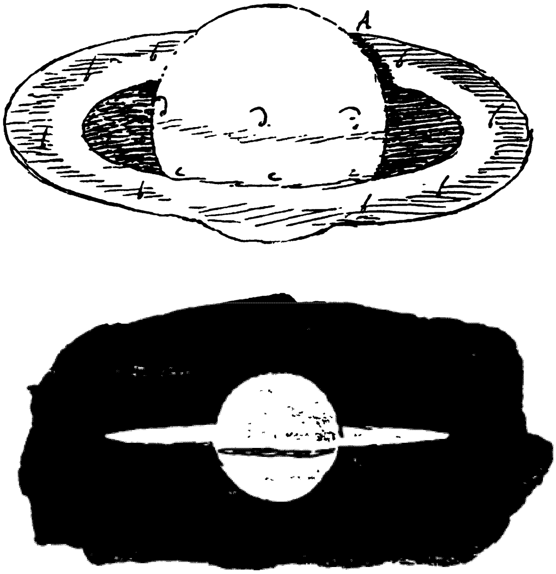
If one compares these images with a photograph taken on 24 November 1943 using a 100-inch telescope, one sees that they are not Figments of the imagination but instead represent observations (see Figure 31).

Figure 31. A photograph of Saturn taken with a 100-inch telescope on 11/24/1943

The saliency of symmetry in these views gave rise to two alternative interpretations. According to one, the planet was assumed to vary in form (see e.g., view XII in Figure 30, attributed to Gassendi, 1646); according to the other, the planet was a perfect sphere surrounded by a variable environment. The latter is especially apparent in view X observed by Divini. Huygens comments on views VIII und IX by Riccioli (1648–1650) as follows: "After somebody has elaborated a hypothesis which leads him to such a consequence, then he deludes himself and believes in the reality of what he hopes to see".[73] Huygens himself arrived at the representation of the planet Saturn, which today we know to be correct (Figure 32 a and b), by combining an invariant form (a spherical planet with a flat ring) with an elliptical orbit; together they produce all the views of Figure 30 as possible observations of the planet Saturn from the Earth (see Figure 33).

Huygens' analysis shows how immediately perceived symmetries may prevent the detection of more basic underlying symmetries and regularities. His solution required that these supervisual symmetries be broken; the resulting model exhibited the invariant features only because the stability of form in the object and its apparent variability, due to its perspective projections, were taken simultaneously and equally into account. Again, as in previous sections, a realistic representation is only achieved by integrating the 'change' and 'no change' aspects.

The essence of the last examples regarding the question of 'form versus matter' or 'perception versus conception' is best summed up by Albert Einstein (1950):



a

b

Figure 32. Huygens' model of Saturn

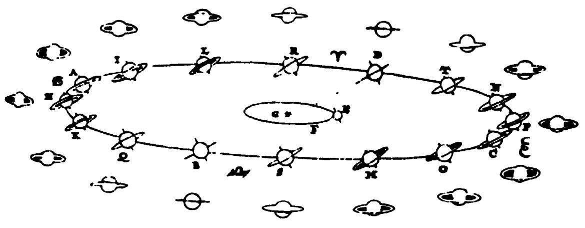


Figure 33. Huygens' integration of the different depictions of Saturn in Figure 30 as specific views due to different constellations of Saturn and Earth

I believe that every true theorist is a kind of tamed metaphysicist, [] The tamed metaphysicist believes that not all that is logically simple is embodied in experienced reality, but that the totality of all sensory experience can be 'comprehended' on the basis of a conceptual system built on premises of great simplicity. The skeptic will say that this is a 'miracle creed'. Admittedly so, but it is a miracle creed which has been borne out to an amazing extent by the development of science.

6. A LESSON LEARNED?

In my opinion, the examples from perception and from the history of science compellingly indicate that the classical juxtaposition of 'form versus matter' and 'perception versus cognition' obscures the real underlying question of whether the relation between these terms is complementary in nature. The first attempt to formalize this relationship can be found in the appendix to Euler's *Methodus Inveniendi Lineas Curvas Maximi Minimive Proprietate Gaudentes* (A method to find curved lines that maintain a maximum or minimun property), in which he proves that the principle of least action can be used to describe the motion of a point mass in a field of forces, an example being the motion of planets around the sun. Euler thus already put forward the conjecture that this principle might be a pervasive underlying principle of nature, provided one is interested in the analysis of action and not in the description of stationary states. This idea was expanded by Max Planck in his lecture delivered at the Prussian Academy of Sciences on 29 June 1920 to celebrate Leibniz's anniversary:

> Present-day physics, as far as it is theoretically organized, is completely governed by a system of space-time differential equations which state that each process in nature is totally determined by the events which occur in its immediate temporal and spatial neighborhood. This entire rich system of differential equations, though they differ in detail since they refer to mechanical, electric, magnetic, and thermal processes, is now completely contained in a single theorem, in the principle of least action. This, in short, states that, of all possible processes, the only ones that actually occur are those that involve minimum expenditure of action.[74]

Gestalt theorists, especially Wolfgang Köhler,[75] have regarded this principle of least action to be at work in the 'world out there' as well as in the world represented in the perceiver; for the Gestaltists this was the reason why there is an order in things (*res*) as well as in their percepts – and they believed that these orders correspond. In my opinion, modern theories of perception should follow this research programme.

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NOTES

[1] E.g. Gibson 1951, 1973. Cf. Schmidt 1992.
[2] For these see Zimmer 1995.
[3] Roth 1992.
[4] For further details see Shepard 1994.
[5] D'Arcy Thompson 1917.
[6] Richter and Scholz 1987.
[7] D'Arcy Thompson 1917.
[8] Köhler 1920.
[9] Koffka 1935, 175.
[10] Gibson 1979.
[11] Bower 1972.
[12] Zimmer 1984.

[13] Julesz 1971; Navon 1977.
[14] Marr 1982.
[15] Köhler 1920.
[16] See McClelland and Rumelhart 1986 for the notion of parallel and distributed processing in perception.
[17] Feldman 1982.
[18] Zimmer 1989.
[19] Guzman 1969.
[20] Perkins 1968, 1972, 1973.
[21] Ditzinger and Haken 1989.
[22] Marr 1982.
23Ibid.
[24] Hubel, Wiesel 1962.
[25] Konorski 1967; sometimes jokingly termed 'grandmother cells'.
[26] Gross 1973.
[27] Maturana, Varela, 1975; Schmidt 1987.
[28] Lettvin, Maturana, McCollouch, Pitts 1959.
[29] Simon 1969.
[30] Trevarthen 1968.
[31] Mishkin, Ungerleider 1982.
[32] Milner, Goodale 1992.
[33] Fodor 1968; Pylyshyn 1981.
[34] Julesz 1971.
[35] Panofsky 1980.
[36] Cf. Deregowski 1980.
[37] Cf. Ivins 1946.
[38] Cf. Goldmeier 1982.
[39] Ramachandran 1988.
[40] Koffka 1935.
[41] Cf. Wilzcek, Devine 1987.
[42] Cf. Zimmer 1986.
[43] Köhler 1920.
[44] Koffka 1935.
[45] Wulff 1922.
[46] Perkins 1968.
[47] Hochberg, Brooks 1960.
[48] Ibid., 354.
[49] Attneave 1981.
[50] Haken 1990.
[51] Gibson 1971.
[52] Gregory 1980.
[53] Panofsky 1976.
[54] Panofsky 1980, 102.
[55] Penrose 1973.
[56] E.g. Stadler 1929.
[57] Leber 1988.
[58] Cf. Panofsky 1976.
[59] Zimmer, in press.
[60] Stadler 1929, § 8.
[61] LaGournerie 1859, 170.
[62] Pirenne 1970, 122-33.
[63] See Zimmer 1986a.
[64] Fodor 1975.
[65] Hochberg 1962.
[66] Gibson 1979.
[67] Ibid.
[68] Zimmer 1986b.
[69] For examples see Weyl 1952.
[70] Bower 1972.

[71] From Kepler's introduction to the *Mysterium Cosmographicum.*
[72] Here Huygens alludes to Francis Bacon "Quod enim mavult homo verum esse, id potius credit" (*Novum Organon* I, aph. 49).
[73] Quoted in Hildebrandt, Tromba 1985, 192.
[74] Köhler 1920.

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FORMS AND EVENTS

1. INTRODUCTION

In a paper of some years ago,[1] I argued about the usefulness of thinking of events in terms of forms. As a student of perception in visual and auditory domains, I referred to those minute facts that are perceptual events, like stroboscopic movements, short melodies, and so on. The conceptual tool I am accustomed to use is *Gestalttheorie*, and my operational method is experimental phenomenology.[2] This tool and method seem well able to provide a reasonable account of the way of appearance (*Erscheinungsweise*) of objects (events) in the behavioural world, in the sense of the famous question asked by Koffka: "Why do things [events] look as they do"?[3] In this paper I shall examine the matter more closely, pointing out some aspects that are relevant to current psychological enquiry into subjective time.

2. DEFINITION OF FORM

The term *form* has in psychology – as in other disciplines – a certain number of different meanings and uses. Here it will be treated as the translation of the German term *Gestalt*.

A Gestalt is a self-organized unity. As Köhler maintains, the word Gestalt "has the meaning of a concrete individual and characteristic entity, existing as something detached and having a shape or form as one of its attributes".[4] The Gestalt is the result of a process of organization, in the sense that "what happens to a part of the whole, is determined by intrinsic laws inherent in this whole".[5] Koffka, when defining the practical use of the concept of Gestalt, adds: "to apply the Gestalt category means to find out which parts of nature belong as parts to functional wholes, their degree of relative independence, and the articulation of larger wholes into sub-wholes".[6]

In my opinion, the above definitions of Gestalt should be completed by the arguments of some other prominent representatives of the Berlin School. For instance, Metzger shows how the concept of self-organization of parts into the whole stems from the failure of any other effort to explain the formation of perceptual units by means of external agents (associations, past experiences, attention, production, and so on).[7] On the other hand, Lewin states, at least as regards psychological matter, the principle of the "relational character of

L. Albertazzi (ed.), Shapes of Forms, 89–106.

causal facts";[8] that is, the actual impossibility of distinguishing, among the parts of a whole, the parts that perform the role of 'causes' and the parts that perform the role of 'effects'. Both Metzger's and Lewin's statements make clear what Gestaltists mean by 'self-organized unity' (a percept, a motor behaviour, an act of productive thinking, and so on): a whole held together by mutually interacting parts, something analysable but which cannot disassembled, since the ablation of any part often leads to the dissolution of the whole.

The main trait of a Gestalt becomes evident when we compare it with a mechanism: when a part is removed from a mechanism, the rest remains unchanged; when a part is removed from a Gestalt, the rest turns to another equilibrium among the remaining parts. This point is particularly important in the study of mental facts: a deprecable fashion nowadays likens mental facts to the processes that take place inside machines such as computers, in spite of substantial evidence to the contrary. What surprises me is that whereas even chemists attribute self-organizing properties to some processes (for example, the so-called Belusov–Zhabotinski reaction[9]), and also physicists cautiously look at chaotic phenomena, psychologists insist on modeling mental facts on machine-like and unacceptable paradigms.[10]

There is no need to dwell here on Wertheimer's well-known 'principles of unification'[11]); that is, the principles whereby Gestalten come into being from their constituting elements (similarity, proximity, continuity of direction, closure, division without rests, Prägnanz, subjective setting, common fate, objective setting, past experience). Concerning the relationships between the whole and the parts – that, is the prevalence of the characteristic of the whole on its parts, or the influence of the characteristics of the parts in the articulation of the whole – I recommend the treatises of Metzger.[12]

3. DEFINITION OF EVENT

As far as I know, the psychological literature does not contain a strict definition of *event*, perhaps because of the uncertain ontological status of the 'event' itself. One could resort to the definition provided by Johansson: "the term 'event' is defined as a generic concept denoting various kinds of relational change over time in a structure".[13] Yet this definition, although sufficient for a student of perceived motion, seems to obscure several problems that I shall seek to elucidate later. Other contributions by distinguished perceptionists, such as Gibson[14] or Cutting,[15] are not a great deal of help.

My tentative analysis of the matter starts from the trivial observation that the very stuff of the environmental field is made up of events, since durableness is a necessary condition for the existence of objects as well. (One remembers the opening discussion in H.G. Wells's *The Time Machine* of the cube that stretches along four dimensions.) I am accustomed to drawing a distinction among *stationary events* (objects), *non-stationary events* (continuous changes of quality or of position) and *quasi-stationary events* (cases where one perceives objects and changes at the same place and time: for example the wave motion on a substantially steady sea).

Unfortunately this way of arguing neglects some facts: for instance the fact that even a flash in the dark is believed to be an 'event', in spite of the absence of any change both in the square wave of light emission and in the surrounding darkness (where is the 'relational change' invoked by Johansson?). Of course, something does change, and namely the whole durable perceptual field, in the sense that the flash brings an alteration in respect of the previous and subsequent dark condition. Yet this means that the sum of an unchanging object (the flash) plus two unchanging objects (the preceding darkness and that which follows) is a change. Clearly the event-like character of the situation is given by the succession darkness-light-darkness, but in so arguing we transfer the cause of the perception of the event from the outside becoming to the inside disposition of the observer. That is to say, time does not exists externally to us but is a product of the act of observing. To the objection that the succession is primarily in the physical sequence of stimuli (or of the related neural processes), we may recall what Lotze already recognized,[16] namely that a succession of perceptions is not a perception of a succession. (Even Aristotle, in *Physica* 223a, hypothesises the inexistence of time in the absence of a perceiving soul.[17])

Another example will perhaps clarify (or obscure?) the point. A continuous tone heard on a silent ground is once again an 'event', in spite of the fact that nothing changes, neither in the stimuli nor in the content of conscience of the observer. We could again object on the ground of the temporal character of the situation, arguing that is the succession of awareness states in the perceiver which makes the tone persist, but in this case too the 'event' or the 'change' does not pertain to the world but to the Ego. Nevertheless, even this conclusion is misleading, since there is another fact to explain. Let us compare two cases: (a) a continuous tone lasting in silence, and (b) a black spot on a white sheet of paper. From the point of view of physical stimuli, and of their related neural processes, we have two identical steady-state situations, in the sense that just as the acoustic wave continues to stimulate the eardrum (thus generating steady processes in the auditory path), so the flow of light waves reflected by the surface of the paper continues to stimulate the retina (thus generating steady processes in the visual path). Now, the perceptual outcome of (a) and (b) is quite different: we call the tone 'an event', and the spot 'an object'. Moreover, we listen to the tone as to something that may by its nature cease at any moment, while we look at the spot as something that is by its nature permanent, unless it is destroyed on purpose. In other words, the tone has an event-like character, where the spot has an object-like character, in spite of the sameness of the related processes and of the supposedly neutral operation of the time machine of the Ego. Why does the Ego give the tone its event-like character, and the spot its object-like character?

I do not intend to address ontological problems here. I merely need a satisfactory definition of 'event' in order to give a clear description of stimulus conditions and perceptual outcomes of the experiments. I learn from a recent paper by Smith and Casati,[18] however, that the students of the field are divided into two camps: on the one side stands a 'bicategorial view', according to which objects and events are of different species;[19] on the other is a 'monocategorial' view according to which objects are a subspecies of events, or events are subspecies of objects.[20] Moreover, some linguistic enquiries[21] show that actual language is rich in subtle distinctions concerning events (eventualities, processes, events, happenings, culminations, and so on), thereby revealing that there are phenomenal features of becoming not yet considered by perceptionists.[22]

To conclude, the psychology of perception lacks a well-grounded definition of 'event'. This, however, does not prevent us from stating the facts that concern us.

4. EVENTS AND PSYCHOLOGICAL TIME

It is today apparently impossible to define the relationship between perceptual events and psychological time. The problems at issue are many and heterogeneous, and almost all of them concern the connection between the experienceable and appraisable duration of events and some cardinal features of subjective time, such as the continuity of the flow of conscience, the limits of a psychological present that is not punctiform, the manifest durableness of the perceptual act by which we perceive not only the successions of events but even the duration itself. In short, we do not know whether the times of events are portions of the time of the Ego.

In general, the present disappointing state of affairs apparently stems from at least two reasons. The first is the uncritical attitude of the students of the field, who regard the need to compare psychological time with the time of mechanics as unavoidable (this is the *Leitmotiv* running through the best general treatments at our disposal[23]) in spite of (a) the obvious evidence that the time of mechanics is not a stimulus[24] and of (b) the growing opinion that the time of mechanics is just one among several formal representations of time:[25] why should we prefer the time of mechanics to the time of particles or of thermodynamics? The second reason is the neglect with which the results of the phenomenological inquiry into psychological time have been treated.[26] The abandonment of these latter lines of research has its historical motives,[27] but I think that academic psychology will very soon have to reckon with these results; that is, with the features of psychological time revealed by the phenomenological method.[28]

5. STROBOSCOPIC MOVEMENT

Let us start with the archetype of any event, which is movement (change in position), and for any movement, with the one that summarizes them all: stroboscopic movement. It is common knowledge that stroboscopic movement is the starting point and the compendium of Gestalt psychology, as Figure 1 illustrates. The left side of the Figure shows the stimulus conditions, which are divided into five phases: (1) complete darkness; (2) a first white spot *a* lights up, no matter how long it lasts; (3) complete darkness for an interstimulus interval of about 50 msec, the duration of which depends on the spatial distance of the second spot; (4) a second white spot *b* lights up, no matter how long it lasts; (5) the darkness condition is restored. The right side of the Figure shows what is actually seen; that is, *one* light moving from *A* to *B*.

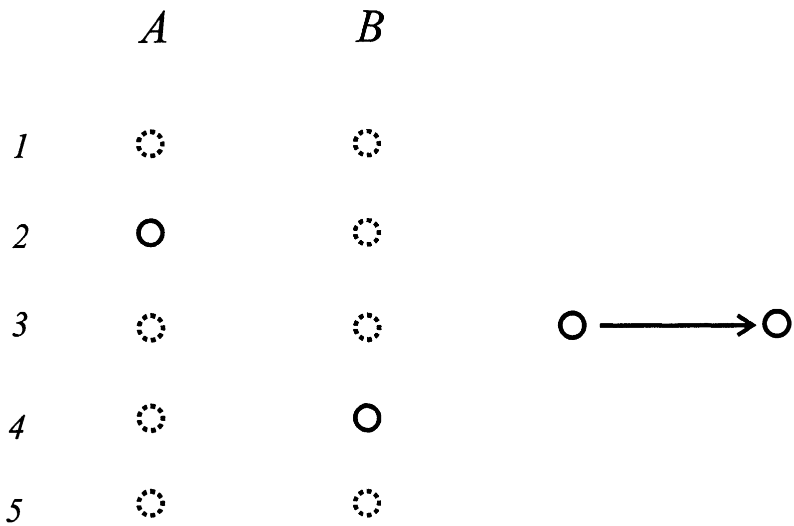

Figure 1. Stroboscopic movement. *A* and *B*: two illuminated spots. 1–5: successive on/off phases, with solid circles for on condition and dotted circles for off condition. Proper on/off times give rise to the vision of a spot moving from *A* to *B* *(on right)*

The Gestalt nature of this event lies in the fact that the quality of movement is not inherent to either of the two light spots, in the sense that one half of the resulting effect does not pertain to each of them. The perceived movement is something undivided that belongs to both light spots when bound together. When theory points out that the whole is something different from (and often more than) the sum of the parts, it refers to the fact that a moving light is clearly different from two stationary lights, and is something new and unpredictable, on the ground of the characteristics of the parts. Moreover, one should bear in mind that the event consists of *one* moving light which takes up the *two* stationary lights, in the absence of residuals.

Yet stroboscopic movement is a remarkable perceptual event also when closer analysis is made of the temporal conditions of the stimulus. One finds, in fact, that the light moves from A to B if and only if spot b lights up: if spot b does not light up, we still see the light in its A place. This implies that the 'cause' of the movement of the light from spot a is something happening in spot b. But spot b lights up *after* spot a – more precisely, when spot a is already turned off, see Figure 1 – and we are forced to conclude that the cause of the departure of the light from A is something that stays in the future of A, just for 50 msec but in the future all the same. We know that the cause/effect distinction rests on the before/after distinction, but if the before/after distinction seems dubious, then the cause/effect distinction becomes dubious as well. The paradox can be resolved by denying that events at a and b have the roles of true (exclusive) causes and effects, in the sense that both occurrences are simultaneously cause and effect of the resulting event. And this is exactly what Lewin means in speaking of the "relational character of causal facts":[29] every distinguishable part (the beginning, the end, the trajectory, and so on) of the total event (the perceived movement of the light) is simultaneously cause of the *Erscheinungsweise* of the other parts, and effect of the way we perceive other parts.

What is also remarkable in stroboscopic movement is that we perceive the beginning of the movement of the spot of light from its initial standpoint *before* we perceive its arrival at its final standpoint. If we insist on considering what happens at spot b to be the 'cause' of the movement of the light, due to the trivial consideration that if nothing happens at b there is no reason for the light to move from a, we are forced to conclude that the stimulus appearing at b acts retroactively on the stimulus appearing at a. But in order to maintain some physical sense in the sequence of happenings, we are forced to conclude that the representation of the beginning of the movement comes a long time after a lights up, namely when also b has lit up.[30] However, since we see the light *first* at A and *then* at B, there must be also a delay in the representation of the point of arrival: in short, what we see is a complete replay of what occurs in the physical world, only for a handful of milliseconds, but nevertheless a replay. This conclusion, however, seems untenable, even though it is apparently not replaceable with any other: adaptive behaviour exhibits motor performances whereby any delay in perception and representation with relation to physical occurrences should be unsustainable.

Whatever the proper interpretation of stroboscopic movement may be, at least one thing seems incontrovertible: this event is a *form* (Gestalt), since we recognized that the main feature of the whole (one movement) cannot be traced back to the main feature of the parts (two stillnesses). Indeed, in my opinion, only the Gestalt interpretation of the stroboscopic movement (all the parts contribute to the building up of the whole resulting event) allows us – for the moment – to avoid the intolerable consequences of a machine-like explanation of the phenomenon; that is, the time reversal about causes and effects, or the unlikely 'replay' condition of event perception. At this point, let us remember that stroboscopic movement is not an exception among perceptual events. We are acquainted with numerous effects that share with stroboscopic movement the retroactive effect of what comes after on what happened before: let me just mention the illumination effect,[31] the tunnel effect,[32] the so-called 'range of action',[33] the perception of wait,[34] motion braking,[35] and the window effect.[36]

6. TEMPORAL DISPLACEMENT

With the stroboscopic effect, the perceived motion at least respects the temporal conditions of the stimulus, in the sense that the wandering light begins its translation from the spot that lights up first, and ends its translation on the spot that lights up second. The order of the stimuli is fairly well mirrored in the order of what we see. We are not so lucky in the case of temporal displacement.

'Temporal displacement' (*Zeitverschiebung*) is a term coined by Wundt[37] to indicate a phenomenon well known in the astronomical practice of his time;[38] namely, the erroneously perceived temporal position of an auditory stimulus in a succession of visual stimuli. Wundt asked his subjects to indicate the temporal location of a bell stroke on a dial bearing a fairly rapidly moving hand. He found that the bell stroke is seldom located where it temporally occurs: sometimes it is positioned before (negative displacement) and sometimes after (positive displacement) the actual point of occurrence. The phenomenon has been investigated by many researchers,[39] some of whom have stressed the different latency of visual and auditory sensory processes while others emphasise the role of attention.

The turning point in interpretation of the phenomenon came with Benussi, who first pointed out[40] that a sequence of very brief stimuli can be perceived as a whole, and that the different phenomenal salience (*Auffälligkeit*) of the stimuli of the sequence could cause their rearrangement in the perceived succession. In this case, he argued that greater salience could be transformed into a temporal advantage, in the sense that perceptually more relevant elements could be seen or heard before (negative displacement) the perceptually less relevant ones. Rubin accentuated phenomenological analysis of the *Zeitverschiebung*.[41] Experimenting with triplets of very brief noises made up of two even and one odd elements (A1-B-A2), he found that temporal displacements were facilitated by the similarity between the two As, in concurrence with small durations for B and for the interval between B and A2. In this way, Benussi's rather elusive 'phenomenal relevance' comes to resemble Wertheimer's 'similarity'. Moreover, Rubin pointed out that displaced successions were by no means 'errors', since the subjects did not experience any 'illusion'. I have found it an easy matter[42] to replicate Rubin's findings with triplets of pure tones well separated in tonal space and in the absence of interstimulus intervals (H1=1760 Hz; L=82.4 Hz; H2=1568 Hz), substituting the still vague concept of 'similarity' with more measurable 'tonal proximity'. I found that, for triplets lasting 300 msec (100 msec for each member of them), the occurrence of temporal displacements reaches 90%: observers report hearing first the two high tones and then the low one (the odd element undergoes a positive displacement).

It is therefore apparent that the perceived succession (that is, the event) is a *form* or a Gestalt, since its *Erscheinungsweise* depends more on phenomenal relations among its members (similarity, proximity) than on the physical sequence of stimuli. To tell the truth, before reaching this conclusion, we must recognize the fact emerging from the experiments of Wundt,[43] also stressed by Fraisse[44] and demonstrated by other researchers,[45] namely the uncertainty of before/after relations for heterogeneous minute events perceived in rapid succession. In conditions of weak constraints governing the passage from stimuli to sensations, it is likely that forces emerging from elsewhere will prevail: in our case the tendency of the high tones to be heard together, leaving the odd low one to wander through the succession.

In my experiments,[46] I took precautions against the eventuality that temporal displacement of the central tone might be attributed to a greater promptness of high tones compared with low ones (the old hypothesis of the speed of sensations), or to the observational setting (the old hypothesis of the direction of attention). Although I cannot set out my results in detail here, I can report that the aforesaid hypotheses do not explain the results. The triplets L-H-L, which should have generated only negative displacements (due to the supposed privilege of high tones) show an equal number of negative and positive displacements; asking subjects to pay attention to the central tone (thereby favouring its prior entry) generated only 25% of negative displacements. For lack of anything better, we must therefore accept the Gestalt interpretation of temporal displacement, in the sense of the perception of an event whose parts have undergone a positional rearrangement due to the mutual influence of the characteristics of the parts.

However, there is another possible interpretation of the phenomenon, namely the 'perceptual moment' hypothesis. This hypothesis, first set forth by Stroud,[47] once reviewed by myself[48] and more recently by Patterson,[49] states that psychological time is composed of strings of 'quanta', lasting approximately 100 msec each, and bearing temporal indifferentiation within them. Temporal displacement should be brought about – although not explained – by this indifferentiation: when two or more stimuli are simultaneously present within one of those quanta, their lining in subjective time is no longer a matter of the sequence in physical time, but of the cognitive processes that extract them out of the quanta. In this way, it is possible that the tones of our triplets falling within one of these 'perceptual moments' may be sorted in an order different from that of their entry, for instance according their pitch, or their similarity, or according to something else.

At first glance, the 'perceptual moment' hypothesis may seem the natural completion of Benussi's and Rubin's arguments, since it gives the hardware ground for dynamic interrelations among the elements of the succession. Unfortunately it does not. Apart from the fact that we are acquainted with perceptual events whose structures exhibit retroactive effects of range far beyond 100 msec (window effect up to 190 msec,[50] visual tunnel effect up to 200 msec,[51] perception of reaction up to 200 msec,[52] perception of causality up to 700 msec,[53] acoustic tunnel effect up to 1.2 sec,[54] waiting effect up to 3 sec,[55] braking effect up to 5.5 sec[56]), the problem is the integration of successive moments in two aspects: (a) the passage through moments of their informational content, and (b) the difficulty of matching the perfect smoothness of perceived continuity with the discrete nature of moments. This latter aspect will be considered in the next section.

7. TEMPORAL SEGREGATION

Let us consider the stimulus situation depicted in Figure 2, where *a*, *b*, *c* and *d* are four neon bulbs lighting up in cyclic succession, with interstimulus intervals equal to 1/4 of light phases.[57]

Figure 2. Temporal segregation. Four neon bulbs lit up in cyclic succession . . .*a-b-c-d-a-b-c-d-a-b-* . . .

The display gives rise to stroboscopic movements which differ according to the durations assigned to the on/off phases (see Figure 3). For values around 150/50 msec, the observer perceives just *one* moving dot which assumes the four positions *a-b-c-d-a-b-* . . . in succession, see Figure 3a. The sequence of stimuli is now accelerated, leaving the on/off ratio unchanged. For values around 105/35 msec, two alternative motion configurations appear: (1) *one* moving dot rising from *b*, attaining a midpoint between *a* and *c* , falling at *d*,

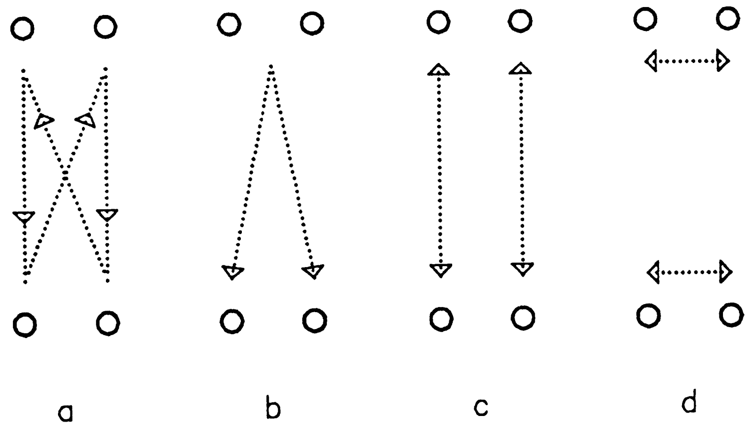

Figure 3. Perceptual outcome of the situation depicted in Figure 3, with varying on/off times (see the text)

then rising again to the midpoint and finally falling at *b*, in cyclic succession, see Figure 3b; (2) *two* dots simultaneously moving on vertical and parallel trajectories (*a-b* and *d-c*), in counterphase, see Figure 3c. For values below 105/ 35 msec, the observer perceives *two* dots simultaneously moving on horizontal and parallel trajectories (*a-c* and *d-b*), in counterphase, see Figure 3d.

The effect described is merely a further development of what von Schiller already ascertained,[58] namely that stroboscopic movement takes place, conditions remaining equal, across positions that are closer in the visual field. Yet the situation of Figure 3 is different from von Schiller's in at least one important respect: here spatial proximity is set in contrast with temporal proximity. For instance, in respect to *a*, *b* is nearer in time (it lights up immediately after) but farther in space, while *c* is nearer in space but farther in time (it lights up after *b*). Will the light dot shift towards the position nearer in space or towards the one nearer in time? The experiment shows that the 'nearer in time' solution is preferred with slow sequences of stimuli (Figure 3a), where the 'nearer in space' solution prevails with rapid sequences (Figure 3d). Intermediate speeds give rise to perceptual compromises (Figures 3b and 3c). But stroboscopic motion towards the point nearer in space reveals a paradoxical state of affairs: everything happens as if the moving dot, before shifting to another position, *waits to see* what the next preferable step is. The waiting time is of course very small: consider Figure 3a. If nothing happens in the arc of 200 msec, there is no choice: the dot at *a* will meet the dot at *b*, giving rise to a downward motion. If, on the contrary, in the same arc of 200 msec two dots appear (because of the more rapid production of stimuli, see Figure 3d), of the one farther (*b*) and the other nearer (*c*), the nearer one is preferred, giving rise to a horizontal motion.

I cannot imagine how many *ad hoc* hypotheses would serve the contemporary theories of motion perception as set forth by neurophysiologists[59] in order to explain the effect reported. I therefore prefer the Gestalt interpretation of the effect, according to which the form of the resulting event is determined by converging factors, among which time plays a role which is not very different from proximity, similarity, common fate, and so on.[60]

The phenomenon reported here is remarkable for another reason. Let us consider the perceptual outcome depicted in Figure 3d. It becomes immediately clear that, whereas on the side of stimuli we have just *one* uninterrupted unilinear chain of physical happenings, on the perceptual side we have *two* events, namely the upper motion *a-c-a-c-a-*... and below another counterphase motion *d-b-d-b-d-*... The point is that the two events are simultaneous, and perfectly superimposed. In addition, the splitting of the unilinear physical chain into two perceptual events does not show, in either perceptual chain, the gaps in time left behind by the alternated stimuli which have formed the other perceptual chain. Figure 4 depicts this state of affairs, with the dotted line standing for the physical chain and the two solid lines standing for the two perceived simultaneous events.

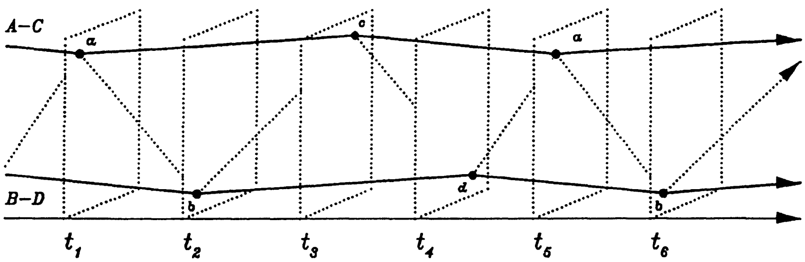

Figure 4. Temporal representation of the outcome depicted in Figure 3d. $t_1 - t_6$ = physical times of occurrence of the stimuli ...*a-b-c-d-a-b-*... Dotted lines represent the unilinear chain of physical stimuli. Solid lines represent the corresponding two simultaneous phenomenal events (stroboscopic movements ...*-a-c-a-c-a-*... and ...*-d-b-d-b-d-*...)

I shall not stress the overt violation of the constancy hypothesis represented by this further discrepancy between physical conditions and perceptual outcomes.[61] Nor shall I linger on the problems raised by the phenomenon for the quantal hypothesis of psychological time: it is hard to understand why the informational content of a moment (say, the dot lighting up at *a*) should be disregarded when inspecting the informational content of the subsequent moment (say, the dot lighting up at *b*), but then taken into account two or more moments later (say, the dot lighting up at *c*). Our concern here is the appropriateness of speaking about events in terms of forms; and if we agree with the identification of the term 'form' with the term 'Gestalt', we are entitled to conceive events as forms. Even the mutual segregation of the above-described movements from the physical chain of stimuli receives explanation in terms of Gestalt processes, where an interpretation of the phenomenon in terms of computational or cognitive processes would most likely lead to a sum of hypotheses fundamentally *ad hoc* and therefore unreliable.

In my opinion, the segregation of events described here is a case of 'double representation', which finds its almost perfect counterpart in the world of objects in the perception of transparency.[62] The transparency effect produces the chromatic scission of the color of the overlap zone, in the sense that there the colour of the lower surface is seen *through* the colour of the superimposed one; moreover, each physical point of the overlap zone counts for two phenomenal points, the one on the upper visible surface, and the other on the lower surface visible through the upper one. In the case described of the scission of *one* unilinear chain of physical stimuli, we have *two* simultaneous movements, separated in space but overlapped in time; moreover, each point of physical time in the chain of stimuli corresponds to a temporal point on the upper movement and to a simultaneous point on the lower one. As in transparency we see two objects in the uniform physical stimulating surface (the overlap zone), so in temporal segregation we see two events in the single and same physical chain of stimuli.

The phenomenon described here[63] is nothing but the transposition into the visual field of an effect already described for the auditory field.[64] This latter has been rediscovered by Bregman and Campbell.[65] Bregman has worked rather extensively on it, giving it a name ('stream segregation') but without realizing its deep nature.

8. PSYCHOPHYSICS OF EVENTS

Two or three years ago I decided to examine the bases of the perception of events using the most traditional tools; namely, psychophysical methods. After recognizing successive comparison as the only way to investigate the fine structure of non-stationary events,[66] I devoted myself to study of a very simple case of evolution: the expansion (contraction) of a line, taking as the observational variable its apparent length measured with the method of successive comparison. After I had determined the succession error for stationary lines,[67] I used a videographic monitor to present subjects with two lines in succession, one in expansion (contraction), the other stationary, and asked them which was longer.[68]

The results were striking. First, no subject noticed the impropriety of the question. For a line that lengthens or shortens, assuming n values during its evolution, any request about the length should be accompanied by specification of the moment at which the length must be estimated: for instance, at the beginning, in the middle, or at the end of the process (which lasted 0.75, 1.5 or 3 sec). On the contrary, subjects found the improper question perfectly acceptable. Secondly, the estimates of evolving lines tended to be more accurate than those of stationary ones. Thirdly, the shorter the exposure time (for evolving lines, the evolution time), the larger the underestimation of both stationary and evolving lines. Finally – and this is the point – the estimation of expanding lines perfectly equalized the estimates of contracting ones. We expected at least a priority or recency effect to emerge, in the sense that estimates had to be influenced by the length present at the beginning or the end of process (zero- or max-value), but such a foreseeable effect did not emerge.

In a preparatory work[69] we put forward a certain number of explanatory hypotheses for the phenomenon, in order to account for the overall quantitative results. For instance, we advanced a *computational* hypothesis (grounded on supposed length surveys performed on each perceptual moment); on the *gamma movement* (the apparent expansion of objects due to their abrupt illumination, and their apparent contraction when the light is switched off); on *Aktualgenese* (the shrunk and simplified perception of objects due to very brief exposure times); on the *dynamic* view (Hubbard and Bharucha[70] found that trajectories of moving points appear longer according to the speed of movements, replicating what Benussi had observed[71])[72]. Since none of these hypotheses fitted, we resorted to a *categorial* one: perceived events could be labelled and then stored, after which comparison was conducted among their labels.

Unfortunately, nor did this hypothesis work well, since it linked back to the process of labelling: on what perceptual ground are labels stuck on to events? For this reason, in a subsequent work[73] we recognized that the perceived length of the evolutionary line may be the result of a Gestalt-like process involving all the lengths actually seen during the lengthening or shortening of the line. This hypothesis would explain why expansion and contraction yield the same perceptual values for the whole line, neglecting the fact that zero values and max ones are in opening or closing position. I obtained a similar result[74] in an extended series of observations on moving pictures projected in reverse: some gestures typical of non-verbal communication preserve their meaning in the normal and reversed version. We may therefore maintain that as in the perception of gestures, so in the perception of the evolution of a line some dimensions of the event (the length, for instance) are invariant with respect to the direction of evolution (lengthening, shortening), thereby reinforcing the conceptualization of events in terms of Gestalten.

This tentative explanation for the behaviour of the evolving line is not fault-free – it is on this that our attention is now directed – but it is attractive insofar as it is useful for the study of perception of both events and objects. In my opinion, results show that Gestalt principles of organization are involved both in the building of events by which we can directly observe the rearrangement of elements (as in temporal displacement or in complex stroboscopic movements) and in the forming of events lacking discernible internal parts. The same holds for the perception of visual objects: it is easy to single out the principles of organization in an optical-geometrical illusion, where the influences exerted by some parts on some other parts can be seen directly, but it is hard to be convinced that these principles continue to apply in the vision of a simple line or of a monochromatic surface.

9. SUMMARY AND CONCLUSION

I hope to have made the reader at least aware that it is perhaps better to think of events in terms of forms (*Gestalten*) than in terms of rather unlikely mechanisms. When stroboscopic movement and temporal displacement are modelled on physical or physiological machinery, they lead directly to hypotheses which are frankly untenable, such as 'perceptual replay' or 'perceptual moment'. Temporal segregation seems difficult to explain in terms of both forms and mechanisms, but at least with the Gestalt interpretation we can resort to a well-known analogue effect in the perception of objects – namely, perception of transparency. As to the length estimation of evolving lines, it must be said that no current explanation of neighbouring phenomena can account for the overall results; on the contrary, a suggestion is forthcoming from Gestalt theorizing. I am well aware that the concept of Gestalt is rather indigestible, but no other formal tool seems to work when we have no clear distinction between causes and effects in the building of perceptual phenomena.[75]

I am likewise aware that the temptation to cite physiological processes in explanation of the *Erscheinungsweise* of experience is very strong – surprisingly so even in Gestalt theory[76] – but it is important to remember that psychology deals with mental facts, not with processes in the brain. As Kanizsa observes,[77] mental facts and processes in the brain pertain to different levels of reality, so that they demand and legitimate kinds of analysis adequate to their peculiarities. Indeed, as Davidson points out,[78] even if we are able to couple any other mental state with the corresponding physiological process, we do not gain any scientific knowledge of the matter, since the knowledge that we require concerns the *laws* of transformation of facts on one level into facts on the other, not a mere correlation between them.

The recognition of events such as Gestalten does not bring us any closer to understanding of the formation of events in the flow of conscience. Whereas in the perception of visual objects it is not hard to conceive the field in which the actions of the 'forces' pertaining to the elements of a Gestalt take place, in the perception of visual (auditory) events it is impossible to gain an idea of what sort of field represents the mutual interaction of the elements of a succession, given that they are scattered along an one-dimensional and one-way layer – namely, subjective time. The refusal to resort to the physical sequence of physiological states in the brain, in order to explain the experience of succession, leaves us disarmed, since we have nothing to put in its place. A theory on this matter is still to be developed, even if we can take advantage of the ingenious speculations on the matter by Brentano[79] and by Husserl.[80] Their most valuable insights have yet to be subjected to experimental proof, and this is possibly the way forward for a psychology of time that is not a re-hash of physicalist and physiologistic prejudices.

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NOTES

[1] Vicario, 1986
[2] On this method, see Thinès 1991 or Vicario 1993.
[3] Koffka 1962, 75–105.
[4] Köhler 1929, 192.
[5] Wertheimer 1925, 7.
[6] Koffka 1962, 22.
[7] Metzger 1941, ch. III.
[8] Lewin 1936, part I, ch. V.
[9] See Nicolis, Prigogine 1987, ch. 1,4.
[10] See Uttal 1990.
[11] Wertheimer 1923; see also Metzger 1966 for their best enunciation.
[12] Metzger 1941, 1975.
[13] Johansson 1978, 676–7.
[14] Gibson 1979, ch. VI.
[15] Cutting 1981.
[16] Lotze 1879, 294.
[17] Aristotle 1983.
[18] Smith, Casati 1994.
[19] The commonsense view: Ingarden 1935.
[20] Kotarbinski 1955; Quine 1960, § 36.
[21] For example, Carlson, 1981.
[22] See also Bach 1986.
[23] See, e.g., Fraisse 1967; 1984; Michon, Jackson 1985; Block 1990.
[24] Vicario 1973b, but also Gibson 1975.
[25] See Fraser 1987.
[26] Brentano in Kraus 1930 and Husserl in Boehm 1966, but also Stern 1897; Meinong 1899; Benussi 1913.
[27] See Thinès 1977.
[28] On this point see also Schaltenbrand 1975, sect. 4.
[29] Lewin 1936, part I, ch. V.
[30] On this point see Beck, Elsner, Silverstein 1977.
[31] Michotte 1950.
[32] Burke 1952.
[33] Yela 1954.
[34] Minguzzi 1961.
[35] Levelt, 1962; Minguzzi 1968.
[36] Vicario 1964.
[37] Wundt 1893.
[38] On this point see Sanford 1888.
[39] See Vicario 1963.

[40] Benussi 1913.
[41] Rubin 1949.
[42] Vicario 1963.
[43] Wundt 1893.
[44] Fraisse 1967.
[45] See, e.g., Ladefoged, Broadbent 1960.
[46] Vicario 1963.
[47] Stroud 1955.
[48] Vicario 1964b.
[49] Patterson 1990.
[50] See Vicario 1964a.
[51] See Burke 1962.
[52] See Kanizsa, Vicario 1968.
[53] See Yela 1954.
[54] See Vicario 1960.
[55] See Minguzzi 1961.
[56] See Minguzzi 1968.
[57] For a more detailed description of conditions see Vicario 1965.
[58] Von Schiller 1933.
[59] For example in Braddick's 1974 sense.
[60] On this point see Koffka 1962, 288–98; also Vicario 1969; 1973.
[61] On this point see Vicario 1986.
[62] See Metelli 1974.
[63] Vicario 1965.
[64] Bozzi, Vicario 1960.
[65] Bregman and Campbell 1971.
[66] Vicario 1964a.
[67] Tomat, Vicario 1992.
[68] Vicario, Vidotto, Tomat 1994a; 1994b.
[69] Vicario, Vidotto, Tomat 1994a.
[70] Hubbard and Bharucha 1988.
[71] Benussi 1907.
[72] See Vicario 1969 for the subsequent literature.
[73] Vicario, Vidotto, Tomat 1994b.
[74] Vicario 1984.
[75] On this point see also Vicario 1993.
[76] Isomorphism hypothesis: see Koffka 1962, 56.
[77] Kanizsa 1984.
[78] Davidson 1980.
[79] Kraus 1930.
[80] Boehm 1966.

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MICHAEL STADLER, SABINE PFAFF AND PETER KRUSE

TOWARDS A THEORY OF FIGURAL FORM

Since the days of early Gestalt psychology it has been well known that figures are by no means constituted by contours alone. The problem is that contours, if they are to delimit figural forms or objects, can have this function only on their one side. On the other side there is, as Edgar Rubin has shown, no limitation, because the ground on which the figure lies stretches uninterruptedly behind the figure. This so called "one-sided limit function of contours"[1] is the reason why the ground usually has no figural form but is instead unlimited. Figure 1 provides a good example of the one-sided limit function, which changes the side of the contour more than once following the course of the ingeniously drawn line. Beginning from the left side, the line first delimits the door, then the man and finally the dog, changing its limiting direction at the beginning and the end of the dog's ear. The question arises as to how the cognitive system decides on which side of a contour the figure stands and on which side the ground.

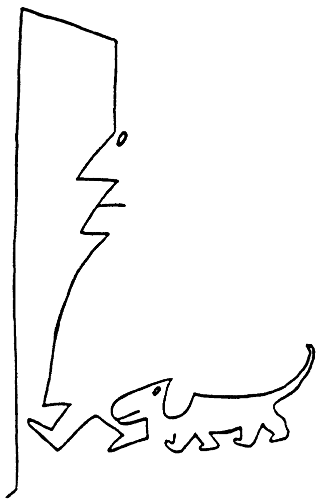

Figure 1. One-sided limit function of a line (after a cartoon by Saul Steinberg)

L. Albertazzi (ed.), *Shapes of Forms,* 107–122.

Let us look at the following phenomenological experiment. Figure 2 shows the well-known vase/face-display invented by Edgar Rubin,[2] where we see either a white vase or two black faces. It seems impossible to see the faces and the vase simultaneously, which is further evidence of the one-sided limit function of contours. If there are contours simultaneously delimiting different objects to the one and to the other side, there should theoretically be no space for a ground lying between the two adjacent figures. But our cognitive system does not accept figures without a ground behind them. Consequently, in the case of an ambiguous situation such as in Figure 2, the figure-delimiting side of the contour is periodically changed, so that we can only see either the face or the vase. The question is this: why do we not always experience changes of the attribution of figural qualities on both sides of contours in our natural surroundings? This general ambiguity of all contour patterns would be probable if both sides of the contours obeyed the same Gestalt laws. This phenomenon has been by used by the Dutch painter Escher to produce amazing patterns.

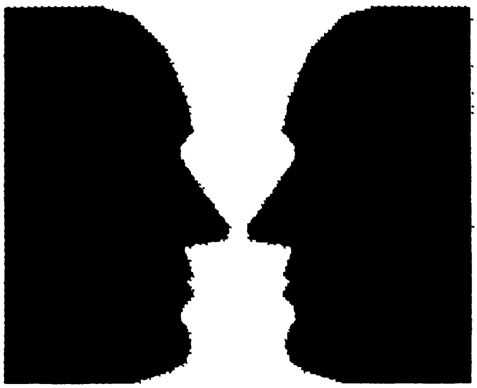

Figure 2. The face/vase pattern[3]

The experiment of Figure 2 is continued in Figure 3, where the two faces are slightly displaced in the vertical dimension. It suddenly becomes impossible to exchange figure and ground. The two faces are delimited as strong figures and the ground in between has no figural qualities. Symmetry seems to be a major Gestalt factor responsible for the constitution of figures. Other factors are the well-known Wertheimer Gestalt laws of closure, common motion, and continuity.[4]

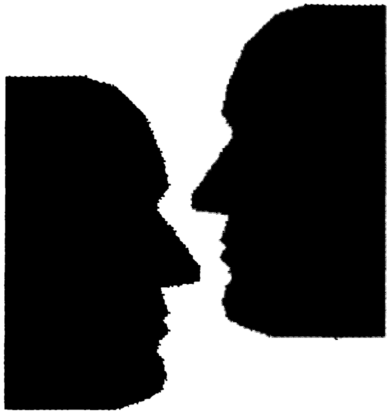

Figure 3. A slight variation of Figure 2: the vase has vanished

If we look at a line such as the one in Figure 4,[5] which is matched with respect to the Gestalt factors, there is still an immediate decision to be taken as to the side on which the figure is situated. Evidently, the possibility of delimiting a meaningful object gives rise to this decision. The meaning seems to be a quality of the line as a whole and the area delimited by it.

The line in Figure 4 seems to intersect two areas with different phenomenological qualities. The white area to the left appears to be the body of a woman and the white area to the right is the unlimited ground, provided that someone is not so restrained as to prefer to see an ugly man's face on the right. There have been many phenomenological descriptions of the differences between figure and ground – for instance, differences in density, color and brightness. Figure 5, the famous Kanizsa triangle, clearly illustrates the brightness differences between the central 'virtual' triangle and the surrounding ground. These brightness differences of the homogeneous stimulus area are so strong that virtual contours are created in vision, delimiting the two areas.

Besides the differences between figure and ground in phenomenological appearance, there are experimental proofs for functional differences between them. In an early experiment, for instance, we found that in the 'figure' areas of an ambiguous three-bladed propeller there are smaller thresholds of figure detection than on the equivalent areas seen as the ground (Figure 6).[7] Another study has shown that much stronger figural after-effects are caused in the Kanizsa triangle by the virtual contours than by corresponding stimulus contours.[8]

Figure 4. Meaning as a determinant of a contour's limit function

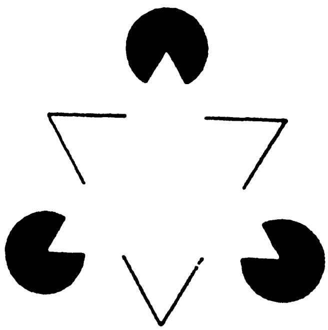

Figure 5. Subjective contours in the Kanizsa triangle[6]

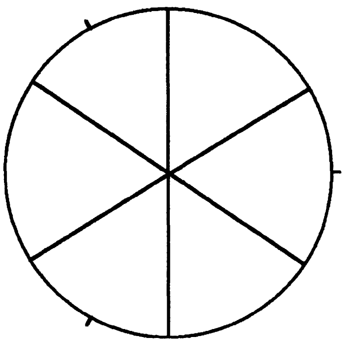

Figure 6. Ambiguous three-bladed propeller

In fact, the figural after-effects paradigm has been used since Wolfgang Köhler's classic investigations[9] to demonstrate the field characteristics of figural forms at a distance from the contours. A simple example is the following (Figure 7). An inspection circle on the left is observed for about thirty seconds with the eyes fixed on the fixation point. After the thirty seconds have elapsed, two smaller circles equidistant to the left and to the right of the fixation point are displayed, one of them falling exactly within the figural field of the previously seen inspection circle. All subjects report – and this is confirmed by psychophysical measurement – that the left test circle, which was affected by the figural field of the inspection circle, is reduced in size compared with the test circle on the right.

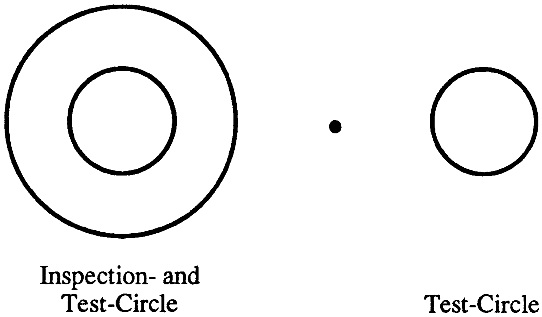

Figure 7. Figural after-effects of a circle on a smaller circle lying within its field

Another example is provided by figure 8. When the triangle is observed for about thirty seconds, the parallel lines displayed afterwards to converge at the bottom. It has been argued that figural after-effects are caused by the same process underlying most geometric optical illusions which show simultaneous interaction of contours at a distance.[10] In optical illusions and in figural after-effects, repelling effects of varying strengths between the contours are always observed.

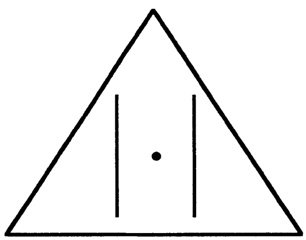

Figure 8. The figural after-effects of a triangle on parallel lines

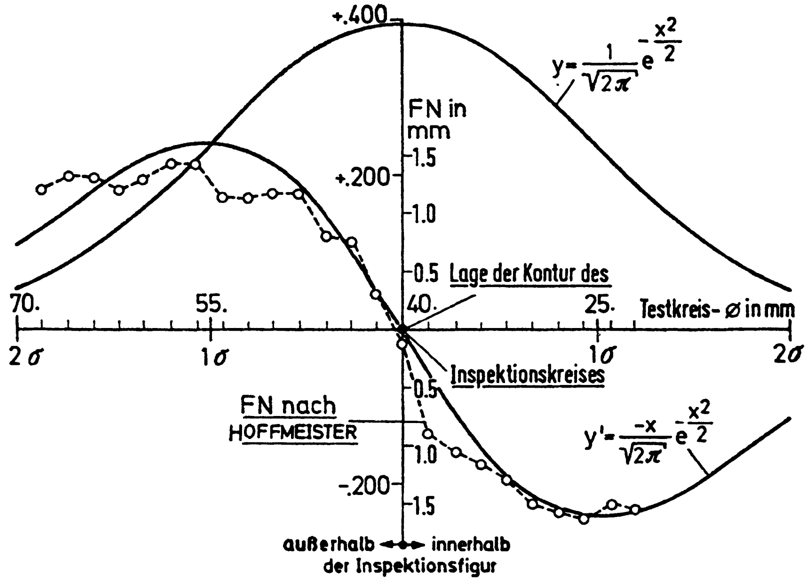

Figure 9. Field strength and figural displacement[14]

The Gestalt psychologist Wolfgang Köhler considered the phenomenon of figural after-effects to be evidence in favour of his field theory of perception.

Regardless of whether Köhler's idea of the brain tissue as a homogeneous conductor, in which electrotonic forces are built up at the cell membranes, has proved to be a physiological fact relevant to perception, there are some general features of the field theoretical approach that may be worth considering in future research.[11] Köhler claimed that there are field forces caused by every contour in the visual field, and that these forces are responsible for the displacement of other contours.[12] Field strength follows a gradient, being flat near the contour, growing stronger at a certain distance and weaker again at a greater one. The existence of this gradient has been proved by numerous experiments.[13] If we assume a normally distributed field force pattern, the amount of figural displacement follows the first differential derivation of the density function of the normal distribution, which is a good match with the empirical values.

Given the enormous complexity of the central nervous system and the fact that every pattern of perception involves at least millions of nervous elements, it makes no fundamental difference whether we explain the given contour gradient by a neural network approach or by a continuous field model.[15]

In what follows we shall propose an experimental paradigm by which the field forces and the corresponding gradients may be measured directly on the level of perception in order to calculate potential landscapes of various figural forms.

When looking at a blank sheet of paper, it is usual to see a homogeneous, unstructured area. In 1951, Bartlett devised an experiment which demonstrates that a sheet of paper apparently has a hidden structure. His experiment illustrated the so-called 'wandering point phenomenon'.[16] A single point is drawn on a blank sheet of paper and exposed to a subject for a very short time. The subject is then asked to reproduce the position of the point. The reproduced point will show a typical deviation from the position of the stimulus point. Applying the method of serial reproduction – that is, using the reproduction of one subject as stimulus for another – the point displays a characteristic 'wandering' towards one of the corners, and this result can be obtained irrespectively of the starting position (see Figure 10). This phenomenon proves that a blank sheet of paper is not homogeneous, but instead represents a potential landscape of stable and instable areas, of attractors and repellers.

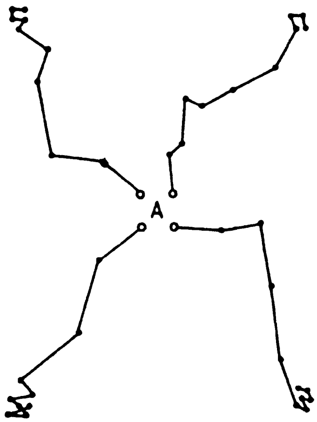

Figure 10. The phenomenon of the wandering point

We developed an experimental procedure to reveal the hidden structure of a homogeneous area,[17] starting with the sheet of paper (DIN A 4) as used in the wandering point investigations.

Experiment 1

A subject was confronted with 609 sheets of paper, each containing one single point (diameter 2 mm). The task was to reproduce the position of each stimulus point after it had been exposed for a short time (<1 s), on another piece of paper. Of course it is very difficult, if not impossible, to do this exactly, especially if the stimulus point is not positioned near the edge of the sheet or its corners. According to the wandering point phenomenon, we expected to find specific deviations depending on the position of the stimulus point.

The 609 points used were distributed regularly over the whole sheet (one point in every square centimeter, see Figure 11a), but they were given to the subject in a random order. In mathematical terms, the deviation between the position of a stimulus point and its reproduction is a vector. Therefore, all 609 stimuli and their reproductions form a vector field (Figure 11b).

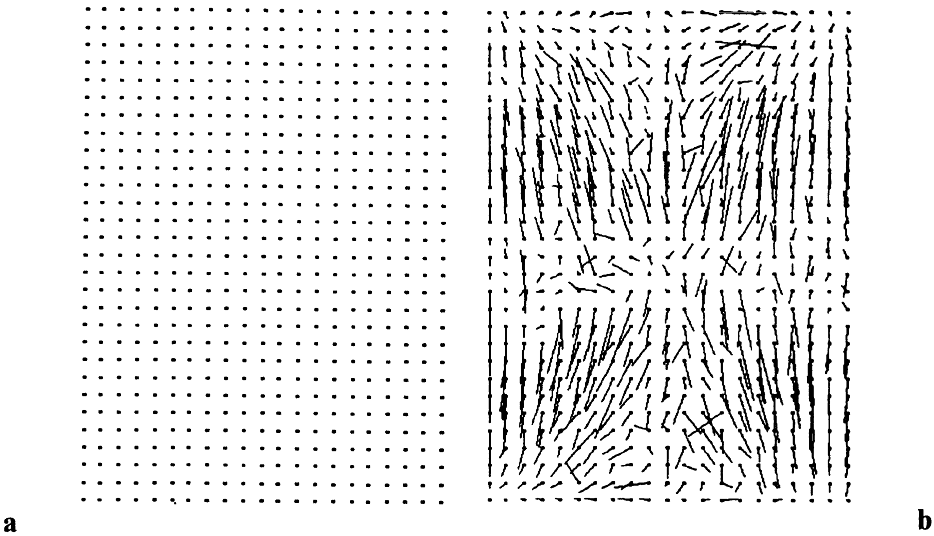

Figure 11 (a) The distribution of the 609 points presented to the subjects successively and in random order. (b). Vector field of one subject, showing all stimuli and the corresponding reproduction as vectors

Using vector analytic methods, every vector field A(r) can be decomposed into two components, the gradient field G = –grad V(r) and the circulation field C = curl W(r). The function V(r) is called the gradient potential, and W(r) the circulation potential. These two potentials provide a natural way to characterize a given field.[18] The decomposition is based on an iteration procedure which has been described in detail elsewhere.[19] The gradient potential may be depicted three-dimensionally, thus portraying a 'landscape' of the stimulus area (see Figure 12). The wandering point can be explained as follows. The rectangular sheet consists of four deep valleys in the four corners. Steep slopes in the middle of the sheet form the sides of a mountain whose peak is located not quite exactly in the geometrical centre of the sheet.

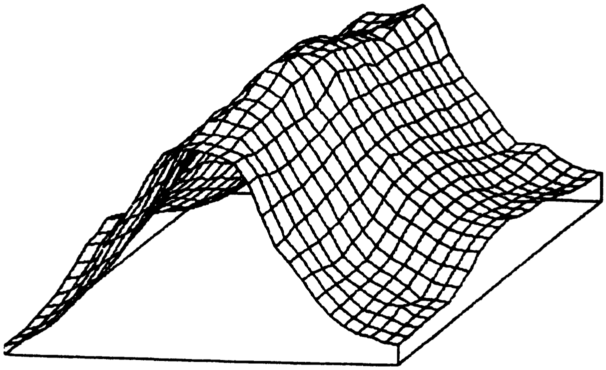

Figure 12. The gradient potential calculated from the empirical data of one subject (rectangular area)

Experiment 2

Since the four corners were considered to act as strong attractors, it was decided to apply the same method to a circular stimulus area. We used a circle with a diameter of 20 cm and 163 stimulus points, expecting to find a circular attractor caused by the influence of the paper's edge, and a 'mountain peak' near the centre, as had occurred in the case of the rectangular sheet. By hypothesis, the potential landscape of a circular frame would look like a Mexican hat. Figure 13 shows some experimental data, the gradient field and the gradient potential of one subject. The Mexican hat is not as distinct as we expected it to be, but on the whole the potential has the predicted form.

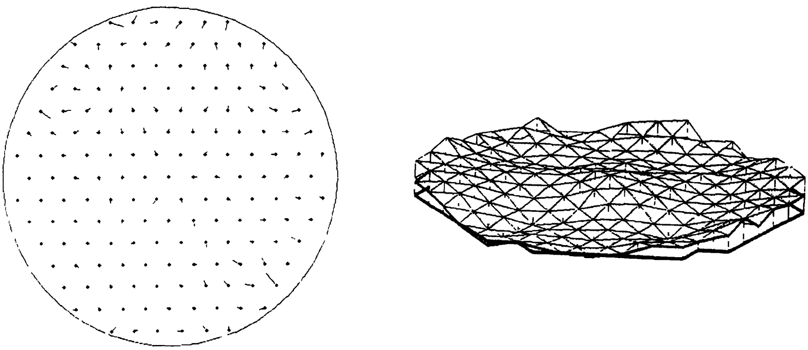

Figure 13. The gradient field and gradient potential of one subject (circular area)

Interestingly, the four attractors found on the DIN A4 sheet occurred on the circle as well, even though it had no corners. This phenomenon could be regarded as indicative of the 'rectangularity' of the human visual field, as was predicted by the so-called 'carpentered world hypothesis'.[20]

Like magnetic fields, experimental vector fields are completely changed when the boundary conditions are altered, for example when a different shape of sheet is used or when the homogeneous area is disturbed by inserting some kind of figure into it (see Experiment 3).

Experiment 3

We used two different trapezoids – one resembling a triangle, the other more quadrilateral in shape – which were drawn only on the rectangular stimulus sheets; the reproduction sheets were blank. The experimental procedure was the same as in Experiment 1. The influence of the figures on the potential landscape was expected to give rise to either a concave or a convex impression of the shape of the figure, given that we could not decide whether a line would prove to be an attractor or a repeller for the stimulus points.

The results show that the whole landscape is turned upside down, reversing the hills and valleys. The contours of the figures used are 'carved' into the landscape (see Figures 14 and 15). The experimental vector fields show that the lines of the figure strongly attract the stimulus points. All the vectors, even those in the more distant corners, point to the center of the sheet. The corners of the figures seem to be impressed even deeper into the landscape. This result corroborates the finding that corners convey a greater amount of information than do straight lines.[21]

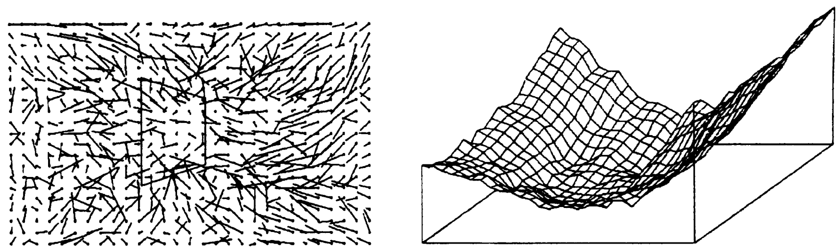

Figure 14. The empirical vector field and the corresponding gradient potential of one subject (rectangular area, "quadrilateral" trapezoid)

Since the influence of a figure is strong enough to alter the whole of the potential landscape, as the next step we decided to test the effect of virtual contours (see Figure 5), which we also expected to give rise to an imprinting in the potential, but possibly less deeply.

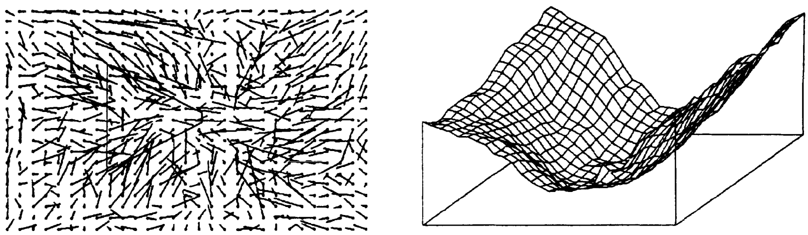

Figure 15. The empirical vector field and the corresponding gradient potential of one subject (rectangular area, "triangular" trapezoid)

Experiment 4

To confirm this hypothesis, the Kanizsa triangle was slightly altered by reducing it to the cut-out circles. The effect of the virtual contours was thus somewhat weakened, but it would not vanish provided the distance between the circles was not too great.

In order to allow direct comparison between virtual and real contours, respectively between virtual and no contours, three experimental conditions were investigated: The cut-out circles were used as stimulus material for virtual contours. For the real contours condition, the same circles were used, but the connecting triangle lines were actually drawn on the sheets. The control condition with no contours was established by cutting out more parts of the Kanizsa circles, which thus resembled radioactivity signs.[22] Figure 16 shows the stimulus material for the three experimental conditions.

The potential landscapes of all three conditions show three deep valleys where the (altered) Kanizsa circles were positioned. At first sight these look very similar, nearly identical. This comes no surprise, since the stimulus material exhibits only small alterations as well. On closer inspection one notes

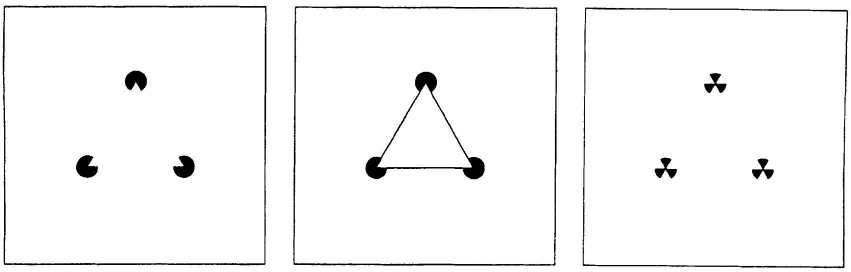

Figure 16. The stimuli for three experimental conditions: virtual contours, real contours, no contours (square sheet)

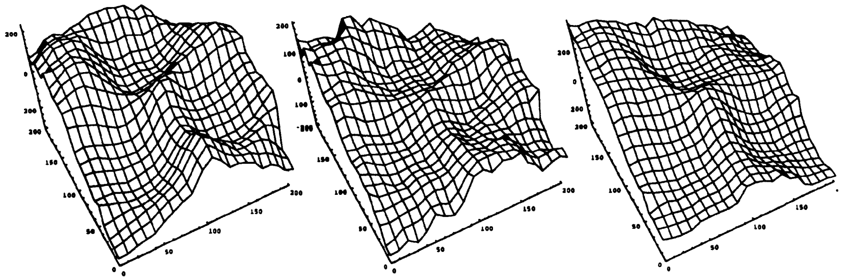

Figure 17. The average gradient potentials (5 subjects each) of the three conditions (virtual, real, no contours)

that in the no-contours condition the landscape shows only three valleys, whereas in the two other conditions the connecting lines are slightly imprinted into the saddles between the valleys (see Figure 17).

This effect even seems to have been stronger in the virtual contours condition. In these experiments the extremely deep imprinting of the triangle corners was certainly caused by the large circles used and not by the information load mentioned above, although the amount of information is even greater when a cut-out circle is used as a corner rather than only two lines meeting. The different degrees of imprinting in the landscape to be found when comparing the Kanizsa circles with the radioactivity signs could be explained by the 'weight' of the two figures. The obviously 'light' fragile radioactivity signs seem to have less weight than the 'heavy' black Kanizsa circles.

As we have shown, the potential landscapes can easily be influenced and altered by different visual stimuli. What is even more interesting, the field seems to represent the 'Gestalt qualities' of the chosen figures. In the next stage of investigation, some types of psychological influence were investigated.

Experiment 5

We investigated one possibility of psychological influence by replacing the stimulus points. These are usually arrows, which suggest a certain direction. In order to avoid too much reactant behaviour, the arrows were elongated isosceles triangles. Two different conditions were tested: In the first, all the arrows pointed to their nearest corner of a rectangular sheet; in the second, they pointed to the geometrical centre. The potential landscapes resulting from these two investigations are remarkable (see Figure 18). The semantic content of the arrows is reflected by the resulting landscape: it is turned completely upside down in the second condition.

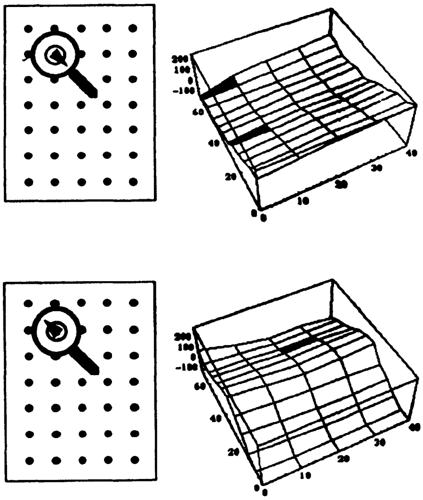

Figure 18. Stimuli and resulting gradient potential of the two conditions (semantic influence towards the corners, respectively the centre of a rectangular sheet)

The results of this investigation prompted another experiment, in which we sought to ascertain whether the potentials are changed by the influence of learning as well, which would prove that it is possible to obtain a persistent effect.

EXPERIMENT 6

In the first step the subjects were trained to find the geometrical centre of a rectangular sheet, which was located somewhat above the psychological centre.[23] Thereafter the standard procedure (see Experiment 1) was followed.

Depending on the subjects, it took more or fewer trials to 'learn' the centre position within a satisfactory range of allowance. Figure 19 shows the resulting landscape: The mountain top in the centre of the sheet is evidently flattened and even imprinted.

A large part of the landscape is affected by this change, as was the case in the other experiments performed. It is impossible to change only a part of the potential; in every case, the whole landscape is influenced by even the smallest changes. Exactly this determination of every local point by the whole, and vice versa, is a typical feature of physical fields.

The results described above bear out the old Gestalt hypothesis of field forces working in visual perception and consequently in the brain. In the light of the experiments described in this chapter, it seems probable that figural

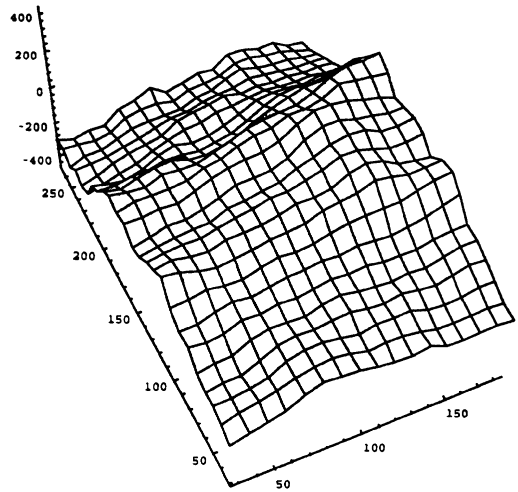

Figure 19. The gradient potential of one subject after being trained on the centre of a rectangular area

forms are constituted by the potential fields extending between their contours. The potential fields inside and outside the contours may exert an influence on the contours themselves. The attribution of meaning to the contours may give rise to the decision regarding the side of the contour on which the figure stretches, and on which side the ground lies. The potentials of the fields usually have a higher amplitude inside the figure than outside the figure on the ground. This may be a functional proof for the gestaltists' theoretical assumption that figures are held together by stronger field forces than the ground, which means that figures raise greater resistance against intrusion by other figures. Exactly this was proved by numerous experiments performed by the gestaltists,[24] although space precludes discussion of them here.

ACKNOWLEDGEMENTS

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NOTES

[1] Metzger 1975.
[2] Rubin 1921.
[3] After Rubin 1921.
[4] Cf. Metzger 1975.
[5] The first Author forgot which Italian colleague invented this nice example, sorry.
[6] Kanizsa 1955.
[7] Stadler 1969.
[8] Stadler, Dieker 1969; 1972; Stadler 1972.
[9] Köhler 1940; Köhler, Wallach 1944.
[10] Stadler 1972.
[11] Kruse, Roth, Stadler 1987.
[12] Köhler 1940.
[13] Sagara, Oyama 1957; Crabus, Stadler 1971, see Figure 9.
[14] Crabus, Stadler 1971.
[15] Cf. Uttal 1988.
[16] Bartlett 1951.
[17] See Stadler, Richter, Pfaff, Kruse 1991.
[18] For further details see Großmann 1988.
[19] Stadler, Richter, Pfaff, Kruse 1991.
[20] Segall et al. 1966.
[21] See Attneave 1954.
[22] Kanizsa 1955; Metzger 1966.
[23] Klix 1962.
[24] Koffka 1935, ch. 5.

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RICCARDO LUCCIO

ON PRÄGNANZ

> Ich schicke mich nicht gerade an, eine heilige Kuh der Gestalttheorie, nämlich den Begriff der 'Prägnanz' bzw. der 'Guten Gestalt', zu schlachten [...] aber ich möchte mir doch gestatten, ihr etwas näher in Auge zu blicken.
>
> F. Hoeth 1981

1. PRÄGNANZ AND ITS AMBIGUITIES

In 1984 the late Professor Gaetano Kanizsa and I presented a paper on the ambiguities of the concept of Prägnanz at a conference on Wolfgang Metzger held at the University of Macerata. Two years later the paper was published in German with minor changes in *Gestalt Theory* under the title 'Die Doppeldeutigkeiten der Prägnanz'. Unfortunately, neither Italian nor German are languages widely read today in the psychological world, so the article aroused discussion only among psychologists able to read Italian or German.[1] Subsequently, Kanizsa and myself developed the line of argument put forward in the paper.[2] Today, ten years later, it may be worth reflecting again on the concept of Prägnanz.

Prägnanz is certainly a cardinal concept in Gestalt theory, but, as Kanizsa and I noted at the time, it has given rise to a number of misunderstandings and provoked a good deal of radical criticism. The Gestaltists have often been criticised for turning Prägnanz into a key to open all doors, without ever having given it a strict definition. The concept was introduced by Wertheimer[3] in his essays on thought processes in primitive peoples, in which he discusses privileged, *ausgezeichnet* or 'prägnant' zones in connection with numerical series, which in the numerical systems used by the peoples studied correspond to numbers such as 10, 12, 20, and so on. Similarly there are prägnant parts for some numbers (for example, the numbers 25 or 50 could be prägnant parts of the number 100). However, Wertheimer spoke of a 'law of Prägnanz' only two years later in 1914, during the VI Congress of Experimental Psychology held by the German Psychologists in Göttingen, where he affirmed that amongst many *Gestaltgesetzen* of a general type, there is a "Tendenz zum Zustandekommen einfacher Gestaltung (Gesetz zur 'Prägnanz der Gestalt')".[4]

Wertheimer gave better development to the topic in his essay of 1923; an essay which on the one hand was the very first systematization of *Gestalttheorie* but on the other reveals the origins of some the ambiguities in the concept of Prägnanz which would accompany Gestalt psychology over the years. In fact,

L. Albertazzi (ed.), Shapes of Forms, 123–148.

here the term Prägnanz is given two different meanings. The first is that of *Ausgezeichnetheit* (or singularity: see below), which is a quality possessed by certain specific objects, forms or events belonging to our immediate perceptual experience; a quality or property that certain perceptual configurations possess while others do not: this property makes the configuration *ausgezeichnet*, that is, 'unique', 'singular', 'privileged'. Wertheimer illustrates this with the celebrated example of the triangle. If there are three points, and one of them moves along a line parallel to the virtual one joining the other two, the three points form a series of continuously changing triangles; this series is objectively continuous, but phenomenally the transformation does not takes place smoothly. At times one sees unexpected restructurings and sudden 'jumps', and this happens in five different positions, when the triangle becomes right-angled (twice) and isosceles (three times). Wertheimer speaks here of 'points' or 'zones of Prägnanz' (*Prägnanzstufen*).

All shapes that are phenomenally singular or 'privileged' are 'good Gestalten'. This is the case of the equilateral triangle, of the circle, of the square, of the sinusoid, and so on. In this sense, 'prägnant' indicates phenomenal structures which are 'regular'; they are endowed with internal coherence; all their parts go well together, and can be said to 'belong' to each other by mutual necessity.

It should be emphasised that 'prägnant' does not only refer to primary or secondary qualities. The *ausgezeichnet* configurations also possess, and to an optimal degree, tertiary or physiognomic qualities (like happiness, or sadness, calmness or tension, monotony or solemnity, and so on), which are just as directly perceived in a configuration or an event as their colour or size. The same applies to static visual configurations and to moving structures, and even more so to acoustic and musical ones. And it also holds when we are unable to give precise specification to the structure of the stimulus that lies at the basis of these impressions. The impression that a melody has ended is only given when there are certain intervals between the last two notes. According to the so-called Lipps-Meyer law, this impression arises only when the ratio between the frequencies of the two last notes is that between an odd and an even number, the last note being even. For example, a minor second (C and C sharp) has a 15/16 ratio, and the sensation of conclusion only arises if the tones are played in this order; otherwise the sensation is of incompleteness, of suspense, of final tension.

But, as said, one notes a second sense of Prägnanz in Wertheimer: that of the *lawfulness* of the process leading to the formation of visual objects. In Wertheimer's view, the main error of associative psychology was to conceive the perceptual process as accidental or arbitrary, as summative and blindly associative in nature. Conversely, and according to this second meaning, Wertheimer uses the term Prägnanz to indicate the fact that the perceptual process is instead 'meaningful' (*sinnvoll*). The principles of organization act as precise laws which the process is forced to obey to achieve maximum economy and simplicity. The result is a perfect balance among the forces at play, and therefore also the maximum of stability and of resistance to change.

Wertheimer speaks of Prägnanz as a general principle with which 'unification principles' (the principles of *Zusammenfassung* or *Gruppierung*) conform. Prägnanz itself, however, is not a principle; all the factors described by Wertheimer therefore act in such a way as to give rise to a 'tendency to good Gestalt'. Hence the law of similarity is only a special case of the principle of good Gestalt,[5] and the factor of continuity of direction acts so that the unification (or grouping) gives rise to a good continuation, is '*kurvengerecht*', takes place according to the *innere Zusammengehören*, and culminates in a Gestalt which obeys its own 'inner necessity' (*innere Notwendigkeit*) and is, for this reason, a good Gestalt.[6]

According to Wertheimer, the process is such that any 'almost good' Gestalt should be perceived as a prägnant one. For example, he writes: "[...] that things are so is clearly demonstrated in experiments where the consistency of a tendency to a prägnant configuration is remarkable. If an angle is tachistoscopically presented, even if its margin of difference from the right angle is noticeable the viewer often simply sees a right angle, assimilating the shown angle to the pregnant one [...]".[7]

After Wertheimer the concept was always used descriptively in the Gestaltist literature to indicate the 'singularity' of a phenomenal outcome, or in explanatory manner to indicate that the perceptual process conformed to rules and tended towards a final state of stable equilibrium. The two concepts are by no means equivalent, however, in that a phenomenal result can be completely stable but it need not necessarily be also *ausgezeichnet* in the sense of phenomenally 'singular'.

Very few attempts were made to distinguish between the two meanings, although Hüppe,[8] for example, called phenomenal goodness *Primarprägnanz*, and conformity of the process to rules and stability of the result *Sekundarprägnanz*. Prägnanz in the former sense – that is, 'singularity' or figural 'goodness' – is thus a given phenomenal *fact* corresponding to a reliable description of visual experience. This notion was destined to play a leading role in later Gestalt theorizing.

After Wertheimer, it was Rausch who made the most important and interesting contribution to the development of the concept of Prägnanz in its first sense.[9] Rausch lists seven *Prägnanzaspekte* (bipolar dimensions, where the positive pole carries a maximum of Prägnanz) according to which the Prägnanz of a configuration can be defined and evaluated. These *Prägnanzaspekte* are:

1. *Gesetzmässigkeit – Zufälligkeit*: regularity, which mean 'conformity to rules' as opposed to randomness, arbitrariness.
2. *Eigenständigkeit – Abgeleitetheit*: autonomy, independence, as opposed to derivation, dependency. For example, the rectangle (original figure or

figure of reference) is maximally prägnant compared with all other parallelograms with the same base and height and which are experienced as 'derived' from the rectangle.

3. *Integrität – Privativität*: integrity, completeness, as opposed to lack, incompleteness. Whereas in the case of derivation there is a transformation or global distancing from the original figure, here the deviation consists in a local disturbance, which may be the lack of a part, a deformation, or even an addition incoherent with the whole.

4. *Einfacheit – Kompliziertheit*: structural simplicity as opposed to structural complexity.

5. *Komplexität – Tenuität*: complexity, structural richness, as opposed to structural poverty. Unlike the previous dimension, where simplicity represents the positive pole of Prägnanz, the accent here is on harmonious articulation, fullness of organization (for example, a symphony as opposed to a folk song).

6. *Ausdruksfülle – Ausdruksarmut*: richness of expression as opposed to poverty of expression.

7. *Bedeutungsfülle – Bedeutungsleere*: fullness of meaning as opposed to absence of meaning.

Rausch also distinguishes three zones around each point of Prägnanz:[10] the zone of *formation* (*Verwirklichungsbereich*), which is the exact point occupied by figures similar to the category of the prägnant one, but which are experienced as badly made, 'bad'; and the *derivation* zone (*Ableitungsbereich*), to which belong figures which are categorically different from the prägnant ones but stand in a relationship of derivation to them.

A further important contribution to development of the concept of Prägnanz was mad by E. Goldmeier,[11] for whom the most salient characteristics of Prägnanz – which he significantly translates as 'singularity' ("The word 'singularity is my translation of the German word Prägnanz [. . .] the two words are intended as synonyms"[12]) – is the 'uniqueness' possessed by some configurations by virtue of their possession of a quality that the all others in a given series lack. They are configurations which correspond to Wertheimer's *Prägnanzstufe*. Apart from being 'unique', the singular patterns are *self-consistent*; that is to say, they have internal coherence, since each part is 'required' or needed by the others. Furthermore, they are *normative*, in that they serve as the norm or point of reference for the other patterns (and particularly for those which fall within the *near singularity* zone and which are experienced as 'almost' or 'nearly' or 'approximately' the singular pattern).

Goldmeier stresses that singularity highlights a peculiar characteristic of our perceptual system, namely its marked *sensitivity to change*. In the near singularity zone (which corresponds to Rausch's 'approximation' zone) the slightest fluctuation of a single value is noticed, whilst the threshold of discrimination rises considerably for those values that fall outside this area, where we are unable to notice even great differences between two adjacent elements in a series. Accordingly, it is very easy to distinguish between an angle of 90° and one of 88°, but it is almost impossible to distinguish between an angle of 54° and one of 56°. Note, however, that this finding fully contradicts the claimed 'tendency to Prägnanz', set out the above quotation from Wertheimer. And it is also in contradiction with all the other Gestalt theorists that claim that a tendency to Prägnanz exists, when Prägnanz is used in the sense of singularity. For instance, Köhler writes:

> [. . .] in physics such distributions are distinguished by simplicity and regularity. Hence if optical structures follow the same principle, we should expect that they also would move in the direction of simplicity and regularity. And this tendency towards the Prägnanz der Gestaltung was discovered in perceptual structures by Wertheimer. In optics, the circle, a form unique in its properties, frequently tends to be seen even when the stimulus configuration deviates considerably from such extreme symmetry [. . .][13]

And Metzger:

> [. . .] in the transfer from the sensory organ to the phenomenal field, a good order has every probability of remaining good, and – excluding constellations of totally confused stimuli – a less good order has every probability of improving. Almost parallel lines and almost symmetrical figures become so completely. Angles of 87 or 93 degrees become right angles. Almost straight lines and imperfect circles are made regular. Gaps are filled [. . .] In short, the majority of deviations clearly tend towards an improved order.[14]

The characteristic of *sensitivity to change* should be set in relation to another feature described by Stadler, Stegagno and Trombini, who pointed out that a singular figure has less 'tolerance of identity' (*Identitätstoleranz*) than a non-singular one.[15] In other words, it has greater resistance to change. This they demonstrated using stroboscopic transformation movement, a technique which consists in the presentation in rapid succession of two not too dissimilar forms. These two forms are perceived as only one form, the first, which transforms itself into the second but retains its identity. With longer inter-stimulus intervals, differing according to the type of figure used, the succession of the two forms can be seen. By referring to Rausch's first four dimensions of Prägnanz (see above), Stadler, Stegagno and Trombini were able to show that non-pregnant figures transform themselves into a pregnant one more easily than vice versa: in other words, they have greater *Identitätstoleranz*. What we have here is a functional effect of singularity, like others (the already-mentioned greater discriminative ability or greater processing speed, as shown by Garner[16]) which presumably demonstrates greater ease in the encoding of singular structures.

Goldmeier's analysis differs from Rausch's in the degree of importance attributed to two other possible meanings (which may seem to a certain extent contradictory) attaching to the concept of Prägnanz – yet another ambiguity! Goldmeier emphasises that the zones of Prägnanz mark the points of discontinuity in a qualitative series. For Rausch, by contrast, Prägnanz is above all a scalar property that can assume all the values of intensity ranging between the two poles of the seven dimensions that he distinguished.

We may conclude from the foregoing discussion that Gestalt theorists use the term Prägnanz to mean *both* a tendency of the perceptual process to assume the most regular and economic course, given the constraints (*Randbedingungen*) present in each specific case, *and* a tendency towards the maximum *Ausgezeichnetheit* in the concrete phenomenal result of the process itself. It seems evident that the Gestaltists envisaged a close logical connection between these two facts. Generally speaking, scientists tend to take it for granted that, in nature, processes governed by a minimum principle tend to produce regular, symmetrical results.[17] The regularity is particularly apparent when we notice some kind of symmetry in a natural object. The mathematical concept of symmetry is a complex one, and detailed discussion of it would be beyond the scope of this article. The point here, though, is that in some cases the free interaction of the forces involved gives rise to a product exhibiting some degree of symmetry. One finds beautiful examples of axial or central symmetry in the inanimate world (crystals, snowflakes, and so on) as well as in the natural kingdom (leaves, flowers, butterflies, and so on). Such instances provide conclusive evidence that natural phenomena are not random in character but closely conform to laws.

Thus far it would be hard to disagree, but the confusion arises when the claim is made that the tendency towards *Ausgezeichnetheit* is a natural consequence of the tendency towards *economy of process*. This, however, is not necessarily the case. Simplicity and economy do not always result in singularity; the given conditions may permit only stable configurations, but ones that are ill-made, bad or irregular like many objects of our visual field. In nature, only a few natural objects have a regular structure, while the majority are amorphous or ill-formed. Consequently, few phenomenal objects and events have a 'good' shape and are in this sense 'better' than the others, well done or *ausgezeichnet*. The tendency towards singularity is only hypothetical, and all possible demonstrations of a tendency towards *Ausgezeichnetheit* must be subjected to very careful evaluation of their empirical validity.

Before examining the evidence, it should be emphasised that such scrutiny must be performed at the moment when visual objects are formed. Consequently, the analysis that follows is only concerned with the pre-categorial segmentation of the visual field – the visual moment in the strict bounds of the perceptual process. The problem of the formation of visual objects through the pre-categorial segmentation of the visual field is a problem of primary perceptual organization. Broadly speaking, it is convenient to distinguish at least two different levels in the perceptual process: (i) the process that determines a first and immediate segmentation of the perceptual field, which therefore appears to consciousness as constituted by many phenomenal objects, each distinguished from the others, prior to and irrespective of the attribution of meaning to them;[18] and (ii) the identification of these objects, with their categorisation and recognition. Following Kanizsa,[19] I shall call the former process, which is specifically visual, 'primary', and the latter, which is more properly cognitive, 'secondary'.

That these two processes should be distinguished is suggested not only by empirical evidence but also by logical arguments. Let us confine ourselves to the Höffding's famous 'argument'[20] that it is logically impossible to recognize an object if it is not already present; recognition is a process which acts on something: it is self-contradictory to think that the visual object can constitute itself after being recognized and on the basis of this process. It is evident that the formation of a visual object as an entity distinct from other objects must take place *before* the object can be recognised, and this is a logical requirement that cannot be refuted on the grounds that it is impossible to observe in a natural cognitive act a phase in which the visual data has not yet been identified. This, therefore, is 'Höffding's argument', which is almost a century old and which, although not disputed, is invariably ignored. Höffding[21] discussed the problem of laws of association in connection with recognition, pointing out that contiguous and therefore immediate associations require the intervention of a similarity factor.

The implications of this argument were developed mainly by Köhler[22] and found immediate echoes in Gestalt theory.[23] In Köhler's view, the argument could be stated thus: Let us take two associated mental contents, *a* and *b* (an association which for Höffding comes about through the 'law of exercise'). Let us now suppose that a new event *A* occurs which is endowed with the same properties as *a*. Now *A* leads to the revocation of *b*, and yet *A* is not *a* and is not associated with it. The only way to explain the activation of *b*'s trace following *A*'s presentation is that a is activated because of its similarity links with *A*. In Köhler's view (and Wallach's too), there is a functional link which is necessarily independent of past experience. In other words, Höffding's argument states that before an external event can be recognised and placed in the pertinent category, it must be constituted in such a way that it is endowed with characteristics which allow it to come into contact with the trace of a similar event. Thus, if the event is a triangle, before it can activate the trace relative to the name 'triangle' it must first come into contact with and activate the trace relative to triangular forms, independently of how these are deposited in the memory, because it is this trace that is associated with the trace of the name, and not the event 'triangle' which has just occurred.[24]

I believe that the tendency to Prägnanz, to the singular outcome, actually exists: not at the level of what was defined as a primary process (see above), but at the level of the secondary process. The tendency to Prägnanz is thus plainly recognizable in the products of secondary process, especially in transformations which are the outcome of memory traces, also in the short term. Moreover, identification of this tendency to Prägnanz in the secondary process is one of the most crucial insights of Gestalt psychology.[25]

Kanizsa and Luccio have thoroughly discussed this thesis,[26] providing a number of examples that argue against the hypothesis of the tendency to Prägnanz as singularity. I report a few of them below, as well as some new ones that I have produced recently and which seem particularly convincing.

2. THE SUPPOSED TENDENCY TO PRAGNANZ

2.1. Conditions of sub-optimal observation

Many authors claim that in conditions of sub-optimal vision, or of impoverished stimulation, the autonomous forces of organization should have greater freedom of action. Thus the 'improvements', which are not noticed in normal conditions of observation because the constraints of stimulation prevent it, should impose themselves.

When we look at a line which includes a gap (Figure 1a) or a deviation from rectilinearity (Figure 1b), and in which the gap or the deviation falls within the area of the blind spot, the result is that we see a complete or straight line (Figure 1c). In this case, elimination of the local 'disturbance' also improves the configuration as a whole. Indeed, this global improvement is achieved only by chance, as Figure 2 clearly demonstrates. When the left extremity of Figure 2A falls on the blind region, what is obtained is Figure 2B, which could be considered the best (the most economical) conjunction between the two parts of the figure entering the area of the spot. However, this local improvement disturbs, or does not respect, the 'goodness' of the overall configuration.

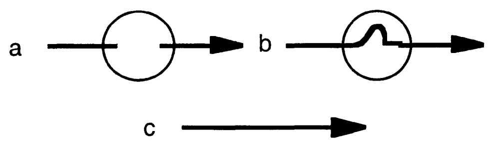

Figure 1. A line which includes a gap (a) or a deviation from linearity (b) falling in the area of the blind spot, is seen as a complete or straight line

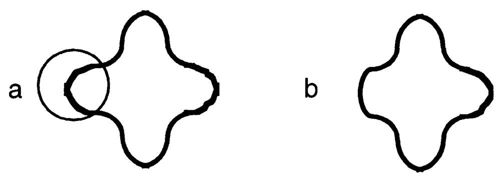

Figure 2. The left extremity of (a) falls in the area of the blind spot; the perceptual result, neither symmetric nor singular, is (b)

In conditions of lability of stimulation it seems that configurations with small imperfections tend to improve. When configurations like those in Figure 3 are presented by means of a tachistoscope, experimental subjects often report that they have seen a circle, a triangle, a square. Indeed, in these cases, where perceptions are fleeting and subjectively uncertain, there is a categorial assimilation without a corresponding perceptual assimilation. In fact, from a visual point of view, the circle is still broken, the minor basis of the trapezoid does not become a tip, the irregular quadrangle does not lose its irregularity.

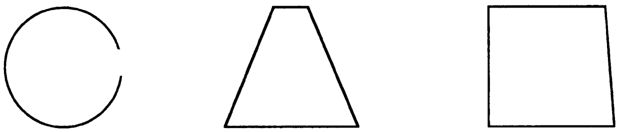

Figure 3. When observers say that they see a circle, a triangle and a square, they make a categorical assimilation

Luccio and Vardabasso have experimentally demonstrated[27] that in tachistoscopic presentation it is easier to detect a gap in the perimeter of a prägnant figure (a circle) than in the perimeter of a non-prägnant one (an amoeboid) (Figure 4). The results show that it is easier to detect the presence than the absence of the gap in the circle, while the opposite occurs in the case of an amoeboid. This finding casts serious doubts on the generalizability of the claimed tendency towards the completion of prägnant patterns in tachistoscopic perception.

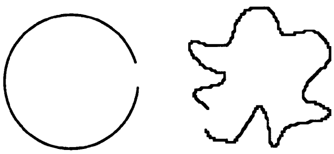

Figure 4. It is easier to see the gap in the prägnant figure (the circle) than in the non-prägnant one

2.2. Conditions of normal observation

Other 'evidence' for the assumed tendency towards the 'best' result is based on research and observations in conditions of normal vision, with stable and not impoverished stimulation. Some examples follow, mostly taken from previous studies[28] but with a number of new demonstrations as well.

In Figure 5,[29] the observer sees a circle and a regular hexagon which partially overlap (a), unlike the two figures in (b), which are equally possible. This well-known example has been used to support the hypothesis of a tendency to Prägnanz in the sense of singularity. But the singularity of the two resulting phenomenal configurations in Figure 5 is merely a by-product of the continuity of direction, which acts locally and independently of the structure of the whole, as the counter-example in Figure 6 shows. The same applies to Figure 7, which is a new one.

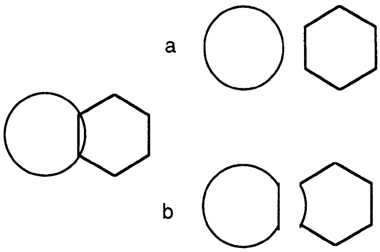

Figure 5. The figure on the left is seen as composed by a circle and an hexagon (a), and not as the two irregular figures in (b)

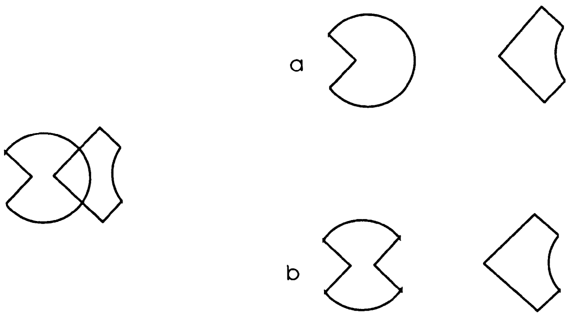

Figure 6. In cases like the one of Figure 6, the effect is produced only by continuity of direction

A-modal completion is an ideal 'detector' of the principles governing perceptual organization at the level of the primary process of constitution of visual objects. In Figure 8 the observer usually sees two squares, one behind the other, and this is considered to be evidence that the completion comes about in such a way that it satisfies a tendency to singularity. However, that the 'goodness' of the completed figure is in this case merely an occasional by-product of the action of other factors is demonstrated by Figure 9, in which for most observers the figure behind is a mutilated square and not the regular hexagon that a tendency to singularity should produce.

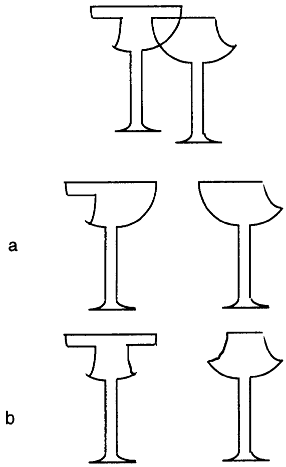

Figure 7. The two partially overlapping "broken glasses" are undoubtedly seen as in (a), again symmetry, and not as in (b)

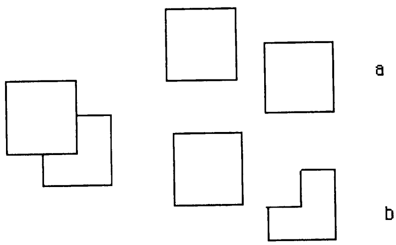

Figure 8. The left figure is seen as two partially overlapping squares, as in (a) and not as two adjacent plan figures, as in (b)

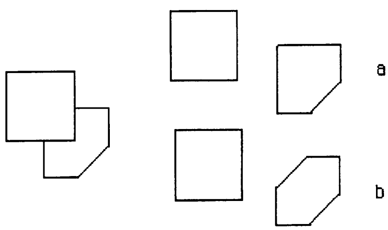

Figure 9. As this figure shows, the effect of Figure 8 is simply due to continuity of direction and not to singularity

The apparent three-dimensionality of flat figures, like Necker's cube, is often cited as demonstrating a tendency to singularity. In Figure 10, (a) is usually seen as a transparent cube or one made of wire, while (b) appears predominantly as a flat figure. The explanation usually given[30] is that the apparently flat figure already has a regular and 'good' form, while the other 'improves' greatly through apparent three-dimensionality: the angles become right and irregular figures lying flat are substituted by three-dimensional squares. But in Figures 11 and 12, (a), irregular though it is, is seen as three-dimensional, and the highly irregular (b) remains lying on the plane. What decides is a local factor, not a global one.

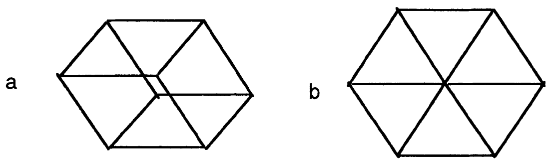

Figure 10. (a) is predominantly seen as a three-dimensional figure, while (b) is predominantly seen as a flat figure

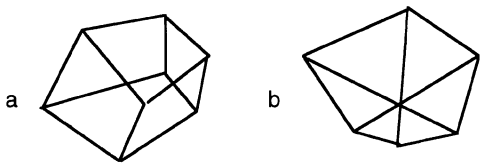

Figure 11. As we can see the effect of Figure 10 has nothing to do with singularity

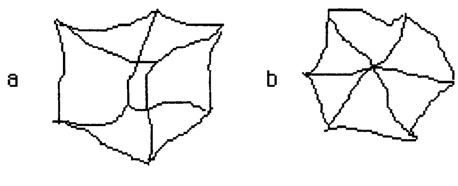

Figure 12. The same as Figure 11

As Kanizsa and Luccio point out,[31] there are many other counter-facts from the field of the binocular fusion of images presented separately to both eyes which contradict the hypothesis of the tendency to singularity. Thus in Figure 13,[32] if the 'incomplete' group is presented to the left eye, and the single dot to the right eye, the latter does not display any tendency to occupy the right place.

Even more significant is Figure 14.[33] If the observer makes the ocular axes converge appropriately, the two rings are seen to coincide perfectly, but the fusion of the two images does not eliminate the gap in the left ring, which does not become filled with the black of the uninterrupted one.

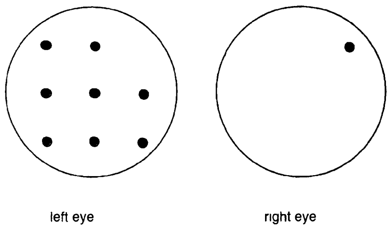

Figure 13. The dot on the right, projected on the right retina, has no tendency to occupy the "right" position among the other dots projected on the left retina

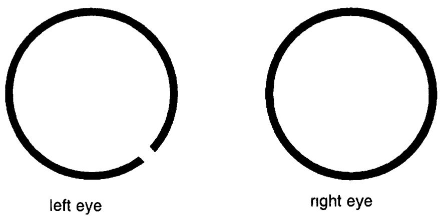

Figure 14. With an appropriate convergence of the ocular axes, one can see the two rings which coincide perfectly; however, the gap on the border of the left one is always present

2.3. Multi-stable displays

There are, however, experimental situations which warrant more detailed discussion. I refer to multi-stable displays, optical illusions, and situations of motion. Let us examine the first.

In multi-stable display, the first problem in discriminating figure from ground is the boundary function of the contour.[34] As will be seen in this new figure of mine (Figure 15), according to the attribution of the contour the different parts of the figure acquire quite distinct meanings.

According to Bahnsen,[35] the attribution of the contour is an overall function of the Prägnanz: the more prägnant the part (in his examples, symmetric versus asymmetric), the stronger the attribution of the contour to it. As a consequence, Bahnsen's figures have always been considered as providing evidence for the intervention of the tendency to singularity in figure-ground articulation (Figure 16: the figures are not original, but mine, and the effect is impressive

Figure 15. The boundary function of the contour

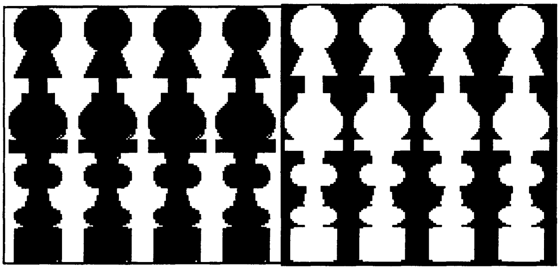

Figure 16. According to Bahnsen, the symmetrical figures are easier seen as figures on the ground

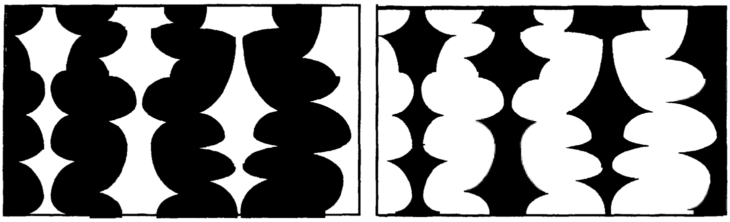

Figure 17. The convex figures and not the symmetrical ones appear preferably as figure on the ground

with no influence of black on white, or vice versa). A counter-demonstration,[36] however, is provided by Figure 17 (the figures are again mine), where the regions which become mainly 'figure' are the ones with convex boundaries, rather than the symmetric ones. Symmetry is one of the structural bases of singularity and has often been viewed (since Mach) as its constitutive character. Kanizsa and Gerbino's example demonstrates that this cannot be the case.

However, Kruse has brought strong arguments against this counter-demonstration.[37] In Figure 18a and b one first sees the faces. Figure 18c and d demonstrates that this effect is not due to the convexity factor; in fact, here it is the pillars that appear first.

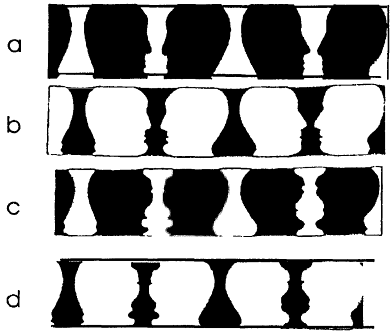

Figure 18. Kruse's figures

The results obtained by Peterson have similar implications.[38] She points out that, even though numerous studies have shown that figure-ground relationships can be determined without shape recognition input, these demonstrations have not ruled out the possibility that figure-ground computations can weigh inputs from shape recognition analysis as well. Her observers viewed both upright and inverted versions of reversible figure-ground stimuli. The central area was favoured by the factors of relative size, convexity, symmetry, inclusion. While in the upright version the surround had a meaningful shape, in the inverted condition it was far less meaningful in shape. Peterson found that, when the surround was upright rather than inverted, it was maintained as a figure for longer durations, and was more likely to be obtained as a figure by reversal out of the centre-as-figure interpretation. Her experiments show that these effects reflect contributions of a shape recognition route entailing access to orientation-specific memory representations and rule out alternative interpretations in terms of eye movements or motivation. According to Peterson,[39] observers' intentions can influence perceived organization. Consequently, her evidence would indicate that figure-ground computations weight shape recognition inputs, as well as inputs from routines assessing other variables such as symmetry, relative area, and so forth.

The results of Kruse's and Peterson's experiments confirm previous findings. Rubin had already claimed that prior experience might influence figure-ground organization. He observed that, once a region of a bi-stable display is singled out as a figure, it is maintained as a figure for longer durations than the other potential alternative. However, according to Rock and Kremen,[40] the procedure used by Rubin contained so many serious flaws that one cannot be really sure that the figural after-effect actually occurred. However, a study by Epstein and Rock seems to support Rubin's results.[41] Their experiment examined the extent to which the widespread conviction that the expectancy set is a determinant of perception was reliable, and their findings demonstrated that it is the most recent perceptual experience that controls the percept finally attained.

Why are the results obtained by Rubin and Epstein and Rock, like the ones by Kruse and Peterson, so interesting? They apparently show that the visual system is not a module which is absolutely impermeable to the influence of higher-order cognitive processes. They also seem to show that Höffding's argument, although apparently irrefutable from a logical point of view, cannot reflect reality as a whole when facts contradict it. As for the rest, reports on perceptual research not infrequently remark on the possibility that some effect on the phenomena under observation may be exerted by prior experience or by subjective factors like voluntary sets. Nor should we forget that although the Gestalt psychologists from Wertheimer onwards argued for a bottom-up conception of the perceptual process, they also included an 'empirical factor' among their organizing principles. Moreover, we are all aware that after finding an embedded figure in a drawing with great difficulty, or after integrating the parts missing in a Street figure, we find them very easy to see in subsequent exposures. On this issue W. Köhler writes: "Wir erkennen also, dass frühere Gestaltbildung spätere beeinflussen kann, und entnehmen daraus, dass im Lebensgang einmal realisierte *Gestaltung* ebenso Dispositionen für ähnliche Hergänge in Zukunft hinterlässt [. . .]".[42]

With Kanizsa, Santisi, Paluzzi and Primi, I performed two experiments using Kruse's figures.[43] In different conditions, with different exposure times, and also with a 'double blind' procedure to avert a possible Rosenthal effect, the results were always extremely straightforward. Nearly all subjects reported seeing black over white (over 95% for each slide), independently of the meaning of the figures. Only *later*, once the meaningful part had been recognised, did it become easier for the subjects to see the meaningful part. But the primary segmentation of the visual field was determined by structural factors, which cannot be interpreted in terms of singularity.

2.4. Evidence based on optical-geometrical illusions

According to E. Rausch,[44] there exists a tendency to *orthogonality* whereby two lines or directions which meet always tend to appear more like a right angle than they really are. This tendency to orthogonality should be able to explain a number of optical-geometrical illusions: Zöllner's, Hering's and Poggendorf's, for instance.

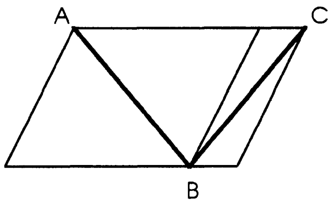

Figure 19. Sander's illusion. AB is equal to BC

A particular case of this tendency to rectangularity is the fact that a perceived parallelogram always tends to modify itself. It straightens and comes to resemble a rectangle, which is a 'good' Gestalt in relation to a series of similar figures derived from it (namely, the parallelograms). Accordingly, this tendency to straighten should be seen as a tendency to singularity. What 'improves' is the configuration as a whole, and as a consequence this may induce deformation in some local dimensions. This fact is convincingly illustrated by Sander's illusion (Figure 19), in which the different phenomenal length of the diagonals of the two parallelograms is a consequence of their rectangularization. The same applies to many other illusions, like Müller-Lyer's, Ponzo's, and others.

If we accept this thesis, a contradictory consequence arises. A force designed to reduce the difference between any angle and a right angle may at the same time conceal the regularities already present in the stimulus, like the colinearity in Poggendorf's illusion, the parallelism in Zöllner's case, and the equality in Sander's, Ponzo's and Müller-Lyer's segments.

But how, then, can we explain Figure 20, where the supposed straightening (although phenomenically not apparent) of some non-right angles deforms such a singular figure as a circle? I shall return to this figure, for it sheds very interesting light on the relationships between local and global factors in the primary process.

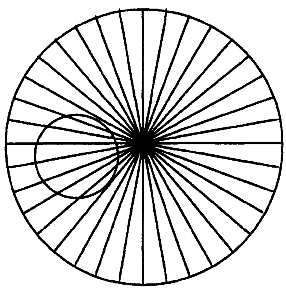

Figure 20. Orbison's illusion. The little circle appears strongly deformed

Moreover, as Figure 21 demonstrates,[45] similar deformations occur even when the angles presented are all right angles. Therefore one cannot appeal to a tendency to orthogonality in order to explain them, since there is nothing to straighten.

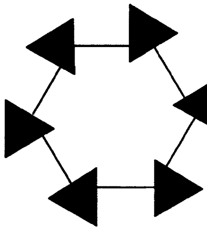

Figure 21. Gerbino's figure

2.5. The destruction of the actual singularity of trajectories

Another persuasive counter-demonstration is provided by experiments on the perception of movement. It is possible to demonstrate that highly singular components of the perceptual field may be concealed, with a perceptual result that is anything but prägnant.

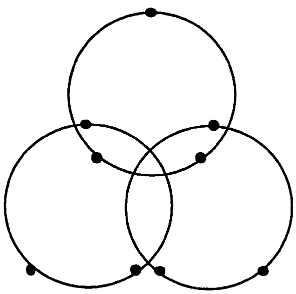

Figure 22. Dots moving on three partially overlapping paths

Imagine three groups of dots like the ones in Figure 22 moving in equal and uniform motion along circular trajectories (the dotted lines). In spite of their 'singularity' (they are circles), it is possible to demonstrate[46] that these courses cannot be seen when the average distance between all the dots is no greater than the average distance between the dots of each trajectory. By contrast, when this distance is smaller, the dots tend to aggregate and disaggregate locally according to their movement towards and away from each other around the area of intersection of their paths, and the paths are *phenomenically* *absolutely absent.* When there are only one to three dots per path, the paths are again phenomenally absent, and the dots are seen to form rotating triangles.

It was hypothesized that the relevant parameter was the difference between the average distance from the dots of other paths (DO) and the average distance from the dots of the same path (DS). In fact, the same results were obtained with a constant number of dots and and varying the distance between paths. From this we may conclude that the relevant control parameter[47] or the higher order variable (in terms of 'ecological perception') is this difference between DO and DS. If DO is clearly less than DS, the order parameter of *common motion* emerges and the system is in a stable attractor state. If DS is clearly less than DO, the order parameter of *relative motion* emerges and the system is in a totally different stable attractor state. On this theoretical view, there are local factors that determine the phenomenal result, and not a global tendency to Prägnanz.

3. TOP-DOWN VERSUS BOTTOM-UP, GLOBAL VERSUS LOCAL

Before drawing any conclusions, a final question requires clarification. The thesis developed in the last ten years by Kanizsa and myself may appear completely at odds with Gestalt Theory. In distinguishing between primary and secondary processes, and in focusing attention on the primary processes (the pre-categorial segmentation of the visual field), as distinct from the secondary ones, we propose a model which may appear to be a bottom-up model in total contrast with the emphasis that Wertheimer placed on the '*von oben nach unten*' procedure as best able to explain perceptual events. As a matter of fact, our thesis asserts that the perceptual processes are autonomous from more strictly cognitive activities; it distinguishes a 'pre-categorial' moment of production of visual objects from the moment of their categorization or identification, and closely resembles the model of 'modularity of the mind' proposed by J. Fodor[48]. But how far is this thesis compatible with Gestalt theory?

Many authors, from Bozzi[49] to Antonelli[50], have insisted that Kanizsa's theory is a return to Graz school via a sort of genetic jump of a generation. One recalls that Kanizsa was a pupil of Musatti, the first Gestalt psychologist in Italy, and that Musatti was a pupil of Benussi. Insistence on the fact that the cognitive processes operate on material hitherto uncategorized, and therefore still without meaning, is liable to lapse into the theory of *Urteilstäuschungen* (judgmental illusions) against which the Gestaltists from Köhler and Metzger onwards fought so bitterly. In my view, the question is another, and in some sense I feel that I can state with confidence that the theoretical position developed by Kanizsa and myself truly reflects the original spirit of Wertheimer.

Careful examination is required of the meaning given by Wertheimer to the expressions *von unten nach oben* and *von oben nach unten*. Unfortunately, these expressions have been identified with 'bottom-up' and 'top-down', which are now common currency in cognitive circles. If by 'top-down' is meant 'concept-driven', this identification is totally misleading. In cognitive psychology, in fact, 'top-down' usually means a 'concept-driven' direction of processing; the opposite direction, 'data-driven', is said to be 'bottom-up'. Once again the definition reveals a good deal of ambiguity, above all when the top-down/bottom-up dichotomy is treated as also synonymous with the global/local dichotomy.

Now, there are paradigmatic conditions in which there is definitely no such correspondence. A case in point is the research conducted by Navon,[51] where the stimuli presented are letters composed of sub-elements consisting of other letters which may be same or different. Here the focus is on the possible influence of the elements on the whole, or vice versa. In this case, top-down is equivalent to Wertheimer's *von oben*, and Pomerantz[52] is quite right to state that if by 'top-down' is meant 'concept-driven', articulation of the field on the basis of Wertheimer's laws is a bottom-up process.

Wertheimer's intention in contrasting a perception from above with a perception from below was to criticise the approach of the elementarist psychologists; an approach which he thought to be completely unnatural. When confronted with the visual objects composing the visual field, the elementarists attempted (first of all) to analyse them by splitting them up into the elementary units of which they believed they consisted. Wertheimer, on the other hand, believed that the most suitable approach, and therefore the more scientific one, is to confront the perceptual field without preconceptions of an elementaristic nature. Instead one should observe in a natural way[53] the units into which the field spontaneously sub-divides. The fact that these units are organized Gestalten, and not an aggregate of elements, does not mean, in Wertheimer's view, that their formation is top-down in the sense of concept-driven. Since this question is laden with significant implications, it is appropriate to quote Wertheimer on the matter:

> Ganzlich abgesehen von Reizbedingungen und physiologischen Faktoren, rein innerhalb der Psychologischen: das theoretische Vorschreiten 'von unten nach oben' ware nicht prinzipiell das adäquate, sondern vielfach ist der Weg 'von oben nach unten' gefordert: das Erfassen bestimater Ganzeigenschaften, Ganzbedingungen, Struktureigenschaften und von da aus der Weg zu 'Teilen' im prägnanten Sinn dieses Wortes. Es ist ein folgenreicher Unterschied, ob ich sage: es ist a da und b und c ... – Inhalte für sich (etwa jeder durch seinen Reiz bedingt oder von stückhaften Reproduktionsgesetzen her) und diese Und-Gegebenheit der Summe als die Grundlage ansehe, an die eventuell sich weiteres knüpfen mag – oder ob ich sage: ich habe diese und jene durch konkrete Charaktereigenschaften und Gesetzlichkeiten bestimmste Ganze und Ganzverläufe, aus denen ich durch Zerstückelung, durch Realteilung (was man als bloßen Wechsel der Aufmerksamkeit ansah oder als glatt subtraktive Abstraktion u. ähnl.) Teile gewinnen kann, – Derivate –, Unterganze zunachst; von denen ich aber unter diesen neuen Bedingungen dann freilich nicht mit Sicherheit weiß, ob sie auch ebenso als Teile in dem Ganzen waren; ja von denen ich unter Umstanden klar feststellen kann, wiefern dieser Vorgang gesetzliche Änderungen bedingt. Und ebenso beim Zusammentreten von Inhalten zu großeren Ganzen.[54]

Wertheimer's *von oben* has nothing to do with the 'top-down' of the present-day cognitivists, whose concept implies a 'guide' furnished by schemata and hypotheses to the organization of visual objects, and to the process of their formation.

An example which aptly illustrates my point is provided by the illusions of distortion. These can be used to verify something of great interest: that the intensity of the influence exerted on each other by the different components of the perceptual field depends directly on the spatial distance among them (also if this is not a linear relation).

The example of Figure 21, to which I now return, is particularly striking. According to the analysis proposed by Orbison,[55] the deformation is due to the attraction that the radial lines exert on the smaller circle, along a vector which is perpendicular to the radii of the greater circle. According to this model, the perpendicularity is not due to a hypothetical 'regression' towards the right angles, which are supposed to be more prägnant than the acute or obtuse ones, but it is due to the factor represented by the simple geometrical concept of distance. As one approaches the centre of the bigger circle, the radii are more dense and the attraction that they exert is thus greater, and the greater therefore will be the deformation.

Orbison's model is certainly too simple; for instance, it fails to consider problems like the need to save the invariances. Other, more complex models like those which use transformation groups[56] probably have a wider range of application. It is my opinion, however, that by means of models of this kind, suitably expanded and specified, we will be able to explain the tendency to stability in the self-organization of the perceptual field.

It should be borne in mind that one of the fundamental principles of Gestalt psychology is that the formation of a Gestalt is the realization of a dynamic self-distribution of forces, a typical case of auto-regulation within a system. The Berlin Gestaltists, unlike the Graz psychologists, never tired of stressing the spontaneous nature of the achievement of equilibrium and order in a system. According to Rausch,[57] the last great theoretician of *Gestalttheorie*, this free interaction of forces leading spontaneously to a certain order – 'order without an orderer' – is well expressed by the verb *organisieren,* used in the intransitive.

Indeed, Gestalt theory is a specific theory of globalities in which unification into a whole entails segregation from the other wholes. No room is left for vague holism, or for universal interactionism. The parts of a Gestalt can be more or less interdependent, but it is a system defended against influence by external forces.

As far as the *Urteilstäuschungshypothese* is concerned, Köhler himself pursued the same aim as my own in his classic article for the 1913 *Zeitschrift für Psychologie.* The supporters of that hypothesis sought to explain the discrepancies between phenomenal data and physical data (like constancies and deformations in optical illusions) in terms of the more or less unconscious effects of judgements on the process by which the percept is formed. In other words, the final visual result, the 'encountered' phenomenal data, was supposedly due to intervention by higher cognitive processes in the crude output represented by primary sensory processing. Against the plausibility of this hypothesis (which has incidentally been resurrected in many new forms and guises, and is typical of the neo-Helmholtzianism best represented by Julian Hochberg and Richard Gregory), Köhler, and later Metzger,[58] resolutely declared that the perceptual moment was completely autonomous, exactly as I am doing now. In my view, therefore, we can safely conclude that there is nothing in Gestalt theory that goes against the proposed distinction between the primary precategorial moment of segmentation of the visual field and the secondary moment of identification of the visual objects.

The local versus global controversy therefore acquires a meaning different from that traditionally attributed to it. If it is true that the field organizes itself globally, its effects are different in the different regions, and acquire particular salience locally because the effects of interaction between elements of the field vary in intensity as a function of the spatial reciprocal localisation of the elements themselves. Moreover, also the anisotropy of the field contributes to this local characterisation. Consequently, the different factors of structure and figural organization mostly exhibit their effects locally, and the balance among them materializes in a perceptual outcome that is as stable as possible.

4. CONCLUSIONS

In the light of the foregoing discussion it seems that a *tendency* to Prägnanz in the perceptual field *does not exist* when Prägnanz is viewed as a tendency to singularity. However, this is not at all to imply that nature does not obey laws. The world that surrounds us, in fact, is normally perceived as highly *stable.* Therefore, if one wishes to speak about tendency, one must say that there is an autonomous tendency of the field to *stability.* In my opinion, the most convincing interpretation to date of the tendency to stability is the one based on economy and simplicity – that is, on the 'minimum' principle.[59]

Note that apart from the very special cases of multi-stability, almost any stimulus situation, although it is in principle plurivocal and can therefore give rise to many phenomenal outcomes, tends *to come perceptually to a unique outcome*: not towards the most singular solution, but in general towards the most stable one. This probably occurs because the structural factors – which in any stimulus situation are usually numerous – are often antagonistic to each other (proximity versus closure versus continuity of direction, and so on). Therefore the more stable situation is the one with the maximum equilibrium among the tensions generated by the counteracting factors. These tensions, however, find a point of balance in configurational structures which only by accident also have the property of figural 'goodness'. Only in special cases – particularly those in which only one factor operates – can one presume that the tendency to stability coincides with the tendency to Prägnanz. But the more numerous the interacting factors are, and consequently the more complex the configurations that occur, the more rarely does the stable solution coincide with the prägnant one.

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NOTES

[1] Cf. in particular Stadler, Stegagno, Trombini 1986; Kruse 1986; Zoltobrocki 1986; Arnheim 1987; Boselie 1992.
[2] Cf. Kanizsa, Luccio 1987; 1990; 1991; 1992; 1993; 1994.
[3] Cf. Wertheimer 1912.
[4] Wertheimer 1914, 11.
[5] Wertheimer 1923, 328.
[6] Ibid. 324.
[7] Wertheimer 1923, 318.
[8] Cf. Hüppe 1984.
[9] Cf. Rausch 1966.
[10] Cf. Rausch 1952.
[11] Goldmeier 1936; 1982.
[12] Goldmeier 1982, 44.
[13] Köhler 1922, 531.
[14] Metzger 1963, 207.
[15] Stadler, Stegagno, Trombini 1974.
[16] Cf. Garner 1974.
[17] Cf. Mach 1896.
[18] See the pre-attentional processes described by Neisser 1967.
[19] Kanizsa 1979.
[20] Höffding 1887; cf. Kanizsa, Luccio 1987.
[21] Höffding 1887, 195–202.
[22] Köhler 1940, 126–30.
[23] See e.g., Wallach,1949.
[24] For discussion of Höffding's argument, see also Zuckerman, Rock 1957; Rock 1962.
[25] Cf. Goldmeier 1982.
[26] See Kanizsa, Luccio 1986.
[27] Cf. Luccio, Vardabasso 1986.
[28] Kanizsa 1975; Kanizsa, Luccio 1986; 1987.
[29] Sander 1928.
[30] Cf. Kopfermann 1930; Hochberg, Brooks 1961.
[31] Kanizsa, Luccio 1986.
[32] Erke, Crabus 1968.
[33] König 1962.
[34] Stadler and Kruse 1990.
[35] Bahnsen 1928.
[36] Cf. Kanizsa, Gerbino 1982.
[37] Cf. Kruse 1986.
[38] Cf. Peterson 1991.
[39] And also to Hochberg, Peterson 1987.
[40] Cf. Rock, Kremen 1957.
[41] Cf. Epstein and Rock 1960.
[42] Köhler 1913, 52.
[43] Cf. Kanizsa, Luccio 1995.

[44] Rausch 1952.
[45] Cf. Gerbino 1978.
[46] Cf. Kanizsa, Kruse, Luccio, Stadler 1994.
[47] In terms of 'synergetics': cf. Haken, Stadler, 1990.
[48] Fodor 1983.
[49] Bozzi 1979.
[50] Antonelli 1996.
[51] Navon 1977; 1981; see also Kinchla, Wolfe 1979.
[52] Pomerantz 1981, 153.
[53] Julesz 1981 would say "without scrutiny".
[54] Wertheimer 1922, 55.
[55] Orbison 1939.
[56] Cf. Hoffman, Dodwell 1985.
[57] Rausch 1966.
[58] Metzger 1954, 73–134.
[59] Cf. Hatfield, Epstein 1985; Zimmer 1986.

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FORMAL CHARACTERISTICS IN VERBAL DESCRIPTION AND SPATIAL REPRESENTATION

> The conceptual system depends on the perceptual system for judgements about the world [...] The input assumed by the conceptual system refers to the outcomes of perceptual judgements about the contents of experience – outcomes that can be made available for purposes determmed by the conceptual system.
>
> Mıller and Johnson-Laird,
> *Language and Perception.*

1. INTRODUCTION

Communication of perceptual experiences by means of a linguistic description constitutes one of the main functions of language. Therefore the processes and the mechanisms that relate perception and language are basic to our cognitive system. When we consider the border zone between perception and language, or when we study how the two modalities function as they interact, and which processes operate in such interaction, we must establish which of them takes the lead. Is it the principles governing visual perception that determine what will be transferred into the linguistic description or is it the rules of categorization and linguistic production that structure and select what will be said about what was perceived? Philosophers of language have preferred the latter view when they make reference to truth conditions in explaining the logical foundations of the propositions of a natural language. On the other hand they suggest that truth conditions are connected to the perception of reality.[1] Nevertheless few of them are willing to tackle the difficult task of identifying the characteristics of such a connection.[2]

Psycholinguists and cognitive psychologists began, first tentatively and then in greater depth, to look for experimental evidence on the role of visual perception in structuring and organizing the input to be delivered to the linguistic system, which in turn transforms it into a topic for a discourse. In these terms the problem is more than simply establishing which system takes the lead and rules out the linguistic description of a visual experience. Rather, the mechanisms and the cognitive processes that allow a matching between perception and language should be investigated, as well as the characteristics of the cognitive system that allow the perceptual input to be translated into the linguistic output.

L. Albertazzi (ed.), Shapes of Forms, 149–176.

Researchers are still looking for a model able to shed light on this phenomenon, which is one of the most perplexing aspects of cognitive functioning. In the 1970s the issue of the relationship between perception and language was first addressed in experimental psychology and approached within the cognitive theory, and specifically in:

(a) studies which, given that non-linguistic knowledge influences linguistic description, pointed out that linguistic performance is not only based on the linguistic system but also on the knowledge of the world and on the perception of reality.[3] Olson[4] and Osgood[5] pioneered work that, from contrasting theoretical points of view, sought to establish the nature of the influence exerted by the cognitive-perceptual structures on the production of verbal messages with referential functions. Olson's conclusions, which are widely accepted, state that of all the features of an object, the ones that are linguistically coded are those that differentiate the object from other objects, whether actually perceived or inferred.

(b) studies that have considered how linguistic structures and processes – long-term verbal memory, semantic memory and subjective lexicon – guide the perception of reality and influence the processes of perceptual discrimination.[6]

A book by Miller and Johnson-Laird,[7] which can be considered a milestone in the history of psycholinguistics, dealt with the relations between words and the world to which they refer both in terms of the perceptual procedures that discern which objects belong to which categories, and in terms of linguistic structures such as long-term verbal memory and semantic memory.

Following McKay et al.,[8] the following different types of relationship between the two systems can be considered:

(a) relations in the sense of influences, constraints and *mutual adaptation* between systems; research by Baddeley[9] on short term memory and by Kosslyn[10] and Paivio[11] on long-term memory has suggested that the two distinct codings of the input – visual and verbal – produce two separate representations. Since they are closely interconnected, straightforward transfer of information takes place between them by means of visual or verbal recoding. As a consequence of the verbal recoding of a visual input, part of the visual information is lost.[12]

(b) relations in the sense of common *representations* or units shared by the two systems; the model of Landau and Jackendoff,[13] which we shall describe later, refers to this type of relation.

(c) relationships in the sense of *processes* shared by the two systems. Clark and Chase write: "One often hears psychologists speak of 'verbal' and 'perceptual' systems as if the two are quite separate and have little in common [...] Underlying both language and perception, we have argued, is a common 'interpretative' system that must be handled by one set of principles no matter whether the source of a particular interpretation is linguistic or perceptual".[14]

(d) relations in the sense of *cognitive structures* shared by the two systems. Jackendoff assumed[15] that there is a cognitive structure, the "conceptual structure" into which the linguistic information is conveyed, as well as information from other systems such as vision, non-verbal hearing, haptic, and so on.

These four types of relations vary in intensity from the weakest (a) to the strongest and most structured (d). We agree with Landau and Jackendoff[16] that, in the case of perception and language, the relationship between them can be identified at the level of the *representations* that they have in common. In fact, the interface between the two systems lies in the representation formed by the perceptual system, from which the linguistic system draws a filtered representation for linguistic description to build on.

2. LANDAU AND JACKENDOFF'S MODEL

In their paper 'What and where in spatial language and spatial cognition',[17] Landau and Jackendoff proposed a model in which the various sensorial systems produce a single representation, whether the incoming information is auditory, visual or linguistic. It is this Spatial Representation – which comprises in a common format all the specific information for every sensory modality – that provides the interface between the various modalities. The Spatial Representation encodes the properties of the objects of the physical world as well as the relations among them, and transfers this information to two systems: the motor and the linguistic. It is possible to speak about what is perceived since the visual information encoded in the Spatial Representation is delivered to the linguistic system, which then assigns linguistic form to it.

Spatial Language thus refers to objects and to their spatial relations. The formulae with which Spatial Language denotes entities and spatial relations are names and prepositions respectively. Landau and Jackendoff refer to the former as the 'What' system and to the latter as the 'Where' system. The magnitudes of these two systems differ markedly, since on the one hand there is a multitude of names which refer to objects and their parts, while on the other there are only a few prepositions which refer to places and spatial relations among objects. It follows that a speaker can differentiate between objects that are perceptually very similar provided they belong to different conceptual categories. This suggests that language has enormous potential in the use of different linguistic labels for slightly different shapes but has scant ability to differentiate among different spatial relations.

What is the reason for this discrepancy? Landau and Jackendoff consider two possible explanations. The Design of Language Hypothesis states that the Spatial Representation includes a large amount of information concerning the geometrical properties of both shapes and spatial relations among objects. Language, however, seems opaque and impervious to some of this information, which is therefore not translated into linguistic form. According to Landau and Jackendoff, this filter ought to be applied to both objects (and shapes) and places (and spatial relations), but in fact, language has many shortcomings regarding the descriptions of shapes as well (one need only consider how complicated it would be to describe a violin!). In order to meet the requirements of economy, the linguistic system reduces numerous distinctions to a limited number of elements.

This interpretation, however, fails to explain why there are so many linguistic labels available to express subtle and complicated differences in shape and so few prepositions, which are able to specify spatial relations only on the basis of a simple and schematic geometry. Landau and Jackendoff incline more towards the Design of Spatial Representation Hypothesis, according to which the discrepancy between the 'What' and 'Where' systems observed in linguistic description is not a linguistic phenomenon but instead reflects the intrinsic nature of Spatial Representation. On this hypothesis, the Spatial Representation is able to contain a large amount of formal characteristics, but it is not equipped to encode many positional or relational characteristics. The discrepancy is due to the fact that the spatial information is processed by two different sub-modules: the one which identifies shape is connected to the naming system, which serves to recognize objects, whereas the one which identifies places is connected to the system of spatial prepositions.

The most productive aspect of this theory is that it establishes the nature of the Spatial Representation and the relations that it creates with linguistic encoding. We agree with Landau and Jackendoff that the Design of Language Hypothesis is not tenable, because the distinction between the What and Where systems does not lie at the lexical level. Nevertheless, we are not completely convinced by the Design of Spatial Representation Hypothesis either, since we believe that the perceptual system does, in fact, capture subtle differences in both shape and place.

We maintain – in keeping with theory of 'direct perception'[18] – that the information collected is rich at the very outset of the process, and for both shapes and places; subsequently two different representations are formed as a function of the type of output system involved. We therefore agree with Miller and Johnson-Laird's statement[19] that only those perceptual predicates are transmitted from the perceptual to the conceptual system which the conceptual system asks for. In our opinion, qualitatively different representations are structured which select information and render it explicit for different goals, namely linguistic, motor, or otherwise.

Motor behaviour is guided by a Spatial Representation that is not poor in information on the place or orientation or type of motion, or on other relations between objects or between an object and an observer. In fact, any motor action requires a rich Spatial Representation which includes these features of the visual information. It is obvious that the more precise the spatial information regarding position, orientation and so on, the more likely successful motor action becomes. For example, in a tennis match it is not sufficient to understand whether the ball will fall 'inside' or 'outside' the court, 'left' or 'right', 'in front' or 'behind' the player; it is also necessary precisely to perceive the ball's position at any given moment of its trajectory, its orientation, speed, inclination, and so on. This spatial information is unique, unrepeatable, ungeneralizable, and nameless (except for some very generic quantifiers); nevertheless, it is perceived precisely and it is fruitfully used by the motor activity. A commentator of a tennis match may use labels such as 'left', 'right', 'inside', 'outside', and so on, but these are very generic terms for what is happening on the court. Landau and Jackendoff rightly complain about the vagueness of these linguistic descriptions. But such vagueness does not mirror the nature of the Spatial Representation. Rather, the discrepancy between the What and Where systems in language is due to the fact that language is attuned to to the description of objects rather than of their locations.

3. THE EXPERIMENTS

In the light of these considerations, we designed experiments to study the different weights of 'What' and 'Where' in constitution of the Spatial Representation underlying the verbal description of visual information. We shall offer psychological evidence in favour of the following hypotheses: (a) in order to produce a verbal description, the cognitive system treats visual information by focusing mainly on the object shape; (b) there is a hierarchy of importance between shape and location when the goal is to produce a verbal description; (c) the difference between these two aspects of visual information is already contained in the Spatial Representation that precedes the linguistic coding; (d) this difference is evident in higher cognitive processes such as categorization and verbal description, but it is also present in the early processes of the visual encoding when the final output consists in a categorization or a verbal description.

We have used a variety of terms to refer to concepts. Henceforth, however, we shall use the terms 'Formal characteristics' and 'Relational characteristics'. We shall refer to 'Formal characteristics', rather than 'Shape', in order to stress that various perceptual aspects constitute the form or appearance of an object. We shall refer to 'Relational characteristics', rather than 'Place' or the 'Where' system, in order to stress that they qualify relational aspects of the object which depend on the context in which the object is embedded, on its relations with the background, on the comparison with other objects, and on its momentary relation with the observer.

This distinction between Formal and Relational aspects of an entity recalls that in Aristotle's *Metaphysics*: the essential component of an object is the shape which forms the material itself and constitutes its being. Shape must be distinguished from incidental, or relational, properties which do not pertain to the essence. These are, for instance, the predicates of substance, such as quality, quantity, relation, location, time, position, and so on.

Regarding the role of shape in guiding the perception and recognition of reality, mention should be made of the pleasure and wonder expressed by the naturalist Henry Baker (1698–1774) on first observing and describing microscopic animals (amoebas) with no precise shape. In his words:

> None of the many different Animalcules I have yet examined by the Microscope, has ever afforded me half the Pleasure, Perplexity, and Surprise, as that I am going to describe at present: whose Ability of assuming different Shapes, and those so little resembling one another, that nobody (without actually seeing its Transformation performed under the Eye) would believe it to be the same Creature.[20]

Baker reveals how difficult it is for us to realize that things which take on different shapes by chance are still the same. Shape is therefore a substantial feature since, when it changes, a radical transformation of the object results. The relational aspects do not produce any metamorphosis, only a different picture of the same object.

Since our hypotheses concerned both verbal descriptions and the nature of the Spatial Representation, an analysis of spatial language was performed *vis-à-vis* non-linguistic spatial representation. We used different task requirements, such as perceptual evaluations, categorizations and verbal descriptions. Our investigation can be divided into two parts. The first sought to verify whether the difference between Formal and Relational characteristics occurs in the linguistic representation, and therefore in the verbal description of visual stimulus. Three experiments were performed in which subjects were presented, under different conditions, with meaningless figures. The second part of the study sought to verify the different roles played by Formal and Relational characteristics in the structuring of the Spatial Representation. To this end, two experiments were performed. In one of them the same visual stimuli used in the study of verbal descriptions were used in a sorting task in which subjects had to choose a suitable criterion for categorizing the figures; in the other, an easy psycho-physical task based on the lower level of visual information-processing was used. The reaction times taken by subjects to judge pairs of figures which differed in formal and relational characteristics were tested. Since a categorization process was involved in the subject's judgement, we expected a difference between Formal and Relational characteristics to arise in this experiment, as well as in the previous ones.

The Formal aspects taken into account by our experiments were the arrangement of the sides in a closed outline pattern (rectangular, quadrilateral) and the type of lines present in the same contour (rectilinear, curvilinear). These we shall refer to as 'Shape' and 'Contour' respectively. As far as Relational characteristics are concerned, the role of Position and Orientation will be analysed.

3.1. Experiment 1

Unfamiliar and meaningless visual stimuli were used to prevent the description from becoming a case of simple recognition and labelling. If no stable referential links were established between a cognizable entity and language, and if the referent lacked a lexical concept, the process of denomination and/or description should have encoded the salient perceptual aspects.

Two Shapes, namely a Rectangle and a Quadrilateral, both with a side consisting of a Wavy line, were shown in two Positions – centred and decentred – and in two Orientations – horizontal and tilted – inside a square (see Figure 1).

The subjects were shown eight figures, one after the other. Their task was to produce "a suitable and exhaustive verbal description" of each configuration shown in succession. There were no time limits either for observing the slides or for task execution. The eight stimuli, presented in random order, were shown for the entire description period. The protocols were analysed in order to identify which characteristics were mentioned by the speakers. Table 1 shows the percentages with which Shape, Contour, Position and Orientation were mentioned. It was found that Formal characteristics were described in all cases, whereas Relational characteristics were mentioned in only half the cases.

A salience criterion clearly operates in the selection of the characteristics mentioned in the descriptions of unfamiliar stimuli. The results support the hypothesis that the process of linguistic encoding selects information in favour of Formal rather than Relational characteristics. Our interpretation is that the frequency with which a characteristic is described depends on its weight in the Spatial Representation.

A further result was that Position and Orientation were almost never mentioned in the description of the first figure presented to the speakers, whatever figure it was (see Table 2).

This result suggests that the descriptions were ruled by the linguistic criterion of referral to distinctive information. This interpretation stresses the communicative functions of language rather than its dependence on Spatial Representation. In the literature on referential communication, in fact, a message is considered to be informative when it provides the information required by the hearer to identify the target within a group of similar stimuli which share some features but differ in others.[21]

It may be that the speakers did not mention the relational characteristics of

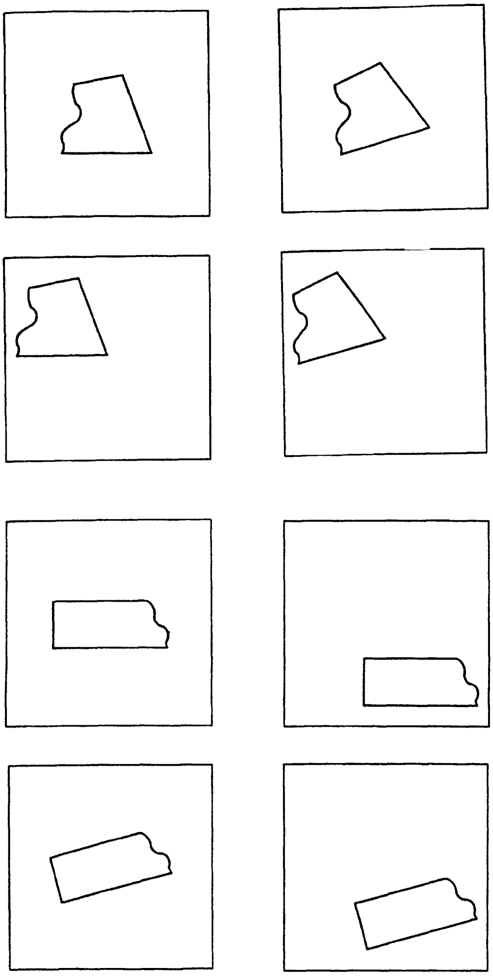

Figure 1. The eight figures described by the speakers

Table 1. Percentage rates of mentions of Formal characteristics (Shape and Contour) and Relational characteristics (Position and Orientation) in Experiment 1

	Formal characteristics		Relational characteristics	
	Shape	Contour	Position	Orient.
Rectangles	95.8%	90.6%	45.8%	45.8%
Quadrilat.	98.9%	92.2%	61.5%	31.3%

Table 2. Percentages with which Shape, Contour, Position, and Orientation were mentioned in descriptions of the first and subsequent stimuli (Experiment 1)

	Shape	Contour	Position	Orient.
Mentions for stimulus 1	100.0%	100.0%	12.5%	0
Mentions for stimulus 2–9	96.9%	91.4%	58.0%	43.8%

Position and Orientation when describing the first figure because they were only able to see that these characteristics were contrastive aspects from the presentation of the second stimulus onwards. If this were the case, they would have described position and orientation even for the first figure if they had been presented simultaneously with various figures differing with respect to Position and Orientation. The aim of the second experiment was to verify this hypothesis and to test the extent to which the descriptions were ruled by the linguistic criterion of conveying distinctive information in order to avoid ambiguity. It could be argued that Relational characteristics may become more salient for communication following comparison, due to the criterion of informative referencing.

On the other hand, we believe that the constraints imposed by the Spatial Representation, and the hierarchies of attributes it contains, are stronger than the need for informativeness in referential communication. In short, the next experiment was set out to contrast the 'Spatial Representation hypothesis' with the 'Referential Communication hypothesis'.

3.2. Experiment 2

In this experiment each of the figures to be described – the same as in experiment 1 – were shown together with three other figures of the same set which varied in both Formal characteristics (Rectangles versus Quadrilaterals) and Relational characteristics (centred versus decentered, horizontal versus tilted). The speakers were presented with four figures at a time, and their task was to describe the one that the experimenter pointed out. After the verbal report, another set of four figures was presented and the procedure was repeated until eight figures had been described.

The protocols were analysed using the same criterion as in the previous experiment. The results were very similar: the Formal characteristics were always described while the Relational ones were mentioned in half the cases (see Table 3). Moreover, in this experiment too, the subjects hardly ever mentioned the Relational characteristics when describing the first figure (see Table 4).

Table 3. Percentage rates of mentions of Formal characteristics (Shape and Contour) and Relational characteristics (Position and Orientation) in Experiment 2

	Formal characteristics		Relational characteristics	
	Shape	Contour	Position	Orient.
Rectangles	97.8%	88.5%	47.8%	42.7%
Quadrilat.	97.8%	89.2%	50.0%	27.1%

Table 4. Percentages with which Shape, Contour, Position, and Orientation were mentioned in the descriptions of the first and subsequent stimuli (Experiment 3)

	Shape	Contour	Position	Orient.
Mentions for stimulus 1	100 0%	100.0%	0	6.3%
Mentions for stimulus 2–8	100.0%	85.7%	56.3%	35.7%

The main result of the experiment was that, even when the Relational characteristics were distinctive features for discrimination of the target from the other objects, they were neglected in half of the cases and totally in the description of the first stimulus. Our interpretation is that the hierarchy of attributes to be linguistically encoded is determined more by the nature of the Spatial Representation than by communicative goals. In our opinion, the linguistic description mirrors the Spatial Representation, the way in which the perceptual organization is assumed by it, and the way in which the different perceptual features are hierarchized. In other words, the propositional content of the message depends primarily on the non-propositional Spatial Representation. Before this conclusion was accepted, a further investigation was performed based on the following consideration. It may have been that the simultaneous presentation of four figures did not force speakers to mention Relational characteristics because they did not take time to scan the figures in order to determine the distinguishing feature of the target. In fact, as soon as they were told which figure to describe, they started their description. A further experiment ascertained whether it was possible to influence the descriptions and induce subjects to name Relational characteristics by asking them to look at all four stimuli, only producing the description after a period of observation. If in this case, too, the Relational characteristics were not mentioned from the first stimulus, this would strengthen the conclusion that they are considered secondary in the definition of an object and that, even when they are distinguishing features, they emerge after comparison with previously given descriptions, and not after perceptual comparison.

Table 5. Percentage rates of mention of Shape, Contour, Similes, Generic Categorization, Position and Orientation in Experiment 3

	Formal characteristics				Relational characteristics	
	Shape	Contour	Similies	Gen. Cat.	Position	Orient.
Rectangles	70.3%	60.9%	45.3%	29.7%	46.9%	23.4%
Quadrilat.	64.0%	48.4%	37.5%	51.6%	42.2%	18.7%

Table 6. Percentage with which Shape, Contour, Similes, Generic Categorization, Position, and Orientation were mentioned in the descriptions of the first and subsequent stimuli (Experiment 3)

	Shape	Contour	Similes	Gen. Cat.	Position	Orient.
Mentions for stimulus 1	93.8%	68.8%	56.3%	43.7%	12.5%	6.3%
Mentions for stimulus 2–8	63.4%	52.7%	40.2%	31.3%	49.1%	23.2%

3.3. Experiment 3

The speakers were told they would be presented with some slides, each of them showing four figures, and that one of these was to be described "suitably and exhaustively". After the presentation of each slide the subjects were first asked to look at all four figures for about ten seconds; only after this period of free observation did the experimenter tell them which one was to be described. The figures to be described varied their location in each slide, occupying all four frames in turn.

The results shown in Table 5 can be summarized as follows:

(a) The frequency with which Shape and Contour were mentioned decreased markedly with respect to the preceding experiment. This was mainly due to the presence of Similes (e.g., "a piece of cheese that has been nibbled"), and other comments grouped under the label 'Generic Categorization' (e.g., "a geometric shape", "an irregular object", "a strange shape", allowing for the simultaneous description of both the Shape and the Contour);

(b) The percentage with which Position and Orientation were mentioned was no higher than in the previous Experiments.

The changes in procedure, and the longer time allotted for stimuli observation, led to a richer descriptive strategy with the use of Similes and Generic Categorization. This descriptive richness worked only in favour of Formal characteristics, which tended to be over-specified and thus benefited from this increased linguistic richness. It seems that there were still resources available in the linguistic representation. These resources consisted mainly in the conceptual categories of familiar objects, as in the case of Similes, or in high level categories, as in the case of Generic Categorization, and they were suitable for the description of the Formal aspects but not of the Relational ones.

Table 6 shows the percentages with which subjects mentioned the Relational characteristics in the description of the first stimulus, compared with stimuli 2-8. Once again, Position and Orientation were largely ignored by almost all subjects in their first descriptions, although they had observed all four stimuli for a sufficient amount of time. On the whole, the tendency to neglect Position and Orientation was not influenced by the procedure; the Relational Characteristics were found to be refractory to the two variables considered in experiments 2 and 3: (a) presentation of four figures at a time; (b) deferred description. Since the Relational characteristics were mentioned less than the Formal ones, and were not mentioned from the first stimulus, the conclusion that the two types of characteristics have differing statuses is strengthened.

The fact that Position and Orientation were never mentioned in the description of the first stimulus, but were mentioned in the description of the following ones, suggests that, as regards the attributes that do not emerge from a first perceptual analysis, namely Relational ones, there was a tendency to construct the description on the basis of comparison with the previous linguistic context. This phenomenon has been studied by Halliday and Hasan, who distinguish between exophoric and endophoric reference.[22] The former is informative with respect to the world; the latter is informative with respect to previous discourse. Our results suggest that the tendency to refer endophorically, namely the need for cohesive reference to previous discourse, seems to be stronger than the need to adhere to the actual characteristics of the stimulus. This finding is consistent with other results reported in the literature: Pechmann used accentuation to infer the significance of particular information for the speaker, finding that subjects tended to stress the distinctive feature that marks out the object from the one mentioned previously.[23] Since the simultaneous presentation of four figures and the deferred description did not activate exophoric reference either, our result suggests that endophoric reference is stronger than exophoric reference in the case of relational characteristics. On the other hand, Formal characteristics were always mentioned, regardless of whether the referent differed from the previous one. In the case of Formal characteristics, subjects did not simply rely on the previous linguistic context. It might be concluded that the salient characteristics, the Formal ones, in Spatial Representation are always transferred into the linguistic coding, whereas a specifically linguistic rule imposing discourse coherence operates in the case of characteristics which are not salient in the Spatial Representation, namely Relational ones.

We conclude that the first requirement to be satisfied when a new perceptual experience is to be described is that mention must be made of Formal characteristics; mention which emerges as a primary perceptual result and occupies an important position in the Spatial Representation. Shape was described by all the speakers in all descriptions. Very frequently, they used the name of the category nearest to the critical figure, i.e., 'rectangle' or 'quadrilateral'. Although our stimuli did not contain rectangles or quadrilaterals, speakers referred to the geometrically closest category; a tendency which indicates that: (a) a shape is a perceptually structured unit that must be indicated as a whole in verbal communication; (b) this unit is best expressed by a lexical item which takes account of its entirety, although the link between the name and the referent is only approximate; (c) the object class is always included in the object description.

Also 'Wavy line' was always mentioned: This is a salient characteristic, being an anomaly in a configuration otherwise defined by rectilinear segments, and an important component compared with the rest of the outline. As such, it is a case of the 'pop-out' effect described by Treisman and Sauther: a dishomogeneous element, with respect to the context in which it is inserted, tends to impose itself in a strongly perceptual way.[24] From both the perceptual and attentive viewpoints, anomalies strike the observer immediately, as studies on attention have shown.[25] Furthermore, they are of high informative value because they act as the element which adjusts an approximate description of the shape, such as 'rectangle' or 'quadrilateral'.

The three experiments on verbal descriptions consistently demonstrate that subjects rely on a hierarchy of attributes which assigns a predominant role to Formal characteristics and a secondary one to Relational characteristics. In psycholinguistic research, various analyses have examined the problem of what determines the saliency or importance of an entity or a quality in a description. Fillmore talks about a saliency hierarchy in which change of state have a primary role;[26] Clark and Clark speak of unexpectedness;[27] MacWhinney mentions agency[28] and Osgood and Bock show that vividness is a contributing factor[29]. Also perceptual factors have sometimes been studied: Flores D'Arcais showed that when a large figure and a small one are involved in an event, the large one is mentioned first;[30] Miller and Johnson-Laird[31] and Talmy[32] noted that if two objects are unequal in size or mobility, the smaller and mobile one is always encoded first as subject of the sentence. Morrow and Clark proposed the Situational Model based on Uniqueness, Contrastive and Salience assumptions.[33] On the whole, these studies confirm the factors which emerged in Osgood's pioneering study[34] in which subjects were asked to describe, in a single sentence, an event involving simple familiar objects, for example an orange ball rolling toward an upright tube. The main goal of Osgood's investigation was to show "how the form as well as the content of sentences can be influenced by manipulating the perceptual context in which they are produced",[35] and to demonstrate that descriptive sentences derive from the non-linguistic cognitive system.

In accordance with this position, in our study the salience criterion was posited on the nature of the Spatial Representation. This is based on perceptual processes and precedes construction of the propositional content of the message. In the first three experiments we showed that the different weights of Formal and Relational characteristics are manifest in verbal descriptions. In the experiments described next we shall demonstrate that the phenomenon is not a purely linguistic one and that, even in pre-verbal processes, a Spatial Representation which obeys the same principles operates.

3.4. Experiment 4

The purpose of this experiment was to verify whether the hierarchy of Formal and Relational attributes is present in the representation that precedes the selection of the propositional content of the linguistic description.

Two different hypotheses could be formulated: either that what we had found in the previous experiment mirrors the fact that language uses more lexical items to encode the shape of an entity than it does to encode its locations, or it mirrors the nature of processes that occur earlier in the process. In order to verify these hypotheses, an experiment was performed in which the subjects were asked to carry out a non-verbal categorization task. The material consisted of the same figures as those used in the previous experiments plus another eight figures in which the Wavy line was replaced with a straight line.

It was possible to group the set of 16 figures according to the criteria of: (a) Shape; (b) Contour; (c) Position; (d) Orientation. It was always possible to subdivide all stimuli into two equal groups on the basis of each of the four characteristics. The participants were informed that they were taking part in a very elementary test, and they were invited to perform in the simplest and most spontaneous way by grouping the figures "on the basis of a sensible criterion". Once they had performed the first sorting, they were invited to divide each of the two groups into two more groups. Finally, they were asked to subdivide the four groups further, again on the basis of the criterion held to be the most sensible. Since there were four distinctive characteristics, this procedure enabled the weight assigned to each of them to be determined.

We expected results which were analogous, compatible and consistent with those of experiments 1, 2 and 3. Formal characteristics are primary in the Spatial Representation, they should be considered more salient than the Relational ones also in a sorting task.

The frequencies with which the participants used the various criteria to carry out the first, second and third classification respectively are set out in Table 7.

Table 7. Percentages with which Contour, Shape, Position, and Orientation were chosen in the first, second and third classification (Experiment 4)

	Class. 1	Class. 2	Class. 3 Rectang.	Class. 3 Quadrılat.
Contour	73.9	26.1		
Shape	26.1	73.9		
Orient.			73.9	26.1
Position			26.1	73.9

In the first classification, Contour was the preferred criterion in 73.9% of cases and Shape was preferred in the remaining ones. No other criterion was used in the first classification. In the second sorting, all the participants who had first used Contour now used Shape, and vice versa for those who had first used Shape. Overall, 100% of the first two classifications were performed on the basis of Formal characteristics.

This experiment was the first step in an attempt to determine whether the different weights of Formal and Relational characteristics is a linguistic phenomenon or whether the differentiation arises at some representational level that precedes the linguistic coding.

Experiment 5 once again posed the question, but at a new level. Two hypotheses could be put forward, which differed according to the point in which Formal and Relational characteristics parted from each other. According to the 'Categorization Process Hypothesis', the various features of the visual information reach the categorization stage with equivalent weights. Only subsequently does the categorization process hierarchize them. According to the 'Spatial Representation Hypothesis', on the other hand, information is organized and structured according to a criterion of salience at an even lower level of perceptual elaboration.

3.5. Experiment 5

A discrimination task was used in which participants judged, as quickly as possible, whether two figures presented on a screen were similar or dissimilar. The figures were the same as the ones used in the previous experiment: they varied in Shape, Contour, Position and Orientation. The figures were presented two at a time and were either the same or different in their Formal and/or Relational characteristics. The two figures varied in just one or in two characteristics, which could be either of the same type (both Formal or both Relational) or of different types (one Formal and the other Relational). Participants were presented with twenty-four pairs of figures; half of them were invited to judge whether the two figures were the same or different with respect to Formal characteristics, and the other half were asked to judge whether the two figures were the same or different with respect to Relational characteristics. All the participants were presented with figures that could vary in both types of characteristic.

The reaction times before giving an answer (pressing a button on the keyboard of a personal computer) were recorded. The reaction times by the two groups of participants should not have differed if the Categorization Process Hypothesis were true, since it is at the level of categorization and linguistic processes, and not at a previous level, that Formal and Relational characteristics assume different weights. We prefer the Spatial Representation Hypothesis that there is a level of representation, namely the Spatial Representation, in which Formal and Relational characteristics are structured according to a salience hierarchy.

If the latter hypothesis is true, we should have obtained longer reaction times from the group who had to judge whether the two figures had a different Position or Orientation, and shorter reaction times from the group who had to judge whether the two figures differed in Shape or Contour. In fact, if the Formal characteristics were higher in the hierarchy, they would be detected in all cases, so that the reaction time by the participants who had to judge Relational characteristics would take longer.

The results confirmed our hypothesis. The participants who had to judge whether Shape or Contour were the same or different exhibited shorter reaction times compared with those who focused on Position and Orientation. These results confirm, from a chronometric point of view, the role of Formal characteristics as a primary factor in perceptual organization and their privileged status in the Spatial Representation.

4. THE MODEL

Overall, some consistent results emerged from the five experiments described above, viz.:

1. Formal and relational characteristics assume different roles when they are processed.
2. Formal characteristics are privileged when we speak about what we see, when we group different figures, and when we perform simple and rapid discrimination tasks.

These results enable us to reject the Design of Language Hypothesis, at least as formulated by Landau and Jackendoff: it is not language, with its lexical features, that produces the difference between the 'What' and 'Where' systems because the differentiation is already present at the level of pre-linguistic representation.

A problem still remains concerning the nature of the Representation that precedes the linguistic description. On the basis of critical analysis of Landau and Jackendoff's stimulating model, and in the light of the experiments described above, we propose a model which illustrates how the system works when a verbal report of a perceptual experience is produced. A graphic representation of this model is given in Figure 2, and the various phases and components characterizing it are described point by point in the following sections.

4.1. The primary spatial representation

The first arrow on the left indicates the activation of the rapid and pre-attentive processes which are triggered by the visual input to produce a 'Primary Spatial Representation'. Following Kanizsa,[36] we call this representation 'primary' because it derives from primary processes: it contains the information which the visual sensorial modality has gathered by means of low level perceptual processes which are mainly automatic.

The visual input is immediately and inevitably processed to form a representation in which phenomenic objects are created and detached from the background. As an effect of constancy processes, these objects are placed in 3D space, chromatic contrasts and assimilation take place, movement is detected, and so on. This representation also comprises relational information concerning the location of objects in space. This location is defined both in absolute terms, in that objects are observed with reference to horizontal and

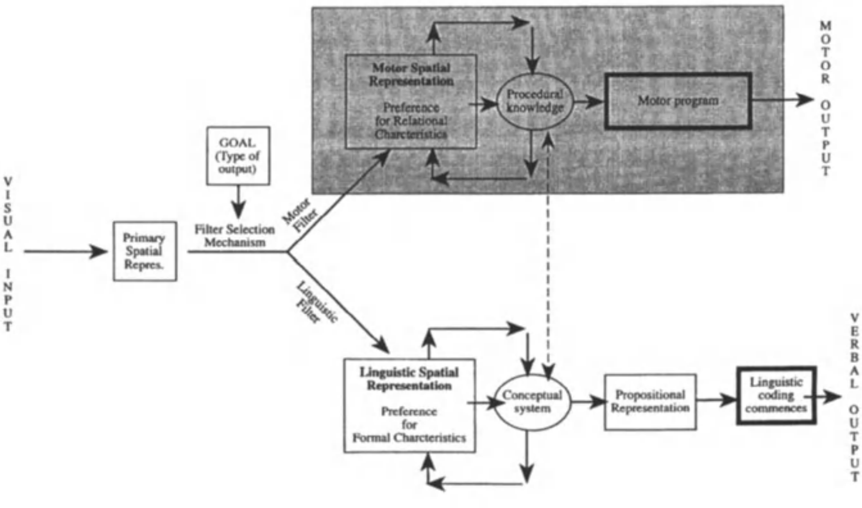

Figure 2. A model of verbal description of usual information

vertical axes, and in relative terms, in that objects are located in relation to the other objects and the observer.

The Primary Representation is densely rich with information which is only briefly accessible to awareness, and constantly changing. Consider for instance what happens when we observe the surrounding environment while taking a walk or while sitting in an armchair and looking around: our attention wanders, but all the information is available should we want to focus on a particular aspect of the environment. The Primary Spatial Representation also comes about when a goal is present in the observer before s/he perceives the visual stimulus. The primary perceptual elaboration is always automatically and autonomously activated and cannot be by-passed. Even when the observer is aware of the goal that s/he wants to achieve from the very beginning, the Primary Spatial Representation takes place: low level perceptual analysis of the environment is always necessary before the observer passes to more intentional analysis of the available information.

This representation comprises all the information that we are able to gather on both the 'What' and the 'Where', but none of it has privileged status as if it were awaiting an intention or a goal to be attained – be it a motor action, a verbal utterance, or some other act. It contains all the information necessary for subsequent activities because it must furnish sensorial information to the cognitive system and the other systems involved in some kind of output production.

The Primary Spatial Representation is the result of automatic processes, presumably modular and therefore involuntary, which precede the activation of both procedural and descriptive knowledge.

4.2. The filter

When an individual has a goal to achieve, or when some aspect of the environment captures her/his interest, the processing is oriented by this purpose. This phase is voluntarily activated and may therefore be controlled by a central processing system. The goal determines the choice of the type of output to be activated, which may be, for instance, motor or linguistic.

The type of output chosen automatically triggers the selection of a filter which varies according to the type of output. As Figure 2 shows, this filter can only operate on the basis of a pre-existing representation. It determines which aspects of the Primary Spatial Representation qualify for inclusion in conscious deliberation. In fact, from all the information contained in the Primary representation, it selects the items that will be processed further, and decides what weight they should have, and how they should be structured within the Filtered Spatial Representation. Starting from a single Primary Representation, various Filtered Representations can be formed which differ in the type of information that they privilege and in the role that they occupy in the hierarchy of attributes.

The purpose of this filtering process is presumably to economize on cognitive resources, which in this way can best handle the information useful for the intended action, thereby saving resources for a specific and suitable output. Let us consider two possible Filtered Representations, one aimed at a motor response and the other at a linguistic behaviour.

The Motor Spatial Representation – the one in Figure 2 is shaded because it will not be considered, except only incidentally, in the following analysis – must give detailed treatment to the Relational characteristics consisting of specific information about a particular situation, although it cannot ignore the Formal characteristics.

More specifically, when an individual has a motor goal (grasping an object, avoiding an object, placing one object on top of an other, separating two objects, clapping, putting something into his/her mouth or into the mouth of her/his baby, and so on) the relational characteristics cannot be neglected; indeed, they must be processed with great precision. Besides the shape of an object, what must also be detected are its location, its size, its trajectory and speed, its orientation in space, and so on. A perceptual configuration always appears before the observer in a specific and contingent manner. In theory, no action can be repeated in exactly the same way, and it is for this reason that the Relational characteristics are so important for the Filtered Representation attuned to motor action: they must be accurately processed for the action to be successful.

On the other hand, if the output is to be verbal, a linguistic filter is activated which leads to the construction of a Linguistic Representation in which Formal characteristics are privileged. In this case, in fact, the filter must enable recognition of the object so that its essence and its attributes can be predicated. The Linguistic Representation therefore contains precise and accurate information about the object so that it can be compared with previous world knowledge. Among all the characteristics, those crucial for recognition of the object and the category to which it belongs are the Formal ones, mainly shape, colour and material.

5. THE LINGUISTIC SPATIAL REPRESENTATION

The Linguistic Spatial Representation receives perceptual information from the Primary Representation via the filter. This perceptual information is delivered to linguistic modules in a form suited to linguistic coding

There is a path which goes from the recognition of the object to the conceptual category to the labelling: this is the path on which language is based, and it is fixed on the Linguistic Spatial Representation. This interpretation may explain the phenomenon described by Landau and Jackendoff, namely, the accuracy with which language refers to the 'what' and its vagueness in the description of the 'Where'. The linguistic filter focuses on the elements that remain constant in an entity, which are mainly shape, color and material, but it tends to neglect the space-time context or to treat it schematically, because the former are the characteristics that can be projected into the conceptual system.

The information contained in the Linguistic Spatial Representation – mainly the formal characteristics – is compared with the *types* of the conceptual categories. A loop operates between the representation and the conceptual system so that after a series of checks the conceptual category to which the object belongs is recognized.

In this process the representation becomes increasingly precise and suitable for linguistic description. Whereas at the beginning of the process the representation is the product of a filter attuned to the linguistic outcome, at the end it is ready for use by the linguistic system itself.

5.1. The propositional representation

The outcome of the process just described is a representation that can be transformed into a Propositional Representation, or a pre-verbal message. In the course of the process of linguistic description, this phase corresponds to the phenomenological experience of every speaker that s/he is aware of the content of the message that s/he is about to produce. Over this representation the process of linguistic coding is triggered: the linguistic modules are ready to operate.

6. CONCLUSIONS

The hypothesis that differentiates our model most markedly from that proposed by Landau and Jackendoff concerns the origin of the discrepancy between the richness of the language used to refer to objects, and shapes, and its vagueness when it refers to places and spatial relations. In Landau and Jackendoff's model, this discrepancy mirrors the nature and constraints of the Spatial Representation, which is the same for every type of sensorial input. In our model, different Spatial Representations are created on the basis of the desired output so that, for a motor action, a Motor Spatial Representation is built which differs from the one required for verbal behaviour.

This interpretation is supported by neuropsychological evidence that has identified two functionally distinct systems for the processing of spatial information. Ungerleider and Mishkin[37] have developed previous studies by Schneider[38] and carried out various studies of the effects of certain brain lesions on the behaviour of monkeys. Their results show that visual information follows two paths: one (ventral) is involved in object recognition and the other (dorsal) in their location. Physiological differences between spatial and object systems have also been identified in lesioned humans.[39] There is now extensive evidence that there are two visual modes in the normal human brain which follow different rules.[40] Called cognitive and sensorimotor respectively, the former is a symbolic system whose contents are at least partially conscious while the latter is uniquely spatial and generally unconscious.

In a recent study, Humphreys and Riddoch have examined[41] neuropsychological aspects of visual attention by comparing two neurological patients. They propose a synthesis of Ungerleider and Mishkin's and Bridgeman's theories, maintaining that two spatial representations are involved in different behaviours, namely a 'within object spatial coding' and a 'between objects spatial coding', the former operating in object-recognition tasks and the latter in object location. After comparing the performances of the two patients – afflicted by different lesions – Humphreys and Riddoch conclude that 'between objects spatial coding' is presumably connected to the system which controls motor actions. By contrast, 'within objects spatial coding', which focuses on shape, is visual in nature and controls objects recognition.

The results of our experiments support this hypothesis; in particular, experiment 5 shows that the construction of a representation assigned to shape recognition occurs at the early levels of visual processing. On the other hand, we believe that, even though the linguistic and motor systems seemingly utilize different information, they gather it from a common previous coding, which we called the Primary Spatial Representation.

The function of the Primary Spatial Representation is crucial, because it provides the system with all the information necessary to perform intentional actions. In human beings, these actions can be either verbal or motor, or even of other types, for example when visual scanning is performed in order to find an object (one thinks, for instance, of fruit picking). Language is a specific and important ability possessed only by human beings, but the perceptual system developed much earlier in phylogenesis than did language and other symbolic systems. It is important to understand which relations are established between the ability to gather visual information from the environment and the ability to use language in order to refer to what the visual system has received. In theory, two possibilities can be considered:

1. Language has hooked on to perceptual processes which were extremely functional and sophisticated and whose function was to represent the results of perceptual activity symbolically and communicate them to others.
2. Language, as a powerful and pervasive system, has adapted the procedures of the perceptual processing to new cognitive possibilities.

We lean towards the first hypothesis, since it seems to be supported by our experiment, as well as by the research cited earlier. Most of our perceptual experience is not described verbally: perception, in the form of Primary Spatial Representation, is always active. We can refrain from speaking, but we cannot refrain from seeing, hearing, smelling or tasting. Our perceptual world tends to be structured in a complete and meaningful way, even though we do not represent it symbolically.

Perceptual experience, which does not usually need to be verbally coded in order to be experienced, can become the topic of a discourse when we want to speak about what we see. In this case, a filter is activated which selects from the great amount of information encoded in the Primary Spatial Representation the items compatible and suitable for the linguistic coding and which will be assumed within the Linguistic Spatial Representation.

Analysis of the verbal descriptions produced by speakers showed that the scant expressions available to spatial language in order to describe object locations tend to be used sparsely and approximately. It was this finding that induced us to suppose that, in general, the Linguistic Spatial Representation encodes Relational characteristics in a rather rough way, while the Formal characteristics are precisely encoded, the aim being to identify the most appropriate conceptual category with which to define the object or figure.

Is it worthwhile considering why the linguistic system, and consequently the Linguistic Spatial Representation, gives priority to the shape rather than the place of objects. What is the reason for the strong bias of the conceptual system, and of language, towards formal characteristics? It is a bias which operates from the first phases of language acquisition when formal similarity is the main criterion for the generalization of names. Landau, Smith and Jones have evidenced, both in children and in adults, the primary role played by shape in the process of name generalization.[42] The differential characteristics of the stimuli used by Landau, Smith and Jones were shape, size and material of the objects. The only aspect chosen by the subjects, who were as young as three years old, in name generalization was shape. Similar results indicating that shape is the predominant aspect in learning names for novel objects have been obtained by Biederman and by Rosch in classification tasks,[43] and by Au and Markman, by Bornstein, by Clark, by Heibeck and Markman, and by Landau and Stecker in labelling tasks.[44] In this connection, Landau and Jackendoff argue that "children should come to language learning prepared to attend only to certain properties when learning names for objects versus names for places. In particular children should attend to object shape for object count nouns but only sparse elements (or none al all) for place words".[45]

Certain principles underlie the acquisition of nouns: for instance, the principle of the 'entire object' (which states that a new name should be attached to the entire object and not to parts of it or to contextual spatio-temporal elements), or the 'taxonomic principle' (that a name should be generalized to similar objects), to cite only those relevant to the present discussion. What these principles have in common is that they are grounded on the priority of formal characteristics and that they induce the child to neglect contingent and spatio-temporal ones. Take the principle of the entire object, which assumes that a name should preferably refer to discrete entities. The characteristic that most typically defines a discrete entity is its shape – certainly not relational characteristics, which are typically continuous dimensions. Objects are uninterruptedly graduated from nearest to farthest, from biggest to smallest.

There seems to be a determinism in the preference of language for shape rather than for place. In theory, we may think counterfactually of a world knowledge and of a linguistic communication system grounded on relational characteristics. But does not such alternative world knowledge also imply a different world, one in which the structure of objects and of the relations between objects is radically different?

Let us try to imagine this counterfactual world, starting from Gibson's direct perception theory.[46] Gibson argues that the perceptual system has developed in order to respond adequately to both the opportunities and threats present in the ecological niche in which animals live. From this point of view, one might suppose that in a different world our perceptual organization would be different too, and consequently also our categorization system. Envisaging a world in which human beings have developed a categorization system grounded not on formal characteristics but on relational ones, and in particular on those related to object location, entails that objects and events are categorized primarily on the basis of these characteristics. There would be concepts like the 'above(s)', which would define a set comprising all things that are usually above – for example, clouds, roofs, ceilings, tree branches, but also space shuttles, the moon and stars, and so on – and then there would be other categories like the 'below(s)', the 'in front of(s)', the 'on the right of(s)', the 'behind(s)', and also the 'below-on the right-behind(s)', the 'above-two centimetres-detached(s)', and so on. A world thus categorized would be dramatically unstable, since every change of position would change an object's conceptual membership. A world such as this would be very difficult to manage cognitively, for if the observer changed her/his standpoint not all the 'above(s)' would remain above. Every shift in the observer's standpoint, and/or in some object within his/her visual field, would require the revising and up-dating of most of his/her conceptual set-up. Knowledge grounded on object locations would be self-defeating, uneconomical and confusing, unless we imagined a world of a very different nature from the actual one: for instance, a world in which objects and beings undergo constant change which strips them of any formal property, and in which objects and beings are subject to tight locational constraints. This would be a world peopled by flexible and extensible objects assuming different shapes as a consequence of constant, seamless deformation. Objects and living beings would be radically anchored to a single point, which remained fixed and unchangeable in space. Consequently, parts of objects and of living beings would lengthen, widen, extend in all directions, merging with other objects and beings without leaving their anchoring points which coincide with their standpoints. If we were living beings in that world, we would observe it from our immutable standpoints, seeing numerous changeable shapes always anchored in the same place. If we were capable of speaking and able to describe what we see, we would employ a set of cognitive abilities suitable for that environment, such as: a visual range of 360°; the ability to gauge the distance between our anchoring point and every other object precisely; the ability to recognize the anchoring points of self-deforming objects and beings, the ability to discriminate prototypical spatial relationships among places; and so forth. A conceptualization and linguistic communication system like the one used in our actual world would be absolutely inadequate. Concepts and nouns related to formal characteristics would be of minor importance, and they would be impoverished and easily neglected. On the other hand, the linguistic terms used to refer to locations would have to be numerous, articulated, precise, and never neglected in verbal communication. A number of shared conventions in describing both points and directions in space would operate; some privileged positions would have names; suitable words defining peculiar spatial regions would be available; other linguistic devices, now unimaginable, would be available to the speaker, but they would certainly concern both spatial arrangements and locations.

This fictional digression takes us back to consideration of the interface between perceptual organization on the one hand and the conceptualization system – and consequently the referential linguistic system – on the other. In terms of linguistic referentiality, the attribution of names to objects and events depends on the way in which our percepts are constituted. In other words, everything that has perceptual saliency constantly seeks to acquire a name so that it may become a referent of linguistic communication. In our model, the interface between perception and language is constituted by the linguistic filter which produces the Linguistic Spatial Representation. And it must preserve those features of perceptually processed information which can be used by the conceptual system.

These features – which are crucial for the definition of shape or formal characteristics – are *discontinuity* and *stability*. Our perceptual organization is sensitive to the discontinuity present in the environment, particularly as regards the percepts of which we are aware and which may therefore become topics of discourse. Wertheimer's law of formal unification,[47] the figure/background articulation treated by Rubin and Koffka,[48] completions, three-dimensionality, and so on, are all cases in which the perceptual system records discontinuity. Within the continuous stream of perceptual experience figures are separated and identified as discrete entities. If there is no discontinuity, seeing becomes confused – as in the case of Ganzfeld.[49]

The perceptual result is the more evident and recognizable, the more it is separable and distinct from its context. Perceptual processes grasp stability within the continuous variability of the sensorial recordings. As a result of constancy perceptual mechanisms, even though variations in inclination are processed in the proximal stimulus as variation in shape, they are not seen as such; which makes shape one of the most stable components of phenomenic experience. Objects and events can acquire names in so far as they are perceived as stable; the perceptual system is able to provide the conceptual linguistic system with percepts that are discontinuous and stable. In our world, forms constitute that discontinuity which is readily detached from the context to which it belongs and which is perceived as most stable even amid changes and dynamic situations. To conclude, although language is an autonomous processing procedure, it is, in our opinion, closely conditioned by the characteristics of discontinuity and stability that the speaker perceives in the world.

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NOTES

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IVOR GRATTAN-GUINNESS

FORMS IN ALGEBRAS AND THEIR INTERPRETATIONS: SOME HISTORICAL AND PHILOSOPHICAL FEATURES

1. FORMS AND STRUCTURES IN MATHEMATICS

The word 'form' has often been used in mathematics, and still is, in various different contexts. Two relatively technical senses (as opposed to very general or passing uses) are of relevance here, and will be noted later: the content-free form of an algebra, as contrasted with its contentual 'matter' in a particular case; and form as a central feature of a structuralist philosophy of mathematics.

This paper contains examples of forms that have emerged in the historical development of algebras, together with related philosophical remarks. The philosophical issues raised are not only methodological ones; epistemology and ontology are also at hand. 'Form' is distinguished from 'structure' in that the latter is used when no content is assumed in the pertinent theory (and the word 'matter' will not be used). 'Algebras' refers not only to that branch of mathematics which includes roots of equations, groups, and differential operators among its topics but also to *any* branch of mathematics in which some kind of formal(ish) notation plays a major role, especially when different interpretations of the same one are available.

Several examples involve interplay between algebras and geometries. Applications to the physical world also feature, since the ubiquity and variety of forms in mathematics and in science are stressed. Some emphasis is also given to what I call 'structure-similarity', where different theories exhibit similar forms and/or structures (hence 'formal similarity' would be an admissible alternative name). This idea is not new – some mathematicians have made a method out of it, sometimes under the name of 'analogy', and others used it in theories in which forms and/or structures play an important role – but its philosophical potential remains to be explored.[1]

Thus the approach adopted here differs radically from normal philosophical offerings, not only for its serious concern with history but also because the great range and variety of mathematics, pure and applied, is a central guide. A philosophy of *algebras* is attempted, rather than a *philosophy* of some bits of mathematics.

To this ambition must be attached a caution. Mathematics comprises a vast and also varied range of knowledge; so it is impossible for all its numerous

L. Albertazzi (ed.), Shapes of Forms, 177–190.

instances to be captured in some comprehensive way, even when confined to algebras. (In its 1806 pages my encyclopaedia[2] only sketches the history of mathematics from antiquity to around the 1930s.) Hence the following strategy is adopted.

The order of material and examples is roughly chronological. The next section notes some features of the birth of common algebra out of arithmetic and geometry in the seventeenth and early eighteenth centuries. The third section takes two particular forms, the linear and the quadratic, which feature in several algebras and their interpretations from early on. The fourth section presents a few algebras which do not take arithmetical or geometric magnitudes as their objects; their popularity dates from the early nineteenth century. The fifth one goes to the late part of the century in its focus on abstract algebras and category theory.

The last section relates to the second sense of 'algebra' mentioned above: signs and symbols rather than the branch of mathematics. The especially studied is that of the basic notations in Leibniz's version of the differential and integral calculus, which have been given quite various readings as the theory has developed in different ways.

General histories of algebra (see Van der Waerden 1985 and Scholz 1990) sadly pass over the newish algebras of section 4. My encyclopaedia is more broad-minded; Part 6 is devoted to algebras, and other kinds of algebra (such as those just mentioned) appear elsewhere, especially in Parts 2, 4, 5 and 7.

2. THE ORIGINS OF COMMON ALGEBRA IN GEOMETRY

Common algebra is not one of the ancient branches of mathematics; supposed historical readings which project it back into the remote past are grotesque anachronisms.[3] It developed rather slowly in Western Europe in the second half of the 16th century. The chief single motivation was the resolution of equations; the main contexts were properties of arithmetic, and especially the expression and solution of problems in the Euclidean geometry of plane and space; the principal mystery was the status of complex numbers.[4]

A major epistemological and ontological difficulty for the early algebraists was the status of negative numbers. They seem to be naturally interpretable in terms both of geometry (as line segments directed oppositely to positive numbers) and from arithmetic (as financial debts – possibly one source of the minus sign in Mediterranean commerce). Yet they earned many pejoratives over the centuries: 'false', 'impossible', 'chimerical', and so on.

One consequence of this dislike was a proliferation of forms. For example, the following two equations

$$7 - 4 = 3 \text{ and } 4 - 7 = -3$$

were regarded by critics as different in form, in that only the first one was legitimate. Again, a method of solving polynomial equations would have to be modified to cover all the various forms required by having all the coefficients positive before their roots (positive or impossible) could be calculated. Thus for example,

$$x^3 = ax + b, x^3 + ax = b, \ldots, a, b, c, \text{positive}$$

were different forms. They were merged when negative numbers gained a better audience during the eighteenth century, with only one general method of solution.

The connections with geometry provide several interesting examples of the place of form. One of these is reading a geometrical diagram: one cannot tell merely by looking at it which lines/areas/... are constant at known values, which are constant but with unknown values, and which are variable. In algebra these distinctions can be registered, by using different letters: the definitive distinction was made by René Descartes in the 1630s, with $a, b, \ldots$ as constants, and $x, y, \ldots$ as unknowns or variables. Then different forms can be clearly distinguished.

But a related puzzle remains; the frequent impossibility of interpreting geometrically *every* solution to a polynomial equation which has been constructed to solve the geometrical problem in the first place. This issue involves clashes of forms in a very striking way; it also has many fruitful educational implications.[5]

Another issue was the difficulty to express powers beyond the third, because of the fact that parent geometry referred to space, which had only three dimensions. François Viète shows the quandary very clearly; for him unknown magnitudes of the (for example) fifth power were of degree 'plano-solidum' and known ones 'quadrato-cubus'. From Descartes on freedom was asserted; x^4 (sometimes 'xxxx') was on a par with x^2. However, the word 'power' ('*potentia*') was still usually restricted to the second degree. For example, following Viète, the special term 'potest' meant 'equal in power': 'a potest b et c' stood for

$$a^2 = b^2 + c^2.$$

Phrases like 'of the third (fourth, ...) power' became current only in the later eighteenth century.

The final and most puzzling issue is a matter of logic, or at least of proof method. It led to very unfortunate consequences for relating forms in algebra to those in geometry. Greek mathematics and its practitioners were well aware, especially since Pappus's emphasis, of the distinction between two kinds of proof: 'analytic', where the theorem to be proved is assumed, and permitted lines of reasoning are deployed in order to arrive at axioms or at results already known; and the converse, 'synthetic' route, where such axioms and results are the starting points and the theorem is obtained as the *last* line of the proof.

From the origins of algebra (Viète is a strident figure here) algebra was associated with the analytic proof method and geometry with the synthetic. I cannot see the closeness of these links even for that time, and they became steadily looser as each branch of mathematics developed.

By the late eighteenth century we have, for example, the treatise by J.L. Lagrange called *Méchanique analitique* (1788); it is actually an *algebraization* of mechanics in which the proofs are *synthetic* (that is, from basic principles to the theorems required). Conversely, the algebraization of geometry which Descartes had launched was then becoming the subject known (and reasonably so) as 'analytic geometry', even with textbooks written under that name![6] This double muddle affects understanding of the study of forms in both algebra and geometry, since its suggest links which often do (or did) not obtain. Indeed, by Lagrange's time both geometry and especially algebra had developed other kinds of forms, as we now note.

Two ubiquitous algebraic forms are worth discussing both for their intrinsic importance in mathematics and as illustrative case studies of the philosophical questions at hand: the *linear combination* (LC) and *quadratic form* (QF). I write them respectively as

$$\mathrm{LC} := \mathrm{ax} + \mathrm{by} + \mathrm{cz} + \ldots (= \mathrm{d}) \text{ and } \mathrm{QF} := \mathrm{AX}^2 + \mathrm{BXY} + \mathrm{CY}^2 + \ldots (= \mathrm{D})$$

Several preliminary points need to be explained.

Firstly, my use of small case letters for LC and upper case for QF is merely a matter of convenience or for reference purposes; the point is that in both cases an algebra *of some kind* is involved, in which operations of addition and multiplication are defined, and normally (though not necessarily) the letters at the beginning of the alphabet are known constants while those at the end are either variables or unknown constants. Secondly, the ellipsis dots cover both a finite and an infinite sum of terms. Thirdly, the sum is conceived algebraically, in that a negative terms may be admitted in a given case; however, the multiplication does not normally accommodate division. Fourthly, the term at the end is bracketed to allow each case to cover both an *expression* of the form involved and also an *equation* which admits a relation with properties like those of the traditional equality (equivalence, for example).

It was not easy to choose a general name for LC, since in its various manifestations it has taken different names (or no special one at all). In traditional examples from analytic geometry it gave the equation of a (hyper)-plane, with common algebra as the underlying theory. In statics it provided a powerful way to express moments and determine the centre of inertia of a body or system. But examples multiplied (as we put it, rather curiously) in the nineteenth century.

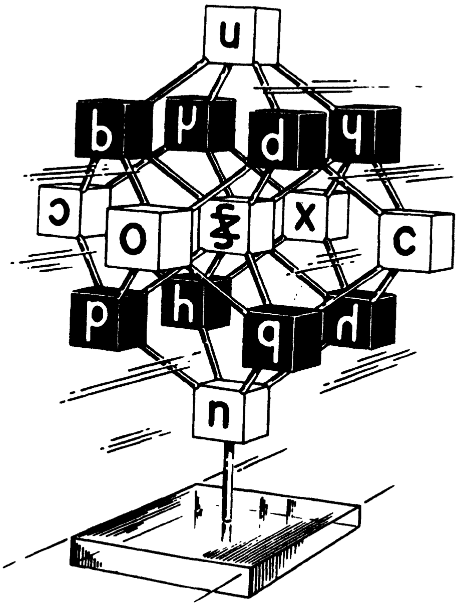
The common algebra of complex numbers was extended in the 1840s to the quaternions of W.R. Hamilton, and later more generally still to hypercomplex numbers, where a,b, ... formed a basis of assumed units which was closed under multiplication.[7] Partly in common was the 'calculus of extension' of Hermann Grassmann (1844), a remarkable algebraic way of describing geometric objects of very many kinds which is still finding new interpretations.[8] Both his theory and quaternions were finally eclipsed early in this century by the growth of vector algebra and vector analysis, in which LC is the fundamental form.[9] Linear algebra drew heavily on LC; not only for such combinations of matrices themselves but also for the formula to define the product element d of two matrices with row $(a, b, \ldots)$ in the first and column $(x, y, \ldots)$ in the second.

The place of form as a general mathematical category was made quite explicit by Grassmann's brother Robert in a suite of five little books called *Die Formenlehre oder Mathematik* (1872). In this remarkable work, which has gained neither the influence nor even the attention that it deserves, he went even beyond Hermann in generality and in the use of LC. For him *Formenlehre* laid out the laws of 'strong scientific thought' of '*Grösen*' (*sic*, from the word for 'shine') denoting any 'object of thought'; each could be composed as a sum of basic '*Stifte*' ('pegs') e (that is, LC with all coefficients unit). He admitted, Hermann-style, two means of 'connection' between *Stifte*, 'inner' and 'outer', symbolized by '+' and '×', but then went further by defining four special kinds of *Formenlehre*, of which Hermann's calculus of extension ('*Ausdehnungslehre*') was only an example of the last. The members of the quartet were distinguished by the basic laws which their *Stifte* obeyed, under suitable interpretations in each case of these *Stifte* and of their means of connection:

'*Begriffslehre*' or logic:	$e + e = e, e \times e = e$
'*Bindelehre*' or the theory of combinations:	$e + e = e, e \times e \neq e$
'*Zahlenlehre*' or arithmetic:	$e + e \neq e, e \times e = e$
'*Ausenlehre*' (also *sic*) or exterior objects:	$e + e \neq e, e \times e \neq e$

A quite different use of LC, contemporaneous with Hermann Grassmann and to which Robert surprisingly was to make no reference, accompanied George Boole's algebraization of logic in the 1840s. He required his logical notions to obey certain basic laws (described in the next section); then he wrote down the logical premises in an algebraic form of his devising in terms of logical concepts (which may be taken as classes here), and solved them for one (d, say) as subject. This gave him an equation in exactly the (finite) form of LC; moreover, the means of derivation were supplied by his 'expansion theorems', again of the form of LC but this time with d serving as the logical function $f(x)$ of some concept x and expanded in terms of base "vectors": in the case of two concepts x and y, they are $xy, x(1-y), (1-x)y$, and $(1-x)(1-y)$. The versatility of the LC form was not lost upon Boole's successors; C. S. Peirce explicitly noticed that it was also used in matrix multiplication.

From the 1870s, Peirce and his German contemporary Ernst Schröder went further in this algebraic way of working. Schröder recognized the power of duality (a meta-form in our terms); for example, to a theorem about universal quantification and conjunction there corresponded a dual theorem about existential quantification and disjunction, and he printed them side by side in parallel columns. Peirce noted dual pairs of connectives and advocated to a novel degree the use of dual pair of signs in logic. This idea was one of his contributions to semiotics (indeed, the renaissance of the word in English is much due to him, around 1900); it has been extended in meta-theories of signs in semiotic families.[10]



An important example of LC in mathematical analysis is Fourier series, especially in Fourier's advocacy from 1807 onwards.[11] Here x, y... are trigonometric functions and the series is infinite (its convergence to the function d is not an issue here); later this became generalized in functional analysis to any set of functions $\{f_r(p)\}$ which, like the trigonometric ones, are orthogonal over some interval of values of p. The word 'orthogonal' was used in imitation of its role in linear algebra, where LC is the expression of a vector in terms of a finite basis (whether orthogonal or not).

QF has also shown a wide range of interpretations. The classical one was of the conic sections in analytic geometry, where certain special cases gave the equations of ellipse, circle and hyperbola (and in the degenerate case, two straight lines); the full QF gave a means to analyse and classify the principal second-order curves and (hyper)surfaces. We noted earlier the use of *potest* for equality in power.

Like LC, QF was also used in other areas of mathematics, especially from the early nineteenth century onwards. For example, mathematical statistics became much concerned with the use of the method of least squares, where QF was taken as a function of several variables, and those values which gave it a minimum value (if any) were sought and analysed.

One minor student of the method was A.L. Cauchy. His work of the 1820s is a remarkable example of the ubiquity of QF; in addition to an extensive account of surfaces in his textbook on analytic geometry, he used the Cauchy-Schwarz inequality (as we now call it) in his version of mathematical analysis based upon limits (see section 6), and ways of solving ordinary and partial second-order differential equations by writing the differential expression as a QF and finding Fourier integral solutions in which the kernel took the same form. He also noticed that elementary mechanics could benefit from the form: theorems about the kinetic energy of a system of mass-points, and about the products and moments of inertia of a continuous body, with beautiful modifications made for use in the linear elasticity theory of his invention. One of the chief questions was the conversion of QF into a sum of squares; and in a marvellous foray of 1829 he found a general means of doing so by inventing most of the basic components of the spectral theory of matrices.[12] Unfortunately he did not recognize the significance of his achievements; otherwise both QF and LC would have risen much more rapidly as central forms in mathematics, and linear algebra with them.

3. ALGEBRAS BEYOND MAGNITUDES

When Boole laid out his algebra of logic, he had in mind a close analogy with a newish algebra of his time: differential operators, in which the process of differentiating a function $f(x)$ with respect to x was interpreted as the operator d/dx, or D, on f to produce the derivative $f'(x)$, or $Df(x)$. An algebra of these Ds had already been developed, in which analogies with common algebra were deployed: for example, integration was taken as the *algebraically* inverse operator to differentiation, written 'D^{-1}', and it was manipulated as if it were an ordinary magnitude. This was magic algebra, in that the results obtained could often be justified by more orthodox means; however, the algebra was not completely reliable, and Boole had sought foundations for the theory by focusing upon three basic properties of functions u and v of D operating upon $f(x)$ and $g(x)$:

commutativity: $uvf(x) = vuf(x)$;
(the LC-based) distributivity: $u(f(x) + g(x)) = uf(x) + ug(x)$;
the 'index law' (his name): $u^m u^n f(x) = u^{m+n} f(x)$, m and n positive integers.

Boole's algebra of logic satisfied also the first two laws, but the different 'index law'

$$x^2 = x \text{ (with corollaries } (1 - x) = 0 \text{ and } x + (1 - x) = 1);$$

because of this law logic departed from other known algebras.[13]

The names 'commutativity' and 'distributivity', and the corresponding notions, had been introduced in 1814 by F.J. Servois, partly with regard to differential operators but principally in connection with another newish algebra of the time: functional equations, where functions themselves were the objects whose values satisfying conditions given by the equation were sought. Servois regarded commutativity and distributivity as principal properties: respectively,

$$f(g(x)) = g(f(x)) \text{ and } f(x + y + \ldots) = f(x) + f(y) + \ldots.$$

Often these equations themselves exhibited LC or QF in some way; for example, in

$$f(x + y) = f(x) + f(y) \text{ or } f(x + y) = f(x)f(y).$$

Another powerful form-al link between algebra and logic was forged by Augustus De Morgan. (His principal mathematical interest lay in algebras, including a last stand against the negative numbers.) One of his valuable contributions to the algebraization of traditional Aristotelian logic was to introduce (in 1860) the logic of relations.[14] Now major properties such as commutativity and distributivity, and also compounding relations and the existence (or not) of inverse(s), were already important in functional equations of which he had written the first general survey in 1836.

4. ALGEBRAS WITHOUT INTERPRETATION

Among other examples of LC, a striking case was used by Henri Poincaré in 1895, when he founded algebraic topology.[15] Taking a 'variety' V to be a general manifold in roughly Riemann's sense of the term, he deployed LC to state that its decomposition into an integral number (positive or negative according to a certain definition of orientation) of varieties of lower dimensions. This time the relation was completed by '~ 0', meaning 'slightly different' within a conception of continuous deformation of a variety, and '0' was the topologically simplest element (the so-called 'zero-cycle').

Poincaré outlined his brilliant ideas in his usual suggestive way; the more refined version produced by his successors used abstract algebras such as groups and fields (for example, Max Dehn in 1907 on homotopy, and Heinrich Tietze a year later on the decomposition of homologies).

These kinds of algebra are structures obeying laws in which *no* interpretation is offered of its objects or connectives: these can then be made across all mathematics and its applications, including those such as the roots of equations and rotations in space which had helped the theory to be developed in the first place. Group theory was the first to rise to prominence in this way, from the 1870s onwards.[16] LC found further uses in this connection, in the theory of group characters and group representations. In the early years of this century, other abstract algebras rose to join them, especially fields and also rings and integral domains; they assumed two operators and gave LC a fundamental role. Each algebra comprises a collection of structures, each one containing structural features of its own (for example, groups including subgroups of certain kinds). In the 1900s these internally structural features were stressed by figures such as Joseph Wedderburn.[17]

In addition, lattices were proposed, and thought by some to provide a general or universal algebra of which the other algebras would be special cases.[18] Such ambitions have not been realised; perhaps the most fruitful development of this kind to date has been category theory.[19] Born in the 1940s out of the next stage of the topological enterprise which Poincaré had launched (namely, the axiomatisation of homological and cohomological groups of topological spaces), it provides a powerful structural theory of algebras. A category C consists of objects A, B, ... and relations ('arrows') f, g, ... between objects such that the associative law is obeyed, and an identity relation 1 obtains; that is,

$$h \cdot (g \cdot f) = (h \cdot g) \cdot f \text{ and } f \cdot 1 = 1 \cdot f = f.$$

Examples include not only topological ones (continuous mappings between spaces) but also homomorphisms of groups, functional mappings between sets, and so on. Categories have functorial relations F, G... between them, which send objects to objects and arrows to arrows in ways which preserve compounding and identities:

$$F(g \cdot f) = (Fg) \cdot (Ff) \text{ and } F1 = 1$$

(for the respective identities of range and domain of F, which themselves are also preserved). Structure-similarity is deployed in a wide range of contexts.

The desire to axiomatize theories, which developed in the late nineteenth century, was not confined to abstract algebras: Euclidean and non-Euclidean geometries also played a prominent role.[20] The approach of putting forward an axiom system and then seeking interpretations of it led to a new twist in the history of forms in mathematics: model theory. It is no coincidence that its pioneers, Americans such as E.V. Huntington and Oswald Veblen, were inspired to their innovations ('categoricity' is Veblen's word) by David Hilbert's 1899 axiomatization of Euclidean geometry.[21]

The mathematician who pushed LC and QF to the limits of his time, as it were, was Veblen's doctoral supervisor E.H. Moore (1862–1932). He elevated his study into a topic which he called 'General analysis', choosing his name in imitation of Georg Cantor's phrase 'general set theory'. His governing methodological principle stated that: "The existence of analogies between central features of various theories implies the existence of a general theory which underlies the particular theories and unifies them with respect to those central features".[22] He had within his sights not only the various algebras discussed earlier but also linear differential and especially integral equations, and associated theories such as infinite matrices, as inspired by recent work of Hilbert. He also tackled the summation of non-denumerably infinite series. He formulated his theory in a formal style, not only deploying Cantorian set theory but also using and adapting Peano's logical symbolism. Although he devoted much time to these efforts,[23] in the end he published little. He seems to have envisioned the general theory as some union of its inspiring component theories, but often he had to work only with their modest intersection, often composed largely of the forms LC and QF themselves. Apart from a few devoted followers his movement died with him; but his effort marked the climax of a long tradition of linear algebrisation of mathematics.

5. ALGEBRAS AND FORMS

Generality can be approached in various ways. A most remarkable but neglected case of the 1880s was partly inspired by another new algebra of that time: graph theory, graphs and combinatorics, as launched by Arthur Cayley and J.J. Sylvester in the 1870s. They were the welcoming but not fully understanding referees of a long paper 'On mathematical form' submitted to the Royal Society by Alfred Bray Kempe (1849–1922), a highly talented mathematician who pursued his career as a lawyer.[24] Seeking "the necessary matter of exact or mathematical thought from the accidental clothing – geometrical, algebraical, logical, etc.", Kempe found it in "collections of units", which "come under consideration in a variety of garbs – as material objects, intervals or periods of time, processes of thought, points, lines, statements, relationships, arrangements, algebraical expressions, operators, operations, etc., etc., occupy various positions, and are otherwise variously circumstanced". Form, his key concept, was predicated of a collection "due (1) to the number of its component units, and (2) to the way in which the distinguished and undistinguished units, pairs, triads, etc., are distributed through the collection". His main advance over all predecessors with part-whole or Cantorian set theories of collections of things was that *he allowed that units could belong more than once to a collection,* not just single membership. For example (one of his), the shape 'Y' was construed as a collection containing one 'distinguished' central node together with three 'undistinguished' extremal ones. In a later paper reviewing his theory he defined mathematics as "the science by which we investigate those characteristics of any subject-matter of thought which are due to the conception that it consists of a number of differing and non-differing individuals and pluralities".[25]

Despite or maybe because of its novelty, Kempe's work was largely overlooked by mathematicians;[26] his theory has been re-invented in recent years, under the name 'multisets', without knowledge of his priority. But he gained a quick reaction from C.S. Peirce: comments at once on a part of the theory called 'aspects', and a much more radical effort on 15 January 1889 when, presumably from looking at the various graphs in the original paper, Peirce suddenly conceived of a similar manner of representing the syntax of well-formed English sentences in a theory which he came to call 'existential graphs'.[27] This insight, quite foreign to Kempe's own purposes, became a major concern of Peirce for many years (and a marked change from the algebraic logic noted in section 2), and the recent recognition of its importance has made him a darling of the artificially intelligent.

The general role given to form has helped to inspire some structuralist philosophies of mathematics, in which structure alone (in our terms, forms without content) play some kind of central role.[28] However, such philosophies can be rather sterile (in the hands of the Bourbakists, for example); structure is necessary but not sufficient for a philosophy of mathematics, for we need also *content* for mathematical theorizing. This distinction was expressed by De Morgan and others of his time in terms of 'form' *vis-à-vis* 'matter', and the content-free approach to algebras was explicitly rejected. Even in the modern structural philosophy of Saunders Mac Lane (one of the founders of category theory), although many nice examples of 'form and function'[29] are indicated and described (with category theory as only one case), many other philosophical features of mathematical theorising are passed over. Far more forms are involved in mathematics in general; and the philosophical issues, especially in applications, go beyond algebra and structure, and reach form. Here is one example, in which notation plays a major role.

6. SIGNS AND THEIR SENSES

'D' is an example of my second sense of algebra mentioned in section 1: a notation with varying readings in the development of the calculus.[30] 'dy/dx' has suffered a complicated career, often misunderstood and mis-represented. When Leibniz invented this notation in the 1670s, it meant literally what it said: the infinitesimally small forward increment dy on the variable y divided by the companion increment dx on x. However, one did have to stomach the uncomfortable idea that such quantities or variables as dy and dx could exist in the first place.

Lagrange offered an alternative approach, which gained general attention around 1800. A companion to his algebraization of mechanics mentioned in section 2, it sought purely algebraic foundations for the calculus in the use of the Taylor-series expansion. In laying out these principles, he avoided the Leibnizian notation altogether; his 'derived' function $f'(x)$ was to be understood as the operation '$'$' of differentiating f to produce f', and the theory of Ds which Boole was to like so much was a later extension of the same approach.

But when Cauchy gave limits a central place in mathematical analysis, a further new interpretation was introduced. He wrote both '$f'(x)$' and 'dy/dx', but in both cases they were to be understood as *integrated symbols*, and the latter neither as a D-style operator nor as a Leibnizian ratio. While his approach undoubtedly raised the level of rigour in the calculus in various ways (which are not at issue here), the notations certainly suffered; teachers of this approach today know very well the students' perplexity at being prohibited from deducing

$$dy/dx \ . \ dx = dy,$$

or at least not reading it in the obvious way which made the original theory so powerful in Leibniz's hands. And the issue is not restricted to educational contexts; Leibniz's original conception as a ratio is often the most useful in applications, for it responds most readily to the geometry of a given case.

The same notation is being forced to cover too many different forms in the same contexts here. A similar difficulty attends '$\int f(x)dx$'. For Leibniz it means how it reads: an LC of the quantities $f(x)$ and dx summed ('$\int$' as an 's' for 'summa') infinitesimally over some range R of values of x. In Lagrange, '$\int$' is the operator inverse to '$'$'. With Cauchy the integral is again a sum, but now defined as the limiting value (if it exists) of any sequence of *finite* sums of the form $(\Sigma_r f(x_r)\Delta x_r)$ across R; once again there are educational penalties, such as not interpreting the rule for changing variables,

$$\int f(x)\,dx = \int f(g(y))\,dx/dy\,dy \text{ when } x = g(y),$$

in Leibniz's natural way of cancelling.

These examples lead to a wide range of problems of interpretation of mathematical symbols, with or without special reference to an algebra. From simple yet ubiquitous situations such as this, the range of forms of mathematics increase, and their relationships grow ever more complicated, requiring indeed algebraic and metamathematical study of their own. In such ways the philosophy of forms extends beyond structure and algebras to notations, and beyond the algebraic branch of mathematics to all its parts. A grand philosophy of mathematics of forms (and structures) to cover the range and variety has never been attempted; it would be worth the effort.

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NOTES

[1] Attempts are made in Grattan-Guinness 1992; 1993.
[2] Grattan-Guinness 1994.
[3] Cf. Unguru 1977.
[4] Klein 1968.
[5] Cf. Cournot 1847.
[6] Cf. Boyer 1956.
[7] Cf. Hawkins 1972.
[8] Cf. Zaddach 1994.
[9] Cf. Crowe 1967.
[10] See Zellweger 1982, from which the figure of families of logical connectives is taken.
[11] Cf. Grattan-Guinness, Ravetz 1972.
[12] Cf. Hawkins 1975.
[13] Panteki 1992.
[14] Cf. Merrill 1990.
[15] Cf. Bollinger 1972.
[16] Cf. Wussing 1984.
[17] Cf. Parshall 1985.
[18] Cf. Mehrtens 1979.
[19] Cf. Bucur and Deleanu 1968.
[20] Cf. Cavaillès 1938.
[21] Cf. Scanlan 1991.
[22] Moore 1910, 1.
[23] Evidence of Moore's efforts are to be found in his *Nachlass,* kept in the Special Collections section of the Regenstein Library of the University of Chicago; see especially the lecture course notes in boxes 5 and 6, and the materials in most of the unprocessed boxes 8–19.
[24] Kempe 1886.
[25] Kempe 1894.
[26] Cf. Vercelloni 1988, ch. 1.
[27] Cf. Roberts 1973.
[28] Cf. Vercelloni 1988, chs. 2–4.
[29] Mac Lane 1986.
[30] Cf. Grattan-Guinness 1987.

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ALBERTO PERUZZI

AN ESSAY ON THE NOTION OF SCHEMA

"We must look for the roots of basic linguistic structures in the relations between the active subject and reality, and not in the mind itself."

A.R. Luria

1. *IN MEDIAS RES*

The time is ripe for simplifying the theory of meaning. This simplification is made possible by introducing a more articulated view of the way intuitive meanings can generate highly complex semantic architecture, as displayed by the expressive resources of natural language.

We have long been told that being a member of a given kind means satisfying the criterion which defines the kind, and that the formulation of such a criterion is essentially a matter of logic. Research in cognitive psychology has provided evidence that (i) most kinds ('categories') are not defined by necessary and sufficient conditions, and (ii) the factors affecting differences in centrality for various members of the same kind are characteristically related to perceptual structures, which also work as support for a pervasive process of metaphorization.

Whereas some researchers have been led to infer from this that any sort of objectivity is culture-relative, I intend to present arguments pointing to the opposite conclusion. Indeed, the presumed universality achieved in semantics by analytic philosophers (through logical syntax and model-theory, applied to natural language) has been shown to be the product of a superimposed formalism. Yet, it should not be replaced by a total renunciation of the attempt to understand and mathematically describe the natural constraints on meaning structures as manifested in natural language, and specifically the constraints on metaphorical patterns. Appreciation of the cognitive role of metaphors does not entail that any content of thought can be taken as metaphorical under a suitably chosen 'cultural' viewpoint. My aim is also to argue that 'direct meaning' makes sense, and the ground for such a claim relies mainly on the recognition that there are basic, schematic patterns of meaning, rooted in perception (and, prominently, on proprioception) of geometric and dynamic relationships.

On the other hand, objectivism becomes an easy target if it is burdened with the whole battery of assumptions typical of naive realism. The very range of

L. Albertazzi (ed.), Shapes of Forms, 191–243.

alternative conceptual systems exemplified in different cultures (or across the historical changes of one and the same culture) is properly evaluated only if framed in a variational perspective: in the end, it is the set of our common kinaesthetic resources that allow us to determine *any* difference between two contents of thought. The deeper the differences among conceptual systems, the deeper the invariants needed for us to understand them as 'conceptual systems'.

For the same reason, any easy transfer of the moral drawn from the so-called theory-ladeness of observational data is unwarranted. What is at stake is something other than a set of neutral criteria of rationality in judging highly sophisticated matters of modern physics or in weighing the evidence for or against any hypothesis, in isolation from the dimension of *intervening* – as Ian Hacking brilliantly argued. Rather, we must pursue an investigation into the range of basic structures of 'intuition' that make the existence (or inexistence) of such criteria *possible.* If we really think that overcoming the traditional gulf, typical of Western philosophy, between disembodied reason and brute matter is a necessary step towards understanding the concrete roots of meaning, then drawing a substitute gulf between different metaphorical structures will not help.

Research on the extensive phenomenology of metaphor and its bodily grounds led to view the architecture of semantic theory as centered on (1) image schemata and (2) their metaphorical projections.[1] With some provisoes, I shall try to elaborate this view. Under (1), I place dynamic patterns (such as the verticality schema that underlies the selection of an up/down orientation) around which actual experience and imagination are organized. Under (2), I place patterns of meaning projection from one domain to another and ultimately from the Concrete to the Abstract. Consider, for instance, the tacit appeal to an oriented vertical axis involved in sentences like: *prices are going up, hopes fell, turn down the heat.*

My aim is not to provide a systematic description of the collection of schemata, such as that of verticality or other similar ones. By resorting to the tools of category theory, formal treatment of schemata can be introduced, which is consistent with relevant discoveries made by linguists. In fact, it is also *necessary* to do justice to the idea that "concrete *bodily* experience not only constrains the 'input' to the metaphorical projections but also the nature of the projections themselves, that is, the *kinds of mappings* that can occur across domains".[2]

The point is that (1) and (2) can play an explanatory role only if the constraints (exactly in the form of mappings) have objective character grounded in definite regularities of the phenomenological world. In the case of *up* and *down*, it is a *fact* that gravity defines in a unique way the direction of fall. Thus, there is a reason for the metaphorical projection of *up* (instead of *down*) on *more*, as also instanced by *the growth of knowledge in that area of research reached its zenith,* where orientation is embodied in nouns and verbs. The surface of the earth acts as a barrier, so that anything (like a connected body, with fixed side boundaries, or a certain quantity of substance) will reduce its height and thus its size when it collapses down, onto the incompressible ground.

Accordingly, the project is twofold: identifying schemata and describing in mathematical terms how they lift to other domains. After the pioneering intuitions of Jeffrey Gruber, the first part of this task has been accomplished by numerous investigations, both theoretical and empirical.[3] The second part has been dealt with by myself in recent papers.[4] Here, my concern will be to provide an analysis, mostly philosophical in character, of the nature of schemata and their organization.

Image schemata are gestaltic patterns intrinsic to bodily movements. By projection, they transfer meaning even to the most abstract domains (such as mathematics and philosophy). This transfer is possible because such patterns have the capacity to support imagination (through typical figurative representations of bodily structures).

As Gestalt theory was mainly devoted to patterns of 'object', so schema theory is devoted to patterns of interaction. The two are more than complementary: each co-penetrates the other as the level of semantic complexity proper of natural language is reached. We must focus on cohesive forms of experience if we are to understand cognition in a deeper sense too. The reason is that location and motion schemata lend themselves to be transformed and projected into domains of objects disentangled from almost any principle governing the modalities by which perception of objects occurs.

The crucial problem comes to this, namely giving a model for the projection of schematic organization to the most diverse domains of cognition, in such a way as to ground the meaning of any sentence expressible in any given language (be it 'natural' or formalized). In this approach, rationality turns out to consist in a grand transfer of meaning from a small base of generating figurative structures (of spatial objects and selected kinds of actions), suitably disentangled and recombined, covering the whole of cognition. An essential stage in such transfer is the formation (and lexical expression) of abstracts – that is, objectification of qualities and actions themselves (from *the boy kicked the white ball* to *the colour of the ball* and *the kick given by the boy*) that can thus be quantified over, as in *there is something the boy did to the ball.*

Some qualifications are needed, for the term 'schema' has been used by various researchers in different senses, although all are similar to that given here. According to Rumelhart a schema is intended to characterize certain propositional models in terms of a pattern linking different nodes (standing for categories);[5] hence, even independently of the peculiar methodological features of his connectionistic approach, schema theory would appear to be one variant of conceptual role theories. My view is different because schema theory is compositional and generative, leaving open the question whether the (sub)symbolic procedural architecture underlying schema fixation is connectionistic or not.

Nor does a schema coincide with any particular mental image, for it lacks the content saturation of images. *Et pour cause*: the schema of being *in* applies to ball/basket as to fish/sea, and so on. Kant addressed essentially the same point in discussing the so-called 'triangle-in-general'. The schema of a triangle is activated whenever a particular triangle is imagined or actually presented to our senses. Analogously, the full image of a body has definite texture, colour and size, while its schema is a skeletal support for such features. Nonetheless, a rich amount of information is already couched in the schema. For instance, think of a closed loop in 3-space and its 'cylindrified' version (a torus).

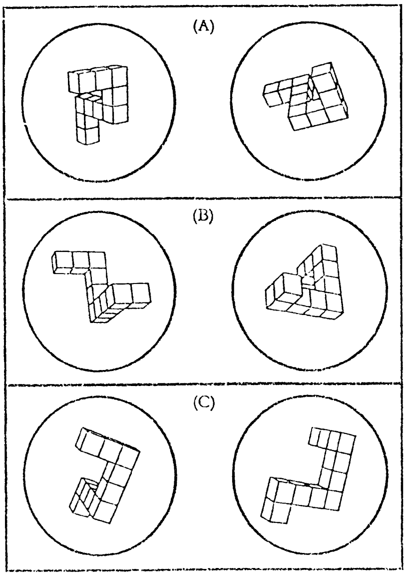
S_1 $S_1 \times S_1$

Important properties of triangulated surfaces can be captured by their plane unfolding – as shown in the standard proof of Euler's Theorem. Physical bodies interact through surface contact and we grasp any 3D image by taking account of mutual relationships among surfaces. Were it not for the informational richness of these facts, it would be impossible to account for the effectiveness of plane geometry and of functions of only one variable in calculus.

In addition, any schema involves space, but spatial abilities are not necessarily confined to vision. Blind people are capable of detecting shapes and forming elaborated charts of their environment. And one may generalize: the relevant schemata are active independently of impedements affecting any particular sensory channel. Kinaesthetic resources, like those concerning movement and orientation, can recur across modules.

After all, we are accustomed to representing weights of bodies **B** by a scalar measure (length), even though the full sensory experience of weight involves dynamic aspects that are not coded by the map w: $\mathbf{B} \rightarrow \mathbf{R}^+$. And we can perform spatial transformations on mental images of bodies never seen before. The by now classical experiments of Shepard and Metzler concerned rotations of oriented shapes and suggested an *analogical* change of imaginative representation, in scanning the intermediate stages of of rotation.

In fact, it is possible to test our ability to follow the continuous trajectory of a moving body in the imagination, as well to focus on its selected positions, at starting, intermediate or end points, even though the metrical notion of distance is absent or only comparatively taken into account. (I can ask someone to imagine a car going from the church to the railways station, or stopping after half way, but not at $\sqrt{2}/2$ of the church-station distance.) No such metrical standard is needed to imagine a set of marbles, all packaged in a small volume (involving nearness, adjacency, contact, etc.) and then their radial scattering (direction, size invariance, path), their fusion into one single big



Differently oriented configurations, Shepard, Metzler (1971). Which of (A), (B), (C) contains non-congruent blocks?

marble (topological sum, additivity of size), just as much as one can imagine a crown formed by a chain of Möbius strips cut from one piece of paper. Schemata not only allow one to form a notion of object stability, by means of basic patterns of manifolds and their relationships, but also to transform them in definite ways.

Another reason why image schemata are distinct from mental pictures is that "the latter are influenced by general knowledge in a way that the former are not".[6] This agrees with the hypothesis that schemata are language-independent. The representability of any image schema in linguistic (propositional) form cannot be taken as evidence for the propositional nature of the schema, no more than description of water in the language of chemistry proves that liquidity is a propositional property.

Hence a schema is neither a rule nor an image, but rather a built-in structure, inherent to our bodily interaction with the macrophysical environment. Furthermore, a schema is something other than a way to organize mushy, rough, materials of sensation, and its working is independent of consciousness.

The character of built-in structures pertaining to schemata does not permit us, however, to infer that they cannot be described in propositions. For they obviously are: what else is the present paper doing? The point is somewhat different: the information afforded by vision, kinaesthesis, manipulation, and so on, is a more suitable *source* of understanding than its linguistically mediated re-elaboration. Paradigmatic cases in point are sailor's knots, mental charts of a new place we are in the process of discovering, and routine motor patterns like riding a bicycle or swimming. It is part of the economy of life that all these activities are not guided by step-by-step rules. Try describing the set of movements that each part of a leg must perform (extending muscle fibres, articulating ankle and knee, etc., at more and more detailed levels) in order for a person to make a single step. It is obvious that learning to tie a sailor's knot is achieved by looking at a model and repeating a sequence of continuous motions of the hands, while it would be prohibitive (and less reliable) to achieve such competence through verbal description. After all, we learned to move before we learned to speak, whereas most present robots exploit extremely complex programs and yet their motor performance is still not as fluent and flexible as ours.

As calculus taught us, the continuity of rotations in Shepard and Metzler's experiments can be precisely described, and the involved symmetries of differently oriented bodies can be represented in discrete form (group-theoretically). Moreover, calculus can be arithmetized, and arithmetic as well as algebra can be reconstructed in set-theoretic terms. But this is far from being an explanation of our experience of what a rotating object is, through apprehension or imagination of lines and angles, manifesting invariant properties under any rigid movement. Once again, we can characterize space by number (though there are limitations, as the undecidability of homeomorphism testifies) but it is our intuition of space that grounds the understanding and use of numbers. Suppose you are given any subject-predicate pair in an allegedly atomic sentence, but you are deprived of any appeal to 'spatiality', thus excluding (i) the localization procedures expressed by *in, at*, etc., (ii) the intuitive representation of 'belong', 'possess' etc., (iii) the boundedness of the subject (say, its emerging as Figure against a Background), (iv) the local/global distribution of sensitive qualities and (v) the dynamic sense of action. Then try to explain what predication means! (Note, *en passant*, that presumed counter-examples like *The universe is infinite* and *Three is odd* provide occasions for further refining our thesis: analyse the roots of their intelligibility and inspect the schematic constituents of such analysis . . .).

In a sense, schemata possess the greatest generality that still preserves bodily concreteness. There are at least three considerations that support this claim.

(a) Any schema is relatively flexible: for instance, *go* and *cross* leave the possible ways (trajectory, speed, etc.) of motion indeterminate. *Mutatis mutandis*, the same applies to *open*, *hit*, etc.

(b) Any schema remains as determinate as is needed (going is crisply opposed to staying, crossing to remaining within, . . .); a deep-seated kernel remains under modality variation,[7] while borderline cases can be described only in terms of an already stabilized kinetic competence.

(c) Any schema is composed of a small number of basic constituents: *A* goes from *B* to *C* by means of *D*, the Agent acts on the Patient with a Tool, etc.

For these reasons, schemata become extremely efficient carriers of meaning across domains, condensing into simple geometro-dynamical patterns of interaction an incredible variety of situations which range through physical, biological, psychological, socio-economic and even logical universes of discourse, as illustrated by the following example:

Peter goes from the kitchen to the terrace. His attention alights upon *the fax just received. His mood* passes from *joy* to *sadness. The realization that his decreasing income will* take *him* from *wealth* to *poverty sends him to his lawyer. But once there, a new idea* comes *into his mind. The arguments* put forth *by the lawyer* lead *him to unexpected conclusions.*

On this view, the essence of rationality is something other than symbol-manipulation (say, in conformity with the rules of logic). For the very notion of symbol cannot be formulated or made stable (nor can the associated 'manipulations' be understood) unless there is a previously exercised imaginative capacity for separating objects in space, arranging them in order, identifying their 'parts' and transposing actions performed on them across different contexts. (Recall, for instance, the verbs by which the steps in the 'algebraic' procedure for solving a polynomial equation of degree two was initially taught us in high school!)

Logic can still be said to be the core of rationality, in so far as logic is acknowledged (in a categorical perspective) to be a precise formalization of the algebraic/topological structure inherent in composing actions on arbitrary objects (of assigned categories) in space. For instance, if any action is invertible, the resulting category of objects with actions supports classical logic (provided the category is suitably 'powered'). Logical axioms and rules remain what they are: *pure* principles – that is, independent of 'subjective' biases – but they emerge out of a complex dynamics, both physical and imaginative, and the 'purity' thus achieved is exactly the ground of schematic structures and their composition. If the phenomenological origin of such schemata underlying the form and content of thought is forgotten, we end up with just another form of ontological dualism or cheap, oversimplified, reductionism. And this leaves the foundations of logic and mathematics wrapped in eternally unsolvable riddles.

The ubiquitous activation of *pre*positional structures suggests that grammar (as cognitively real rather than a merely formal system) is closely interwoven with topological organization of perceptual space, without diminishing the autonomy of syntax. The constraints imposed by such organization on the expressive resources of any grammar are mathematically more sophisticated than standard model-theoretic theories of meaning and truth lead us to believe, and at the same time they are more intuitive. The present study is a contribution to making such constraints explicit.

2. ON CATEGORIZATION

According to a classical view, any complex concept can be characterized, by means of definition, in terms of other simpler concepts: the definition provides a necessary and sufficient condition for 'falling under' the concept (say, for being a member of the corresponding set). Thus the meaning of any predicate can be given in the same clear-cut way as we say that a bachelor is an unmarried man, John's mother is the female who gave birth to John, and so on, with additional information about possible ambiguity.

Further investigations into the semantic structure of natural language during the 1970s elucidated the phenomenon of graded membership: a robin is more a bird than a penguin is, a cow is more a mammal than a whale is, and so on.

This phenomenon was modelled by means of fuzzy set theory introduced by Lofti Zadeh. At around the same time, the notion of prototype entered the scene, particularly through the work of Eleanor Rosch (and associates) on *basic-level* kinds. Rosch developed a far-reaching investigation of prototype effects related to scalar judgments of membership in a kind K (some members are better K-examples than others; the examples with top rating are prototypes).

Roger Brown was one of the first to call attention to basic-level categories. Significantly, he noted that "Flowers are marked by sniffing actions, but there are no actions that distinguish one species from another. The first names given to things fall at the level of distinctive action but names go on to code the world at every level; non-linguistic actions do not".[8] No less important is the fact that Brown also tied the child's early categorization (cats, flowers, etc.) to the level of *distinctive* action (scratching/sniffing; pettable/pickable, etc.) whereas "there seem to be no characterizing actions for either superordinate or subordinate categories".[9]

It is at the basic level that overall shape is decisive, becoming an optimal support for memory and imagination; and it is again at the basic level that motor programs are characterized. (This does not prevent experts' groups or whole cultures from occasionally shifting this level through specialized training or under-utilization.)

The salience of basic level categories is ultimately due to a kernel common to all human beings: our built-in systems of perception and motion. Shape is decisive for grasping prototypicality and establishing the degree of similarity with a given prototype. Thus the topological properties of surfaces have primacy in fixing reference and categorizing. Many semantic theories have raised numerous questions that, although subtle and deep-seated, prove to be unsolvable if this primacy is neglected. Which aspects of shape are relevant, in each category, is an empirical problem: it simply cannot be predicted *a priori* in every case. Nonetheless, we can list a set of principles that constrain the possible range of variation, and these principles are already at hand in any textbook of differential topology or algebraic topology. Suppose W is the extension of a given phenomenon in spacetime M, with the relative topology inherited from M. Suppose further that n different quantities q_i, $i \leq n$, are defined on W (like colour, temperature, etc.). A point $w \in W$ is regular if all q_i are continuous at w. Let R be the set of regular points in W. Since R is open (it contains a neighbourhood of each of its points), its complement $W - R = K$, i.e., the set of singularity points, is closed. K codes the qualitative morphology of the phenomenon, intended as the set of its salient discontinuities. Each region of the resulting state space is organized around an attractor. Trajectories over $w \in K$ correspond to instability. This idea, suitably developed, can be applied to a range of linguistic phenomena – suffice it to recall its application to case morphology.[10]

According to schema theory, language is a semantic motor only in the sense that it acts as a meaning multiplier and accelerates semantic *bricolage*, in virtue of syntactic 'manipulation' of symbols. Thus, if there is one autonomous science of language, it deals with syntax: any formalized 'semantics' encountered in books of logic and linguistic theory is just a translation framework between two languages, and in such a context meaning and reference occur in an already transposed (Pickwickian) sense.

In similar fashion, definitions (meaning postulates and their variants) started to be recognized as unable to account for metaphor, as in *the song in your heart* and *the mother of all battles*. In sum, necessary and sufficient criteria for membership came to be seen as an idealized fossil that only a superficial linguistic analysis in terms of classical predicate calculus might still dare to propose – for many linguists that calculus was the same as logic *tout court*. However, doubts have emerged about the ability of fuzzy set theory to provide a suitable formalism for categorization, and even about the consistency of such a theory with the notion of prototype. I shall not enter that debate, merely noting that (i) together with fuzziness, a wide-range phenomenon has progressively come to attention: what George Lakoff called the 'radial structure' of many lexical items in natural language; (ii) much of that debate (and of its present legacy) rested on the assumption that the kinds denoted by nouns are sets of *indefinite* extension. Otherwise, the comprehension principle might be dispensed by enumeration: for every predicate ϕ one could state that $\phi(x)$ *iff* $x = a_1 \vee \ldots \vee x = a_n$. It is the potential reference of predicates that is hard to deal with in (fuzzy or not fuzzy) set theory.

If traditional model theory is taken at face value, the world is described as made up of sets of entities, sets of sets of entities, and so on. As Quine put it in *Ontological Relativity*, "kinds can be seen as sets, determined by their members. It's just that not all sets are kinds".[11] In the first chapter of their treatise, Barwise and Perry presented the programme for a situational semantics by saying: "We begin by pulling out of real situations the basic building blocks of the theory: individuals, properties and relations, and locations ... We then put these pieces back together, using the tools of set theory ... [A situation type is] a partial function from n-ary relations and n individuals to the values 0 ('false') and 1 ('true')".[12] The ensuing heated discussion on situation semantics has apparently failed to realize how problematic such classical set-theoretic assumptions are.

Per Martin-Löf has claimed that to give a set means to give its canonical elements. Accordingly, '$a \in S$' is read as: a is a program the value (output) of which is a canonical element of S. Usually, the name of an individual is nothing but a disguised program (in elliptic form) to identify it (e.g., '*3+5*', 'the black pencil on the desk').

The question is: what are the canonical elements out of which a set is given? If the above reading in terms of programs is accepted, this question essentially means: which programs are canonical? From a constructive point of view, many options can easily be excluded. Thus we cannot say that *any* arbitrary set has its associated canonical procedure, if only because this would presuppose the notion of an arbitrary (though determinate) set as independently graspable. If, on the other hand, we talk primarily of concepts, we can say either that any concept *has* its associated canonical procedure or that each concept *is* such procedure. The latter option leads to various brands of operationalism – each with its own much discussed difficulties. The former requires explanation: how can a concept be separated from the related program (or programs) for identifying its extension?

In the case of the natural-number object **N**, once 0 is given, a canonical procedure is provided by s, the 'successor of' map, so that if x is an element of **N**, $s(x)$ is too. This is all well and good, but for most sets, the situation is far less ideal – at least if the theory we ask for is to be conceptually adequate, instead of being merely a formal exercise. We can frequently give a description of what we mean, although we are apparently unaware of what the involved canonical elements and procedures actually are. In similar cases, Martin-Löf would speak of 'categories', for he considers the power set of **N**, P(**N**) to be a category, not a set.

In his approach, any proposition can be taken as a set by identifying the proposition with the set of its proofs, so that the canonical elements of the proposition are its canonical proofs. Thus one might take the fact that only a few concepts expressed in natural language possess a prototype as evidence for the above technical distinction.

There are two difficulties here: first, this view is 'logical', and it is intended to refer to propositional forms, not to concrete, contentful, propositions; second, the lack of consideration for the dialectics mentioned above boils down to a reformulation of Plato's Problem: how can you try to give a proof if you do not know what to prove?

A different sense can be given to constructive proposals of this sort, and in what follows I shall give some hints as to what this sense might be, testing the effectiveness of a properly 'categorical' approach to the analysis of language. I can already advance one critical consideration, however. Any and all of the previous 'logic-minded' lines of attack are defective in one way or another, but essentially for the same reason: namely, the absolute distinction that they establish between, on the one hand, concepts, procedures and sets, and on the other, the vital experiences of object and action as rooted in bodily patterns.

In fact, as soon as we approach the issue from the perspective of a general morphogenesis of the form *and content* of thought, the situation appears much more articulated: the working of certain procedures on certain given inputs stabilizes into a concept, thanks to certain schemata. The concept turns out to admit other presentations as well, which converge in determining the elements of the set of entities that fall under the concept; but this fact allows conceptual variation, while taking the set as fixed, and so on and on. In order to show this dialectics, however, one has to focus on the range of schemata with which we are endowed; therefore the problem of how a type theory can be developed in such a way as to embody the above 'dialectics' – in greater measure than in most constructive type theories of which I am aware – will remain behind the scenes. Henceforth, the discussion will be largely confined to identification of a number of schemata and to clarification of their status. The reader interested in investigating the detailed impact of these ideas on type-theoretical architecture is referred to more technical works.[13] There are a number of logical issues of prime importance still to be tackled from the perpective of schema theory, so that it can be ascribed full foundational import.

Compare the case of 'radial structure' with the case of natural numbers (generated by one rule recursively applied from zero on), or of any decidable concept[14] for which a criterion given in advance suffices to state membership in the absence of a perceptual prototype – as seems to occur even in the four-part taxonomy used in the Dyirbal culture of Australia reported by R. Dixon in 1982.[15] Fuzziness and radial effects cannot be explained by any extensional analysis of concepts. If any linguistically expressible quotient is finite and ruled by criteria of economy, membership in a kind obviously depends on the overall partition. But reality often manifests itself as richer than any criterion inducing the partition: which not much sanctions holism as calls for examination of the local/global dialectics in the presence of procedures for internalization and externalization.[16]

Any attempt to interpret radial categories in terms of weighed feature bundles is confined to the description of single cases, with no projection power, and consequently leaves the cognitive motivations for the weighing (and its changes) unexplained.

Both Putnam's stereotypes and Minsky's frames are only based on default values for the determination of standard instances of a given concept. They therefore turn out to be deficient in three respects. Two have been pointed out by Lakoff: "First, they have only propositional models; they do not include any of the 'imaginative' models – metonymic, metaphoric, and image schematic. Second, they have a single representation for each category; this makes it impossible for them to account for complex radial structures like those in Dyirbal".[17] But there is a third deficiency, namely that they tend to superpose stereotypical frames, which are highly culture-dependent, and perceptual prototypes, which are Gestalt-governed.[18]

It is fair to add that the model-theoretic approach to meaning has already been undermined by Hilary Putnam. The problem is rather what exactly is the interpretation to be assigned to Putnam's arguments, particularly those set out in his *Reason, Truth and History*. Sometimes they are taken as saying: the definition of (sentential) meaning as intension, that is, as a function from possible worlds to sets (truth values) is incompatible with the compositionality requirement, that is, the claim that the meaning of a whole (say, a sentence) is a function of the meaning of its parts. But this is hardly correct. For what Putnam argues is that the truth-value of a sentence is stable under global changes in meaning (reference) of the component parts – 'global' in the sense they involve a re-interpretation of the entire language. If so, almost any interesting consequence is prevented. (Suppose *the cat is on the mat* now means *the cherry is on the tree*, what do *cherry*, *tree* and *is-on* mean? Of course, this game of variational arguments and counter-arguments can be played indefinitely.) If global holism is set aside, the situation is more fruitfully taken as analogous to permuting the roots of an equation. More generally, you can have $f(xy) = f(x)\,f(y)$ as well as $f(xy) = g(xy)$, although $g(x) \neq f(x)$ and $g(y) \neq f(y)$.[19]

In order to raise objections against the idea that the meaning of a sentence is representable as a function from abstractly possible worlds to truth-values, one may simply point out that the 'function' in question is not faithful to the complex structure to be represented, and that the set-theoretic notion of function is inadequate. One may likewise dispute that a non-standard interpretation can really be given to the whole of language without affecting the metalanguage used to compare standard and non-standard interpretations, if only because natural languages are supposed to be semantically closed. But I shall explore a more challenging view.

There are two claims behind arguments like Putnam's: one is the thesis of indeterminacy of meaning and the other is the thesis of 'equivalence of descriptions'. Both are controversial and deserve to be discussed at length. In particular, Putnam projects equivalence from the case of pairs of isolated theories to pairs of whole world-views: a problematic jump indeed. Apart from this reservation, the main upshot of Putnam's arguments is a threefold *reductio*: the idea that reference can be coded by an arbitrary map is bankrupt; the idea that reference can be plugged into the world in point-by-point physicalist terms is bankrupt; and the idea that meaning can be characterized *per multiplicationem mundi* is bankrupt, too.

The Kantian moral that we are invited to draw from all this still remains unconvincing. For the set of epistemological ingredients called for by 'internal realism' is not principled (there is no room for any criterial view or rationality), and so we are trapped in a coherentist web of beliefs: human beings enter the picture as nodes in the web, not as organisms: cognition is an angelic game (and one hardly scriptable). It comes as no surprise, then, that reference is disembodied: its separation from Gestalt, imagery, kinaesthesis and manipulation prevents understanding of the very notion of 'internalization'.

There is an undoubted consonance between the neo-phenomenological approach I have been developing in the last decade to the foundations of logical and mathematical concepts and Lakoff's 'experientialism'. Both lines of inquiry are inspired by Gestaltic constraints on cognitive architecture, and both purport to go beyond the manifold, often disguised, clothes worn by formalism in twentieth-century semantics. The essential tenets of experientialism are in contrast with 'objectivism' (much the same as the conjunction of rationalism and metaphysical realism):

> On the objectivist view [. . .] the only roles accorded to the body are (a) to provide access to abstract concepts, (b) to provide 'wetware', that is, a biological means of mimicking patterns of transcendental reason, and (c) to place limitations on possibile concepts and forms of reason. On the experientialist view, reason is made possible by the body – that includes abstract and creative reason, as well as reasoning about concrete things. Human reason is not an instantiation of transcendental reason; it grows out of the nature of the organism and all that contributes to its individual and collective experience: its genetic inheritance, the nature of the environment it lives in, the way it functions in the environment, the nature of its social functioning, and the like.[20]

Some divergence instead concerns Lakoff's ambivalent interpretation of schemata, now as just sociocultural models, now as Kantian *a priori*'s. But before we tackle this problem, there are at least four points to stress with regard to the objections Lakoff raises against realism.

1. Even if realism is rejected, the fact that we categorize entities other than material things is still not evidence against the realist claim that our categories naturally fit the kinds of things in the world. If indeed the mechanism of metaphorical projection from the basic level is taken as a resource of our species, it calls for some sort of 'material objectivity', though one less naive than the target of Lakoff's criticism.

2. Losing the guide provided by the distinction between the way a linguistic symbol refers and the way something is an inductive signal of something else is bankrupt. Thus schema theory should harbour a phenomenological analysis of reference and truth as relating language and world, instead of paving another road to holism.

3. Many modern philosophers' expectations notwithstanding, the inference from transcendentalism to functionalist dualism of form and matter (here, mind and body) is invalid; the sort of objective dialectics of being and knowing I suggested in *From Kant to Entwined Naturalism*,[21] insofar as it is consistent, proves the contrary.

4. Standard logical formalization of language is not the only possible way to express, in mathematical form, the structures of meaning and truth; and this is far from being a vague 'in principle' chance offered for the survival

> of traditional analytic philosophy, since it is grounded on what is by now a vast area of mainstream mathematics, that is, category theory. If the rigour of predicate calculus, as usually applied to language, is *rigor mortis* in the study of meaning, the conclusion is not the exclusion of any precise treatment of semantics. We must simply recognize that a certain formal (and formalistic) treatment is insufficient and misleading, even though it was long accepted as the very standard of semantics. There is another, more refined way in which a rigorous formalization can be accomplished.

Lakoff's experientialism is an improvement on internal realism and still inherits from it a free-floating linkage of cognition to perception, as well as a corresponding risk of cultural relativism, so much so that 'natural' boils down to whatever may be "motivated by the structure of our experience",[22] with the suggestion that this structure is unexplainable in its relationships (still admitted as constraints) with spacetime, physical laws of stability, biological inheritance and, more generally, with any definite condition for the cosmological emergence of order. Nevertheless, the notion of truth remains a *radial* concept rooted in preconceptual structures of experience. Central truths are characterized in terms of direct access to basic-level objects and kinaesthetic schemata: they are true "by virtue of the directness of the fit between the preconceptual structure of experience and the conceptual structure in terms of which the sentence is understood".[23] Thus the extension of truth and meaning to sentences about objects of other levels (trough microscopes as well as metaphors) is largely a bootstrap operation that has its ground in the basic-level experience – which is anything but unstructured.[24]

On the other hand, my fibred approach to the lifting of schemata seeks to give mathematical form to an idea shared by Lakoff as well.[25] Now, if we frame such lifting in category-theoretic terms, we allow for primitives with internal structures: objects defining a category relevant for type theory have sub-object algebras and still they are the 'target' of basic reference. The notion of category can also be seen as an enrichment of the notion of graph: in any graph, it is the nodes and the arcs that matter, and neither are necessarily sets and functions. If anything, set-theoretic notions proper enter into the manipulation of the collection of all nodes and arcs of a given kind as *one* object of discourse.

As a result, what we have here is not so much another defence of common-sense as a systematic search, motivated by detailed linguistic investigations, for the preconditions of common-sense and the richness of their schematic structure: this same richness is what allows the wide spectrum of conceptual (re-)combinations that cultures exploit, until the production of differences gives rise to seemingly incommensurable systems of beliefs – one thinks, for example, of the notions of *paideia* for classical Greece and *tabu* for the Polynesians. Nor do conceptual systems work as butchers, with reality as their carcass, or as sculptors who can mould a piece of clay as they wish. Leibniz suggested that innate ideas are like the veins in a block of marble to be respected by the sculptor. It is well known that, since his time, the status of the debate has become more articulated and grounded on detailed studies about language, especially since the rise of cognitive science. However, the recognition of innate resources for the structure and coordination of cognitive modules out of which meaning emerges is no obstacle against recognition that human beings create social reality and their own history. What is at stake is the exact range and source of the basic ingredients in any conceptual construct. If schema theory turns out to be inadequate, at least it will have been a precise attempt at *explanation* in semantics.

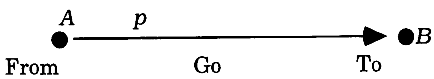
3. FUNDAMENTAL SCHEMATA

I shall now sketch a list of fundamental schemata in terms of which it is possible to frame the meaning of any sentence involving more than mere sense qualities (of appearances supposed to be given in isolation). My concern is simply to remind the reader of something so obvious that it would hardly deserve mention were it not for the numerous philosophical errors that spring from taking such 'obviousness' to be different in nature. Each schema in the list is illustrated by simple figural patterns and a number of examples. The list is intended to be neither complete nor independent. Much work has yet to be done before a satisfactory axiomatic presentation will be possible.

My synthetic description of each schema rests on previous research by numerous linguists, although they have used different terminology and also dealt, in great detail, with subtle issues omitted here.[26] In addition, each schema could be characterized in much more rigorous terms by drawing on the concepts and results of algebraic and differential topology.[27] But this would have made it hard for some readers to grasp the main points, which do not require technicalities to be appreciated, although occasional references will be made to mathematical notions in order to suggest how the problems under discussion might be treated formally – and this applies to my references to category theory in particular. The range of cases taken into account and the degree of precision of the analysis should be sufficient for the purposes of this essay.

The PATH *schema*

In view of its ubiquity in every domain of cognition, the PATH schema is a suitable point of departure. It can be represented by means of the following picture.



There are two locations A and B, possibly occupied by two entities, and a path FROM A TO B along which some entity changes its location. Typically, the locations are thought of as 'points' even though they correspond to extended regions of space. The slots tagged by A and B, as well as the entity which moves along p, can be filled with any kind of body. The oriented arrow refers to either continuous or discontinuous change, but the intuitively basic case is the former one. In fact, a path in a space X is usually defined as a continuous image of the unit interval $[0, 1]$ into X; so, if A and B are two points in X, a path *from A to B* is a continuous curve of X-points such that $p(0) = A$ and $p(1) = B$. In particular, a loop is a 'closed' path: $p(0) = p(1)$. And a constant path corresponds to an object staying where it is. There is a fundamental equivalence relation between any two paths, p and q, defined on the same space X, that is, *homotopy*. Intuitively, p is homotopical to q if p can be continuously deformed into q (the deformation remaining internal to X).

Paths can be composed with one another, as long as the point where one ends is the point where the other starts from. In fact, paths form a category under composition – more specifically, a groupoid, since each path is invertible in principle. Homotopy of paths is the subject of a vast and profound mathematical theory, which is an essential part of algebraic topology: indeed, the number and the algebraic properties of homotopy classes provide basic information for characterizing the topology of any given space. I shall not go into details of this fascinating topic,[28] since the point at issue here is rather that the original meaning of the notion of path, closely related as it is to our physical environment – not one space but a web of spaces – and to our bodily resources, is also the source of an extremely rich collection of metaphors. In fact, the PATH schema manifests itself in language in many ways that reveal the essential role of homotopy. For, even apart from dynamic aspects (associated with the FORCE schema), salient information on paths concerns the existence of obstacles of different kinds in between the SOURCE and the TARGET of a path.

One first instance of schematic transposition is the well-known metaphor of life as a journey, with its 'difficulties' and its problematic 'sense of direction', not only in its generality but also in a variety of determinations as expressed by ordinary language usage: *Bill surmounted the difficulties against achievememt of his goal*; *the development of algebraic geometry changed course when it passed from the Italian to the German style.*

Spatial metaphors linked to PATH are the ground of locative deictics also in discourse. A few examples: *start reading from there*; *here is a difficult passage*; *I'm lost. Where are we? Can you go back to the central point?* This projection of space onto discourse is closely related to the way in which we talk about inference – deductive or inductive – and more generally about any feature of logical syntax.

The point can be expressed thus:

> [W]e understand ourselves as starting at some point (a proposition or sets of premises), from which we proceed in a series of steps to a conclusion (a goal, or stopping point). Metaphorically, we

understand the process of reasoning as a form of motion along a path – propositions are the locations (or bounded areas) that we start out from, proceed through, and wind up at.[29]

Consider the following brief text, as a paradigmatic instance of how natural is for us to treat argument as space for action:

I want to reach the above conclusion, but if I start out from your premises, I can't get there. Therefore, I'll proceed by excluding the restrictive hypothesis A. In this way I can also reach a position from which it's easy to see that your previous steps lead, if not to contradiction, then into a blind alley.

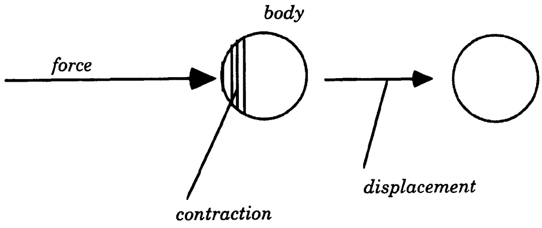
Here, not only each preposition but almost every word is space-laden: *conclusion* is a substantive form related to *closure,* while in Latin *cum* means *together with*, *ex-cludere* means *close out* and *contra* means *against*; the Greek υπο means *under* and θεσιζ means *position.*[30] The presence of spatial intuition is ubiquitous (!) and transparent, from everyday discussion to philosophical argument. Moreover, recognising the pervasive character of schemata such as PATH (and others) seems to be the only way we have to confer and preserve any shadow of *sense* for reasoning. Whatever inferences 'really' are – say, complicated processes in neural networks or just symbolic patterns – it is in terms of paths that we represent them intuitively.

The FORCE *schema*

Force is characterized by intensity and direction: it is an instance of the vector notion. The theory of vector spaces has iconic power, it is algebraically productive, and it has proved to be indispensable in natural science – linearity is pervasive. Any force has a 'point' of application and a field – that is, a medium through which it acts. Forces compose themselves according to principles set out in physics. The transmission of force occurs along a path in the field, and this results in a particular effect on one or more test bodies.

Natural language categorizes forces in a qualitative way. Typically, exact quantitative information is skipped in ordinary usage; what is relevant in most cases is only whether a force exercised on a test body B is sufficiently strong to achieve a certain goal – essentially, strong enough to make the body cross a state 'barrier' which is prevalently lexicalized. For example, sentences like *the bullet will not pass through the armour* and *Lila cracked the cup* focus on the barrier-crossing effects of actions involving the integrity of the entity subject to the force. Quantitative aspects may prove to be essential: for instance when we consider the set of distinct bodies (of the same weight) to be 'added' in order for a lever device to accomplish a given task, independently of the shape of the bodies. (This, of course, involves number.)

We may represent the intuitive content of a force acting on a body as follows:



There are innumerable metaphorical projections of the schema centred on the action of a physical force: *Lila broke my heart*; *political difficulties forced the government to withdraw the bill*; *he was overwhelmed by remorse.* The simultaneous effect of (i) direction along a path and (ii) resistance due to an obstacle on the path (exercising an opposing force) leaves a trace in a typical metaphor like *the project must avoid Major's opposition.* Usually, what matters is only the partition between directions meeting the (transposed) object under (transposed) displacement and those that do not – in the last example: any project is *directed* toward a goal.

The link between the PATH schema and the FORCE schema is expressed by any sentence that can be analysed according to the pattern

Y CAUSES [X TO GO (FROM A TO B)][31]

while the specific modality of CAUSE is further analysed into

Y ACTS ON X IN THE WAY Z

so that the result of such action is X GOES FROM A TO B. Symbolically, if we indicate the result of a Y-action of kind z on X by $Z_Y(X)$, then the schematic meaning of any sentence of this form is given by the implication

$$\mathrm{LOC}(X) = A \rightarrow \mathrm{LOC}(Z_Y(X)) = B$$

Three qualifications are in order: (i) since any real action occurs in time and is trasmitted by contact, we could attach a temporal index to either localizations, in the premise and the conclusion; (ii) differing stresses on the components of this pattern can be matched by a suitable reformulation of the above implication, provided we use a higher-order language like the one in which we express the theory of G-Sets (the category of sets closed with respect to the action of a group G, with action-preserving maps); (iii) the effect of Y's action on X may come about directly or through a chain of actions (by contact), the first of which is directly affected by (in contact with) Y, and the last of which affects X directly, as the following sequence of sentences shows:

Ray bumped against Ernie; *Ray hit Ernie with a stone*; *Ray provoked an avalanche that killed Ernie* (cf. *the addition of the new axiom makes the system inconsistent).* Although our first sensory acquaintance with force as transmitted by *contact* is in need of detailed description, the idea of contact is preserved in many metaphorical projections.

In terms of the FORCE schema and its proper analysis based on a group-action, we can account for reflexive actions performed by the same entity on which they are exercised (*he is a self-made man, she convinced herself not to do that*), as well as for reactions and their combination with reflexivity (*Ann's moral responsibility prevented her from lying).* In all these cases, one must be careful to keep the pointlike localizations A and B distinct from the entities respectively located at them.

The concrete spatial origin of the schema also underlies our intuition of the schematic ingredients accompanying FORCE: orientation, topological difference between IN and OUT, adjacency, path, and so on. No adequate psycholinguistic theory of meaning will be achieved unless the mathematical content of each schema is made explicit. Our goal is not a developmental or comparative (cross-cultural) analysis of schemata. The fact of the matter is that each schema allows for innumerably many variations and enrichments to be framed against a specific situational background (be it natural or cultural, concrete or abstract). Their semantic skeleton, however, relates back to the activation of the schema, in view of its bodily basis.

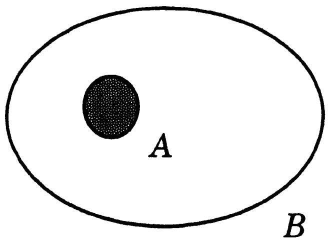
Also, it is from the FORCE schema that our primary understanding of *modalities* stems: their grounds of sense are within our bodily experiences, fine-tuned with the affordances provided by the macrophysical environment on earth. The surrounding world is a rich source of opportunities for different, but well defined, kinds of physical action, particularly of manipulation: one can bend the branch of an oak with one's arms but not the course of a river, turn a turtle upside down but not a mountain; one can climb a mountain but not flat ground, sail across a lake but not across a desert, hide behind a rock but not behind a flower, and so on. Its is precisely in our assimilation of these affordances and their limits that modal notions emerge. The *actual* world contains the whole range of *possibilities* senseful for us, and more: the definite character of the proper alternatives to a given state of affairs is part of the very order of the world. The notion of a round object is already modality-laden, as are the notions of path, container, and so on – anything comes with its range of afforded variations and their limits.

The function of limits experienced in physical interactions is transposed from nature to culture and from the 'external' landscape of things to the 'internal' landscape of concepts and thoughts, as when we describe psycho-sociological and epistemic matters. Leonard Talmy has been one of the first to advance the hypothesis that modalities are rooted in our experience of physical forces, within an environment rich with barriers. Hence modalities are transposed to epistemic, ethical and purely logical contexts as expressed in the following sentences: *you can (not) reach the beach through there*; *you can (not) test the validity of the theory through this experiment*; *you can (not) violate the law*; *you can (not) prove that any set is finite.* A detailed account along these lines of central modal notions has been provided by Eve Sweetser.[32]

Possibility arises from the existence of at least one path from the source-location (state) to the goal-location (state), overcoming the barrier (a given but variable set of obstacles). Necessity arises from the convergence of any possible path into one location. Accordingly, freedom is grasped as the absence of barriers or constraints on physical movement, responsibility as the consciousness of the limitations on the range of paths and their endpoints, the necessity of an inference as a compulsory force that leads 'inevitably' to a conclusion given a certain starting 'point' (in the form of a 'set' of premises). Significantly, the Latin root of conviction means *to tie.* 'To be able to', 'to have the resources for', and similar expressions, mean access to a (metaphorized) location in a suitable state space. We must link (i) the dependence of the behaviour of connectives on the structure of the base space in a topos, and (ii) the schematic meaning of inferences as paths. For if modalities acquire their original sense through the FORCE schema, then their logical properties depend on homotopic properties of the state space – which varies noticeably, as shown by the above four examples with *can.*

The CONTAINMENT *schema*

The topology of most of the spaces into which our *Lebensraum* decomposes is such that things are contained within other things. And containment is another basic meaning resource on which we draw when interpreting even the most abstract matters. Again, this relation can be illustrated by means of a picture:



Body B is the container in which A is contained. If A and B are not homogeneous in substance or function, B may be merely an extended location in which A lies; if they are homogeneous, A can also be said to be a PART of the WHOLE B.[33] The phenomenology of CONTAINMENT is vast, and once again the fundamental features (of 'formal' character) involved in the relation are the subject-matter of a rich mathematical theory. As the PATH schema is typically rendered in most European languages by the prepositions *from* and *to*, so the CONTAINMENT schema is manifested through the prepositions *in* and *out* (and their variations: *within*, *internal to*, etc.), and most of the metaphorical uses of this schema focus on the IN/OUT contraposition.

Note the different kinds of entity and action covered by the schema: *people poured into the hall*; *pour out the water*; *pick out a coin*; *write it out*; *in August he was in good humour*; *she is in with the director, BMW has just brought out its latest model*; *it finally came out that John was right*; *such a phenomenon is out of reach of previous theories*. These examples also show the variety of ways in which CONTAINMENT is related to PATH but one underlying feature is constantly present: if A is contained in B, any path from A to a point external to B is likely to meet the surface (boundary) of B at some point. So this schema is originally tied to the topology of the physical environment, but very early on it shifts to cover *functional* states of affairs, as when we say that *The match is in the ash-tray*.

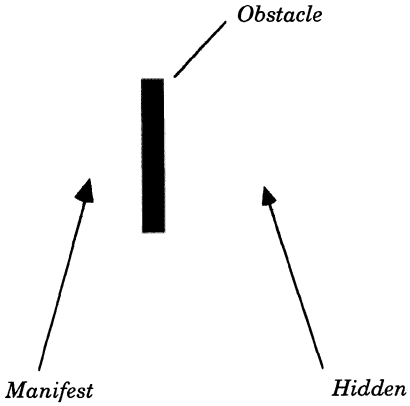
It is reasonable to suppose that there are prototypical instances of this schema as well, and associated with them is a range of (pre-metaphorical) variations. Schematic prototypes might be identified with those of proprioceptive origin, centered on one's own body and only later applied by change of 'coordinate frame' to anything else. In this interpretation, the prototypical container is *one's own body*.

In addition, the containment of an object X within another Y is associated with a shield effect: the surface of Y, the bounding object, *protects* the inside object X; equally, Y can *hinder* or keep X *captured*. Thus viewed, the schema proves to be the static pattern corresponding to the result of a dynamical *morphe*. In fact, the topological schema of CAPTURE is of fundamental importance, even for the inner experience of emotional life: it is widely testified to in psychoanalitic theory – for example, in Freud's taxonomy of personality types – but the origins of this schema probably lie in more general biological phenomena. The morphology underlying capture has been described by René Thom using methods of differential topology, in terms of singularities, and applied to predication.

Location of one object *within* another is also the ground for the imprinting of such *functional* notions as restriction, limitation, accessibility (to be within the range of observation and action) that underlie many metaphors and are the core of a good deal of mathematics. The 2D boundary of a body is particularly rich in meaning, for it can act as barrier. Significantly, the same feature is inherited when attention is confined to any inter-*section* of line segments. Finally, what may be considered to be the ancestral example of a transitive relation in our experience concerns the container/contained relation; since Piaget, developmental studies have provided evidence on the matter.

The MANIFEST/HIDDEN *schema*

Another constant source of metaphors is the polarization between what is MANIFEST and what is HIDDEN. Any cognitive situation is intuitively thought of as if its elements were divided into two parts in this respect: the MANIFEST elements are before us, visible, graspable, easy to access and to understand, whereas the HIDDEN elements are obscure, confused, out of control, etc. – different nuances of these features are selected in each given case. We may represent the basic pattern as:

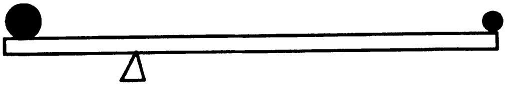


Understanding is treated essentially as seeing and grasping. This presupposes an organization of cognitive data into a bounded accessible region within a larger space where barriers are encountered while moving towards the unknown. The schema is related to PATH and bodily orientation: the obstacle may be so effective that what lies behind cannot be reached, but it may also reduce to a very long distance to cover before what is HIDDEN becomes MANIFEST. And the possibility of seeing supports the possibility of grasping: if something is seen it is easier to grasp, as significantly shown in cases such as: *if you don't see the point of the argument, you can't grasp the concept*; *there is nothing of relevance under that mountain of words.*

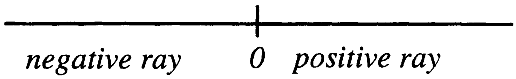
Often, the specific nature of the obstacle is indeterminate, and yet something can be hidden behind or under, whereas the physical environment of our species does not allow something to be hidden *on* (except perhaps in rare circumstances which, significantly, are not a source of metaphor). Moreover, the direction of understanding and knowledge is represented as downwards *to deep-seated problems*; *below the surface where the received view stands*; *searching for the ultimate foundations.* Almost any epistemological discussion is replete with applications of this schema, even as it claims that 'empirical evidence' requires the light of reason in order to manifest its meaning.

The BALANCE *schema*

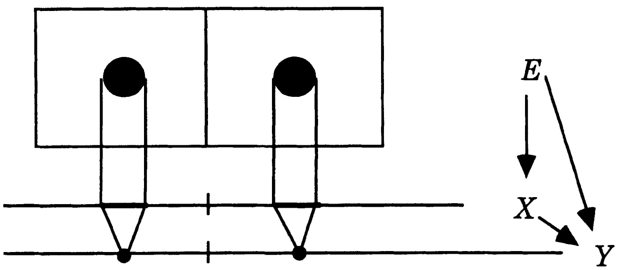
Rooted in proprioceptive *Erlebnis* of verticality, the BALANCE schema is activated when one experiences the stability/instability of objects on a 'base' which is in contact with a given support surface. Consider, for example, a tower of blocks with a knife on its top. The schema exhibits a close correlation between shape symmetry and static equilibrium; a linkage which is one reason why children find it difficult to grasp that a bar with an unequal distribution of weight can be stably balanced on a fulcrum only if the arms are of different lengths.[34] In the course of cognitive development, symmetry is re-established by *balancing* (!) the difference in length by an inverse difference in weight.



Numerous aspects of our lives are described in terms of the polarization of features around an 'equilibrium' point: *too near/too far, too early/too late, too dry/too wet, too warm/too cold, too aggressive/too submissive; too simple to be true; a balanced report on the state of the art,* etc. The underlying pattern is an ordered line which works as schematic axis with a 'central' point representing the neutral state.

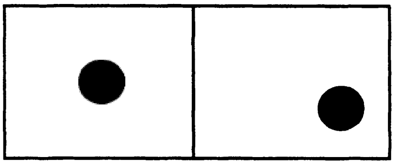


The application of the schema to 2D, 3D and metaphorized contexts is gauged by projection onto the schematic axis, as in



(a)

to be contrasted with



(b)

The range of metaphors couched within this pattern is extremely broad. A pair of examples: *the balance tips in favour of Bill's theory*; *the weight of recent evidence is conclusive.*

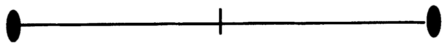
Is this a totally unconstrained, at most context-biased, creation of our own? If we take a pair of scales and place two marbles in one dish and no marbles in the other, the balance tips to one side. This is a physical fact, not one imposed by any act of perception. If this schema (like any other) is presumed to be subjective, it makes perfectly good sense to regard figure (b) as balanced, *ceteris paribus*; but then the matching between weight balance and shape balance is lost, and this constitutes an obstacle against schematic transposition across domains. If 'anything goes', why bother with an explanation for the observed pervasiveness of perceptual schemata? Figure (b) is fine (think of a Zen garden) but accordingly a well-balanced person is now someone inclined, say, to accept some arguments rather than others, *ceteris paribus* – if not, we are tacitly resorting to the good old pattern at a higher level.

Balance is associated with bilateral symmetry. It consequently involves the reflection (around a given axis) of 3D objects which are ideally compressed on to a plane, and here the collapsing projection of figure (a) applies. Rotational symmetry is present too – think of the different groups associated with the rectangles in (a) and (b). The basic import of VERTICALITY for our bodies is directly related to BALANCE: *standing upright* (ideally) implies *not falling*, and falling is a negative event. The metaphorical projections of this are numerous: *Mary fell into difficulties*; *the whole research project was dropped*; *morale rose.*

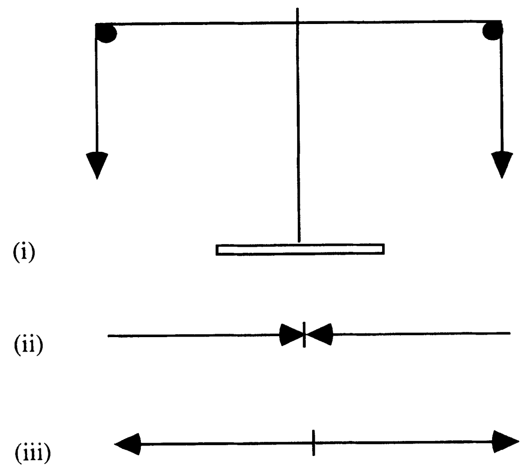
BALANCE also illustrates another recurrent ingredient of schemata: the reduction of dimension. Places, objects, actions, situations, and so on, are plotted on a space of lower dimension which is still able to control the relevant degrees of freedom for the entities involved. One might conjecture that the development of drawing and geometry (and their applications in architecture and cartography, for example) has been due to their objective effectiveness as well as to the fact that they manifest, in its pure form, some schematic kernel around which all meaning is structured. The suggestion is that the two aspects are closer than is usually believed.

Moreover, BALANCE is the source of a primary instance of an equivalence relation rooted in geometrical and kinetic intuition through its connection with a simple quotient map (from body to weight, from weight to number). See the diagram on the right of figure (a).

I have already said that any schema has indeterminate features that become saturated in concrete situations (and parenthesized in abstract ones), supporting many variations. This holds in particular when the BALANCE schema is associated with FORCE. The pattern



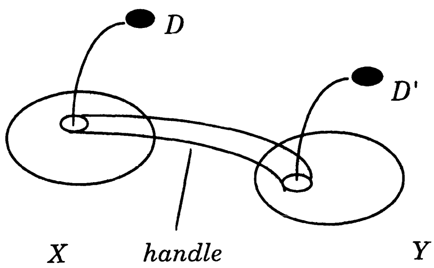
can, in fact, give rise to either (i), (ii) or (iii):



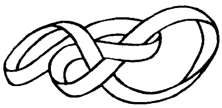
Although the physical situations corresponding to the three cases are associated with different processes, they share a basic pattern encoded in the law of vector addition. If the body imagined as lying at the centre point is supposed to be relatively rigid, what remains is just equilibrium, as in (a): vector addition equals zero. Patterns (i), (ii) and (iii) all remain invariant under rotation in a plane or in 3-space, providing instances of a loop, a disk, or a sphere stable under pressure. The shape itself of a body can be conceived as the dynamic result of inner and external forces. Indeed, the same schema underlies our understanding of numerous dynamic configurations in which balance is not instantaneous: one thinks, for example, of Volterra equations for the prey/predator dynamic system. A sentence like *the front of the second army corps is stable* is, analogously, far from meaning that no fighting is taking place there. More generally, symmetry can be globally re-established at the cost of changes in the single components, as conservation principles in physics prove (for example, the CPT Theorem requires an inversion in the direction of time). The same phenomenon occurs in simple experiences: the discrepancy between local and global equilibrium is exhibited by levers, pressure and stress, as when we realize that a small massive body within a tall but light container balances a large light body in a low but heavy container. The corresponding metaphorical *liftings* have to do with situations in which different sorts of entities are weighed. A case in point is *the benefit of explanation is greater than the cost of a huge amount of formalism.*

The CONDUIT *schema*

A fundamental pattern in much of our ordinary talk about communication and emotions centres on the notion of CONDUIT which consists topologically in the addition of a handle to two otherwise mutually disconnected bodies *X* and *Y*. Here, by 'handle' is meant any homeomorphic image of an empty cylinder, and its 'addition' involves, first, removing two open disks *D, D′* from the surface of *X* and *Y* respectively and then glueing the top and bottom circles of the cylinder to the boundary of *D* and *D′*. This makes it possible to have paths from the surface of *X* to the surface of *Y*, as well as paths from the interior of *X* to the interior of *Y*.



The region of space external to both *X* and *Y* is taken into account only as an ambient space within which the handle is located. Related to this schema are two kinds of action of fundamental importance in any domain of cognition: *open* and *cut*. In fact, if we progressively reduce the length of the handle and compress *Y* (deprived of *D′*) onto the *D′*-boundary, we obtain the open/cut pattern. Yet, intuitively, the actions of opening and cutting (and their inverses: closing and glueing) have slightly different aspects: they place the region of space internal to an object in contact with the space external to it, as in entering a room, ingesting food, putting a coin in one's wallet or an air-chamber in a tyre. In addition, one notes that the CONDUIT schema becomes effective when the PATH schema is activated: the existence of a handle linking *X* and *Y* allows for paths between *X* and *Y*, so that it is now possible to establish 'communication' between their interiors (as with a channel between two lakes, or an umbilical cord) and their surfaces (as with a bridge across a strait). When $X = Y$, we may have a simple knot, like the one drawn below, or more complex ones, depending on the interlace structure.



Finally, when more than one handle is considered between X and Y, (Y and Z, and so on), we have a braid. Not only are both the theory of braids and the theory of knots elegant branches of algebraic topology, they capture fundamental aspects of human thought overlooked by the purely logical picture of rationality.

CONDUIT is the schema by which we interpret almost every form of communication, particularly of symbolic character, be it verbal or otherwise: from social links to relationships between historical events, to logical connectives.[35] Here is a short list of examples: *do it through the proper channels*; *don't spill the beans.*

As with any other schema, here too we find that the basic nature of schemata consists in affordances for transposition (lifting) to whatever domain. The schema is a meaning carrier, and by virtue of its universality it contributes to the unity of knowledge while remaining anchored to patterns of space and basic types of physical interaction.

The FLUIDITY *schema*

The FLUIDITY schema parallels the CONDUIT schema, because what is trasmitted by means of a conduit is typically represented as a *flow* (of information, current, capital). Lakoff has argued that the experience of emotions follows the hydrodynamical pattern of a fluid motion within the prototypical container (our own body), the surface of which may allow the flow to spill out: *John's anger erupts, the tension boils over*; *good feelings well up*; *there is an overflow of emotion in her words.*

These examples also show that FLUIDITY requires the notion of barrier as experienced through PATH and FORCE and that it sometimes involves BALANCE. The fluid model of emotions is probably rooted in the sincopated build-up and release of muscular tension and of pressure in blood-vessels, rather than in abrupt changes. More or less consciously, a normal human being interferes actively with the flow by resorting to some inhibitory strategy (re-pression) which shields the inside, or by letting emotion issue forth (ex-pression). But the model also applies to thoughts, and extends across the whole of personal resources, as in *Tom was drained by the experience.*

Various theories of the Self, no less than the way in which we customarily talk about the dynamics of mind, are mostly concerned with an inner system of communicating vessels, the turning on and off of 'taps', and the global stability thus achieved (or not) in view of a transposed 'Archimedes Principle'. The FLUIDITY schema, however, is not confined to persons, but extends to activities and products of thought so that it reappears in further projections: *he poured a lot of money and energy into that business.* In other similar cases, though, the emphasis is solely on barrier crossing, independently of the fluid nature of whatever crosses the barrier: *her anger exploded.*

Indeed, there are yet other aspects of the previous schemata, as well as further schemata. I lack the space to deal with them all here, but at least two should be mentioned, since they have already been cited in discussion. One, which relates to CONTAINMENT is the RADIAL character of locatives transposed to concepts (*Mike is here*; *John is out there*; *that is the grey area between enthusiasm and madness*). In fact, as already noted, radial structure is at the basis of the fuzziness of concepts. It concerns dichotomies like centre/periphery, near/far, container/boundary, as well as the graduality of IN/OUT. Suffice it to consider a metaphor like the following: *the whole discussion revolves around one idea.* The second is the TEMPERATURE schema as illustrated by *his manner is cold*; *the discussion was heated.*

This list of schemata may be much improved for the sake of completeness and independence. Undoubtedly, refined analysis of each schema in the list would require a separate essay. But even so, the point should be clear: we are unfolding universals that provide semantics with foundations very different from meaning postulates, semantic networks, or any other sort of modelling in terms of purely set-theoretic 'relations' and 'functions'.

Each schema is a bodily, precognitive, dynamic Gestalt within which any positional role is space-anchored in a way that determines a meaning molecule. The linguistic relativity suggested by European structuralism is thus rejected, because (i) both the underlying topology of macro-space and the morphology of salient kinds of actions are independent of language, although each language has its own peculiar ways of expressing schemata, while (ii) meaning is defined non-holistically, since schemata act as molecular generators of what may be properly called 'deep structure'.

The finiteness of the list matches the closed-class character of prepositions and logical operators. It also suggests the existence of constraints on the construction of verbs, whereas the saliency of basic level kinds is far from contrasting with the open-class character of nouns. To adapt a felicitous expression of Talmy's, the closed-class forms of a language not only represent a skeletal conceptual microcosm, but this microcosm also codes, and efficiently, the proper sites for the flesh of conceptual macrocosm.

4. LANGUAGE MATTERS

The schematic structures listed and discussed above enable us to grasp *any* organization of the world into objects, qualities, interactions and events, even those that take the form of speech acts. Although syntax may have patterns of its own, meaning cannot be 'brought in' by mapping abstract symbols onto naked set-theoretic entities without lapsing into either plain metaphysics or formalism (actually, two sides of the same coin). If such mapping ('interpretation') is used, the most that is achieved is a translation of one abstract system of symbols into another (if possible worlds are taken seriously, the situation becomes exponentially worse).

At this point, it is clear why we have not to pave the way for any sort of radical anti-objectivism: if the notions of reference and truth have been misconceived by the naive realism that accompanies standard 'correspondence theory', renouncing either notion is far from compulsory. The idea that what we refer to are sets, sets of sets, and so on, is as ingenuous as it is metaphysics-laden; yet it is not the only possible precise account that can be given of meaning. Truth-conditions must be properly understood in the context of object-and-action imaginative schemata which correspond to patterns of bodily interaction in the macrophysical world. Thus the level of the atomic sentences and basic patterns that support predication must be recognized as one that is not at all 'atomic' for conceptual analysis. The genealogy of logic devised by Husserl can be accomplished once it made to rest on the *anschauliche Topologie* of object-and-action schemata described here, for these schemata are the source of the sense itself of human knowledge. In short, the body is in the mind – to use an apt expression by Mark Johnson – just as much as the mind is in the body.

All this means a radical shift with respect to traditional analytic philosophy, one more radical than most versions of hermeneutics, whose global holism is, in fact, an inevitable outcome of assumptions also shared by the Wittgenstein-Quine school. And these very assumptions prevent the theory of meaning from being systematic, whereas any sort of meaning molecularism must appeal to constraints related to epistemic modular resources acting in parallel to language, if not prelinguistically. Assigning this objectively prime role to schemata entails recognition that the roots of semantics are geometrical in character. Even if a satisfactory description of Fregean *Sinne* were achieved along the lines suggested by the 'linguistic turn', it would not be explanatory, because the level at which the theory is formulated presupposes the constitution of objects and the 'anchorage' of this constitution to schemata of intuition which are not logical in themselves but rather topo-logical.

By the same token, model-theoretic semantics for natural language (or, rather, for fragments of it) is doomed not so much to failure as to circularity, since such fragments are identified by implicitly adopting a former formalization standard couched in logico-linguistic terms; and these 'terms' presuppose patterns of spatio-temporal organization no less than the constitutive role of imagination in passing from actual contexts of perception to contexts of representation in its full generality.

At first sight, abstracting is forgetting. But it is impossibile to forget what makes abstraction possible, namely the ubiquity of schematic content-forms. Contrary to the usual assumption, 'abstraction' does not mean a progressive distancing from bodily experience. Rather, it means focusing on the skeleton of content, which must be kept distinct from both its actual *Erfüllung* (the satisfaction of meaning patterns in definite ways) and the combinatory aspects involved in the manipulation of symbolic representations. Furthermore, there is no Kantian 'pure understanding' other than that which results from abstraction *in the form of going to the schemata themselves.* What is essential for the spread of meaning through experience is the process of mapping schemata across domains – and the articulation of this mapping is categorically described. But schemata can be decomposed into their constituents, which become equally rich objects of investigation (before they are recombined and their recombination is applied), whereas the traditional view was that, by focusing on 'forms', cognitive activity is apparently led further and further away from bodily experience. I am arguing exactly the opposite: the more we enter the Abstract, the closer we stay to basic schemata[36] – to their constituents and to the related compositional principles.

Language provides a toolbox for the analysis, objectification and recombination of each schema, but it is an accompaniment to, not the source of, thought. Rationality is 'formal' precisely in the sense that schemata are basic forms of experience. Logic simply inherits and distils their distinctive features. The ultimate root of any sort of coherence is in the mutual integration of schemata – which physical reality supports and reveals through static and dynamic patterns.

The simplest propositions, such as *John pushed the button*, manifest in discrete symbolic form a particular saturation (or *Erfüllung*, in Husserlian sense) of one or more schemata involving continuous processes. The propositional representation omits information (about the intensity of forces, the trajectory of bodies, etc.) This lost information is recovered through other propositions, the content of which can be made as precise as need be, for example in the language of calculus and physical theory. The point is that the finite condensation of such a large amount of information in a single sentence like *John pushed the button* is essential for effective communication, but it cannot account for the analogical richness of the FORCE schema underlying sentences as different as *he made that happen* or *pressures by Wall Street led the government to change the law.*[37]

We are able to codify in a 1D-object like a sentence our ordinary experience with surfaces of 3D-objects. Nonetheless, we already need to access basic experiences in order to confer and extract meaning to and from a sequence of discrete symbols. And such access is principled – my hypothesis is that it is governed by the same schemata, even though the coding and retrieval procedures may differ.

On the other hand, it would be misleading to say that a schema of the sort instantiated by *pushing X*, with the *X*-slot filled by something *button-like*, is or is not propositional. In either case, a categorial error is committed. Schemata come before any ascription or denial of 'propositionality'. Likewise, any talk of literal or metaphorical meaning is dependent on the existence of such schemata as semantic building blocks (i.e., basic patterns of any possible meaning). Saying that any schema can be, in its turn, a transposition of something else would be cheating indeed. This is the bottom line, and if there are standards of rationality, they are to be looked for in the constraints on composing schemata.

Since each schema gives a primitive molecule of meaning, it lies at a deeper level than any frame, script or other kind of stereotype for objects and events: for image and sensorimotor schemata are presupposed by all of these.

For instance, understanding a more or less typical situation of selling/buying presupposes both the schema of PATH (to go from the source *x* to the target *y*) and the schema of ACTION, with an agent as the source, or cause, of the transfer leading an object from *x* to *y*. The two schemata combined express *movement* along a path under the action of something (someone).[38] This is a basic notion of topological dynamics, inherent to kinaesthetic perception and exploration of the physical environment by means of motor modules. Indeed, it already involves feedback mechanisms for the purpose of checking, with continuity, the location of the transferred object and the matching between the result of its movement and the target location. The motor abilities involved apply to the most diverse kinds of objects, starting from the macro-objects with which we interact in everyday life. The complementary constitution of the *object* notion is required (as re-identifiable in space and time at minimum), so that it can be effectively exploited in any transposed situation.

Starting from PATH every schema has been recognized as independent of the categorization process: what kind the agent, etc. belongs to does not matter. In many languages, prepositions are the basic vehicle of topological information. They abstract not only from the particular kind of entities that they relate, but also from metrical and qualitative features of the same entities. So prepositions reveal aspects of knowledge at least as deep as those dealt with in classifying and measuring: the former involve independence from time, perspective change and features that may affect prototypicity, the latter consider forms and magnitudes apart from position and material composition. As emphasised by Leonard Talmy, *in* is size-independent (*in this room*, *in this galaxy*) as well as shape-neutral (*in the cube*, *in the doughnut*), and these distinctive features of *in* are in fact paradigmatic: the same applies to any locative preposition and, *mutatis mutandis*, to any schema typically expressed through the use of prepositions.

Thus if we wish to construct a type theory that mirrors the architecture of cognitive patterns as shown in natural language, we must start from *polymorphic*, universal constructions; and if we accept this option for basic schemata, then we have for free a treatment of deictics as well. Suppose, on the contrary, that 'this' is introduced as a term in a theory with strict typing. Consider a sentence like 'This is a dog'. By virtue of strict typing and the mediating role of types required to refer to something (there are no 'bare individuals'), the sentence would be equivalent to 'dog (This: Dog)' and therefore any ostensive definition would be analytic. It may be that there is no truly ostensive definition, but it is hard to believe that if some ostensive definition does exist, it is redundant. Moreover, the kind-independence endorsed here is rather different from the hypothesis that 'this' is always implicitly typed by a suitable superordinate kind (as This: Animal), in the absence of any perceptual constraint.[39] Finally, strict typing would preclude metaphor proper, since in order to make room for metaphors, an unregimentable proliferation of ambiguity would have to be accepted, which conflicts with the evidence on language acquisition.

Ostension is an event complex indeed, not because it is description-laden, but because it requires activation of different cognitive capacities that need to be integrated in what Gardner and Walters have called "crystallizing experiences" – that is, those salient encounters with objects and situations that allow the display of coordination among *formae mentis*. Experiences of this sort are essential to the development of semantic competence, but they are not inherently *linguistic* (much less metalinguistic).

Hence the coherence of our basic interactions with the world results from the amalgamation of object-stability and motor schemata. The 'plans' of cognitive scientists are nothing but complex combinations of action-schemata: they can be modified, obviously, just as different houses can be built from the same set of bricks, but (the forms of) the building blocks remain the same.

As to the phenomenological constitution of objects, our first experiences concern resistance to pressure, differences in light intensity and temperature changes; very early on, though, the separatedness of bodies, with *their own* shapes, textures and colours, shows up. The steady state in the evolution of the notion of object arises with the articulation of CONTAINMENT. Bodies possess an interior bounded by a surface; the surface separates what is IN from what is OUT. The fundamental kinetic feature involved here is crossing the barrier represented by a surface (and the relevant action concerns what allows or prevents the CROSSING). This schema is tied to OPEN and CLOSE (the mouth, the box, the door, etc.) respectively, and it also activates early attention to continuity violations. The environment progressively factorizes into recognizable figures emerging on a background, into different *kinds* of 3D objects, whose size remains constant, as they are approached or their distance increases, by virtue of projective corrections.

The relation between CONTAINMENT statics and OPEN/CLOSE dynamics is central to almost every aspect of life. Indeed, the *functional* role of an 'open' container might be better interpreted as a closed manifold that has been 'punctured' and the resulting hole dilated (consider the progression: bottle, bowl, vat). *The child gets out of bed and enters the bathroom*; *Greg puts the ball in the basket with one hand in his pocket.* (So what enters X may just pass through X for a while.) The schema is essentially topological, but identification of each slot is related to size, straight or curve edges, angles (accessed by light reflection and aptic sensitivity), depth (through binocular vision), resistance to pressure, and so on. Schemata are not isolated from one another. The subtle way in which they coherently match is the basis of many connections among geometry, topology, mechanics and optics through the pervasive role of kinematic notions (as shown in the build-up of geometric 'constructions').

Space is grasped as an extremely organized arena for exploration, and an expanding chart of locations is memorized. The genus of a surface emerges as closely associated with bodily movement, as when the child pushes a toy under an arch of small blocks and finds that it is impossible to bring the toy back along a path around one of the arch sides without the hand being trapped. This does not happen with a tower of blocks (assumed to be fixed to the ground), because rotating the arm around the tower allows contraction of the path.

Language is built on all such resources. A sentence synthetises the outcome of this articulated genesis into a sequence of discrete symbols; the resulting expression of thought exploits the cognitive traces of continuously re-identifiable objects-and-actions, as invariants that can be composed sequentially and in parallel (*the child stands up, vertical to the ground, moves backwards from the table, looking at the ball and pulling a stick with both hands until it hits the ball* . . .). It is the same set of resources which yields the flow of meaning for basic nouns, adjectives and proper names, no less than for verbs and prepositional phrases, such as IN/OUT, FROM/TO, THROUGH/AROUND, ON/UNDER, BEFORE/BEHIND, FORWARD/BACKWARD. However, this organization of spatial intelligence develops independently of language.[40] As Piaget rightly emphasised, it is significant that prepositions, as well as logical connectives, become explicit later than do nouns, verbs and adjectives. It as if, when a language is being learnt, that the attention stress is on the acquisition of information not already included as an implicitly active resource: the more constitutive a tool is of cognitive architecture, the less pressing the demand to express it.

5. BEHIND LOGIC, IN FRONT OF NUMBERS AND SETS

We have seen how closely the IN/OUT schema intertwines with other basic schemata of direct topological character. But for X to be identified as something *contained* in Y, X must be separated from Y, and the separatedness of objects (or actions, objectifiable in turn) is also the source of *number*. The following remarks are not intended to provide an account of number and set, however simplified. Their aim is once again to recall too-often forgotten facts underpinning all notions defining rationality.

The notion of ordinal number is at work, and becomes progressively explicit, in visual and rhythmic experiences of serial patterns (as when a child slots disks of different sizes on to a pole in the correct order), of objects of differing weights independently of their shape, thermal increases independently of their cause, pressure on the skin independently of the source, and so on. By contrast, the notion of cardinal number is at work, and becomes progressively explicit, when we count the apples in a bag independently of their size, the periodic cycles of nature, such as days and years, independently of what happens, the fish in an acquarium independently of their motion. It is because of such 'obvious' independence that we are induced to generalize, taking it for granted that number is given as a definite concept, one abstracted from *any* structure inherent to its phenomenological genesis. As these examples show, of relevance is *what* we are abstracting from in order to obtain definite results of counting, and this means counting homogeneous entities with respect to salient features. (The same holds for the emergence of other notions, too, like the superimposition of the group of integer numbers on a linear order: behind this there lie certain salient 'axes', just as in space there are privileged directions relative to the standard orientation of the observer, and these directions are expressed in metaphors like *prices go up and down* – not east and west, or left and right).

No elementary school teacher would draw one slash after the other *in the same place* on the blackboard when representing a number. And yet we tend to forget the relevance of spatiality (the width of our visual field, tactile scanning, etc.) to our understanding of plurality. Forgetting is not altogether bad, though, as I have already pointed out. Even the fact that we are able to disentangle any numerical notion from the geometric aspects accompanying its origin is effective for the aim of cognitive projection; we are left with bare units of thought, in complete abstraction from space and qualities, and this autonomy improves 'manipulation'. The problem (too often removed) with all sorts of formalism is that any talk about such 'pure' units (and the 'abstract' operations thereupon) keeps track of the imprinting meaning – that is, of those natural affordances extractable under the form of schemata (and their objective syntax): *this string moves there, while the starting occurrence of that term is replaced by the string with minimal nesting.* It is impossible for us to understand and reason in any other way. We can only use essentially geometrical intuition crystallized in language when dealing with the meaning of arithmetical sentences. One of the great achievements of mathematics is that it has made the axioms and rules for dealing with numbers (of the most diverse kinds) explicit. Nevertheless, the real 'foundational' problem still remains, and unfortunately it often tends to be obscured by formal subtleties.

Were the list of schemata not fixed (while still allowing flexibility in each of them), there would be no explanation for the startling stability of rational arguments and, in particular, of mathematical proofs. What should never cease to amaze us is that a relatively small set of generators supports such a rich variety of metaphorical projections to any domain of knowledge. From its beginnings, mathematics has devoted itself to the task of going back to schemata, for these are the source of our concepts of form, symmetry, continuity, and becoming. Since the birth of mathematical logic, many aspects of language have undergone formalization, but only recently has the need for a mathematical description of the roots of meaning and the structure inherent to the lifting from the basic schemata to the whole of cognition led to develop the tools required to accomplish the task – for, category theory is able to fill the gap between the schematic theme and its cognitive variations. Here, however, at least three important provisoes are necessary.

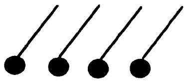
First, schema theory is in no way a new *characteristica universalis*. Even if the generators and the mechanism of their lifting were identified and completely described, it would not follow that control had finally been gained over any and all significant combinations of the generators, much less over the range of their possible projections in new meaningful wholes. To assume as much would amount to thinking that, given the generators of a group, we can determine the group itself, whereas the relations among the generators are also required (otherwise we can only obtain the free group on the given generators). In our case the identification of suitable 'relations' depends on largely unpredictable factors – the discovery of new facts and new theories, for example, or the discovery of previously undetected aspects of received views which offer new perspectives on humankind and nature. Moreover, just as the free group plays an essential role in factorizing homomorphisms, so schemata enable us to understand novelties and to communicate across the centuries, bridging differences in language, culture and history.

Second, the fact that category theory is able to fill the gap (telling algebraists that they are speaking in intuitive topological prose although they are unaware of doing so) cannot in itself (on pain of a blatant vicious circle) bear the burden of a mathematical foundation of semantic competence, since the meaning of categorical constructions also resides in basic schemata. And yet this remark does not prevent us from recognizing the operational advantage of category theory over set theory as the medium of semantics, given the central function assigned to universal maps. The suggestion is that the phrase 'foundations of mathematics' has hitherto been generally used in disguise, as simply meaning a uniform, global, translation of many formalisms into one: this is all well and good in so far as it gets rid of *explanatory* worries.

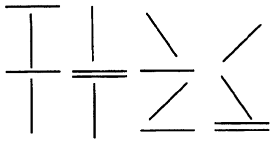
Third, it is wrong to interpret the view advanced here as an argument for the primacy of epistemology over ontology. Elsewhere I have argued that the 'transcendental subject' is no subject at all, but rather a sheaf of structures lying at the root of any graspable notion of object. It is therefore improper to consider these structures as either internal or external to the mind (which, of course, presupposes spatiality once again). On the contrary, schemata can be viewed as the ultimate vestige of a dialectical unity – which even the Russell of 1918 might not dislike, although the price to pay is a less central place for logic and set theory than he would have been willing to accept. In fact, the view of nature advocated and qualified as 'entwined' in Peruzzi (1991) seems to be the only philosophical option consistent with the former two provisoes.

Bearing these provisoes in mind, we may resume our task of going back to the schemata themselves, now concentrating on the notion of set. This notion is primarily understood in the case of a path-disconnected space, with its closed and bounded components as elements of the set: that is, as essentially a pattern of distinct bodies. Gestalt structure allows

to be treated as isomorphic with



but not with



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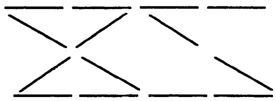
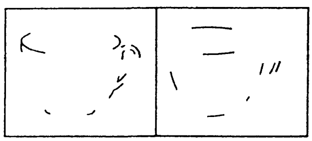


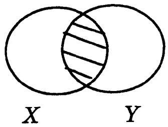
Our understanding of the notion of PART arises from identification of perceptual differences in one extended body, through solid angles, articulation points, reflectance cues, and so on, which are transposed, in imagination, to the result of one or more possible cuts in the body. (Significantly, the action of inverting the upper and lower part of a pack of playing cards is known as *cutting the deck*). The importance of salient areas in object recognition has been stressed by Biedermann (1985).[41] Remove, for instance, 65 per cent of the boundary from the picture of a cup. The result is very different if the 'intersections' are preserved or not.



In this perspective, the notions of set and number emerge as Gestaltic configurations which constitute the ground for extension and division in the imagination, and they are uniformized into an always accessible iterative procedure. Recall the odd primary school teacher who introduced each number n by drawing on the blackboard n dots on top of each other, thereby producing a picture consisting of only one visible dot. The pupils would be entitled to infer that he was counting by drawing gestures, instead of dots. There would be no cue, spatially inspectable, of the bijection between iteration steps and figural patterns, which is the core of counting. Should the subsequent gestures employed to introduce the notion of number be compounded into one fluent motion, number could still be acquired by virtue of the children's sensitivity to dynamic patterns: the quotient of the entire motion into n cycles of touching the blackboard. (One would still perceive something as subtle as it is perverse in the method used by the teacher.)

As for logical arguments, the diagrammatical sense of inference has been increasingly acknowledged in recent years. In 1992, I began a project centred on the notion of 'precategory of paths' in order to reformulate the elements of proof theory in terms of braids. Since logic is not the intended 'target' of the present paper, the details of this project are not relevant here; consequently, I shall confine myself to outlining some considerations preliminary to a schematic approach to logic.

Not only are sets and theories generally thought of as containers but, more precisely, even specific aspects of logic are subject to spatialization. Topological models of intuitionistic logic reveal only the tip of the iceberg: any sentence A is interpreted as representing an open region U in a space X of possible states of knowledge; negation of sentence A refers to an *outside* region (the largest open set, within X, disjoint from the open corresponding to A) and other logical notions are dealt with along similar lines. This sort of formal model is not philosophically telling, since the involved spaces, such as X, are *already* by-products of abstraction. One reason for the success of topology in twentieth-century mathematics lies in its recovery of the subtle but still intact thread that links certain constructions back to the intuitive, universal basic level from which meaning stems. And there is a whole range of facts that motivate a more in-depth link with logic than the above topological models. For instance, certain properties satisfied by the *internal language* of a topos of sheaves depend on the connectedness of the base space. But, to keep to a familiar example, consider Venn diagrams. The trace of a spatial meaning of logical constructions is evident in such diagrams, because we identify the intersection $X \cap Y$ of two sets X and Y with the common shaded region of two circles.

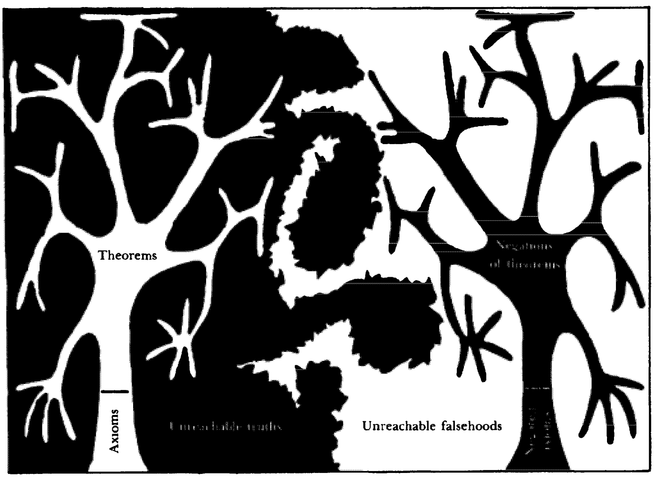


Suppose the identification of intersection with the overlapping region is conventional. Then try divorcing set-theoretic intersection from superposition and look at what is left of your *understanding* of intersection. Maybe nothing; perhaps you are going to match more and more the software of your computer.

Moreover, it has become standard practice to represent predicates as 'pure' sets, while preserving expressions like: x *falls under* the concept P, x is *in* the range of the function f, and the like. Try replacing *under* with *above* and *in* with *out of* in the previous expressions. Note also that recognising $\{a, b\}$ as *included* in $\{a, b, c\}$ involves visual (or auditory, aptic, and so on) patterns transposed to symbols. The more complex our syntactic manipulations become, the more such transposition is implicit, as in the passage from sheep to money, and from exchange of objects to exchange of information.

Nor is it merely a matter of convention that functions are called 'maps' or 'morphisms' *from* the domain of arguments *to* that of values. Further, it is customary to say that any function f, symbolized as an arrow $A \to B$ from A to B, *sends* (or *brings*) elements of A to elements of B in a definite way (all the A-elements if f is *globally* defined, that is, if f is defined *over* all of A, for every x variable *in* A.

Of course, Venn diagrams can be forgotten and nothing essential will be lost, in so far as the trace of spatiality remains in verbs and prepositions of spatial character (or, for other kinds of languages, in other morphological/syntactic features). Furthermore, we can focus on the *width* of the boundary separating the extension of predicate ϕ from predicate $\neg\phi$, and raise questions about the Excluded Middle or the fuzziness of membership; likewise we can represent the incompleteness of a theory as in the picture:[42]



Well-formed formulas
Strings

Hence we are induced to re-examine even situations in the life-world when matters are not such that $\phi(x) \vee \neg\phi(x)$ holds – that is, situations in which x does not definitely lie inside or outside ϕ-extension. Again, if we consider going from IN to OUT (or vice versa) as a continuous process, we come to realize that the arbitrary character of the 'cut' between ϕ and $\neg\phi$ can affect logical validity. To avoid misunderstandings, the presence of spatial fossils in logical syntax is insufficient by itself to account for all the subtle details of conceptual structure: the cognitive *bricolage* supported by language has been effective indeed in the evolution of abstract thought. This presence only hints at connections with latent meaning. We must strive to discover exactly which aspects of the fine structure of logic are directly transposed patterns of spatial intuition, which, it should by now be clear, is far from monolithic.

In any case, correlations between topology and logic might be thought of as philosophically marginal only prior to the achievements of topos theory, which made manifest how algebraic topology goes much deeper than model-theoretic renderings of the relations between terms and sets because it concerns a large variety of spatial patterns and their systematic links in terms of which such relations are understood. In fact, there are two modes of generativity in semantics: the componential mode, which governs the inner articulation of thought relative to any given domain, and the lifting mode, which governs the transfer of meaning from one domain to another via schemata extracted from the basic level. This twofold process recurs, for we can objectify the very structure of each lifting, making it a new domain, and then operate on schemata thus transposed.

Now an old problem reappears: are metaphorical projections *constitutive* of any autonomous domain D of reference or are they just a way of organizing the linkage of D to the kinaesthetic level of basic kinds of objects-and-actions (the origin of schemata)?

Insofar as the phenomenon of metaphor is conceived along traditional lines, no firm answer is possible. Each perspective can be justified; the matter can be decided only case by case. The entomology of metaphors rules: in the nuances detected by the most sensitive linguists, in literary criticism, and also in the formal models of the various facets of each metaphor. The physical world may be represented as an enormous living being or as clock, life may be represented as a trip or as a rhythmic dance, atoms as miniature solar systems or as vibrating clouds, theories as mirrors or as nets connected to empirical data only at some nodes, sound arguments as reliable paths, and so on. It seems that there is no objective constraint on the range of such possibilities. Any of these representations has its own rationale, depending on the actual role played by the metaphor in context. Accordingly, to ask for the 'truth' or 'falsity' of a metaphor is to miss the point.

However, if what is at stake is a phenomenological problem to be formulated with mathematical precision, this context-centred answer is misleading. The very identification of 'higher-level' objects and their mutual relations calls for activation of *certain* schemata. (Consider *Mary's equanimity was shattered* and replace *shattered* with *strengthened*.) The richness of schemata should not be confused with either their potentially infinite range of instantiations or their contextual value. Different schemata are involved at different stages. They do play a constitutive role in determining the 'higher-level' objects and their mutual relations, but as soon as a new domain of thought becomes consolidated, they are no longer active and the componential mode takes over. Schemata become once again generative when the domain is exploited as a basis for the construction of (or comparison with) another one. When they are already at work, no conscious objectification is needed for their effectiveness, while their introduction (or thematization) can help to (re)structure a whole field of knowledge: forces as vectors, concepts as functions, systematic relationships between a surface S and the algebraic properties of loops on S as a functor, crystallographic families as defined by symmetry groups, laws of nature as programs implemented by the material world.

Schemata are the ultimate resource for judging the validity of each of these cases. However, as already noted when discussing the generators/relations example, schema theory is not normative: it is designed to cover the range of case-studies that linguists (as well as psychologists, historians, and others) bring to light, but it primarily focuses on generators and their lifting, without assuming that the range of possible implementations of schemata is decidable, although the set of basic schemata is finite. The general notion of fibration (of a class of categories over one base category) is already available and can be exploited to provide a model of the lifting process. On the one hand, there is no bootstrap (meaning is not created by transposition); on the other, bootstrapping is inherent in the universality couched in the base category. Hence any answer to the question whether schemata are constitutive or comparative requires careful qualification.

We are only beginning to realize the reasonable effectiveness of categorical notions such as functor, natural transformation and, above all, adjunction: the universality in question and the variety of liftings can be properly described in terms of 'universal arrows' (like the unit and co-unit of any adjunction). No physicalistic reduction of epistemology and semantics is within sight here. The intention is to trace back the constitutive ingredients, in the form of structural patterns of (inter)action, of both nature and thought, progressively organized into layers of complexity, as information collapsed by successive quotients, where each layer is a precondition for the one that follows, without being able to absorb the emergent order entirely. Yet there is a layer at which the structure of previous ('sub-symbolic') layers shows up and stably informs all the 'upper' layers: it is the layer of schemata. As a result, atomism and holism are avoided in semantic theory.

6. IS THIS A KANTIAN POSITION?

The sense that I ascribe to the notion of schema can be made clearer by comparing my topology-inspired approach with Kant's doctrine of schematism. Kant was doubtlessly right to link the notion of schema to imagination, and also to treat it as necessary, thereby achieving a meaningful conceptualization of sense data and providing concepts with an anchor in the phenomenal realm. Consequently, apart from the fact that contemporary cognitive science would refrain from considering imagination as a 'faculty' of its own, what is lacking from and what is wrong with Kant's doctrine?

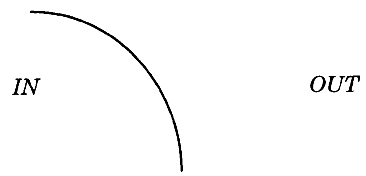
To begin with, the more than merely sequential nature of continuous processes involved in any schema is given little emphasis by Kant. One reason for this may be his thesis that schemata are determinations of time, not of space. This thesis could work only if time were the source of spatial continuity, so that intuition of space as a continuous manifold is derived through the temporal unfolding of our awareness of any extended entity. But the analysis of language envisaged by schema theory suggests that schemata should be assigned a directly *kinematical* status. On the other hand, any local direction of time presupposes that we are able to grasp differences in structural configurations of a given system – at least, there is a dialectics of determinations. The fact that we use two apparently independent nouns, 'space and 'time', is no guarantee that they refer to independent entities: Einstein *docet.* The inner experience that suggests their separation may be epiphenomenal on top of a deeper dialectical unity. Although both are supposed to be continuous, dimensionality is not the only structural difference. Now, if the notion of number pertains to time, as Kant claims, and any product (as $\mathbf{R}\times\mathbf{R}\times\mathbf{R}$) is taken as an 'arithmetical' operation, we can construct space as a *concept*, and it is thus no longer necessary as an autonomous form of intuition. I have argued the opposite.

There is a further point of departure from critical philosophy. According to Kant, information mediated through schemata (by relating forms of intuition and concepts) is by no means extracted from hyletic data; rather, it is conferred on them. Objects, events, situations are constituted into an overall order by the Knowing Subject; herein lies the only source of Order.

In my perspective the active character inherent to the subjective process of constitution is regarded as no less central, but it must be understood in its conditions of *objective* possibility, and these conditions define a layer of structure which is neither purely internal nor purely external. Human understanding cannot be isolated from the natural, bodily, constraints that make the existence of any Knowing Subject possible. We are again faced with a dialectics of Subjective and Objective, the poles of which are identified in the tension itself that occurs at definite stages in the evolution of cognition.

The essential role played by proprioceptive systems and processes is able to manifest itself only because reality is sufficiently rich in structure to provide information ready to be packaged into forms and concepts (or, better, into schemata of object and action) out of which the structure of space and time, as well as the compositionality of concepts, can be extracted by a gauged dialectics of analysis and synthesis. For this reason, schemata turn out to be other than conventional and language-laden, and we are able to make sense of 'literal meaning' as relative to bodily patterns of interaction – that is, as plotted into the original phenomenological landscape where each basic schema emerges.

Take, for instance, the IN/OUT pair. This is such an obvious constituent of primitive experience – and through its lifting of mature conceptual organization – that we tend to use it directly as a logical tool. It is worth noting the correlation between the region inside and the convex side of a frontier line.



This correlation is not at all conventional, language-laden or metaphysically necessary, since it depends on physical facts which explain the ellipsoidal shape of most pebbles in a river-bed, the hexagonal shape of cells in a beehive and the positive curvature of the surfaces of most living beings, from viruses to radiolars, from turtles to our own bodies.

Likewise, time orientation is typically *from* past *to* future, and nor is this conventional, language-laden or metaphysically necessary, for future is the locus of the results of action. This also accounts for the standard metaphors, and their multiple instantiations, which envisage our fronts facing towards future and our backs towards the past. Analogous considerations apply to other schemata.

Consequently, to mimic Kant's description as closely as possible, one may say that a schema is a determination of space-time. It is thus possible to give full content to Kant's few and isolated hints in the *Critique of Pure Reason* concerning pure kinematics as *parallel* to arithmetic and geometry, in that it is a synthetic *a priori* science grounded only in the forms of intuition, with the consequence that the Aesthetics is a threefold subject. The third component, expunged in the *Critique*, is indeed the fundamental one. Schema theory draws the consequences of this recognition, coupled with re-interpretation of 'pure concepts' in the Analytics as *free constructions* generated by combining 'aesthetical' patterns.

This notion of free construction is taken in the technical sense proper to category theory. I have addressed the problem of identifying the way this overall construction can be formalized elsewhere. Here I merely note that the 'freedom' alluded to is bound up with the subject itself of the *Critique of Judgment*. As pointed out by Johnson,[43] "once we no longer demand a disembodied (or nonphysical) rationality, then there is no particular reason to exclude embodied imagination from the bounds of reason. Therefore, if imagination is not strictly algorithmic, then this cannot be essential for rationality". Though fascinating, this argument could be subtly misleading if it were taken to suggest that computability exhausts the range of mathematical forms. Here, however, I prefer to emphasise the points of convergence with Johnson in laying stress on the status of Gestalten and the different articulation of schema theory with respect to Kantian doctrine.

In fact, the admission of Gestalt principles in cognition has been interpreted as supporting a neo-Kantian argument for the existence of active in-built forms that organize sense data and package information so that it is ready for the symbolic format. Otherwise data would lack any cohesive structure; they would be in themselves atomistic because no objective correlation would exist among them. It would follow that the unity of experience is merely a gift of subjectivity.

This interpretation, however, is unfair to the objectivism subscribed to by leading figures in Gestalt theory. And Gestalten do not concern perceptual appearance alone, but also other layers of cognitive reality. If any consistent image of the world were built by means of the unity bestowed by the subject on raw, scattered materials of sensation, such a unity would be, if not a miracle, in need of explanation: how have human beings acquired this power and, more generally, how is it possible for a single system to be the source of structure for every other system? Less presumptuously, and more in line with contemporary cosmology, Gestalten can be taken as a manifestation of patterns of structure emerging under definite conditions.

What Kant called the 'synthesis' of the sensitive manifold concerns the intermodular mapping and transposition of Gestalten: the activity of imagination organizes something other than an unprincipled collection of associations. Kant develops three points: (i) the schema mediating each 'pure concept' (category) and intuition is 'void of an empirical content' (*CPR*, B 177), and yet (ii) the schema must be 'homogeneous' with the poles to be linked in order to perform its function; finally, since its 'formal' character can only be applied to the inner flow of representations, (iii) the schema only involves time, not space. It should be clear from the foregoing discussion that (i) and (iii) are rejected in schema theory, as they were in Gestalt psychology, whereas ii) is *strengthened.*

The upshot of all this is not a refutation of the claim (endorsed by mainstream analytic philosophy) that sense and/or reference are objectively fixed. Rather, the objective stability of sense and/or reference can be grounded only after we take account of the mediating, while fixing the class of schemata of bodily experience. Schemata are not by-products of culture and history: they make culture and history possible. And the existence of such and such schemata is a matter of fact, no less than is the manifestation of certain electromagnetic wavelengths as *colours*, or the manifestation of pressure increase as a 'buzz' in the ears. (Evolutionary epistemology can 'naturally' investigate the origins of each schema, but this is not our present concern.)

Replacing a God's-eye view with a Man's-eye view is a well-known strategy; unfortunately, it excludes us from the adventure of natural philosophy, from Thales to Galileo, from Darwin to Einstein. What schema theory properly supports is neither a pre-established relation between Language and Reality, nor an absorption of the world within subjective 'bounds of sense'; it rather points to the objective constraints on embedding a living system X in the environment U while X is acting in definite ways on U as 'opposed' to X. To say that existence and essence (what there is and what an object is) are relative to the observer and they can only be understood as internal to the observer's interface systems instantly raises the question: what kind of object is an observer and what makes its existence possible? If everything is internal, is the system to which everything is internal, internal to itself? If, moreover, the meanings of 'internal' and 'external' are to be conceived internally, is not any universal sentence about object and existence Pickwickian?

If the matter is framed in such global terms, as philosophical tradition wants, the fly can only continuously repeat its desperate attempt to escape the bottle until it dies. (Perhaps the bottle is a projection of the fly, still it works perfectly well as a barrier – but where does the notion of a barrier come from?) If, instead, the problems we face are approached step by step in the light of schema theory, the outcome is somewhat different: in semantics and epistemology, as in any other subject, *definite* affordances provided by our own body, plugged into a system of *definite* interactions with other bodies, are ready to be exploited for *definite* cognitive tasks in *definite* ways.

Only if we keep sight of this 'definiteness' can the notions of object and existence be *abstracted back* (or *ad-stracted*) to the phenomenological level where the imprinting of meaning and reference occurs. So we reconstruct the sedimentation of sense into symbolic units of progressive complexity (from short verbal exchanges between primitive hunters to myths and scientific theories). This process is parallel to the internal/external dialectics and repeats itself with every 'deepening' of our life-world. But when this very process is *cycled in* knowledge, philosophical problems emerge that schema theory helps to solve. In sum, the alternative is not between how to carve out the world and how to access its autonomous structure, but rather between paying attention to the conditions of possibility for the basic interactions which underlie the structure (and the very existence) of an *animal symbolicum* and maintaining the opposition of a Man's-eye and a God's-eye view irreducible (or reducible to one single eye).

In other words, any discussion about realism and anti-realism simply puts the cart before the horse if there is no clear grasp of the meaning of the 'actions' that we perform when 'manipulating' symbols (to *start* the philosophical discussion): a meaning cycled in and fixed through bodily interactions. (In a sense, philosophy is an activity to be exited over and over in order to make it progress, for one must recall what it has forgotten; but philosophy has also consisted in this very recall, and it is precisely here that its *analytic* character manifests itself.) Organism and environment cannot be divided if we are to elucidate the natural roots of meaning. Yet this recognition is far from implying holism or Kantian idealism.[44]

A recurrent objection against this sort of attempt to escape internalism is raised in the domain of vision. We are told that the equation seeing = seeing-as is widely supported by psychological experiments. A case in point, repeatedly mentioned, is the phi-phenomenon. The experimental setting consists in showing a subject two quickly flashing lights on a screen: the subject sees one single light moving across the screen. What s/he sees is not necessarily what happens externally. And, so the argument goes, the case is paradigmatic. Reality is only a construction out of many integrated mental processes.

The two-flashes example is paradigmatic indeed. It means that we can avoid examination of the variety of similar cases supposed to provide further evidence for the above conclusion. However, I regard it as evidence for the opposite conclusion. Why is the inference flawed and the evidence spurious? The answer is rather simple: we are living beings who did not evolve in a laboratory which allows a disconnected visual experience of this kind. The objects we meet *en plain air* are not just visible, they can be approached and inspected from any side; they are dissectable, they provide possible targets, obstacles to turn around, and so on. What such laboratory experiments show is that our input systems possess their own modular structure and that objective knowledge results from the coherent integration of sensory-motor information: the psychologist *exploits* this integration by preparing artificial situations in which the test subject is prevented from performing the integration.

Analogously, one could devise a sort of (more abstract?) inverse experiment such as the following: high-school students are presented with the outputs from a computer program for calculating the absolute value of any subtraction of integer numbers, but the program is so constructed that whenever a pair of numbers $<m, n>$ is given as input, it adds them, divides the result by m^2-n^2, and computes whether the result is greater than zero: if so, it prints the denominator, otherwise n-m. The students are asked what operation the computer has performed. Of course, they will say $|m$-$n|$, but according to the argument, *we* should say that the students have not grasped subtraction, but only as-if-subtraction. Something similar might occur in the relationships between the actual brain processing and the consciousness of the psychologist preparing the experiment. (Also in the case of a single flashing light in motion: perhaps God recreates the world instant by instant, merely exchanging the flashing lights in the room! Thus the lights really moved after all, and what we see as standing is an infinite number of moving lights.) The outcome is an infinite regress: seeing would *never* be veridical; and at the same time, if one indeed adheres to the view that phenomenal objects are subjective constructions, seeing would *always* be veridical (relative to *any* given subject in *any* given context): everybody sees what s/he sees, what else? Both horns of the dilemma can be (unduly) elaborated at will. The unending story of traps continues. The wound inflicted by the first philosophical doubt never heals. (We can access the computer program and discover the trick, no less than we can *see* that there are two flashing lights in the laboratory. Of course, we cannot check what God is doing, but, if no empirical difference follows from divine light exchanges, we are entitled to treat the two cases as one and the same.)

Although common sense is so close to the domain of schemata that they tend to be confused, the foregoing discussion is not another defence of common sense. The puzzle here is clearly related to substitution in belief contexts, and the solution is much the same in either case.[45]

Another allegedly decisive argument for subjectivism is based on colours. Wavelengths of light form a continuum, colour nouns correspond to a discrete categorization; the finite partition of the light spectrum into colours such as red, green, blue, and so on, depends on our visual system and cultural biases; even though we admits that wavelengths exist in the world, colours are a product of mind and culture. The statement that leaves were green and heated metals red before there were eyes (and brains) to see them might be taken as literally senseless, but the matter is not so reducible: if an objective tuning exists between our visual system and the electromagnetic properties of the environment, the question becomes: *why* do surfaces manifest such and such reflectance properties and not others?[46] *Mutatis mutandis,* the moral drawn concerning the nature of schemata applies here as well.

The importance of epistemic constructions is undeniable, but all construction operates on top of schemata which have always been the subject matter, and the source, of mathematical thought. In substance, this is Kant's position, too. The major difference between my position and Kant's consists in this, that concepts are no longer separated from the forms of sensitivity. Whereas Kant proposes a classical distinction of faculties (sensitivity and understanding related through imagination), I expand the range of Aesthetics to cover the whole base of cognition: concepts, organized into judgements, are the (more or less stable and pure) synthesis of experiential schemata. Moreover, this synthesis is only partially active, for its ground patterns are archetypical content-forms already in-built within the interface structure of mind and nature. Rational thought is the result of the iterated transposition of schemata to any domain, through objectifiable kinds of objects and actions, sequentially expressed in the medium of language.

After all, Kant's famous 'theorem' in the Analytic (B 275)[47] can be fully justified in my perspective, while it remains a source of embarrassment for any consistent defence of ontological dualism or reductionist monism. Kant's 'theorem' calls for a *direct* link with the doctrine of schematism: in my account this link is obtained for free, because forms of sensitivity and categories of the understanding do not preexist separately from schemata. On the contrary, they can be isolated from each other only by means of analysis.

In consequence, no room is left for 'Pure Reason'. The antinomies that Kant denounces in the free flight of thought from phenomena to noumena give rise to *metaphysical* difficulties not because of an illegitimate divorce of categories from space and time but because, in order to be understood, antinomies themselves preserve the use of those very schemata rooted in our bodily experience. Hence metaphysical dilation of our control on the underlying imaginative lifting is doomed to failure. *Die Überwindung der Metaphysik* does occur *durch Analyse der Sprache*, but such *Überwindung* does not carry with it any evidence for empiricism. Essentially, the core of meaning and of rational thought lies in imaginative structures and processes, against any dualism of body and soul. The function of the 'pure ego' (renewed in the functionalists' computational programs) can only be preserved if it is identified with the uniform translation of schemata across all cognitive domains.

7. CONCLUDING REMARKS

What does this all add up to? If we wish to say that thought is manipulation of symbols, we can. If we wish to say that there is a clear-cut distinction between dictionary and encyclopedia, we can. If we wish to say that language mirrors the world, we can. We can say these things *provided* we recognize such tenets as lying 'behind-the-lines', that is, after schemata and their inner history have accomplished their task of injecting and spreading meaning. This is the 'concrete' base required by any self-referential symbolic system. In the same way we can retain our good old notions of reference and truth.

Attempts to enrich or revise the correspondence pattern (with sufficient ingredients to provide treatment for aspects of language neglected by logic-inspired research) have resorted to the myth of 'use': pragmatics was to be the semantic skeleton fleshed out. These attempts have repeatedly failed – as is always the case: giving voice to a real need is no real satisfaction of it. If pragmatic parameters are placed in the logical framework of semantics, what is obtained is just another skeleton; and if they are conceived as unsuitable for formalization, what is obtained is a collection of case-by-case descriptive studies with spared principles blatantly insufficient to fill explanatory gaps of 'pure' semantics.

The perspective envisaged here is different: semantics and pragmatics are all well and good *provided* the schemata amalgamating perception, kinaesthesis and cognition are already at work. This underground of meaning must be made explicit, however reluctant we may be to focus on the obvious.

Why do we *grasp* concepts, *see* the *point* of a question and *arrive at* a conclusion? Why do we represent life as a journey, why do we link e-motions with *fluid* motions, why do we see theories as *buildings*, justice as *balance*, scientific hypotheses as *weighed* through experimental evidence? Are these all arbitrary associations which would change with different cultural conventions?

Are they the mere product of cognitively biased preference-rules, so contingent that their import for a proper understanding of rationality is marginal or nil?

I have pointed out that the correlation between goal (the conclusion of a proof, for example) and endpoint is not arbitrary at all. The structure displayed by a PATH, as a map $p : I \to X$ from a closed interval I in $\mathbf{R}$ (say [0,1] to a space X, is mediated by two isomorphisms: one of I with a period T of time, so that the path is continuously parameterized by instants (the order of which can be analysed in dynamic terms) and one of a partition of T with the sequence of stages of the action referred to. The whole process relies on a built-in resource, that of *recognizing isomorphisms*, and the natural medium for implementing this resource is experience of spatial form (*Gestalten* of objects and processes).

Schema theory is another link in the chain of efforts to achieve a systematic understanding of the complexity of the universe and of the way in which such complexity wraps itself with mathematical form. In this precise sense, category-theoretic notions become a new organon which replaces logic in the task ascribed by the fathers of analytic philosophy. Through their link with geometric intuition, categories provide the tools for precise analysis of the objective preconditions of logic itself.

Since I have also referred to the project begun by Thom and pursued by Petitot to develop a theory of phenomenologically salient structures in the common-sense world (Thom's 'semiophysics'), it would be of relevance to determine whether and how this project can be computationally implemented (of course, not with a desktop computer). This question relates to that of establishing an experimental meaning for schema theory. For schema theory owes an obvious debt to Thom's topological approach, as well as to research on qualitative physics within Artificial Intelligence, for example on CONDUIT models. Suppose we are given an artificial system S endowed with schemata and expressive resources for abstracts: the question is whether S can understand or introduce metaphors such as *the president opened the discussion* and *the launch of the new programme is meeting demand.* One could start by asking whether the set of metaphors adopted by iconic systems like Macintosh (with its user-friendly interface) could be grasped by S.

Such questions would undoubtedly be an important source of evidence for the theory. For the moment, however, schema theory is deliberately directed towards weaker goals, its only concern being to develop a mathematically rich framework for the description of meaning structures in natural language. It claims neither to provide specific axioms for naive physics nor to specify the design of artificial systems as partial approximations of our entire sheaf of cognitive resources.[48] Further elaboration is necessary. In a sense, schema theory focuses on an 'intermediate' phenomenological layer along the spectrum from Carnap's *Aufbau* to Aristotelian substantialism; it is a hierarchical theory, but the upper stages are reached in a functorial way, rather than through an ontologically homogeneous progression. Moreover, its predictive power is still weak, although the importance assigned to the notion of quantity distinguishes it from purely qualitative theories of concepts: what really matters for the stability of objects and actions is the precise dialectics between local quantitative change and global qualitative change. This seems to be the price to pay for a workable, explicit and hierarchical theory of tacit semantic competence in its full generality. On the other hand, the kind-independence required by any schema leads to basic patterns of *concrete* interaction with the environment. Thus, rather than a survey of the common-sense world, we achieve an understanding of its preconditions, which are also set out in specialized *theories* at odds with common-sense.

A question sometimes asked concerns the change in our knowledge of the world that would ensue from a change of schema. The question is ambiguous, for on the one hand it suggests that a schema is a specific way of interpreting data, while on the other it suggests that schemata embody the general ways of perceiving anything. In the former sense, we can access variation because the same cognitive resources are exploited in different ways; in the latter, classical functionalism would seem inevitable – what would you feel if you were a syntactic machine?[49] Those who claim that meaning flows via schemata and their metaphorical projection cannot be comfortable with this unhappy ending. If schemata were free creations, it would be difficult to find any additional constraint sufficient to prevent everything from changing with any change of schema.

We would be left with no reason for correlating the case of two marbles of equal weight in balance on a seesaw with the equilibrium of a skater cutting a figure of eight, or of a judge faced with a difficult decision. In dealing with the BALANCE schema, different aspects concerning symmetry coalesce in objective ways which can be distinguished, analysed and mutually related by means of linear algebra, geometry, group theory, statics, optics, and so on. The superposition of different symmetries in the initial bodily experience of BALANCE (concerning distance, volume, weight, shape, etc.) contributes to the generative power of the schema in an essential way. This conceptual analysis identifies building blocks of autonomous character which, in turn, can be variously recombined, covering the whole phenomenology of symmetries that we discover in the world. Each basic schema is sufficiently rich to admit a wide spectrum of projections, and sufficiently simple to be obtained from a few structural components. At the same time, basic schemata are collectively necessary for the 'circulation' of meaning across domains, and they enable us to understand talk about cultural/abstract entities.

Through instantiations and recombinations of each given schema, the original spatial pattern tied to a particular kind of bodily experience and intuition extends meaning into every area of knowledge. The effect of this spread feeds back on our understanding of the origin: you are reading an essay on the notion of schema! (You are exploiting a good deal of information yielded by entwining schemata, and lifting this braid to abstract, self-referential thought.) Not only can symmetry be fully described by means of group theory, but also the history of the group notion reproduces this same dialectical spiral: from a particular type of group of permutations (on the roots of a polynomial equation) to a general group of transformations, hence to an abstract group and then back (Cayley's representation theorem) to the weakenings (monoids) and enrichments (rings) of the notion required by its amalgamation with other algebraic and topological notions and their applications in science, with the result of new insights into the original notion.

We are the way we are, and we could not think in a way any different from the way we do (as members of the species *homo sapiens sapiens*). Yet it is perfectly legitimate to raise the questions given above. And since they concern the roots of meaning and rationality, the answer can only yield renewed understanding of the bodily roots of mind. Schema theory provides a route to such understanding, and at the same time it sheds light on the architecture of mathematical form, tracing its source back to the patterns by which our commerce with the (external and internal) world is determined. We must spell out the boundary conditions that permit this commerce with all its variety of phenomenological manifestations. Contemporary research in cognitive science, logic and foundations of mathematics, naive physics and complexity has broached numerous topics of relevance in answering our why's. Resorting to a traditional philosophical answer is to miss the point, for we are investigating the very presuppositions that make philosophy (in all its brands) possible. And yet the arguments put forth in schema theory intimately touch on subjects addressed by philosophers of the past.

I have argued that two classical answers to the questions posed above are misleading. If the answer that 'we have such and such meaning mappings since the world is as it is' is trivial, the answer that 'we have such and such meaning mappings since the mind is as it is' begs the question. Both answers overlook the detailed mechanisms by which statics and dynamics mould the background of biological and cognitive systems, as by-products of the cosmological evolution. If we instead take account of these mechanisms, with their fine-tuned correlations, then we find the true area of research for semantics.

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NOTES

[1] Cf. Johnson 1987; Lakoff 1987; Lakoff, Johnson 1980.
[2] Johnson 1987, xv, emphasis added.
[3] See Jackendoff 1983; Langacker 1986; Lakoff 1987; Talmy 1983; 1985. However, Talmy's first contributions to the subject date back to the early 1970s.
[4] Peruzzi 1995; 1995a.
[5] Rumelhart 1975.
[6] Johnson 1987, 26.

[7] This feature would also suggest a concrete and testable rendering of some components in Husserl's notion of noema, see Peruzzi 1988.
[8] Brown 1965, 318.
[9] Ibid., 321.
[10] See Thom 1980 and Petitot 1985.
[11] Quine 1969, 118.
[12] Barwise, Perry 1984.
[13] See the contributions of category-theoretic import in Macnamara, Reyes 1994.
[14] Sometimes, as here, I shall adopt the more traditional term 'concept', using it in the same sense as 'category' in linguistics. The reason for this substitution is simply that the term 'category' is reserved for the mathematical notion which is the subject matter of 'category theory'. However, when there is no risk of confusion, I shall conform with the established use in cognitive science.
[15] See Lakoff 1987. The fourth class is simply described as containing any entity that does not belong to the former three!
[16] This is a theme that deserves separate investigation; see the case analysis in Peruzzi 1991a.
[17] Lakoff 1987, 117.
[18] Lakoff would probably not subscribe to this third point, in view of his rejection of any form of objectivism.
[19] This argument is further developed by Peruzzi 1993.
[20] Lakoff 1987, xv.
[21] Peruzzi 1991.
[22] Lakoff 1987, 276.
[23] Ibid., 297.
[24] All of this is in line with remarks by Hans Reichenbach in an underservedly neglected paper: Reichenbach 1930.
[25] "Schemas that structure our bodily experience *preconceptually* have a basic logic. *Preconceptual* structural correlations in experience motivate metaphors that map that logic onto abstract domains. Thus what has been called abstract reason has a bodily basis in our everyday physical functioning. It is this that allows us to base a theory of meaning and rationality on aspects of bodily functioning". Lakoff 1987, 278.
[26] The interested reader can enlarge and refine this picture of schemata by consulting the works of Jackendoff, Lakoff, Langacker and Talmy listed in the references.
[27] It might be objected that there is a vicious circle here. But even the most exact laws of nature presuppose the 'inexact' nature of concepts that makes it possible to state them. More specifically, set-theoretic topology and geometry assume the notion of point as primitive. One is free to take whatever *Ur-elemente* one likes after developing the capacity to perceive objects as individual entities. Thus the possibility of providing equivalent formal systems in which points are defined does not change the situation but again puts the cart before the horse. The development of a mereotopology has recently been proposed in order to bridge the gulf between mathematical topology and the phenomenological description of spatial structure represented in natural language. Reservations about such a project have already been presented in Peruzzi 1994a. The errors occasioned by the conventional use of set theory and topology have provoked harsh criticism of their use to model the dream of a First Ontology. Where these criticisms seem to miss the point is that they neglect the chance offered by categorical topology and topos theory to look at 'conceptual space' by means of the techniques developed for fibre spaces and generalised for fibrations – see Benabou 1985. These techniques permit precise analysis of the lifting process that constitutes metaphor.
[28] See Brown 1988 for an introduction to homotopy and its relationships with category theory.
[29] Johnson 1987, 38.
[30] Etymology is a useful source of information with which to re-trace the long evolution, sedimented in language, of liftings from Concreta to Abstracta, particularly as regards the terms that we use to describe knowledge, grammar and logic. Consider, for instance, words such as: *examine* (Latin: ex-augmen = out of the row), *analysis* and *synthesis* (Greek: $\alpha\nu\alpha - \lambda\iota\sigma\iota\zeta$ = set apart, $\sigma\upsilon\nu - \theta\varepsilon\sigma\iota\zeta$ = lean together), *perceive* (per-capio = I take through), *discern* (dis-cerno = I separate), *subject* (sub-jectum = put, thrown under), *object* (ob-jectum = thrown against), *consequence* (cum-sequi = follow together), *infer* (in-fero = I bring within), *contradiction* (contra-dico = I say against).
[31] Actually, the FORCE schema embodies this link. As already noted, my present concern is not to provide a logically independent system of schemata.

[32] Some of Sweetser's remarks, however, very specifically concern English – see Sweetser 1988. There are languages, such as Italian, in which possibility is not articulated in two verbs like *can* and *may*. Since schemata are supposed to be universal, they should not support a schema theory for anglophones. It therefore seems that some of Sweeter's arguments on this topic are in need of revision.
[33] Metonymy is not discussed in this essay, for three reasons: (i) in some respects, metonymy is more obscure than metaphor, and current views about metonymy seem unable to achieve the level of a theory proper, (ii) the modifications required by such views would occupy too much space in the discussion of schemata, (iii) apart from details, metonymy does not add anything essential to the main point – the kinaesthetic roots of meaning – developed here, because the part/whole substitution and relations such as container/contained, location/located (*Quick Hand strikes back*; *Florence was replaced by Milan in fashion leadership*; *the White House is expected to intervene*; *the hall is murmuring*) can be dealt with in schema theory by refining the analysis of the fibrations involved, without enlarging the family of schemata, along the lines of the model proposed by Peruzzi 1995a.
[34] For a detailed account see the experiments reviewed by Karmiloff-Smith 1992.
[35] See Reddy (1979), although the philosophical moral that Reddy draws from his analysis of the CONDUIT metaphor is at odds with many of the points made here.
[36] There are metaphors which also exhibit the backward movement from Abstract to Concrete. Schema theory rightly takes account of this process.
[37] Brouwer's remarks about the language of mathematics might be interpreted and re-formulated accordingly.
[38] Language typically focuses on x and y as the starting point and the point where motion stops. In the case of inertial events, as with motions simply crossing x and y, language selects patterns assigning x and y a different role: the given entity *passes* through x and (later) y. Since, the exact source and target of motion are indeterminate, it may seem as if the actor is indeterminate too – in partial agreement with dynamics.
[39] For thorough discussion of this point see Macnamara, Reyes 1994.
[40] For this reason, the existence of languages in which spatial information is carried by expressive means other than our prepositions and verbs is not to be taken as evidence against the generality of schemata.
[41] Biedermann 1985.
[42] From Hofstadter 1979.
[43] Johnson 1987, 168–9.
[44] See Peruzzi 1993 and Peruzzi 1991, respectively.
[45] Without any appeal to realistic assumptions, I have shown in Peruzzi 1991a why the traditional approaches to 'opacity' are misleading.
[46] Dennett 1991 conducts subtle discussion of various views on colours and other *qualia*, although I am not sure that his conclusions are unobjectionable.
[47] The theorem claims that the empirically determined consciousness of my own existence proves the existence of external objects in space.
[48] Notice, however, that the categorical language of schema theory is richer than any first order language, such as the one in which Patrick Hayes' axioms for naive physics are formulated. See also Smith 1992.
[49] Whilst the traditional doctrine of the mental substance that persists beyond behaviour was effectively expressed by Gilbert Ryle as 'the ghost in the machine', the functionalism that arose from the crisis of behaviourism might be termed 'the machine in the ghost'.

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ROBERTO POLI

QUA-THEORIES

1. REDUPLICATIVE EXPRESSIONS: SOME INTRODUCTORY NOTES[1]

I shall call a theory of the functor '*qua*' a '*qua*-theory'. This functor is used in expressions like 'A *qua* B is C'. Some synonymous expressions are 'as', 'insofar as', 'in virtue of', 'with respect to'.

'*Qua*' is a technical term. The word is the Latin translation of the Greek '*he*' in the expression '*on he on*' which in the seventeenth century gave origin to the term 'ontology'. That is to say, a *qua*-theory is an ontology, and ontology is the heart of philosophy.

The definition of ontology that Aristotle advanced itself involves the functor '*qua*'. His definition of ontology at the beginning of the fourth book of *Metaphysics* is universally known: "there is a science which studies being *qua* being [...]". My problem is this: why does Aristotle does not simply say that ontology is the theory of being? Is there any difference between 'theory of being' and 'theory of being *qua* being'?

In brief, the problem is deciding whether the two expressions 'the theory of being' and 'the theory of being *qua* being' are equivalent. If they are, the '*qua*' does not play any interesting role. On the contrary, if the two expressions are different – that is to say, if there is a difference between the theory of being (*simpliciter*) and the theory of being *qua* being – we should study the role played by the (operator) '*qua*'.

The main reason for distinguishing between theory of being and theory of being *qua* being rests on Aristotle's opinion that the analysis of being *simpliciter* cannot be developed in a scientific fashion. Aristotle's intention to submit being to scientific analysis was the principal reason for his adoption of a reduplicative kind of analysis.[2] His position derived from the thesis that being is not a genus.[3]

It is well known that Aristotle believed that scientific analysis can be developed only if there is a common genus for the entities under examination. If being does not have a common genus, the study of being cannot be a science.

From this arises a fundamental difference between study of being and study of being *qua* being. If ontology is a science, we must admit that there is a common genus for the entities studied by ontology: the main role of '*qua*' is precisely that of assigning a surrogate for the lacking common genus to beings by making explicit the *context* of the being referred to.

L. Albertazzi (ed.), Shapes of Forms, 245–256.

Qua-theories will be collectively referred to as reduplicative-theories or as theories of reduplication. Since Aristotle, *qua*-theories have been intensively used, although only in very few cases has there been *explicit analysis of the theory as such*. Among the authors that conduct discussion of the topic, besides Aristotle and without any claim to completeness, mention should be made of: Albert the Great (*De sophisticos elenchos,* I.III.6), Avicenna (*Ibn-Sina* (*Sufficientia*), William of Sherwood (*Introductiones ad logicam* 77, 18–28), Occam (*Summa logicae* II.16), Burley (*De puritate artis logicae tractatus longior*), Wyclif (*Tractatus de logica*, I.5), Thomas (*Sentences* III.XI.1; *Summa theologiae,* III.16.8–10); Scotus (*Sentences* III.XI.2). Leibniz also used the theory of reduplication when formulating his principles of identity.[4]

A number of modern writers make reference to the theory: among the analytic philosophers, Frege, Russell and Quine, while more recent contributions have been by Wiggins, Fine, Henry, Tichy, Benardete, and Bäck.[5]

Anscombe recalls,[6] with regard to the expression 'under a description' introduced in an earlier work as a tool of the philosophy of action, that "some people have observed [that] 'under the description' is '*qua*' or Aristotle's '*he*' in modern dress".[7] The link with the philosophy of action derives from the fact that actions may prove to be intentional under one description and non-intentional under another.

Generally speaking, the problem of reduplication is one of the many facets of the problem of *context dependence*. In his most recent book, the mathematician and phenomenologist Gian Carlo Rota reports a conversation with his colleague Stam Ulam. It is worth reporting the main passages:

(Ulam): Now look at that man passing by in a car. How do you tell that it is not just a man you are seeing, but a passenger?
When you write down precise definitions for these words, you discover that what you are describing is not an object, but a function, a role that is inextricably tied to some context. Take away the context, and the meaning also disappears.
When you perceive intelligently, as you sometimes do, you always perceive a function, never an object in the set-theoretic or physical sense.
Your Cartesian idea of a device in the brain that does the registering is based upon a misleading analogy between vision and photography. Cameras always register objects, but human perception is always the perception of functional roles. The two processes could not be more different.
Your friends in A.I. are now beginning to trumpet the role of contexts, but they are not practicing their lesson. They still want to build machines that see by imitating cameras, perhaps with some feedback thrown in. Such an approach is bound to fail since it starts out with a logical misunderstanding . . .

(Rota): Do you them propose that we give up mathematical logic? . . .

(Ulam): Quite the opposite. Logic formalizes only very few of the processes by which we think. The time has come to enrich formal logic by adding some other fundamental notions to it. What is that you see when you see? You see an object *as* a key, you see a man in a car *as* a passenger, you see some sheets of paper *as* a book. It is the word 'as' that must be mathematically formalized, on a par with the connectives 'and', 'or', 'implies', and 'not' that have already been accepted into a formal logic. Until you do that, you will not get very far with your A.I. problem.[8]

The main difficulty is that we know very little of contextual dependency. My guess is that the traditional theory of reduplication may provide some hints.

I shall now present and discuss a number of examples of the problems that a theory of this kind should be able to handle. I shall consider three cases: one taken from Aristotle, one from Quine, and one devised by myself.

EXAMPLE 1

The following example is taken from Aristotle.[9] The road that leads from Athens to Thebes is the same road that leads from Thebes to Athens: but in the former case it goes uphill, while in the latter it goes downhill. We may therefore say that this road, *qua* road from Athens to Thebes, is uphill, and that this same road, *qua* road from Thebes to Athens, is downhill. One thus concludes that there is a relation between the object and the standpoint or the point of view of looking at it. In entirely similar terms, Anscombe states that, "there aren't such objects as an A *qua* B, though an A may, *qua* B, receive such-and-such a salary and, *qua* C, such-and-such a salary".[10]

DISCUSSION

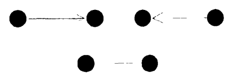
The problem presented by the above example concerns the thesis that certain ontological aspects or dimensions depend on epistemological evaluations.

Husserl introduced the distinction between states of affairs (*Sachverhalt*) and situations of affairs (*Sachlage*).[11] For Husserl, cases like 'A is part of B', 'B contains A as its part' are two states of affairs which have the same situation of affairs as their foundation. Corresponding to the same situation of affairs may be two or more states of affairs, in the same way as corresponding to the same state of affairs may be two or more propositions (thoughts).

Let us consider again the examples above. The statements 'A is part of B' and 'B contains B as its part' refer to two different theories of part and whole, one of which has '... is part of ...' as primitive or definitionally-derived, the other of which has '... contains ... as its part' as primitive or definitionally-derived. To say that the two are grounded in the same situation of affairs is merely an allusion to the possibility to show that the two theories are inferentially equivalent (e.g., the one definition can be set up in the other theory, or something such). As Henry writes:

> The sameness of the alleged situation of affairs is then not something primary or 'in itself', but merely (at this stage) an intuitive anticipation of the possibility of some more sophisticated theory which embraces the vocabulary of the two 'states of affairs'. But this anticipation is not merely metalinguistic. It is about how things are. The theories are interpreted, not taken formalistically or metalinguistically.[12]

On the other hand, the distinction seems manageable between descriptions based on 'pure' relations as opposed to descriptions based on 'indirect' relations. Consider the difference between the following directed and non directed graphs:



The two directed graphs in the first row can be interpreted as 'the road that leads from Thebes to Athens' and 'the road that leads from Athens to Thebes'. These interpretations are explicitly linked to a direction. On the contrary, the graph drawn below 'says' *only* that the two vertices (points) are connected. In other words, it exemplifies only the pure situation of 'being related to'. It is clear that the graphs in the first row result from the graph drawn in the one below as soon as an indication of direction is added (and vice versa).

We may therefore distinguish between two representational spaces: ontic space composed of situations of affairs (a-directed graphs), and ontological space composed of states of affairs (directed graphs).

The situation can be further elaborated by introducing a third representational space which mirrors the difference between the ontological viewpoint and the specific representation in the judgements of some cognitive agent. This opposition was first discussed by Daubert. In the words of Schuhmann and Smith:

> To capture this opposition between how things stand in themselves and how they are asserted to be in our judgements, Daubert [...] distinguishes between the *Sachverhalt* and what he calls '*Erkenntnisverhalt*', the 'state of affairs as cognized' or as 'unfolded' in cognition [17v]. The former is the objectively existing structure of things, properties and relations as they are in and of themselves. The latter is that side or aspects of the former which serves as the immediate objectual correlate of a given concrete act of judging [...]
>
> Thus consider: 'The chairman opens the meeting', 'The chairman is opening the meeting', 'The meeting is being opened by the chairman', 'The opening of the meeting is being conducted by the chairman', 'The chairman has opened the meeting', 'The meeting has been opened by the chairman' [17v, 63r]. Each of these sentences differs as to its associated state of affairs as cognized, but they are in fact concerned with one and the same objective *Sachverhalt*.[13]

The examples quoted require some theory able to unify all of them into a coherent whole. This will contain 'chairman', 'meeting', 'opening the meeting', and so forth, as primitive or derived terms. It will be about the worldly structure of meetings – that is, it will be about how things are.

It follows that at least three different levels can be distinguished: the level of the *Sachlage*, the level of the *Sachverhalt*, and the level of the *Erkenntnisverhalt*. From a formal point of view, aspects of the latter can be represented by allowing more edges between two adjacent vertices (as in multigraphs).

The theory of reduplication presented in this paper will concentrate mainly on *Sachverhalt* level.

EXAMPLE 2

Quine states: "Mathematicians may conceivably be said to be necessarily rational and not necessarily two-legged; and cyclists necessarily two-legged and not necessarily rational. But what of an individual who counts among his eccentricities both mathematics and cycling? Is this concrete individual necessarily rational and contingently two-legged or vice-versa?"[14]

In fact a formal contradiction seems to arise. Consider the mathematical cyclist Jones. If every cyclist is necessarily two-legged, Jones is necessarily two-legged. But if no mathematician is necessarily two-legged, Jones is not necessarily two-legged. So Jones is both necessarily two-legged and not necessarily two-legged.[15]

Quine's solution is that Jones is necessarily two-legged *qua* cyclist and not necessarily two-legged *qua* mathematician.

DISCUSSION

In the above example, the *qua* operator is an indicator of context, of semantic field, of level of description. To assert 'A *qua* B is C' is to present an object A under a certain aspect B. Frege speaks of the mode of presentation. Others speak of 'the particle of representation'.[16] When it is necessary to distinguish among different senses of concepts or different aspects or different modes of things, or when it is necessary to qualify an expression in some way, the use of *qua* is almost unavoidable.

Consider now the difference between 'Jones *qua* cyclist' and 'Jones *qua* Jones'. In the two cases we are confronted with the indication of different levels of description. As a matter of fact, we can construe 'Jones *qua* cyclist' as 'provided that Jones is *one of the cyclists*, he is . . .'. In the other case, this reading does not work. In effect, what does it mean to say 'provided that Jones is *one of the Jones*'?

If Quine is right, there are at least two levels pertinent to the distinction between essence and accident. Jones *qua* cyclist has certain essential properties and certain contingent properties. For example, *qua* cyclist it is essential for him to be two-legged. But Jones *qua* Jones (that is, Jones as such) has other essential properties. Being two-legged is not in fact essential to Jones *qua* Jones. The problem is this: what relations hold among the essential (and accidental) properties of Jones *qua* Jones and the essential (and accidental) properties of Jones *qua* something else (say, B)? There must be some foundational relation between the essential properties of Jones *qua* Jones and those of Jones *qua* B.

EXAMPLE 3

Consider now the following cases: (i) 'Jones is sweeping the leaves', (ii) 'Jones, *qua* roadsweeper, is sweeping the leaves', 'Jones, *qua* Jones, is sweeping the leaves'. Let us try to *prima facie* interpret these three cases.

DISCUSSION

The first is a normal case, one which is true or false according to the existence of a corresponding state of affairs in the world, and it does not seem to raise particular problems (apart from those which usually accompany the theories of truth and reference).

The second case differs from the first because it contains the *justification* or the *reason* of the content expressed. For this proposition to be true *two* different conditions must be fulfilled: firstly, the relevant state of affairs must exist (that is, there must be a bearer of the proposition's truth, as in (i)); secondly, one must verify whether the action described is one of the tasks that the subject is duty-bound to perform. The two conditions are *independent* of each other: the proposition may be false because, for example, there is no-one who is sweeping the leaves (condition (i)), or because although Jones is sweeping the leaves he is not doing it in his function as a roadsweeper (condition (ii)).

Very different is the case of reflexive reduplication. The linguistic form of this reduplication is typically 'Jones, *qua* Jones, is ...'. While in the two above cases the truth conditions were respectively due to the existence of an external bearer (case (i)) and to the twofold presence of an external bearer and of a relevant 'aspect' (case (ii)), in the third case the truth conditions are also tied to *internal* conditions. The conditions necessary for one to be able to say that 'A, *qua* A, is B' is that B is (intensionally) included in A, or that being A entails being B. An interesting variation is to move from the hypothesis that B is *explicitly* contained in A to the hypothesis that B is obtainable from the notes present in A (for example by conjunction, or by means of some other more complex operation). This latter problem is obviously a very awkward one and involves the problem of complex properties (negatives, disjunctives, and so on).[17]

I have already mentioned the relationship between thing and description of the thing (that is, the problem of the dependence of certain ontological aspects on epistemic aspects). The theory of reduplication is relevant here as one of the most interesting tools available to us because it has formal features with which the categorial can be separated from the epistemic component. The former, in fact, is connected with the *reflexive* use of reduplication, characterized by the occurrence of the same term (say A) on both sides of the reduplication functor: 'A *qua* A is ...'. The second case, for which I will use the expression 'locative reduplication', is instead characterized by the fact that the term occurring to the left of the functor is different from the one occurring to its right: 'A *qua* B is ...'.

2. TOWARDS A SYSTEMATIC THEORY OF REDUPLICATION

The above examples enable me to establish some initial premises. I shall say that the functor *qua* (i) makes manifest the relationship between the object in itself, its ontological frameworks, and a certain mode of looking at the object, or (ii) functions as an indicator of the context (semantic field or level of description) in which the object is being considered. In the former case, as I have already said, it is important to find a criterion which enables us to separate cognitive components from categorial ones. In the latter, it is important to recognize the two levels pertinent to the distinction between essence and accident – that is, the level at which the object is considered in its totality and the level at which it is considered according to one of its moments (that is, its non-detachable parts).[18]

In both cases, the conditions must be found which justify the passage from an analysis of the object *simpliciter* to a reduplicative analysis. When the second level is reached, the formal criteria emerge which can be used to distinguish among the various cases of reduplication. The most important of these criteria is that between the reflexive and locative forms of reduplication. In the former case, the structure of the reduplication takes the form 'A *qua* A is . . .'; in the latter it takes the form 'A *qua* B is . . .'. I shall call the latter form of reduplication 'locative' because it indicates – *localizes*, precisely – the context of description.

Barry Smith has offered the following puzzle: what about 'A *qua* considered outside any context of description is . . .'? As far as I can see, there is no puzzle. The 'B' in 'A *qua* B is . . .' range on the universe of the theory or is one of the trascendentals (*res*, *ens*, and so on). The expression 'considered outside any context of description' does not refer either to an element in the universe of the theory or to one of the trascendentals. If so, the expression 'A *qua* considered outside any context of description is . . .' is not a well-formed formula of the language of our theory.

Before beginning systematic analysis, I must classify the expressions of interest to us here. As already said, I shall assume the form 'A *qua* B is C' as typical of reduplicative expressions. Expressions in which the operator *qua* appears in other positions may be taken to be merely stylistic, not substantial, variations.

According to the standard Aristotelian analysis developed at the end of the twelfth century, there are two principal types of *qua*-proposition: reduplicative in the strict sense and specificative (or 'reductive' in my terminology).

Aristotle's examples are:

Every man *qua* rational is risible	reduplicative
The Ethiopian is white with respect to his teeth	reductive

This classic distinction must be refined by distinguishing the reduplication in reflexive and locative reduplication. A reflexive reduplication uses the same term to the left and the right of *qua*. Locative and reductive reduplications are distinguished by whether or not they admit to simplification – that is, by whether the passage from 'A *qua* B is C' to 'A is C' is possible.

This amounts to saying that we have the following cases:

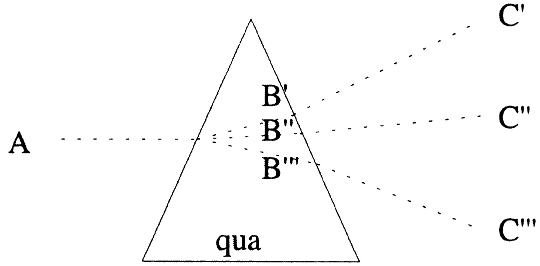
		simplification[19]
1. reflexive reduplication	A *qua* A is C	NO[20]
2. locative reduplication	A *qua* B is C	YES
3. reductive reduplication	A *qua* B is C	NO

I now analyse each of these various reduplications in the following order: locative, reductive and reflexive.

2.1. Locative reduplication

In this case the *qua* functions as a prism which singles out various aspects of the original entity:

What are the formal aspects of locative reduplicative expressions? In the expression 'A *qua* B is C', the three connections A-B, B-C, A-C must be distinguished.



The expression 'A *qua* B is C' is a double judgement which can be decomposed into two different expressions: (i) A is B and (ii) every B is C (many mediaevals added 'and being B entails being C'). Other conditions can be added in special cases: for example, causal reduplication arises when B is intended as the cause of C.

In more general terms, we may say that formal analysis decomposes the reduplicative expression into:

(i) A is B

(ii) All B's are C's.

(iii) B is the reason why the A is C.[21]

The type of relation that holds between A and C depends on the type of relation that holds between A and B. If the A-B connection is contingent, then the A-C connection is contingent too; if the former is essential, then the latter is too; and so on.

Simplification manifests interesting relationships with the mediaeval theory of the *suppositio*. Compare, for example:

Trento *qua* city is sultry	$\Rightarrow$	Trento is sultry
Trento *qua* word is bisyllabic	$\Rightarrow$	Trento is bisyllabic

The simplification obviously holds in both cases. One notes from the examples that the reduplication also serves to render explicit the *suppositio*, the *mode* in which the subject is considered. When simplification is used, the mode is made implicit, whence the greater likelihood of equivocation. In these cases we have a reduplication which assigns to the subject its reference category (that is 'material object of a certain type', 'linguistic name', and so on).

Theoretical understanding of this form of reduplication depends entirely on the relationships between A and B. If both of them belong to the same common genus, then the reduplication will have this genus (for example, when B is an element constitutive of the definition of A); otherwise this common genus may not even exist (when B is an accident or a modifier of A).[23] Generally speaking, when the genera of A and B are different, the genus of B predominates.

2.2. *Reductive reduplication*

In the Middle Ages reductive propositions were studied in terms of part and whole. The classic Aristotelean expression

The Ethiopian is white with respect to his teeth

was justified by the fact that the teeth are an integral (material) part of a man. In this case, 'in respect to' changes its reference from the body as a whole to a specific part of it. One thus understands why this reduplication became known as reductive.

These reduplications do not admit to simplification; that is, the inference from A *qua* B is C to A is C.

2.3. *Reflexive reduplication*

Reflexive reduplication is certainly the most interesting case. If one assumes the hypothesis that the theory of reduplication operates by selecting an aspect of A, what in this case would be the aspect selected from A *qua* A? More than an aspect, in fact, what we have here is reduplication in the sense of a mechanism which selects the *canonical perspective* from which A is considered. On the one hand it seems indubitable that perspectives are intrinsically related to the point of view adopted. On the other, the objectivity of an object seems to be in some way independent of the perspectives on it. From the point of view that interests us here, the objective dimension of objects is precisely that structural invariant that unifies and underlies all its possible perspective-based variants.

A similar proposal is to be found in Merleau-Ponty. Here I draw on the synthesis by Heft: "I see the next-door house from a certain angle, but it would be seen differently from the right bank of the Seine, or again from an aeroplane: the house itself is none of these appearances; it is, as Leibniz said, *the flat projection* of these perspectives and of all possible perspectives, that is, the *perspectiveless* position from which all can be derived, *the house seen from nowhere*".[23]

For every entity, the perspective selected by the reflexive reduplication is that which is most proper to it, that which asserts it in its essence. As regards general terms, the perspective is their field of reference (numbers *qua* numbers, material objects *qua* material objects, images *qua* images, and so on). As regards proper names, it is the direct consideration of the individuality involved, in the sense of 'this particular individual'. In this latter case, however, reduplicative analysis is no different from direct analysis. The expressions 'Socrates is ...' and 'Socrates *qua* Socrates is ...' give rise to the same consequences. Hence it follows that reflexive reduplication performs an independent theoretical role only in cases of general terms. One therefore understands why it is possible to simplify in only one of the two cases. These specifications further emphasise the function of reduplication as a tool for scientific analysis.

Reflexive reduplication is definitional and normalizing. The combined use of reflexive and locative reduplication can be used to map the dependence relationships internal to the so-called radial categories.[24] Generally speaking, therefore, reflexive reduplication is the fulcrum for mappings of prototypicity. The formula 'man *qua* man' renders explicit the components that constitute the human being and their (immediate) consequences.

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NOTES

[1] I wish to thank both D.P. Henry and K. Schuhmann for their detailed comments and B. Smith for helpful remarks on an earlier version of this paper.

[2] The sole assumption that the expressions 'being *sempliciter*' and 'being *qua* being' are different in meaning runs explicitly counter to the interpretative tradition of Owens and Merlan, for whom *kath auto* or *per se* should be construed as *simpliciter* or 'as such'. A persuasive reason for rejecting their interpretation is the consequences that arise from analysis of geometric entities, which become ideal entities. As Leszl 1975, 155 notes, "This is no doubt how it should be conceived, if the line were supposed to be given as something *ideal* instead of being *idealized* by means of an intellectual process ... It would be peculiar to find a return to Platonism in the use of precisely those conceptual instruments, such as the qualification '*qua* X', which Aristotle uses in order to avoid any form of Platonism, e.g., to fight against the theory of forms" (my stresses).

[3] The thesis is not controversial and is explicitly asserted in various passages, for example *Metaphysics* III, 3, 998b14ff (to which should be connected *Topics* VI, 6, 144a36ff); *Metaphysics* I, 2, 1953b22-23, *An. Post.* II, 7, 92b13. See Leszl 1975, 72.

[4] See Angelelli 1967. When discussing some consequences of his famous thesis "*eadem sunt quorum unum potest substitui alteri salva veritate*", Leibniz adds "*excipiendae autem sunt propositiones reduplicative*" (Couturat 1961, 261). On page 96 of his paper, Angelelli notes also that "the interesting phenomenon of *reduplicatio* seems to have been forgotten in contemporary philosophy; perhaps Bolzano was the first and the last modern logician having paid attention to it, and in a very interesting way indeed". Schuhmann reported to me that extensive discussions of reduplication are to be find also in Fichte's *Wissenschaftslehre.*
[5] Wiggins 1980; Fine 1982; Henry 1987; Tichy 1988; Benardete 1990 (ch. 1); Bäck 1991. Bäck's recent 1996 provides an impressive historical reconstruction of reduplication.
[6] Anscombe 1981b, 208.
[7] Anscombe 1957, 11.
[8] Rota 1997, 57–59.
[9] And was quoted by Anscombe, Geach 1961.
[10] Anscombe 1981b, 208.
[11] Rosado Haddock 1991.
[12] D.P. Henry, personal communication (January 1994).
[13] Schuhmann, Smith 1987a, 367–8. During his lifetime, Daubert published not a single word. Quotations refers to a manuscript transcribed by R. Smid and has been given referring to page numbers with recto/verso markings. For more information see Schuhmann, Smith 1987a, 358–9. On Daubert's life see Schuhmann, Smith 1987b.
[14] Quine 1960, 199.
[15] Benardete 1990, 10.
[16] Dieter Henrich cited in Bernadete 1990, 9.
[17] For treatment of this topic see at least Armstrong 1978 vol. 2; Grossmann 1983: Meixner 1992. For some connected topics see Forbes 1992; Hochberg 1992; Simons 1992.
[18] For the difference between parts and moments, see Smith 1982.
[19] *Salva veritate.*
[20] Unless A is a proper name. Cf. *infra.*
[21] Maritain 1937. Note that in (iii) 'reason' could also be 'cause' or 'instrumental condition'. Cf. Barth 1974, 136. For a formal analysis of reduplication, see Poli 1994.
[22] On modifiers see Poli 1993.
[23] Merleau-Ponty 1963, as reported by Heft 1996, 125, my emphasis.
[24] On the concept of radial category see Lakoff 1987.

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LILIANA ALBERTAZZI

FORM METAPHYSICS

1. A NOT UP-TO-DATE PREMISE

Can metaphysics be a science? The question has long been dismissed as obscurantist and in bad taste, as well as being obfuscatory, impossible to frame and methodologically inadequate. And yet it is an entirely legitimate question when stated in the following simple terms:

(i) what *exists*?

(ii) what are the best methods with which to *describe it*?

(iii) and, subordinately, why do things sometimes *appear* differently from what they *are*?[1]

Questions of this kind stem from an empirical and experimental vocation.

The first step to take in analysis of an "elementary doctrine of the components of experience", as Kant put it, is an apparently simple one.[2] One asks oneself, in order to remain on certain ground, what it is that exists here and now in the present moment.

A first answer concerns those apparently indubitable situations in which *something* – that is, *objects* of some kind – are seen, felt, smelt or touched. Yet an immediate certainty based on sounds, colours and things that are experienced apparently without mediations and usually with an emotional connotation – the bold red of a dress, the strident sound of violently applied brakes, the glittering gold of the decoration on the facade of a Viennese building, the pale moon that fades with the morning – at once raises the problem of the *terms used to describe it*, since these are extremely difficult to manipulate. *Here, now, something, object*, and so on, but also and more simply *colour, sound, emotion*, etc., are all terms which are widely abused and apparently bankrupt if analysed on the basis of linguistic definitions. And as for *seeing, feeling, hearing*, etc., these are veritable speculative pitfalls for the unwary. Are they acts? If they are, on what do they rest? Do they have some sort of substratum or are they wholly unconnected? And then, what is their origin? Metaphysics thus seems to oscillate perilously between the mute *deixis ad oculos* of the moment-now and the atemporality of abstract definitions of terms such as *be, exist, become*, and so on.

L. Albertazzi (ed.), Shapes of Forms, 257–305.

Not surprisingly, therefore, several philosophers have given up in the attempt and devoted themselves to the much more reassuring theories of epistemological *models* and logics of the existent, declaring metaphysics to be 'off limits'.

For those who persist in their empirical endeavour, the only option is to adopt a different approach: a minimalist one which analyses the *situation* to which these terms refer and their genesis in the duration. This is an essentially *descriptive* approach; it has close ties with psychology and it is, specifically, an *experimental phenomenology.*[3]

1. EXPERIMENTAL PHENOMENOLOGY

What is an experimental phenomenology? The discipline belongs to a tradition known only in its macroscopic aspects, and largely as a result of the developments (almost always non-experimental) given to Husserlian phenomenology.[4] Unlike classical phenomenology, however, the discipline is experimental: it is part of the Gestalt tradition of psychology and therefore also engages in laboratory analysis – something that Husserl at a certain stage of his analysis would have partially rejected.[5] Experimental phenomenology is regarded as true experimentation, its *experimental variables being mental contents of direct experience* rather than physical stimuli or physiological processes.[6] Experimental phenomenology, then, is not only a *theory of consciousness*, it is also a *science* which could be defined as a *descriptive psychology* of perception.[7]

In the first instance we may say that experimental phenomenology sustains the (ontological) independence of the phenomenological level of perception (that is, it claims that the phenomenological level is *not reducible* to the physiological or to the physical levels) and that it uses an empirical and experimental method.[8]

Moreover, it claims that the analysis of the phenomena of experimental phenomenology moves in two directions, *descriptive* and *morphogenetical*, so that it analyses phenomena (i) as they are given to consciousness in the moment-now and (ii) in terms of their genesis.

Developments in experimental phenomenology have been mainly descriptive in form – one might say *phenomenological* in the strict sense. They have not sought to establish any relationship with physiology, and to date they have not played any significant role in the development of the cognitive sciences. There are still very few gestaltists working in the cognitive sciences, and gestaltists in general are treated with scant respect by cognitivists.[9]

This antipathy or lack of mutual esteem stems from a cultural misunderstanding. Consider, for example, the representation of a certain type of motion, that of a thrown object. The *exact* (so to speak) sciences represent such motion according to the rules of classical dynamics, which are univocal and numerical. Experimental phenomenology, by contrast, offers a representation which resembles a *naïve physics* and harbours a number of surprises.[10] In fact, when motion is analysed in the laboratory or simulated by computer, there is a tendency to describe it in terms of Aristotelian physics – for example, in terms of the theory of *impetus* – so that an object thrown into the air moves horizontally for a certain stretch of time and then falls vertically to earth.

The two descriptions are apparently irreconcilable, and the usual approach is to seek to reduce one of them to the other – that is, the phenomenological description to the description furnished by the exact sciences – because the former is dismissed as a perceptive 'illusion'.

As early as 1906, however, Benussi pointed out that so-called perceptive illusions like those devised by Müller-Lyer or Poggendorf *are not errors but inadequate perceptions of form.* Whilst it is an error to mistake a pen for a pair of spectacles, a perceptive illusion is something that we continue to see or to feel in a certain way even when it is actually not like that: for example, the twig in a glass of water is not broken, the two main segments of the Müller-Lyer figure are of the same length, and so on. Obviously, there also exist contrary illusions, for example when we look at a round disc from above and from one side: the image on the retina is oval, but we see the disc as circular. These 'illusions', of course, have played a major role in the development of the theory of perspective.[11]

In principle, therefore, experimental phenomenology is not antithetical to physical, physiological or neurophysical description. The reason why experimental phenomenology initially gives precedence to perceptological observation and does not, for example, begin with a physiological theory, was well explained by Koffka in 1935, when he pointed out that recognition of phenomena in the physiological field is already a logical instance and part of the search for an *explanatory* theory. It therefore already operates at a level of abstraction at one remove from the facts under observation: in other words, physiology is already part of the *epistemology* of the world.[12]

1.1. Of the various conceptual categories of experimental phenomenology, the following three are of especial importance.

1. The notion of *observables* as formulated by Koffka and taken up by Bozzi. An observable is whatever lies within the range of the eye, is 'at hand' and is amenable to manipulation in the actual duration. Observables possess at least one property of colour and place and one property of direction and velocity.[13] They are material and may be static and/or dynamic objects; they are part of the surrounding environment or they may be constructed artificially – for instance using pencil and paper as in the numerous examples provided by Brunswik or Kanizsa.[14]

2. The notion of an *event* as formulated by Vicario, and which, in general, states that the *objects of perceptive fields have duration*, and that the perception of events is therefore tied to the perception of *temporal structures.*[15]

Phenomenologically, as to 2., we may distinguish among:

2.1 stationary events or *objects* (permanent objects, like mountains, houses, etc., but also fleeting objects like flicks, flashes, etc.);

2.2 non-stationary events or *changes* (continuous changes of quality or position: a disc continuously changing colour, a ball rolling from left to right);

2.3 quasi-stationary events or *states* (simultaneous perception of objects and changes: the movement of leaves on a tree, the movement of waves on the surface of the sea, etc.). A particular case is the induced movement analysed by Duncker, examples being the apparent movement of the moon behind clouds or the classic illusion of being on a moving train as we watch a train leaving from the next platform.[16]

3. The notion of an *invariant* developed mainly by Gestalt psychologists and which concerns the essential properties of observables.[17]

One of the fundamental problems of descriptive experimental phenomenology, however, is the following:

How can one pass from a set of *observables* given in perception, like 'something green, scented and velvet to the touch, here and now' as a salient figure on a multiform background of actual impressions, to the *identification* of true perceptive *objects* (like, for example, 'musk')?

Even more simply and descriptively: why in actual perception do I see in front of me, for example, a tree, with thick foliage, in a field, against the background of a blue sky, and not an indistinct patch of colour?[18]

In philosophical terms, do there exist *material* and *formal* invariants of events, which justify the recognition of *objects*, their salience on a background, their profiles, and so on?

The distinction between material and formal invariants was drawn by Husserl, and it is important from both a descriptive and a genetic point of view.[19]

Descriptively, perception shows us effectively existing *situations of affairs* like yellow houses, green fields, grand pianos, etc. That is to say, it only shows us (i) physical objects and (ii) sensible properties. These constitute the terms and the predicates of our statements about the world. Perception does not show us connectives (*and, or, if, then*, and so on); nor does it present us with quantifiers (*each, some, all, many*, etc.) or relations of the kind 'Liliana is to the right of Alexander'. These types of constituents are part of a *categorial perception* which, though founded on sensory perception, concerns higher-order objects, to use Meinong's expression; objects, that is, whose existence is dependent on other objects.[20] Examples of categorial objects are the sets of models theory, the states of affairs of the mental contents of our assertions, literary objects, epistemological theories, and so on.[21]

The distinction between material and formal constituents becomes even more subtle in the case of the genesis of events; that is to say, even before these actual events in the continuous flux of the duration assume the stable characteristics of objects. An intuitive example of what constitutes a material invariant from this point of view is the tendency of some perceptive structures to complete themselves in a specific direction, and not vice versa or in another way: this is the case of the onset of a tonal melody which tends towards a certain type of closure, or the immediate perception of an oblique line as a deviation from a horizontal line, or the directionality of angles. From a genetic point of view, then, also conjunctions and quantifiers are implicit in perception as forms of modalization of its elapsing; and, as the phenomenological geneaology of logic shows, even the existential copula has a pre-predicative origin.[22]

These various aspects can be understood in terms of a theory of intentionality, and particularly when set in relation to phenomena of directionality in the constitution of perceptive objects in the duration. Still today, the only available examples of this theory are Husserlian phenomenology and Benussi's experimental research on temporal apprehension.[23]

1.2. Generally speaking, we experience objects which remain broadly phenomenally constant, small variations in their proximal stimuli notwithstanding. If we strip the invariants of perceptive phenomena down to their bare essentials, we can summarize them in:

1. *temporal* determinations (of localization)
2. *spatial* determinations (of localization)
3. *qualitative* determinations (of filling)
4. *change*
5. *movement*
6. *shapes*
7. *forms.*

Shape and form are not synonyms. In the first instance, I propose to distinguish shape (silhouette, outline, profile) from form. The former is static and spatial; the latter is dynamic and temporal and includes perception of change and/or movement. In particular, forms are temporal events, integrated totalities whose parts contribute to the formation of wholes. A classical example of form is a melody; a classical example of shape is a triangle. Forms, in their turn, can be *shaped*, if considered in a static instant of their process: think, for example, of a photograph of a jumping rabbit.

Secondly, I distinguish shapes from forms because I am referring to the distinction drawn above between the material and formal invariants of perception.

Thirdly, in a psychological and cognitive sense, the distinction is a product of the Graz school and in particular of Benussi.

Benussi distinguishes (1) *objective* and (2) *subjective* conditions in perception.

(1) *Objective conditions* are the external conditions that form the basis of, for example, the laws governing the absorption of light by a white surface.

(2) *Subjective conditions* are further divided into (1.1.) *external* and (2.1.) *internal* determinants.[24]

(1.1.) *External perceptive determinants* are the so-called inadequacy-bearing elements (or Gestalt elements) like the vividness of colour, the secondary inward lines of the Müller-Lyer figure, the difference in clarity between background and figure of objects, etc. For example, if the main line is removed from the Müller-Lyer figure, the inadequacy increases because the distance between the apexes has the same colour as the background (zero salience). If the saliences of the Gestalt elements and of the opposing elements are different (clarity remaining equal), the greater the salience of the former, the greater the inadequacy will be. This is also the case of Zöllner's figure and of the chessboard figure.[25]

(2.1.) *Internal perceptive determinants* (the more properly *cognitive* aspects of perception) are those conditions which influence perceptive performance and play a major role in, for example, inadequate perceptions of form. For example, four points arranged as the apexes of a square can also be perceived as the structure of a cross delimited by four points.[26]

It is important to bear in mind that an experimental phenomenology considers *neither* the apparent colours and movement of perception *nor* stereokinetic or stroboscopic movement, *nor* inadequate perceptions of form, to be illusions – even less errors, as we have seen – but as specific *descriptions* of particular phenomena.[27]

1.3. As said, analysis of the objects of the world of perception has: (i) a *descriptive* aspect, which consists in their perceptive recognition as 'objects'; (ii) a *genetic* aspect, which consists in the analysis of the stages and phases through which the constitution of objects or, better, of objectual forms in the time of presentness is realized.

In its turn, the recognition of perceptive objectual forms requires: (i) a theory of *fields* and of *perceptive continua*. Genetic analysis, for its part, requires: (ii) a theory of *consciousness* and intentionality.

These two aspects are closely connected.

As far as perceptive fields are concerned, Musatti, for example, distinguished sensory fields into physiological and perceptive.[28]

Physiological fields are those that relate to the organs of sense; perceptive fields are those which, *on the basis of* the physiological fields, construct a different kind of phenomena *founded* on specific qualities of perceptive data as such.[29]

Perceptive fields, in their turn, are either (i) *independent* or (ii) *dependent.*

(i) *Independent perceptive fields* are those whose data group themselves into independent classes: that is to say, a datum from one class is transformable into any other datum of the same class, but not into those of other classes dependent on different perceptive fields. For example, we can transform yellow into green, but not yellow into bitter.[30]

(ii) *Dependent perceptive fields* are those whose elements are always given together with elements originating from other fields. For example, the perception of spatial shapes is always given together with the perception of loci. In this case, shape is *founded* on its locus. The shape, that is, is not simply joined to the locus, as in the case of clarity, saturation and tonality; rather, there is no perception of shape *independently* of the perception of locus.[31]

2. PERCEPTIVE CONTINUA

As Aristotle pointed out, the concept of continuum is an intuitive one; it is, in other words, part of the immediate perception of observables. There are different kinds of intuitive (that is, perceptively given) continua: temporal, spatial, qualitative (like sound and colour, but also velocity, density, temperature, pressure, etc.).

From the point of view of a perceptive continuum we see objects which alter or else remain the same in a sort of phenomenal identity and a sort of (multi)stability; objects which do not have *exactly* defined parts and boundaries, but which are nonetheless recognized as such. There are, in short, saliences of different *types* and different *oriented* patterns.[32]

But there are also continuous presentations of past events. In its twofold aspect as perceptive and mental, the presentation can be conceived as a continuum of something which is, for example, experienced or remembered in motion or at rest, in change or in stasis, and so on. Actually present percepts and memories obey different rules of formation, but the continuum nevertheless arises from the *experience of a qualitative change in a psychic state*; in other words, from a *diverse mode of presentation* of objects in the actual duration.[33]

However, phenomenological analysis of perceptive continua is something different from, for instance, logico-formal analysis of continua. Let us take the example of temporal continua: perceptological analysis conducted in the laboratory of the phases of the duration differs profoundly from the elaboration of logical primitives of the 'before' or 'after' type required to model continua. They are in fact two different conceptualizations of experience which refer to ontologically different layers: the former is *material* and relates to a naïve physics; the latter is *formal* and relates to an epistemological theory of reality.[34]

Specifically, logico-formal analysis addresses the theme of temporal qualities on the basis of abstract definitions, and time is represented as a formal system in the sense given to it by models theory: a totality of individuals arranged in a certain temporal order. The temporal continuum is in this case represented as a set of discrete points connected by external relations. The primitive relation is constituted by before and after, which presupposes a complete *representation of the temporal order*.[35] This, however, is a conceptualization which becomes highly questionable in perceptological analysis, and especially in analysis of events experienced in extremely rapid succession, where even phenomena of temporal inversion may occur.[36]

Moreover, as has been shown by researchers in the formal field, punctiform structures induce structure-periods through the creation of intervals, while punctiform structures can be recreated out of structure-periods by means of limitative constructs. Hence the choice between temporal instants or extensions is not a particularly important one in formal analysis, although it is pertinent in material analysis.[37] Indeed, in material analysis the existence of a temporal extension (i.e., *a non-punctiform time of presentness*) is an indispensable condition for the recognition of objects, as laboratory research shows: a series of disjoined instants would not provide the *patternability* conditions of the content of the presentation.

Moreover, although intervals of time – those *apprehended* in the duration – can be mapped on to an objective time of milliseconds, they have an essentially *qualitative* nature. In fact, they can be varyingly *experienced* according to the nature of the content filled. To give a banal example, time passes quickly in exciting situations – that is, the interval is *apprehended* as *brief* – independently of the objective time of the duration.[38]

The phenomenological analysis of time therefore examines its *actual genesis* in the duration, and in particular its *qualitative* or qualifying aspects connected with the activity of consciousness.[39] In other words, it is analysis of the *structure* of the duration, of the constraints that it imposes on the *objects of the presentation*, and of the relations internal to the structure itself. As such, it provides the basis for a broader *theory of intentionality*.

Finally, the material investigation of time, unlike its formal counterpart, benefits from the fact that it is able to show the material temporal structures actualized in the phenomena of the perceptive field, prior to any possible modelling of them.[40] From this point of view, the material investigation of time is of great importance for metaphysics, if by metaphysics is meant, *à la* Meinong, that which really exists in the world.[41]

To conclude: if the analysis of temporal perceptive continua is a key component of experimental phenomenology, it is also of great importance for the construction of a scientific metaphysics.

2.1. In the twentieth century, the principal role in founding a metaphysics of this kind has been played by *physics*, with the exception of Carnap and Goodman on the one hand, and of Musatti on the other.[42] However, although Carnap's and Goodman's primitives are based on qualitative analysis, they are substantially definitional in nature. They are therefore not *invariants* in the perceptive sense; that is to say, they are not the observables of an experimental phenomenology. As for Musatti, his ideas have circulated to such a limited extent that they have done nothing to direct attention to the role of perceptology in the founding of a scientific metaphysics.

A metaphysics of this kind has been outlined in its essential components only by Brentano, on whose account the following analysis is substantially based.

Brentano's metaphysics has a psychological foundation (the theory of intentional reference), and on a number of points it resembles the physiological theories of Johannes Müller, according to whom there is a rough correspondence between perceptions and somatic processes.[43] Far from being superseded, Brentano's metaphysics provides the cognitive sciences with a series of extremely up-to-date insights, in that it gives original treatment to such phenomena as continua and the boundaries of continua, or to phenomena analysed by the contemporary naive physics of AI, such as skewing, cutting, connecting, assembly, etc. Brentano distinguishes among various kinds of continua. Firstly, continua divide between:

(A) *primary*
(B) *secondary.*

Secondly, continua can be:

(C) *uniform*
(D) *multiform*
(E) *multiple.*

(A) Primary continua

Generally speaking, primary continua are uniform, homogeneous and have continuous borders. Primary continua are, in the first instance, temporal and spatial continua. An example of a primary continuum is a line which extends indefinitely.[44]

(B) Secondary continua

Secondary continua are co-extensive with primary continua, but they are heterogeneous and qualitatively differentiated. Secondary continua, moreover, can be experienced, or are amenable to presentation, only on the basis of a primary continuum, according to some sort of ideal dependence between the two. For example, the length of a line is a secondary continuum with respect to the line itself, and likewise its colour or direction.

From a metaphysical point of view, however, the primary continuum in the strict sense is *time*, considered as the actual present, as the only centre of potential expansion of the time of presentness. Traditionally, analysis of perception has underlined the relation between mind and the *spatial* layout of the environment, but time is primary also with respect to space, since it governs the constitution of the *form* of perceptive objects in the actual duration.[45] From an acoustic point of view, for example, the primacy of time over space is manifest in the localization of sounds, which are 'identified' spatially on the basis of the temporal difference in the excitation of the sense organ. When I say: 'the sound is coming from up there on the right', I am merely expressing the following situation: functionally, the direction of the temporal continuum has assumed a spatial determination.

In its turn, space is primary with respect to the qualities of perceptive objects – that is, to the dimension of colour, texture, temperature, granularity, etc.

In reality, therefore, actual perception never presents us with simple continua, but always with complex continua in reciprocal dependence.

Primary continua are characterized by:

(a) *boundaries*
(b) *velocity of change*
(c) *fullness of direction* (orientation) and consequent velocity of movement.

(a) Boundaries

A *boundary* is what enables us to *represent* to ourselves the concidence or otherwise of the objects of the continuum.[46] Individuations of boundaries at the perceptive level are of essentially two types: (i) *temporal* and (ii) *typological*, and therefore relate to whether the boundary is temporal or spatial. The former is a temporal closure which coincides with, or bounds the duration of, the presentation of an entity; the latter consists of an encompassing by one or more closed surfaces of a spatial neighbourhood coinciding with or bounding the extension of a physical object.

In perception, boundaries expand in different directions and with different velocities of change. They have different modes of existence according to the continuum to which they belong. Finally, there are external and internal boundaries, which in their turn may have internal or external sides.

The external boundary delimits the continuum to which it belongs only according to certain possible directions, while the internal boundary delimits it according to all possible directions. An example may be of help. Take a simple object like an apple: the peel is its external border, while any point of its pulp is a (potential) internal boundary which is actualized when the apple is cut. The peel of the apple, moreover, has an external side which presents a particular direction and an internal side which presents a different direction.[47]

Let us take the more complex case of a process: an internal boundary of the process is the last instant in which that process is active; an external boundary is the first instant in which the process is no longer active. However, in the case of *extremely restricted temporal events* lasting for a few hundreds of milliseconds – for instance a trill which sounds for only 40 msec or a beat on the kettledrum in music – the division between internal and external boundaries becomes extremely subtle and can only be *assumed* to exist. In this case, in fact, quasi-timeless, or fleeting objects to use Meinong's expression, are involved.[48] An analogous case occurs in the visual field: a red square shrunk until it becomes a point also loses its colour. In these cases, acoustic matter and visual matter behave in similar fashion because of the shrinking of the primary continuum.

Boundaries may also vary *functionally*, as evidenced by cases of formal plurivocity or geographical maps (the contrast in profile between land and water), and also by the fact that boundaries pertain to figures and not to backgrounds: in fact, we see things and not the voids that separate them.

(b) Velocity of change

Continua have or do not have *fullness of velocity of change*. Consider the most straightforward case of a body which moves from one place to another, rapidly or slowly, and therefore at differing speeds. Consider also a coloured rectangle which varies in hue horizontally but remains invariate, in colour, vertically: in this case, the vertical dimension is in constant fullness of velocity of change, but not so the horizontal dimension. Velocity is therefore the *degree of change in form or in position.*

(c) Fullness of direction

Continua have or do not have *fullness of direction*. Consider a disc coloured with a regular pattern of red and blue. Each of its radii – that is, each internal boundary – manifests the differences in the continuum to which it belongs, so that the red that begins with a constant variation towards blue can never be *entirely* red. In other words, the point is both red and blue – or better, it is at the same time a ceasing-to-be-red and a beginning-to-be-blue. Consider then an object thrown into the air: the temporal boundary is still in full direction while the secondary, directional continuum is only in partial fullness of direction, since it *changes orientation* or, more simply, *moves*.[49]

Implicit in the fullness of direction, therefore, is also change of position. Direction in space is obviously important for the recovery of symmetries. Moreover, many ambiguous figures, like Jastrow's duck-rabbit, are the effect of inversion in the principal *direction* of the visual continuum.[50]

Fullness of velocity and fullness of direction are closely connected. The difference between them consists mainly in the differentiation of place (like the limit of shape) and of relative position (limiting points) of the continuum. Moreover, the fullness of direction affects the fullness of change, and vice versa. Consider a perceptive whole located in what Gestalt psychologists term an *anchoring point* (i.e., in relation to the salience of the principal axis with respect to the orientation): a change of position by all the points of the whole situated on trajectories different from the background is always related to the anchoring point.[51]

However, as we shall see from the perceptive analysis of colours, the velocity of change between contiguous colours (from yellow to red, for example) does not immediately entail change of direction as well, although it does entail change between antagonistic colours (from red to green, for example).

A classic example for a phenomenological theory of this kind is provided by Mach's rings: the case, that is, of a graduated disc which grows uniformly lighter or darker as one moves from the centre to the edge (this being a case of a directional continuum). If a line is drawn which divides the surface into two zones, the uniformity of colour disappears and only persists in the partial surfaces.[52]

The limits, direction and velocity of change of continua have important effects on the *shaping* of perceptive objects. Consider Michotte's launch effect, where two distinct events form, in continuity and change, a single whole, a shock which launches.[53] Experiments show that the differing correlate of the presentation is due also to the *internal determinants* of the act, or more simply to its *temporal modes* of recognition of the object: there is a strict relation, in fact, between the saliency of a (symmetric) shape and the speed of information about it.

2.2. From what has been said, therefore, it seems that although continua are abstractly distinct according to species, in concrete perception they are always united. Nevertheless, we may distinguish continua into:

(C) multiple continua

A *multiple* continuum is a continuum of bodies and surfaces like that of space. Other examples of multiple continua in perception are the doubling of the continua of movement of the same continuum, as in the case of a rotating wheel, which has twofold movement in its rotation and change of position.

(D) multiform continua

A *multiform* continuum is a unity (not a plurality), cases in point being such acts of perception as *spatially seeing* or hearing a series of tones, or, in tactile-kinetic perception, the perceptive multiplicity which distinguishes between the shape of the angle and the trajectory of the hand that draws it.

Our acts of seeing, feeling or touching something are part of a continuum of this kind, because they are based on a texture of symmetries at a different level which is anchored in the perceptor.

Analysis of perceptive continua yields other important information. In fact, modifications in the kinetic state of a perceptive object in relation to others, variations in the spatio-temporal distance among objects, and in the direction of movements, have different perceptive outcomes. The most important points of such analysis concern:

(i) the *moment-now*
(ii) the phenomenon of *change*
(iii) the genesis of the concepts of *identity* and of *causality*
(iv) the relationship between *meaning* and *expression.*

(i) The moment-now

The moment-now is fundamental, in the sense that awareness of the change, of the identity, of the causality and of the meaning of objects is actualized in the temporal structure of the duration. What is the moment-now? Experiments show that when the intervals are prolonged beyond the limits of the perception of a simple discontinuous change, *new situations of consciousness arise* which are circumscribable to the so-called time of presentness.

By *'psychically present'* is meant that series of perceptions which can be apprehended without being 'rhythmitized', that is, broken down into *quantitatively* distinct groups.[54] As regards the question of how long an act of presentation objectively lasts – that is to say, whether it is an instantaneous moment-now or a temporal extension – experimental research has identified the subjective indeterminate duration (c.700 msecs) as the type of duration which characterizes the psychic present. Internally to the present, however, research has detected *qualitative moments* of presentness, of varying degrees of prominence, which are due to *phenomenal salience.* In particular, it has been shown that:

(i) with shorter intervals (630 msecs), it is the succession of *sensations* that is analysed;

(ii) with longer intervals (1000 msecs), apprehension concentrates on *sensations* in themselves;

(iii) with intermediate intervals (700 msecs), the experimental subject intuits these intervals as *time* and not as succession, and above all apprehends them in a single act, thereby corrobating the results obtained by Stern in his pioneering experiments.[55]

The moment-now, time of presentness, or more simply the presentation, is therefore a temporal extension in which a *simultaneous content* is apprehended. But it is apprehended on the basis of *individual elements perceived in succession* (and which differ according to the perceptive field).[56] The various phases of the constitution of presentness are governed by the laws of the grouping and unification of apprehended contents relatively to the diverse and successive aspects of the presented object.[57]

The time of presentness is fundamental because perceptive continua are continua which *really exist only in the moment-now*, this being the *boundary* of the temporal primary continuum. The moment-now is a point of the temporal continuum *in potential extension* to the unidimensional uniformity of the continuum itself.[58] In fact, although the temporal duration, qualitatively filled, can be mapped onto chronological and spatialized continua of a qualitative type, it cannot be reduced to them; that is to say, it continues to be ontologically different and independent. This has been shown by analysis of perceptive phenomena, and in paradigmatic fashion by stroboscopic movement, by stereokinetic movements and, most strikingly, by the phenomena of temporal displacement in the acoustic and visual field.

In fact, experiments show that:

(i) *above* a certain temporal threshold, stimuli retain their *real* physical sequence

(ii) *below* this threshold the place occupied by an element in the succession perceived depends on other factors, such as the *similarity* of sounds (e.g., notes as opposed to noises) or their *phenomenal salience* (e.g., sounds or colours of greater intensity as opposed to sounds or colours of lesser intensity).

Particularly striking, is the phenomenon of the *acoustic tunnel* analysed by Vicario, which occurs when there is the *amodal* continuation of a sound beneath a noise which seems to cover a stretch of it.[59]

(ii) Change

In our natural disposition objects are perceived as undergoing alterations: a figure grows smaller as it moves away from us; the sun changes colour as it sets in the evening; a boat abruptly changes course on a lake; a light increases in intensity; the colour of the sea rapidly changes as dark clouds gather; and so on.

Genetically, however, matters are more complicated than this: it is *the perception of change that is original*, not change in the object.[60]

Laboratory research demonstrates, in fact, that the sequence of the perceptive contents involves primarily the *experience of change*, and that this conditions the experience itself of succession. In short, awareness of perceptive objects (and/or their phenomenological morphogenesis) begins with change.

It emerges, in fact, that *with shorter durations* change is perceived although the perceiver still has no impression of the succession; and that the perception of change is the simplest and most rudimentary form of unification of the representative multiplicity – indeed, that change is almost the *most elementary phenomenon of the consciousness.*[61]

In this sense *qualitative* change is explained as a relationship among the various *phases* of *what is* to other phases of *what is* which are in different stages of enfoldment. The qualitative change given in duration has an *implicit order* ('implicate', Bohm would say) in terms of a series of interpenetrating elements in different degrees of enfoldment characterized by the fact that *they are all co-present* in the time of presentness.[62] This is the phenomenon of co-variations of elements; as in a melody, where the single parts of the whole form themselves in the *duration of the current presentation. In the time of presentness*, in fact, there are no notes in succession *and* the relations among them; indeed, the succession itself may undergo shifts of position.[63] The same holds for every actual perception of events or of a series of events which *tend* to a certain pattern.

(iii) a. Identity

To identify the *objects* of the duration, at least three conditions must hold:

(i) there must be a certain *succession of impressions* with a certain *order* and a certain *continuity*;

(ii) these successive impressions must be *connected*;

(iii) these impressions must have *boundaries*, they must be delimited and *marked out* from the rest of the continua of colours, sounds, tactile-kinetic sensations, grounds, and so on.

Every possible phenomenal object, then, is formed by undergoing a sort of *closure*, a tendency towards the assumption of a good shape in which individual impressions are unified and made homogeneous according to the similarity and unification of shared aspects or parts. This means that the features of the perceptive object are *grouped*, so that a whole may emerge from of them.[64]

Husserl's theory of double intentionality, although tentative, is a theoretical approach to the question of the phenomenological identity (and of causality as well) of objects, since it shows that the retention of the *content* of perception also comprises retention of the *act* of perceiving, which coincides with the *identity* of content. Husserl gave a *description of the intentional structure* of the act of presenting which consisted of at least two levels: (i) *latitudinal*, concerning the formation of phenomenal content; (ii) *longitudinal*, concerning the form of the ordering and succession. According to the double structure of intentionality,

(i) an object has its identity because it emerges as a non-summative whole;

(ii) an object emerges as a symmetrical whole because it is the content of an act;

(iii) the modalities of the act impart symmetry to the object.[65]

Finally, Husserl's theory identified a *multiple structure* of the act of intentional presentation (a whole composed of a micro and a macrostructure) and the different *modes* of direction of the act towards its possible objects.[66]

(iii) b. Causality

The perception of causality in particular is tied to *movement*, and therefore to the characteristic of *fullness of direction*. From an abstract point of view, movements can be distinguished into:[67]

(i) *natural*

These are movements like that of a ball rolling downhill, the swinging of a pendulum, an object thrown from a height, but also snow drifting in flakes or pelting rain.

(ii) *passive*

These are movements that involve mechanical causation: for example, oxen pulling a plough, a magnet attracting iron, colliding billiard balls. What is perceived in these cases is an *external action* on a body which is hit, shifted, dragged, and so on. For instance, in the triggering effect analysed by Michotte, the observer has the distinct impression of an object which releases energy and acts upon another object, like a shot from a gun.

(iii) *expressive*

These are movements which *connote certain behaviour* (irrespective of whether it is by a person, an object or an animal), like the whirling of leaves in the wind, the movement of waves, the slithering of a snake. They are movements which intrinsically convey the impression of rhythm, uniformity, repetitiveness, and so on.

Concretely, these three types of movement are to be found *mixed* in the perception of events, and, as Michotte has shown, it is according to their temporal modulation that the observer perceives causality, a 'drag effect', a 'push effect', and so on. In short, under certain conditions of variation in distance, velocity and direction, the observer *sees* causal behaviours where one object pushes or collides with another; or s/he sees reactive behaviours involving distancing, flight or expectation – that is, cases in which one object retreats from another, waits for another, and so on.[68] The perception of causality is ensured by the fact that, in the actual duration, the phenomenon possesses pregnancy and uniqueness: the various phases of the phenomenon, in fact, are *fused* within the actual genesis of the phenomenon itself.

2.3. An experimental theory of the *actual genesis of phenomena in the duration* was developed by the Leipzig school. One of the fundamental assumptions of Gestalt is that in the perception of forms the Gestalt quality of the whole predominates over that of the individual parts.

The generality of this assumption, however, has almost always obscured the fact that there exists a time of the development of forms which *inheres in the onset of a form at a certain temporal point of consciousness.* From this point of view, the individual Gestalten are *sub-wholes* of a larger whole, that is, the entire content of consciousness.[69]

Once again, Husserl's theory of dual consciousness was the first attempt to develop a theory of intentionality which took account of both the *structural framework* of the time of the development of a form and of the *distinct salient individual forms* of the moment-now.[70] For all its innovativeness, however, Husserl's theory lacked precision. The empirical analysis of the topic conducted by Benussi, on the other hand, developed the theses of phenomenology on an experimental basis.[71]

It is possible to observe the actual genesis of Gestalten in the laboratory by restricting the stimulus conditions – for example by projecting optical figures with a tachistoscope, or by increasing clarity in darkness, or by shrinking or magnifying the normal sizes of the objects of vision, and so on. In this case analysis is conducted of *pre*-Gestalten, these being characterized by greater mutability in all connections among their parts, and by their endeavour to assume a stable form. In pre-Gestalt experience, the sentiments play an important functional role and are connected to the so-called tertiary qualities.[72]

(iv) *Meaning and expression*

Analysis of perceptive continua also reveals that they are expressive. That is to say, they are endowed with meaning, and it is meaning which is *not* immediately linguistic. This, too, is an important finding for a scientific metaphysics.

The expressive movements considered above at (iii), in fact, also involve *intentional movements*, which in their turn comprise:

(i) moods

(ii) intentional movements in the strict sense as movements which perceptively manifest end-directedness.

The theoretically important aspects of all experiments concerning the perception of the direction and velocity of movement is that the latter phenomenon is not random but only occurs under particular *spatio-temporal conditions* of stimulation. Put otherwise, by increasing or reducing the velocity of movement or the distance among objects, certain expressive qualities appear or disappear to make way for others; in other words, a different *rhythm* takes over.[73]

A particular case of this type of analysis concerns *social expressiveness* and interpersonal relationships. In this connection, a highly significant example is provided by Marigonda, who by presenting two triangles of differing heights, slopes, positions in space, sizes, etc., obtained the following result:[74] the descriptions furnished by observers confirm that static objects convey a social expressiveness (command, dutifulness, obedience, etc.). And this also corroborates, amongst other things, the thesis of the homeostaticity of the ecological qualities propounded by Gibson.[75]

From analysis of expressive movements we may conclude that:

(i) *movements* in general have a high degree of expressiveness;

(ii) every specific expressive quality arises within *well-defined spatio-temporal conditions* specific to it.[76]

Visual Gestalten, in fact, would only be invariances of relations, as Schlick rightly pointed out, if perception of movement did not exist as well. And since spatial perception enables movement to be seen only in specific and definite temporal conditions, overall the perception of forms is identical with that of a *dynamic functional system*.[77]

3. CONTINUA OF FORMS: COLOURS

I have given a broad definition of the relationship between phenomenological and experimental analysis of experience and a scientific metaphysics.

A further distinction, to which I have already referred in passing and which I borrow from Meinong, concerns the difference between metaphysics and ontology: *metaphysics* is the analysis of *what is existent*; *ontology* is the analysis of *what is possible*, that is, of every possible object, existent, unreal, imaginary, fictitious, etc.

From this point of view metaphysics is distinct from ontology and can also be defined as a *material ontology*, under which label we may classify both the Brentanists' analysis of act, content and modes of presentation and the researches of the Gestalt psychologists. In fact, they all maintain that the contents of presentation are essentially *forms*. In this sense metaphysics is closely connected to a descriptive or a Gestalt psychology as well, as said.[78]

On what type of entity is a metaphysics of forms based?

I shall seek to provide a description which starts from *encountered* phenomena, to use a favourite expression of Husserl, Benussi, Kanizsa and Metzger;

that is, a description which starts from the phenomena immediately given in actual perception.

The classical division of qualities distinguishes them among:

(i) *primary qualities*, like extension, size, position, motion;

(ii) *secondary qualities*, like tastes, sounds, odours, because they are subjectively connoted.

From a perceptual point of view, however, *extension* (*Extensität*) too is a phenomenal quality of objects, and this is the case of all the so-called primary determinations of objects, *movement* for example. In certain conditions of duration, in fact, we see perceptively present, *phenomenally real*, movements directly before us, a case in point being stroboscopic movement, which is in fact wholly *unreal* from a strictly *physical* point of view.

There is then the determination of the *position* of objects, defined as the relationship among points in space. Phenomenally, all ambiguous figures undermine certainty in primary qualities.[79]

An example of the primitive qualities of a metaphysics of forms is furnished by analysis of the perceptively founded *geometry of colours*.

3.1. Obviously, in this case no questions are raised concerning chromatic perception as a function of the central nervous system connected to the structures of the cortex, to the peripheral organs, and so on; nor concerning colour as pigment or as electromagnetic oscillation.

A metaphysics of forms, in fact, is *primarily* founded neither on the physiological level nor on the physical level, but on the phenomenal level, although there exist laws of ontological dependence among these various levels whose analysis is the task of ontology.[80]

The colour continuum manifests all the features of Brentanian secondary continua, which structure themselves on the basis of the temporal continuum of the duration. Since scientific debate on the nature of colours is still unresolved, a brief summary of the question and the adoption of a clearly-defined terminology are advisable. I should also make clear that here I am concerned with those aspects of colour most closely tied to the description and the genesis of the *form 'colour' in the duration*, and less with the objective aspects of its *spatialization* in surfaces.[81] Obviously excluded from this inquiry is the linguistic analysis of colours and the relative literature.

All colours, whether pure or compound, have a distinct *chromatic value or character* deriving from their position in the chromatic sphere (from Goethe to Hering to Itten, with some variations) and they are divided into:

1. basic colours (like red, yellow, blue, green)
2. additive colours (like orange, violet)
3. complementary colours (like red-green).

Colours possess saturation and hue. The maximum of saturation is the same for all the pure colours; but saturated pure colours are not all of the same hue (red and yellow, for example, are brighter than green and blue). Hue is the *tonal value or character* of colours.

As well as saturation and hue, colours possess a *tertiary value or character*, in the sense that there are, for example, warm tonalities and cold tonalities. Colours based on yellow-red *convey* a warm tonality (fire, sun, etc.), while colours based on green-blue *convey* a cold tonality (snow, water, leaves, etc.). These qualities are emotive and they are morphogenetically primary in the sense that they imbue surfaces with *values* other than linear: distant objects in fact appear colder than those close to us, and the same is the case of opaque objects compared with transparent ones. Again, complementary colours close to the observer give the impression of greater solidity than do other colours. Moroever, colours can be classified according to polarity or contrast: for example, as well as the warm-cold contrast, there are the contrasts between transparent and opaque, restful and stimulating, close and distant, light and heavy, damp and dry, etc.[82] In this sense colours are *dynamic* qualities.[83]

Analysis of chromatic perception, therefore, shows that it is the phenomenal qualities (which comprise chromatic, tonal and tertiary character), and not physical qualities, that are *primary*. Colours are the *simple qualitative elements*, so to speak, of vision, and they are a *constitutive property* of objects.[84]

Simultaneously actualized in the perception of colours are forms of *cognitive completion* (internal conditions) which concern, for example, opposition, contrast, hint, fusion. Itten has detected at least seven colour contrasts: as regards pure colours, between lightness and darkness, between warmth and coldness; as regards complementary colours, contrasts of simultaneity (e.g., grey on green assumes a reddish colour), of succession (as when with our eyes shut we have the complementary image of the colour), of quality and of quantity. And in all cases their realization reveals a tendency towards totality and chromatic harmony, in the sense than every contrast tends to re-establish an equilibrium. Chromatic equilibrium depends on the reciprocal positions of colours, on their orientation, on their brilliance, but also on the quantitative relationships among colours, on their rhythm and structure.[85]

3.2. *Perceptively*, colours constitute a *continual variety*. Given one colour it is possible to find another which is minutely distinct from it. To use Musatti's formulation: the colours form a perceptive field in which each element is indiscernible from the one immediately adjacent to it and distinct from all the others.[86]

Also in the field of colour, however, a distinction must be drawn between at least two different kinds of continuum: between continua of achromatic tonalities and those of chromatic tonalities. Reflections on these matters from a phenomenological point of view – reflections which originated with Goethe's masterly *Farbenlehre* – are to be found in Meinong and Benussi on the one hand, and in Köhler, Hornbostel and the classical Gestalt psychologists in general, on the other.

Phenomenological colours are a fundamental component of experimental phenomenology because they concern the *genesis of the objects* of observable experience. The first gradation of the corporeality of phenomenologically distinguishable objects is given by light and shadow, by chiaroscuro: *contrast* is the first *form* of individuation of objects, and it constitutes the *boundary* on which the colour may arise. In phenomenological terms, the boundary is the *profile* of the perceptive object (and of its parts) which – to the extent that it is delimited and circumscribed with respect to the background – exhibits some of the object's characteristic properties like shape, cohesion, individuality. This is relatively intuitive in the field of visual perception: the perceptive field is in fact spatially constituted by delimiting shapes, and specifically by *coloured shapes*. The boundary is identified by dividing the perceptive whole into its parts: for example, into 'gliding' phenomena where in a certain part of the visual field one image is replaced by another with vivid contrast, or when a surface changes colour while the shape remains the same, or when we see a surface of the same colour divided into two different parts. In each case, a boundary or dividing-line is *perceptively* drawn between the parts of the whole. Goethe declared that colour is a *value of shading*.[87]

From this point of view, phenomenological colours are *material determinants* of the moment-now. As well as darkness-lightness, they comprise consecutive images, coloured images and shades of contrast, auras and irradiations like, in certain conditions, the apparent extending of similar chromatic extensions, figures or shapes beyond the limits of their effective extension.

The colour of one surface may also affect the colour of an adjacent surface: for example, yellow influences green, and an orange surface tinges an adjacent white surface with greenish blue – that is, with its complementary colour. In these cases, superimposed on the chromatic continuum is the *positional* continuum, which alters certain of its founding characteristics.

The perception of colour also depends on the *orientation* of the continuum, as in the case of the so-called MacCollough illusion. If one looks at a pattern of vertical red and black lines for some minutes, and then at white and black lines, some of them vertical and some of them horizontal, the vertical lines also display their complementary colour, namely green.

Temporal and spatial constraints act equally effectively in the perception of colours, as shown by the jerkily rotating wheel of the Greeks or more generally by spinning tops, whose colours become fused.

Another distinctive feature of the colour continuum is its direction, which in some way obeys the laws of complementarity and contrast: one does not say, in fact, that violet tends to yellow or that orange tends to blue, but that violet tends to red and orange to red.

In fact, the pure colours divide between:

1.1 *contiguous* colours: those between which there is a continuous passage *without a change of direction* (yellow→red, red→blue, blue→green, green→yellow);

1.2 *antagonistic* colours: those for which this passage involves *a change of direction* (red→green, blue→yellow).

Common to all these features is, as Katz pointed out, the fact that the colour that we perceive on a surface is to a large extent *independent* of the wavelength of the light reflected by the surface, and of its intensity. In other words, colour is *processed* by the eye but *perceived* by the mind.

3.3. Let us now consider the relationship between chromatic and achromatic continua, and specifically the *greys*, which constitute a continuous passage and a *polarity between a plus and a minus* – to use an expression of Goethe's once again. We may conceive the spectrum of greys as a continuum aligned on a segment the extremities of which are white and black; a continuum which, in nature, ranges from barium to black velvet.

Within the continuous variation from black to white it is possible to distinguish a further type of variation: whiteness and clarity, which *in its turn* forms a linear continuum *superimposed* upon the previous one. White and black represent only the limits and the extreme point of contrast between light and dark.[88]

We may now consider chromatic tonalities irrespectively of their qualities of brightness-darkness, whiteness-blackness.

One notes immediately that yellow, for example, has such kindred colours as orange-yellow or greenish-yellow, but *not bluish-yellow*. We may therefore locate the colours similar to yellow and red on one line (yellow→red), and those similar to yellow and green on another (yellow→green).

Consider the yellow extremity of the first line, which coincides with the yellow extremity of the next one.

The operation is repeated with colours close to green and blue, which are arranged on a (green→blue) line. Now consider the green extremity of this third line coincident with the green extremity of the second line.

Finally, we align the colours that resemble blue and red on a (blue→red) line and consider the blue extremity of the fourth line coincident with the blue extremity of the third line.

These various operations produce a quadrilateral consisting of straight segments (Figure 1).

Let us now examine the relations between this quadrilateral and the white-black segment of achromatic perceptions.

The whiteblack segment passes perpendicularly through the centre of the quadrilateral. In fact, if we try to join green with red, and yellow with blue, the line that we draw passes through a grey in the centre. And it is exactly thus in reality: we may indeed find it possible to pass from green to red, but only via

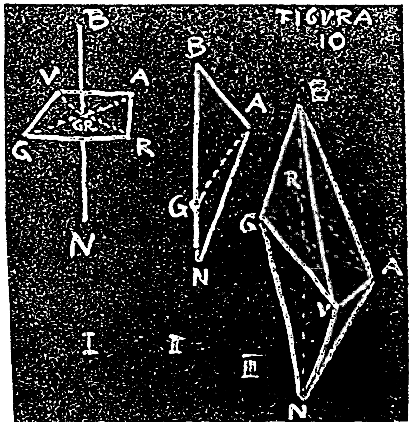

Figure 1. Drawing by Benussi 1922–3

grey. Specifically, the passage comes about through the progressive loss of chromatic saturation. Itten's solid of colours – the first three-dimensional colour scheme – is a derivation of this model.

Let us try another test: consider one of the triangles formed by white, black and one of the points of the quadrilateral – blue, for example. As blues approach dark grey, they progressively lose not only saturation but also brightness. Hence we may conclude that:

(i) the *saturation* of a colour is given by its dissimilarity from the achromatic tonalities, that is, by its distance from the gamut of greys;

(ii) the *brightness* of a colour is given by the distance of white from the base of the perpendicular, that is, the distance of the colour in question from the gamut of greys.

Specifically, brightness is a *material quality* of extension, whether of an object or of a chromatic sector.[89]

Qualitative analysis of colours thus yields another finding for the metaphysics of forms. It demonstrates that the perception of objects, and specifically of coloured shapes, is *stratified*, even at the same phenomenological level. This is a stratification of different continua, one of which is founded (superimposed) on the others. It also shows that in the perception of colours as *elementary observables*, there operate functionally different so-called 'bottom-up' and 'top-down' cognitive processes.[90]

4. CONTINUA OF FORMS: SOUNDS

Analysis of the qualities of the sound continuum – which is founded on a different type of *substratum* with respect to colours (not on extension but on *duration*) – yields similar results endowed with perhaps even greater significance for the metaphysics of forms.

Nor in this case is there any question concerning the frequency of sounds or the physiology of the ear that perceives the differences among them. At issue is the phenomenology of sounds as qualitative materials, or phenomenal saliences of the perceptive field, which fill a duration – an example being musical notes.

That sounds cannot be reduced to frequencies is demonstrated by cases which although straightforward from the aesthetic point of view are ontologically complex, like the perception of melodies or the simple perception of a differential sound – of a sound, that is, which physically does not exist.[91]

Not only do sounds occupy a stretch of time but this stretch is *apprehended* as a temporal elapse: experiencing a sound, in fact, means also experiencing the phenomena of *simultaneity* and *succession* – the features of the phenomenological duration that manifest themselves in perception. Sounds are therefore distinctive perceptive materials in which the *temporal structure of consciousness* is made manifest.

Listening to music, with its continuity, shows how the perception of individual sounds takes place in a certain temporal extension: the *time of presentness*, in which, moreover, there occur a series of internal references of functional type, of anticipations and of retentions of previous sounds. Musical sounds are temporal *Gestalten*, thematic unities stratified into various levels according to phases of passage and coagulation corresponding to the structure of James's flow of consciousness.[92]

That sounds are consummately phenomenological is shown by analysis of the melody, which is an *object* whose complex structure occupies a distinctive place in ontology and whose perceptive presentation raises major problems from a theoretical point of view.[93] The presentation of a melody is akin to the presentation of movement, of diversity (*Verschiedenheit*),[94] of distance, of intervals, of forms of emphasis or phrasing (for example, the metrical form of a sonnet), of forms of rhythm or of change. What do these various kinds of presentation have in common?

Benussi called them 'produced', or better *asensory*, presentations, and viewed them as *presentations of form*.[95]

This and similar cases do not involve errors of perception but perceptive *inadequacies*, whose origin may be both sensory (as in antagonistic chromatic induction when, for example, I see a grey disc on a red field as green) and asensory (the Müller-Lyer, Poggendorf, Zöllner illusions, etc.). The difference between sensory inadequacy and asensory inadequacy is that in the former case, under constant conditions, the inadequacy remains constant; in the latter case, instead, the inadequacy changes with repetition, practice and the way in which it is framed.[96]

More specifically, sounds are individuated by means of the internal localization of a certain temporal place, or of a specific moment in the continuous flow of consciousness, and in the same way as a specific colour is individuated in a spatial continuum. The *presentness* or *pastness* assumed by a note in the melodic continuum is a characteristic of temporal experience.

The character of pastness may be attributed to the apprehension of a past time only if it is experienced in *gestaltic correlation* with a note characteristic of the present. In other words, pastness emerges from the apprehension of the object which *bears* this feature only in relation to its position with respect to a moment-now. At the perceptive level, in fact, a connection is established between two different points of the localization of the temporal continuum which are not individuated according to a linear progression but according to saliences of a quantitative type: one note calls forth another, one chord summons another, more because of their tonal similiarity or dissimilarity than because of their pause distance.[97]

In the tonal continuum, *direction* indicates the constitutive modality of intentionality: in fact, corresponding to different directional modes of intentional acts are different types of objects, or *configurations* (*Gebilde*) to use Stumpf's term.[98] Consider the changes that a chord undergoes as the base note varies: this too is a case pertinent to the direction or the centering of the parts of continua. In this specific case, the basic note is the central part. Similar examples are to be found in the visual field.[99]

Acts of localization internally to the temporal continuum may or may not be *saturated* (*ausfüllt*), *filled* (*erfüllt*), exactly as happens with the fulfilment of any sort of intention.[100] In the case of acts of external localization, in fact, there may be a perceptive or a merely imaginary filling; but even negative fulfilment may occur, as in the case of disappointment or the non-realization of an anticipated intention. Also acts of internal localization may be saturated or filled, in the sense that their form *is completed* and the intentional act achieves some sort of enclosure within an objectuality of some kind, in this case acoustic.

4.1. Within the sound continuum, the *time of presentness* (*Präsenzzeit*) denotes the time of an act of apprehension, perceptive or mental, while the *time of simultaneity* (*Gegenwartszeit*)[101] denotes the characteristic of the element endowed with greatest phenomenal salience and which acts as the *semantic nucleus* of the entire time of presentness: an example being individual notes as they succeed one another in a melody.[102] Internal time therefore has points of reference, semantic fields and frameworks, that is, structures.

The difficult distinction between time and rhythm can be grasped as the difference between the concrete sound content and the temporal structure as its frame of reference. As Metzger pointed out, musical duration is indicated in two ways: by the various indications of 'adagio', 'andante', 'allegro', etc., which concern the density of the framework, and by the indication of 'whole', 'half', 'quarter', etc., notes, which concerns the density of the filling content.[103]

All these movements of internal localization – which comprise (i) direction, (ii) velocity of change, and (iii) the diverse orientation of successive phases of the sound continuum – are perceptively evident in musical compositions: consider Chopin's *Mazurka*, in which there is a constant movement of aperture and closure of the perceptive contents due to the lack of definitive closure given to the configuration.

The problem of *the functional co-variance of the elements* of a complex construct like a melody raises both ontological and cognitive issues relating to the nature of *sound objects*. From the ontological point of view, in fact, the object 'melody' belongs among higher-order objects, to use another expression of Meinong's. In other words, it belongs to a particular class of objects which demonstrate themselves to be constructed upon other objects in such a way that these latter constitute their *inferiora*. Note that the *inferiora* are neither stimuli nor sensations but the base components present in observable structures. It is precisely in the analysis of melody that a Meinongian ontology draws an important distinction between *elementary* objects and *founded* objects, or between objects of experience and the objects that are founded upon them.[104] In this sense, melodies also provide an excellent example of implicit-order structures because they display a succession of events structured into a pattern which enables recognition of previous phases and anticipates phases of future realization.[105]

4.2. In music, too, *external* and *internal determinants* act on the material of the sound continuum.[106] In fact, one can discern:

(i) an *objectual content*, like a noise, and individual note, a chord, a phrase, a melody, etc.;

(ii) a *functional content*, like simultaneity, succession, duration.

Acoustic succession comprises a *duration of continuous movement* and a *static sequence* of salient events internally to a whole which displays the Gestalt features of closure, contrast and good form – as immediately demonstrated by the example of melody – as well as a stratified foundation of the perceptive structures which can be perceived in polyphonic song or in Goldbach's variations.

The perception of sounds, however, is governed principally by:

(i) the law of *proximity*

(ii) the law of *good form*

(iii) the law of *continuity of direction*.

The dynamics of *proximity* are evident when melodic lines are separated – so-called 'stream segregation' – as happens in the cases of unification by tonal proximity analysed by Bozzi.[107] An intuitive example is provided by Bach's fugues, where a repeated note acts as the background to the development of the melody, or by the *basso albertino* so recurrent in Mozart's compositions. These examples demonstrate the *independence of musical materials from the physical continuum of the frequencies*, which is also the case of the phenomenon of the double trill, of grace-notes, and so on.

As in the visual field, therefore, so in the acoustic field there arise syntheses of contiguity, identity and similarity (to use Husserlian terms).[108] Consider the phenomena of consonance and dissonance, which only occur in intervals close to each other, according to the Gestaltist law of *proximity*. Consider again the tonal segregation which imposes itself on that of the silent intervals, as Bozzi has shown.[109] The synthesis of contiguity among the phenomenal components of experience best conveys the phenomenon of tonal proximity, this latter being the relational property of sounds defined in terms of musical *intervals*; in short, the distance between the tones of the scale. The operation of the law of the continuity of *good form* is evidenced principally by Tchaikovsky's compositions, where one hears the theme and the accompaniment fluctuate from one instrument to another.

4.3. With regard to the identity, causality and difference of perceptive objects, musical perception offers a great deal of material for reflection.

As far as the *identity* of sound materials is concerned, a first distinction internal to the sound continuum is that between *sounds* and *noises*. We may use the term 'sounds' to refer to sonorous masses, classifying them as *objects* with distinctive features, and assign everything else to the generic category of 'noise'. For example, a *whistle* or a rumble are not so much objects like doh or soh as *typicities*; that is to say, they belong to a generically restricted class of sounds.[110]

One may distinguish among intensity, pitch and timbre in sounds just as one distinguishes among hue, brilliance and saturation in colours.[111] Timbre is an essentially phenomenological property of sound. It covers the entire gamut of sound and is therefore a feature of both sound-objects and the so-called sound phenomena of typicity, like noises, while pitch represents the sound-object in its determinateness. Also in the case of the sound continuum, therefore, perception is stratified by the *superimposition* of qualitatively different continua.

In fact, one may distinguish:

(i) limitation of form

(ii) velocity of change (more or less full)

(iii) velocity of direction (more or less full).

Sound therefore exhibits two distinct and complementary aspects, one of which is continuous and the other discrete. Consequently there are, so to speak, *object-sounds* and *event-sounds.*

When sounds are identified as object-sounds, we may also properly speak of intervals that constitute their extremes, like points which mark out their *limits* within the sound continuum. In sound space, the limits of sounds are given by the intervals, which are perceived as *moments* in the process. In a Husserlian sense, they are *non-independent parts* of the whole to which they belong: that is, in concrete reality they cannot be separated from the whole, although of course they can always be thought separately by abstraction.[112]

The concept of sound space therefore comprises perceptive sound nuclei which can be represented as points on a line in the same way as they are plotted on the musical stave. The point can also be conceived as instantaneous and as counterposed to the duration; or as a sound which endures as the simple nucleus of a sound material which continues and extends indefinitely. But for all the divisions that can be made in the sound continuum, and for all the representations that can be given to it (for example, point, line, segment, rising and falling curve in low and high-pitched sounds, etc.), we must not forget that sounds and their limits – the intervals – are originally *parts-of*; they are non-independent moments of a continuum.

Sounds, moreover, are not made up *solely* of time. For example, it is a common experience to find that an interrupted melody tends to continue for a brief lapse of time, because it has an *inner coherence* and a *system of relations* that naturally *impel* its completion in a particular direction.[113] It is therefore necessary to define the *nucleus* of a sound material, given that it manifests its own form of pregnancy and an internal tendency. In other words, we must give precise definition to the external and internal determinants of the sound continuum. Analysis of rhythm is of help to this end.

4.4. *Rhythm* is the form or the pattern of sounds, because it requires the parts of the wholes of which it is the form to have inner logical coherence. As *the form of movement*, rhythm is the pattern of a process – of an objectuality in *motion at the moment* when it is considered. In this sense rhythm is a form of translation symmetry typical of serial phenomena.[114] Moreover, rhythm expresses Gestalt laws (proximity, similarity-identity, closure, etc.) in the acoustic field, given that beats in succession necessarily organize themselves into groups.

In music, rhythm is established by beats or taps, which express the ideal tendency towards the instantaneous of sound, like duration and continuity in events.[115] Rhythm is therefore situated between *sound event* and *temporal pattern*, as an event that is repeated, a sound module (phase) which scans and thus also *renders the rules of its constitution manifest*. Also identifiable in rhythm is the *time transposition rule*, which is manifest in sound phenomena and which in a certain sense expresses the base rule of the perception of symmetries in general.

In sounds, therefore, the temporal *structure* itself of consciousness (simultaneity and succession) is especially evident and in a certain sense provides support for their manifestation, as does extension in the case of colours. One accordingly understands that sound has phenomenological duration; that is to say, it appears to us in the form of elapse, alteration and repetition. The time of the duration, in fact, is *shape* because it constitutes the structure of the possible completion of perceptive contents.

As regards sound materials, the nexus between continuous and discrete, between object-sounds and glissandos, constitutes their analogy with the figure-background nexus in the visual field. One perceives this aspect clearly when listening to music. As Metzger pointed out, gypsy music weakens the reference structure – that is, the temporal and rhythmic framework – by constantly slowing down and accelerating, and thus sharpens the perception of a continuous glissando.

Temporality, therefore, acts as the background to substantially two types of musical *figure* or configuration: the enduring, continuous sound and the instantaneous sound. The different relationships that arise between musical figures and ground give some sort of *texture* to sound material. A good example of the correlation between them is provided by the object '*consonant chord*'.

Meinong's theory of production, with its stress on the aspect of the *inner determinants* of perception – that is, the forms of cognitive completion – emphasises that cognitive aspects intervene in the perception of consonance by operating on two notes of the chord (the founding elements of a unitarian whole) in which they are apprehended as similar or identical.

Perceptively, however, consonance depends not so much on a cognitive intervention as on the features of the interval, and therefore on *external determinants*. Let us take the octave interval as an example. Here the sound tends to remain within the segment of sound space that delimits it: between doh flat and doh sharp, for instance, the sound acts retroactively on itself. This phenomenon is not a static relation between sounds; it is a dynamic relation which is actuated along an ascending and descending line, where the highest point of the downward curve represents the moment of maximum consonance. One may therefore say that the limit of consonance is not fixed by a characteristic of sounds, nor by the cognitive capacities of the subject, but by the sound space itself in relation to a certain reference sound, or a Gestalt quality of correlation internal to the structure.

Another apparently paradoxical point that derives from this notion of sound space is that unison – that is, the moment of maximum consonance – is achieved by exaggerating the differences in increasing dissonances.

Perceived sound space has iterative structures and it exhibits a structural subdivision. The phenomenon of alteration, however, reveals the existence of a restriction on the freedom of the subdivision and distinguishes between principal sounds and secondary sounds. In the case of the alteration of doh flat through doh sharp, doh, ray, etc., the alteration of the note obeys the rule of contiguity, which is unable to determine any point within the interval. Able to do so, though, is the consonant chord, at its point of maximum consonance, by identifying two particular intervals (a fourth and a fifth). The fourth and fifth intervals are therefore inscribed in the structure of the sound space. We may therefore apparently conclude that the continuum comprises natural segmentations, tendencies and nuclei which are approximations to the limit on consonance.

The phenomenological rule of contiguity (modification of the fundamental note within the octave interval) is closely bound up with the form and the modes of the perceptive material. It is founded on necessary nexuses, on the structural legality which is the foundation of theories of phenomenological realism.

Moreover, music expresses not so much sentiment as emotional dynamics, something which even a positivist like Helmholtz acknowledged.[116]

5. CONTINUA OF FORMS: EMOTIONS

A characteristic feature of perceptive objects is that they trigger emotions. The fire in the hearth attracts us, a dark storeroom repels us, a smiling face reassures us, a hostile gaze chills us. Now, the question is as follows: from the point of view of an experimental phenomenology, is it possible to develop a *geometry of the emotions* like a geometry of colours or an analysis of sound space? Köhler, for example, thought that all the senses were connected by shared qualities like those of lightness and darkness.[117] In other words, is it possible to detect a pleasure/pain continuum like the white/black continuum in the spatial order of colours, as the axis around which the spatiality of all emotional situations rotates?

If it is indeed possible, we should also be able to detect a passage, a boundary in the emotional continuum, as well as a *polarity* between a *plus* and a *minus* of emotions aligned on a segment whose extremities are pleasure and pain. In the constant variation of emotions, moreover, it should be possible to discern a further type of variation: that between evidence and absence (one should not in fact confuse emotional *content* with emotional *function*) arranged along a rectilinear continuum *superimposed* upon the emotional one. And one should also be able to discern within this continuum the same features of *velocity*, *direction* and *orientation* as displayed by the other perceptive continua.[118]

Inquiry of this type (which, as far as the emotions are concerned, approaches the limit of an experimental mystique, as Benussi put it) has been conducted internally to experimental phenomenology, and specifically by Benussi himself.[119]

Benussi's experiments investigated the *autonomy of emotional functions*. However, first we must specify Benussi's premises. His reconstruction of the *genesis of the forms of the emotions* started from the assumptions of a descriptive psychology, namely:

(i) *objectuality* is the characteristic note of all psychic phenomena;

(ii) psychic processes *transform* non-reality into reality, given that every non-real object of the past or of the future may become *mentally present*;

(iii) *perceptive presence* may be external (environment) or internal (subjective attitude);

(iv) *perceptive* presence is characterized by *assimilative* functions and *synthetic* schemata; *mental* presence is characterized by *reproductive* functions and *additive* schemata;

(v) words are *conveyors* of reality: understanding a word is to experience the *mental* presence of an object.

Benussi's experiments focused on two aspects in particular:

(i) do there exist *emotional* functions which are *distinct* and *autonomous* from intellective functions?

(ii) do *object-less* emotional functions exist?

His experiments consequently set themselves three tasks:

(i) to prove that psychic functions can be *isolated* and *decomposed*;

(ii) to induce an *object-less emotional state* by means of suggestion;

(iii) to establish whether a corresponding *somatic* expression can be detected in the form of breathing by means of graphic or metrical analysis of chest movements recorded by a pneumograph.

And they distinguished among:

(i) a *hypnic attentive state* inducing a base sleep (WL)

(ii) *base hypnic sleep* (BS)[120]

(iii) a *quotient of velocity* of inhalation and exhalation (Qv)

(iv) a *quotient of capacity* of air consumption in a unit of time (Qc)

(v) a *surface area* of the average respiratory curve (S).

From a general point of view, Benussi's experimental method was to produce a hypnosis-induced transitional stretch. The experimental subject was given a task to perform by means of *words*: for example, "now you will experience a state of anxiety, or of well being, or of fear", etc., without the reason for such a state of well-being, anxiety, fear, etc., being specified.

The base sleep (BS) condition was induced via an attentive induced stretch (WL).[121] The *base sleep* (BS) thus induced lasted 3-5 seconds, which ensured uniformity of experimental conditions and greater control over effects. In base sleep a *pure* emotional situation was triggered.

Recordings of the type of breathing that marked the onset of the two different hypnic states revealed the following:

(i) a correlation *stability* between the subjective state of the *situation* of consciousness as present in base sleep and the correlative *shape* of breathing as registered by the pneumograph;[122]

(ii) the *shapes* plotted for induced attentive state and base sleep were different: corresponding to induced attentive state was a *convex* shape, to base sleep a *concave* one;

(iii) attentive induced state and base sleep had different *velocity* quotients.[123]

As well as the velocity quotient, Benussi also calculated the *quotient of capacity* (Qc) proportional to air consumption in a unit of time, and the surface area of the average respiratory curve (S). The shapes were plotted by joining the points marking:

1. the onset of inhalation
2. the depth reached at mid-inhalation
3. the maximum point of inhalation
4. the reflux
5. the point of maximum exhalation.

Note that in BS all elements of *spatial* orientation were annulled, while the *temporal* orientation remained intact.

A first result, therefore, is that *erasing the contents* of thought does not annul the activity of consciousness or of inner perception.

5.1 In detail, Benussi's experiments proceeded as follows: after an initial state of wakefulness (W), following a first stage of attentive hypnic state (WL), different but equally *object-less* emotional states were triggered in a BS state of intellective (i.e., object-less) sleep. The procedure was then reversed until the state of wakefulness was reached. The different phases of the process therefore followed each other in the sequence:

$$W - WL - SB - (BS + E)(BS - E) - WL - W$$

The pneumograph registered two interesting facts during the process:

(i) transition from one phase to the next place of the emotional continuum took place *abruptly* (with a sudden rather than gradual *change of direction*): that is, the boundaries between the phases were very clear;

(ii) each transition was characterized by its *specific shape*, *surface areas* and *velocity quotients*.

In short, the experiments showed that each transition is a *boundary* of emotional continua depicted by the respiration graphs – the so-called *respiratory shapes* – as *pentagons* whose upper side show the time coordinate.

Specifically, BS has a *bi-concave* symmetrically-shaped shape with a low quotient of capacity (Qc) and an average surface area (S).

Transitions from one state to another are characterized by a breathing profile of biconcave-rectilinear symmetrical shape with a high quotient of capacity (Qc).

Another distinctive feature of emotional forms is that, although they are externally imperceptible from a somatic point of view, they internally differ from the intellective functions expressed by respiratory mimicry. In short, *emotional forms* are *internal invariants* of the perceptual continua.

The fifty emotional situations analysed by Benussi upheld the following hypotheses:

(i) The *emotional functions are autonomous*: object-less thoughts exist, and emotional states exist in a consciousness devoid of thoughts and/or images (according to the theories of the Würzburg school);[124]

(ii) Different emotional states can be *graphically expressed* by two types of shape, biconcave and biconvex;

(iii) Specifically, the process from W to BS can be depicted by *biconcave shapes* (rectilinear to concave), usually of large surface area; the process from BS to W can be depicted by *biconvex shapes* (rectilinear to concave) of smaller surface area;

(iv) Since BS is a state of maximum well-being (describable as an ecstatic state), its relative graphic forms are progressively concave or convex.[125] The graphic profile of physical pain is opposite in shape to physical pleasure; that is, the velocity quotients (inhalation and exhalation) are inverse. In other words, pleasant states all have similar shapes, and the same holds for unpleasant ones.

(v) The continuum of bi-rectilinear profiles expressing the pleasure/pain continuum therefore seems to correspond to the white/black continuum in the perception of colour.

What conclusions can be drawn from this *geometry of emotional states*?

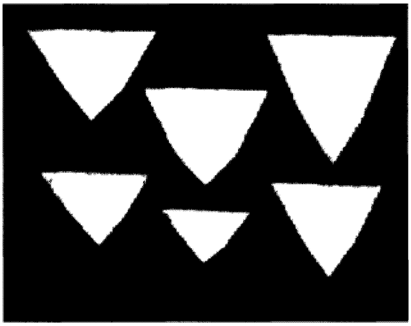

Figure 2. Shapes of physical pleasure, sympathy, evidence, relief, contentment, well being. Pneumatograph trace in Benussi 1925

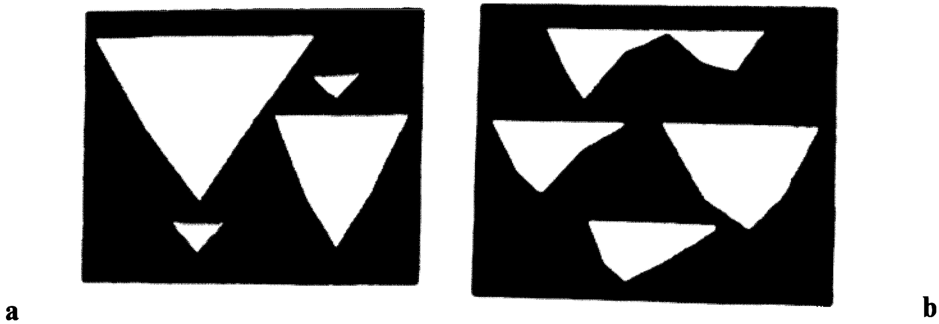

Figure 3. (a) Shapes of hope, diffuse physical pain, desperation, physical pleasure. (b) Shapes of unhappiness, yes, no, moral sufferance. Pneumatograph trace in Benussi 1925

Benussi's real analysis – *real* because it allows effective variation in the conditions internal to the onset of psychic phenomena – demonstrates:

(i) the existence of similar *perceptive invariants* in diverse kinds of perceptive continua; today we would say it demonstrates the existence of a naïve physics;

(ii) the *uncoupling* of the emotional functions from intellective ones, and the independence of functions (or of aggregates of functions) from each other;

(iii) the *phases* of development in the continua of consciousness and in the strata of consciousness of which we are usually unaware;

(iv) the possible elision of conscious reflexes to certain external stimuli while all the others (combinations of orthogonal movements) are preserved;

(v) the difference between (grasping) the *sense* and (understanding) the *meaning* of a sign or a word. Sense, in fact, is grasped by experiencing a *concrete situation* devoid of discourse elements and constituted by *fragments of behaviour*: that is to say, emotional-affective states come into play. The meaning of a sign is understood by actuating particular objectual functions directed towards to 'higher-order objects': meaning depends on (written or spoken) *discourse situations*;

(vi) the fact that the mental presence of the comprehension of the sense of a word (the task performed by the subject in BS) is realized through the transformation of the sense into the internal perceptive presence of the meaning also sheds light on (a) the difference between *assimilative* and *additive* processes (i.e., between perceiving and thinking in the strict sense) and (b) on the morphogenesis of *sense* and *meaning*;

(vii) the *expressive dynamicity* of the emotional states depicted by the respiratory graphs shows that they are behavioural in character; that is, they are *schemata* or diagrams of facts and/or actions;

(viii) the identity between BS and a state of mental union or mystic ecstacy which allows experimental analysis of these phenomena;

(ix) since Benussi's findings have been corroborated in intellective situations involving states of evidence, negation, doubt, and so on, the transformation of mental presence into perceptive presence gives rise to states of extreme lucidity which may even assume the character of reality, which is an important step towards comprehension of altered psychic states as well.

To conclude: one of Benussi's findings of closest interest to an *experimental metaphysics of forms* is the correlation among the fifty respiratory profiles plotted for the emotional situations analysed. Independently of the individual emotional states that generated them, the straightforward *formal grouping of the profiles* evidences that situations of a certain type belong to the pleasure/pain continuum, or vice versa. In other words, biconcave curves belong without exception to states of well-being, and biconvex ones in varying degrees to states of malaise.

Theoretically, this finding points to important conclusions: firstly that erasing the thought of objects does not entail erasing consciousness or its ontologically intentional character; secondly that emotions are not so much a class of psychic phenomena as a *form of colouring*, a *tertiary quality of the actual genesis of the Gestalten* corresponding, as Metzger said, to the *momentary structure of the impulse* of the phenomenal self towards their transformation.[126] Giving even greater significance to the finding is the fact that the *priority of the whole* over its parts corresponds morphogenetically to the *priority of the expressive qualities* over the whole.

6. THE METAPHYSICS OF PROPRIOCEPTION

As we have seen, internally to musical structures and to the visual field, and internally to the field of the emotions (but the same applies to tactile-kinetic perceptions),[127] there arise forms which are patterned in a certain way. These configurations derive from *a perceptive material* that originates in continua which, although qualitatively different, are all based on the temporal structure of the *duration* of consciousness. In short, the nucleus of a phenomenological metaphysics consists of a *theory* of intentional reference, in the sense that the categorial structure of the intentional presentation is an integral part – not one superimposed from above – of the perception of forms and of the configuration of objects, of whatever type they may be.

We may sum up as follows.

(i) There exists a discrete *physical continuum* which follows its own laws and which can be described, at various levels, according to the quantitative laws of physics. This continuum furnishes or sets constraints on perception.

(ii) The physical continuum is *cut* by a singularity (the intentional consciousness) which shapes it via the modes of direction to the object into a *representative continuum* with features of *qualitative salience*. These latter are *forms* which display properties of shared destiny, closure and inner coherence based on functional invariants and are the basis for the individuation of *objects*.[128]

Obviously, the metaphysics of forms concerns itself, not with the physical continuum (frequencies, waves, atoms, quanta, and so on), but with the second type of continuum, which we may call *intentional*. In other words, it concerns itself with those *forms* that are endowed with greater stability to the extent that they are *internalized*.

This thesis is realist in that the effectively *objective qualities* of phenomenal objects operate in the perceptive 'cut'. As we have seen, by 'objective qualities of phenomenal objects' is meant not so much the so-called primary qualities of classical theory as secondary qualities, and especially tertiary and figural qualities: invariants of invariants, to use Luccio's apt expression.[129] These qualities – for example, harshness, softness, roughness, rapidity, slowness, tallness, deepness, lightness, heaviness, strength, weakness and even sadness, happiness, and so on – *express sense*. In fact, the objects of perception are also *physiognomic* in character, which gives them immediate pregnancy.[130] Consider Kandinski's simple forms: line, point and surface.

In the visual field, for example, we see that colours are always inseparable from the surface and the type of structure to which they belong, and we see that a surface is rough, soft, porous, etc.; or we see that angles, as perceptive data, have a certain directionality, with a vector that orients them towards a certain point, or that three unaligned points in the perceptive field organize themselves in a certain way, and so on.

The same applies to sound perceptive materials. In this case, there are qualities which present themselves in a perceptive field (the sound space) endowed with its own structural principles (direction, segmentation, points of collapse into consonant chords, etc.). No one would wish to deny that sharp or flat notes have expressive qualities or that a minor third interval, e.g., A-C flat, is a *sad* interval. In precisely the same manner as the perceptive contents of the visual field like colour or texture, these tertiary qualities provide us with information about the composition of the *substance* under observation. In a metaphysics of forms, to put it *à la* Brentano in his later works, it is the accidents that instantiate the substance and not vice versa.[131]

Thus the perceptive continuum (or better the totality of the superimposed continua of the various fields) is a *dynamic system* which *tends towards a structure*. That is to say, it tends towards the organization of forms and configurations: like a melody, for example, which emerges from the perceptive continuum because of the relationship between the conditions of the field and the (formal) relations of similarity, contiguity, succession, direction and completion of the elements of the field.

Consciousness of this dynamic system *comes about in a duration* which has the features of the multiple and multiform continuum. For example, in the continuity of seeing and hearing, the perceiver is a *continually multiple* seer and/or hearer. By the same token, when we perceive *ourselves* as seers, hearers and rememberers, or when we are moved by some emotion, it is not that we perceive different things but that we perceive only *one multiple thing*. Obviously, this is always a general perception which takes place in a time of presentness, where the individual aspects of the intentional object are singly connected and are perceived as belonging to the same unit, for all their distinctiveness, by successive *partial attributive syntheses*.

As for the temporal determinations, in the single act of apprehension (in the time of presentness) there are distinct and partial moments relative to individual partial presentations of the object of presentation, and therefore diverse moments of the genesis of form. It is in this sense, I believe, that Shepard talks about successive glances at the perceived object – which would account, for example, for what happens when we look at pictures by Escher.

6.1. I have thus reached my conclusions. In order to explain the genesis of forms, one must assume that also intentional consciousness itself is *internally stratified*.

The temporal determinations of the duration – as *indirect* and *successive* modes in which we apprehend the same object as more or less past, more or less close – constitute the necessary distinction and connection among the various aspects of the object to which form is given. In other words, they give origin to the perception of symmetries. But the position, the direction and the motion of objects in the morphogenetically realized continuum takes place *with reference to a single origin*: namely that relative to the presentation of the perceiver.

The role of inner perception in presenting the elements of the continuum in succession is therefore essentially that of constituting a (temporally extended) *centre* in which a temporal stretch (of which it is the limit) is indirectly apprehended. This centre is located *qualitatively* (not metrically) at a certain distance from the boundary. The implicit boundary is set by the limits of inner perception. In fact, the indirect temporal determinations of the duration *comprise material differences with respect to the substance* (as Brentano maintained), such as those of distance and position, rotation, motion, and so on, while its direct *propriocentric* direction constitutes a predominant 'axis' or anchoring point for the symmetries perceived. It is no coincidence that identification of the axis of symmetry is vertical not in relation to the viewer but in relation to the frame of reference relative to the spatial orientation of the viewer.[132] Furthermore, as experiments demonstrate, symmetry alone is not enough to give configuration to stable percepts. For this purpose convexity is also required.[133]

This situation expresses the point of view of a *theory of intentionality* which explains *relative* movement, direction and schemes of reference as significant features given in relation to an *absolute position*, that of the perceiver – where by 'perceiver' is meant not so much a concrete person as a *role* like the subject of impersonal statements (something of which Brentano and Marty were well aware) which as *position* maintains perceptive (multi)stability and is essentially temporal in the sense of the actual duration.

Form is therefore essentially *time*, or *time is form*, as the memory of perceptive organization at various levels up to the most sophisticated.[134] The continuum of seeing, feeling, hearing, and so on, is multiple and multiform precisely because of this stratification of reference schemes fitted one within the other and founded upon a specific and unique actual moment-now which optimizes their multiplicity of constraints according to a rule of multistability. Time, space, movement, direction, tension, colour, sound, heat, and so on, are all *continua superimposed* upon one another, beginning with the initial observable. Moreover, similar phenomena can be observed in abstract art, where the point is the most concise form in time (the moment-now), and the difference between a straight, vertical and oblique line depicts time as the time of the development of form, space as the secondary continuum of development in a certain direction, direction in its turn as superimposed on the tension of the movement of development; and finally expressive quality as relative to the heat or the coldness intrinsic to the lines themselves.

In other words, I believe that if a metaphysics of forms is to found itself on an experimental basis, it must also take account of what we may *call generative models of intraphenomenal type* relative to the development of the various phases and properties of the form.[135]

The qualities of a phenomenological and experimental metaphysics are the *characteristic notes* of objects by which we know them. They are constitutive properties which belong to the *So-sein* of objects, and they are situated at different levels of the ontological stratification, depending on the scene considered.[136] Consider solely the different theories of colour and their diverse classification according to the point of view adopted: red and blue are primitive categories if the scheme is the tertiary one of warm/cold colours; white and black, instead, are primitive categories in atomistic or formal analyses of matter, so that colours originate from the augmentation or diminution of light; or the multiplication of colours in the linguistic morphological classifications of colours first formulated during the Renaissance.[137]

To radicalize the argument, we may also state that, overall, perception is only a variegated Ames' room. That is to say, the observables of a metaphysics of forms (visual, auditory, tactile-kinetic events and their indefinite complexions) only provide *support* ('ecological' as Gibson would put it, although Brentano had already done so) for *proprioception.*[138] The thesis might run roughly as follows: the battle waged by the psychology of form against sensations or pure processes, and the principle of observation that holds in physics, move in the same direction. What is radical about this thesis is the absolutization of the moment-now as *the primitive boundary of the temporal development of form.*

The moment-now, in fact, is a punctiform temporal tension which distends elastically in the duration. If the *point* is the most concise form in time, the duration is the dynamic product and the *external limit* of the point's tension. Unlike a point, however, the linear continuum (the line), like the chromatic continua (the colours), has a direction as well as a tension: there are straight, curved, undulating, broken, etc. lines just as there are colours which naturally merge into each other, without contrast, and in doing so entail a drastic change of direction.[139]

Linear continua contain the nucleus of the subsequent development of the form into *surface*: a curved line gives origin to a circle, a straight line to a triangle. In the development of form from the punctiform moment by virtue of tension and direction, also the colour continuum is superimposed on the primary temporal continuum. As I have already pointed out, when a coloured form is reduced to a minuscule point, its colour disappears. Colour is therefore the external *continuum* of the development of form, just as sound is its *inner* development. Colour, or better light, is therefore the origin of the phenomenological individuation of the object, while sound expresses the rule of time transposition. In other words, the moment-now is subject to constant *transformation* of the tension internal to the temporal continuum according to the external forms of a spatial continuum of surfaces.

Finally, the conclusions of a metaphysics of form introduce an aesthetic grammar of forms.[140] At this point, in fact, we possess all the primitive coordinates with which to develop an aesthetic grammar of forms by combining the primitives into diversified structures, with the repetition of the base elements according to qualitative and quantitative rhythms. My conclusions as regards a theory of form lean towards a *morphism* of structures, in the precise sense that, in perceptive events, consciousness is not *blindly coupled* to corresponding psychophysical processes; it is also *similar* to them in its *essential structural properties*. This amounts to saying that emotion, perception and thought, as molar phenomena and unfolding processes, have the same *dynamically*-based structure.[141]

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NOTES

[1] On this latter question see Koffka 1935, ch. 3.
[2] Cf. Kant 1781.
[3] On the phenomenological and psychological method of the form see Katz 1944, ch. 4. For a similar point of view cf. Merleau Ponty 1945; Musatti 1965.
[4] For the definition of experimental phenomenology see Thinès 1977; Bozzi 1989; Vicario 1993.
[5] Cf. Husserl 1930, Nachwort.
[6] Cf. Vicario 1993.
[7] Cf. Brentano 1874.
[8] 'Empirical' is used here in the Brentanian sense, i.e., as descriptive of psychic facts evident in inner perception. Cf. Brentano 1874.
[9] Cf. Kanizsa, Legrenzi 1978; Luccio 1989; Zimmer 1989.
[10] For the definition of naïve physics see Sander and Volkelt 1962; Bozzi 1990, especially ch. 1. Cf. also McClosey 1983; McClosey, Caramazza, Green 1980. The expression 'naïve physics' is currently used, with some variations, in the cognitive sciences. Cf. Hayes 1985. As qualitative physics it has been analysed by Petitot: cf. Petitot 1985 and 1996 and Smith and Petitot 1990.
[11] Cf. Benussi 1906a and 1906b.
[12] Koffka's explanation conveys the general idea, although the more properly 'experimental' aspects of phenomenology entail the use of cognitive models in experimentation.
[13] Cf. Koffka 1935; Bozzi 1989.
[14] Cf. Brunswik 1934 and 1935; Kanizsa 1991.
[15] Cf. Whitehead 1929; Vicario 1973.
[16] The distinction is in Vicario 1991. For induced movement see Duncker 1929.
[17] On the concept of invariant see Koffka 1935, ch. 6; Zimmer 1989. On the distinction between formal and material invariants see *infra*.
[18] Cf. Also Katz 1944, ch. 5.
[19] On the concepts of 'descriptive' and 'genetic' see Albertazzi 1996c.
[20] Cf. Meinong 1899.
[21] For the distinction between situation of affairs and state of affairs see Haddock 1991.
[22] Cf. Husserl 1939. On this see Albertazzi 1989a.
[23] Cf. Benussi 1913; Husserl 1966b; Albertazzi 1996b, 1998c and 1998a.
[24] Cf. Benussi 1922-23; Musatti 1926, part II, ch. 3.
[25] Cf. Benussi 1906a, 1906b and 1907; Musatti 1926, part II, ch. 3. Benussi's acknowledgement of the influence of objective factors on subjective patterning to some extent weakens Koffka's criticisms of his theory. For the Benussi-Koffka polemic see Benussi 1914; Koffka 1915.
[26] According to Meinong's theory of production, the formal plurivocity of the perception of form can be attributed to the active completion of the mind. Cf. also Musatti 1926.
[27] Cf. Albertazzi 1996d.
[28] A conception of this kind is also present in Carnap 1928; Goodman 1951; Shepard 1981.
[29] Cf. Meinong 1899.

[30] The matter is more complicated than this, however. A perceptive datum (e.g., a chromatic tonality) is more a resultant from particular qualitative aspects than an individual perceptive datum.
[31] This dependence is in fact partial because, as Benussi showed, cases of a-sensory perception can occur. The same figure, in fact, can be perceived on the basis of differing groups of loci, as we saw in the case of the four points.
[32] Cf. Palmer, Hemenway 1978.
[33] Cf. Bonaventura 1929. For the distinction between perceptive and mental presentation see Benussi 1922–23; Albertazzi 1996d.
[34] Husserl distinguishes between *material* (or metaphysical) ontology and *formal* ontology. The former concerns whatever is really existent in the moment-now of the presentation; the latter concerns objects in general, regardless of their givenness in the duration. On this see Albertazzi 1989a; Poli 1993b; Albertazzi 1996c.
[35] This relation corresponds to McTaggart's B series, i.e., the series of temporal positions ranging between preceding and subsequent. Cf. McTaggart 1908; van Benthem 1991.
[36] Cf. Vicario 1973 and 1984.
[37] Cf. Van Benthem 1991, especially chs. 1, 4. See also Augustinek 1991. Belonging to this type of analysis are, in various respects, the theories of Reichenbach 1928; Mehlberg 1980.
[38] Cf. Benussi 1913; Bozzi 1993.
[39] With some variations this aspect corresponds to McTaggart's A series, that is, the series of temporal positions that range from the remote past, through the proximate past, to the present, and from the present through the immediate future to the future. Cf. McTaggart 1908.
[40] For the difference between description of outer experience and inner experience see De Sarlo 1903, 66ff.
[41] For the distinction between metaphysics and ontology see Meinong 1904. The consciousness of time has been analysed mainly in Husserl 1966b. On this see Albertazzi 1989b; 1990/1; 1994.
[42] Cf. Carnap 1928; Goodman 1951; Musatti 1926.
[43] Cf. Brentano 1874 and 1976; Albertazzi 1993c.
[44] The distinction is in Brentano 1976.
[45] Albertazzi 1996b.
[46] In truth, Brentano argues that the limit is not a product of abstraction, but of an idealization; it is, in fact, the outcome of an ontological operation which transforms the givens in question, whereas abstraction is a linguistic and substantial classificatory operation. On the difference between abstraction and idealization cf. Poli 1988 and 1993a.
[47] Cf. Brentano 1928, 10 ff.
[48] Cf. Bozzi 1996.
[49] This theory of continua permits solution of Aristotle's famous paradox of the instant that ceases; which is more satisfactory, from a perceptive point of view, than the set theory solution of points converging on a limit. Cf. Aristotle, *Metaphysics*; Brentano 1976.
[50] Cf. Jastrow 1971; Ehrenstein 1930.
[51] Cf. Bühler 1913.
[52] The phenomenon of Mach's rings, which was originally an example of contrast, was also used by Koffka, who applied it to field theory, and also to phenomena of temporal succession. Cf. Koffka 1935, chs. 4 and 10.
[53] Cf. Michotte 1957.
[54] Cf. Bonaventura 1929, 95; Koffka 1909.
[55] The limit of 700 msecs refers to the continuity of attention. The difference between the time of presentness (*Präsenzzeit*) and the time of simultaneity (*Gegenwartszeit*) is also discussed in Benussi. The time of presentness is the magnitude of the time that can be grasped intuitively, without remembered parts; the time of simultaneity is the length of the time during which we are able to pay attention to a particular impression; it is, so to speak, the *focus* of the time of presentness. Cf. Benussi 1907 and 1913, ch. 16, 272–339. On this see Albertazzi 1995 and 1996b.
[56] Cf. Bonaventura 1929, 84.
[57] This was in fact Meinong's (1899) thesis. For a preliminary outline of the problem see Albertazzi 1994.
[58] Cf. Kandinski 1926 *infra*.
[59] Cf. Vicario 1969 and 1973.
[60] Cf. Bonaventura 1929.
[61] Cf. Bonaventura 1929.

[62] Cf. Bohm 1980.
[63] Cf. Benussi 1913; Vicario 1973. On this see Albertazzi 1996b.
[64] Cf. Mally 1922; Metzger 1954.
[65] Cf. Husserl 1966b.
[66] Cf. Albertazzi 1994.
[67] Cf. Kanizsa, Vicario 1968.
[68] Cf. Minguzzi 1968.
[69] Cf. Klages 1933; Krueger 1926 and 1953; Sander 1930.
[70] Cf. Husserl 1966b.
[71] Cf. Benussi 1913; Albertazzi 1995 and 1996b.
[72] On the tertiary qualities see Klages 1934; Köhler 1938; Bozzi 1989.
[73] See also Yela 1954; Kanizsa, Metelli 1961; Minguzzi 1968; Gyulai 1987. On this topic see Vicario 1991.
[74] Cf. Marigonda 1968.
[75] Cf. Gibson 1979.
[76] Cf. Johansson 1950 and 1975.
[77] Cf. Wertheimer 1912; Schlick 1938b; Zimmer 1989 and 1990.
[78] Cf. Albertazzi 1996a. On the concept of material ontology see Husserl 1913; Albertazzi 1989a and 1996c. On the relation between psychology and metaphysics see Meinong 1904; Husserl 1930.
[79] Cf. Kanizsa 1991.
[80] Cf. Kanizsa 1984; Kanizsa, Luccio 1987.
[81] For the ongoing debate see Westphal 1987; Thompson 1995.
[82] Cf. Itten 1961; Kanizsa 1991. On Itten see Neu 1978. On the kinaesthetic character of colour perception see Argelander 1927. On the concept of the 'tension' of colour see Moholy-Nagy 1925.
[83] Cf. also Arnheim 1986.
[84] Cf. Mally 1922.
[85] Cf. Itten 1961.
[86] Cf. Musatti 1926.
[87] Cf. Goethe 1974, § 69. On shade phenomena as the basis of the perception of colour see Kardos 1934; see again the work by Moholy-Nagy internally to the Bauhaus group.
[88] There may, moreover, be several variations along the grey spectrum. In the Bauhaus group, for example, Kandinski viewed the process as caused by distinction, Klee by interrelation.
[89] The light-dark contrast may be linguistically expressed in different forms: for example, as shallow-deep, with reference to water, in Chinese.
[90] Cf. Husserl 1966a.
[91] A differential sound is the difference between two sequences of sounds (with a 2/3 ratio between them) heard together.
[92] Cf. James 1890; Schütz 1976.
[93] Cf. Albertazzi 1993b.
[94] See Meinong's distinction between *Verschiedenheit* (qualitative difference) and *Differenz* (quantitative difference) in Meinong 1904.
[95] Asensory presentations are those which – on the basis of a constant set of sensory impressions – yield greater perceptive returns, i.e., the perception of several different *objects* at once. Cf. Benussi 1914, § 3.
[96] It was this question that provoked the controversy between Benussi and Koffka. Cf. supra note 25.
[97] See Tenney 1988.
[98] Cf. Stumpf 1883.
[99] Cf. Fuchs 1920; Wertheimer 1923; Bühler 1913. See also Metzger 1941, ch. 5, § 1 ff.
[100] The terminology is Husserl's. Cf. Husserl 1900–1, *First Investigation.*
[101] The terminology is from Benussi 1913.
[102] Cf. Benussi 1913; Calabresi 1930; Bonaventura 1929.
[103] Cf. Metzger 1941, 180 ff.
[104] Cf. Meinong 1899 and 1904. On this see Albertazzi 1996d.
[105] Cf. Bohm 1980.
[106] Cf. Révész 1913 and 1937.
[107] Cf. Bozzi 1993; Bozzi, Vicario 1960.
[108] Cf. Husserl 1966a.
[109] Cf. Bozzi 1993.

[110] Cf. Piana 1991.
[111] For the similarity between pitch in sounds and brilliance in colours, see Brentano 1907.
[112] Cf. Husserl 1900–1, *Third Investigation.*
[113] This is the position taken up by Husserl, for example, in contrast to Meinong, when he developed his theory of intentionality. Cf. Husserl 1966b; Meinong 1899.
[114] Cf. Koffka 1935, 108; Deutsch 1982.
[115] Cf. Piana 1991.
[116] Cf. Helmholtz 1867; Wellek 1935.
[117] Cf. Köhler 1947, ch. 11; Benussi 1922–23.
[118] Cf. Brentano 1976; Albertazzi 1996a; Benussi 1922–23.
[119] Cf. Brentano 1976; Benussi 1922–23; Klages 1927; Benussi 1925.
[120] Attentive hypnic state and base sleep are both suggestion phenomena.
[121] More precisely, there were *two* passages before a state of BS was reached. On this see Wallon's criticism in Wallon 1926.
[122] Benussi learned this method from Otto Gross in Graz.
[123] In fact, whereas the ratio between the velocities of the first and second stages of inhalation was practically the same as the ratio between the velocities of the first and second stages of exhalation (Qvi=1.40; Qve=1.56), the *velocity quotients* for base sleep were Qvi=1.24, Qve=0.80. In the latter case, therefore, *changes in velocity* were symmetrical.
[124] Incidentally, the hypothesis of autonomous emotional functions is akin to the hypothesis of the existence of different cognitive modules in contemporary cognitive science.
[125] Benussi considered the affinities between his findings – on the basis of reports by Signorelli, his experimental subject – and descriptions of ecstatic states by St Teresa (the so-called *orazione di quiete*) and St John of the Cross, for example.
[126] Cf. Metzger 1941; Koffka 1921; Krueger 1928; Werner 1926; Volkelt 1933; Klages 1934.
[127] Cf. Benussi 1917; Calabresi 1931; Bonaventura 1921.
[128] Cf. Bohm 1980; Bohm, Hiley 1993.
[129] Cf. Luccio 1989b.
[130] Cf. Albertazzi 1997c.
[131] Cf. Brentano 1933.
[132] Cf. Zimmer 1989.
[133] Cf. Kanizsa, Luccio 1987.
[134] For a similar point of view cf. Leyton 1994.
[135] For the term 'intraphenomenic' see Witte 1960.
[136] Cf. Meinong 1904; Mally 1904.
[137] Cf. Tilesio 1528.
[138] For a similar point of view see Shaw and Brandsford 1977 who, expanding Gibson's view, would describe my position as an interaction of effectivities and affordances, thereby stressing the *active* character of perception. I owe this remark to Alfred Zimmer. Cf. also Albertazzi 1997a.
[139] Cf. Kandinski 1911; 1912a and 1912b; 1926; 1930. A similar point is in Whitehead 1929.
[140] As often happens, I find that someone else has already made this point. Cf. Kandinski 1912a and 1912b; 1926. See also Fechner 1897; Arhneim 1971; 1896.
[141] Cf. Köhler 1920, 193; Koffka 1935, ch. 3; Katz 1944, ch. 11; Husserl 1996a; Albertazzi 1989a; Bagnara, Sambin 1977.

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JOHN F. SOWA

ONTOLOGICAL CATEGORIES

Top-level categories of an ontology are derived from contrasting features that distinguish the entities of a subject domain. Each distinctive feature is associated with axioms that are inherited by every entity or category of entities that have that feature. A hierarchy of categories can then be derived as a lattice formed as a product of the fundamental distinctions. This paper develops such a lattice based on philosophical distinctions taken primarily from the theories of Charles Sanders Peirce and Alfred North Whitehead.

1. CATEGORIES, DISTINCTIONS, AND AXIOMS

Ontology is the study of existence, of all the kinds of entities – abstract and concrete – that make up the world. It supplies the predicates of predicate calculus and the labels that fill the boxes and circles of conceptual graphs. Logic and ontology are prerequisites for natural language semantics and knowledge representation in artificial intelligence. Without ontology, logic says nothing about anything. Without logic, ontology can only be discussed and represented in vague generalities. Logic is pure form, and ontology provides the content. The most general categories of an ontology are the framework for classifying every thing else.

Distinctions

More fundamental than the categories themselves are the criteria for distinguishing categories and determining whether a particular entity belongs to one or another. Those distinctions are the basis for Aristotle's method of definition by *genus* and *differentiae*. Each distinction contributes a pair of primitive features or differentiae, and the conjugation of all the differentiae for all the genera or supertypes of a compound concept constitutes its definition.

In his efforts to automate Aristotle's logic, Leibniz assigned a prime number to each primitive feature. Then he represented each composite concept by the product of the primes in its definition. Leibniz's method of combining primitives generates highly symmetric hierarchies called *lattices*. That symmetry, by itself, is not essential to an ontology, but it is an important guide to knowledge acquisition: every combination that is generated theoretically should be tested empirically to determine whether entities of that type happen

L. Albertazzi (ed.), Shapes of Forms, 307–340.

to exist. If so, then the combinatorial method may predict new types of entities and aid in their discovery. If no entities of the predicted type are found, then the combinatorial method may aid in the discovery of axioms or constraints that rule out those combinations. In either case, the method helps to ensure completeness by directing attention to possibilities that may have been overlooked or by suggesting new scientific principles that explain their absence.

Axioms

Besides classifying things, the ontological categories provide the hooks to which the definitions and axioms of a knowledge base are attached. By the rules of inference of logic, those axioms are inherited from supertypes to subtypes to support inferences about entities at every level of generality. For example, one of the most general ontological distinctions is the dichotomy between the two categories of Physical and Abstract. The following axioms, which may be encoded in any suitable version of logic, are associated with that dichotomy:

- Physical: If x is physical, then x has a positive mass or energy and a location in space-time.
- Abstract: If x is abstract, then x has no mass, energy, or location.
- Physical-abstract interaction: An abstract entity x may be *encoded* or *represented* in some physical entity y without changing the mass-energy or location of y.

These axioms, which are associated with the categories Physical and Abstract, can be combined with the axioms and definitions for other categories to derive more specific implications. They can also be combined with matters of fact represented in a database or with physical laws, such as the conservation of mass-energy. As a result, the inference engine of a knowledge-based system could derive implications like the following:

- If x is physical with mass m and x is transported from location l_1 to location l_2 then the total mass at location l_1 is decreased by m, and the total mass at location l_2 is increased by m.
- If x is abstract, an encoding of x in a physical entity y at location l_1 may be copied to an encoding of x in a physical entity z at location l_2 without changing the total mass-energy at either location.

Such axioms and inferences associated with categories at the topmost levels of an ontology may be inherited by entities at every lower level.

Modularity

This paper discusses some distinctions that have been discussed and analysed in the philosophical literature and shows how they can be combined to generate the top levels of an ontological hierarchy. Each distinction, by itself, is philosophically and empirically interesting. In combination, they create a framework that can be used to classify and define the common word senses of natural languages as well as the technical terms used in the various fields of science, engineering, business, and the arts.

Since each distinction must be justified on independent grounds, a new sublattice of categories can be generated automatically by combining any subset of distinctions. The combinatorial method can therefore facilitate knowledge sharing between systems with different ontologies. If two systems share any distinctions whatever, their common sublattice provides a vocabulary of concepts with associated axioms and definitions. Any propositions stated in terms of that common core could then be communicated between the systems. Furthermore, inferences drawn from the shared axioms would generate the same conclusions in each system. Although extensions beyond the core could not be made automatically, the method can help knowledge engineers determine how incremental changes to the framework would affect the categories, definitions, and axioms. The resulting modularity in system design and development is a major benefit of the combinatorial method of defining categories.

2. PHILOSOPHICAL FOUNDATIONS

The last two great ontological system builders were Charles Sanders Peirce and Alfred North Whitehead, both of whom were also pioneers in the development of symbolic logic during the late nineteenth and early twentieth centuries. Although their logic has flourished, their ontologies have been neglected. Yet the ontologies of Peirce and Whitehead, when combined with logic, can serve as a foundation for AI knowledge representation and natural language semantics.

Peirce's categories

Peirce began his philosophical career as a Kantian, but his work on logic led him to find discrepancies in Kant's framework. In his lectures of 1898, he made the following comment:

In the early sixties, I was a passionate devotee of Kant, at least, of that part of his philosophy which appears in the Transcendental Analytic of the Critic of the Pure Reason. I believed more implicitly in the two tables of the Functions of Judgment and the Categories than if they had been brought down from Sinai .... But Kant, as you may remember, calls attention to sundry relations between one category and another. I detected some additional relations between those categories, *all but* forming a regular system, yet not quite so. Those relations seemed to point to some larger list of conceptions in which they might form a regular system of relationship. After puzzling over these matters very diligently for about two years, I rose at length from the problem certain that there was something wrong with Kant's formal logic. (p. 124)

Peirce observed that each of Kant's four major headings was divided in exactly three subheadings. That symmetry could have been the result of chance, of Kant's esthetic taste, or of some deeper principles of logic. After extensive analysis, Peirce concluded that some, but not all of Kant's triads reflected three more basic categories, which he called Firstness, Secondness, and Thirdness:

First is the conception of being or existing independent of anything else. Second is the conception of being relative to, the conception of reaction with, something else. Third is the conception of mediation, whereby a first and a second are brought into relation. (1891).

As Firstness, Woman represents a type of person without considering any other relationships. But the same individual could be considered relative to or in reaction with many other things, as in the concept types Mother, Attorney, Wife, Pilot, Pedestrian, or Employee. These roles are defined by Secondness. They represent the individual in relation to another type, such as Child, Client, Husband, Airplane, Street, or Employer. Thirdness is a conception of mediating circumstances that bring the first and second into relation. Motherhood, which comprises the act of giving birth and the subsequent period of nurturing, relates the mother and the child. The legal system gives rise to the roles of attorney and client. Marriage relates the wife and the husband. Aviation relates the pilot to the airplane. The activity of walking in a situation whether other people are driving relates the pedestrian to the street. And the business enterprise relates the employee to the employer. These mediating situations are examples of Thirdness, whether they are named categories like Motherhood and Aviation or unnamed categories like walking-where-other-people-are-driving. If such a category is frequently used, it may be given a name, such as Pedestrianship.

Firstness in independent, Secondness reacts to something else, and Thirdness depends on some mediating effect that brings other entities into relationship. As an example, a human may make an *animal* (Firstness) into a *pet* (Secondness), by establishing a *contract* (Thirdness) with it. As the fox said to Saint-Exupéry's Little Prince, "You become responsible, forever, for what you have tamed". The responsibility on the human's part and the trust on the animal's part constitute the contract that binds them together. Peirce's formal criterion for distinguishing these three categories is the number of entities that are involved in their definition:

1. Firstness classifies an entity by its intrinsic pattern, structure, or form, independent of any relationships it may have to any external entity. In logic, Firstness can be represented by monadic predicates such as circle(x), potato(x), or elephant(x), which describes the form of an entity x without taking into account any entities external to x.

2. Secondness classifies an entity according to some relationship it may have to some other entity. Despite their structural differences, a potato and a steak can both be food for some human being; a horse, a bicycle, and a jet plane can be a mode of transportation for somebody; and a human being and a business organization can be classified as legal persons for some contract. Each of these entities can be described by its own form (Firstness). But by its relationship to some external entity, it is classified as a type of Secondness: Food, ModeOfTransportation, or LegalPerson. In logic, these types may be represented by explicit dyadic predicates or by monadic predicates food(x) or legalPerson(x), whose definitions involve an implicit dyadic relation to something else: x is food only if it is suitable for eating by some animal y; x is a legal person only if x can be a party to some contract y.
3. Thirdness classifies an entity by its mediating effect of bringing other entities into relation. As an example, the Firstness of an architectural drawing is its form as pencil marks on paper. It can be described by a monadic predicate whose truth or falsity is determined by the pattern of marks without regard to their meaning. As Secondness, the pattern of the drawing reflects the structure of some building. It could be described by a dyadic predicate that relates the pencil marks y to the physical structure z. As Thirdness, the drawing is a guide for a contractor or builder who translates the pattern of marks to a structure of wood, steel, and concrete. As a guide, it would require a triadic predicate that determines how the builder x follows the drawing y for the purpose of building the structure z.

Peirce maintained that it was not necessary to go beyond three, because Fourthness, Fifthness, and higher-order relations could be constructed out of triads. In his constructions, Peirce arranged the triads in all possible levels, metalevels, and combinations to form a rich architectonic.

Whitehead's categories

After collaborating with Bertrand Russell on logic, Alfred North Whitehead developed an ontology that combined the insights of some of the greatest philosophers, both ancient and modern. In the book *Process and Reality*, he agreed with Heraclitus that "the flux of things is one ultimate generalization around which we must weave our philosophical system". But he considered the other ultimate generalization to be the "permanences amid the inescapable flux", which Plato tried to capture in his eternal, unchanging Platonic forms:

> Plato found his permanences in a static, spiritual heaven, and his flux in the entanglements of his forms amid the fluent imperfections of the physical world .... Aristotle corrected his Platonism into a somewhat different balance. He was the apostle of "substance and attribute", and of the classificatory logic which this notion suggests. But on the other side, he makes a masterly analysis

of "generation". Aristotle in his own person expressed a useful protest against the Platonic tendency to separate a static spiritual world from a fluent world of superficial experience. (p. 209)

Of the modern philosophers, Whitehead was primarily influenced by Descartes, Locke, Hume, and Kant. Although he never mentioned Peirce, his eight "categories of existence" constitute two Peircean triads, supplemented with two extra categories for generating combinations. To classify "the ultimate facts of immediate actual experience", Whitehead defined categories for *actual entities, prehensions, and nexūs*, which make up a triad of physical Firstness, Secondness, and Thirdness:

1. "'Actual entities' – also termed 'actual occasions' – are the final real things of which the world is made up. There is no going behind actual entities to find anything more real. They differ among themselves: God is an actual entity, and so is the most trivial puff of existence in far-off, empty space". (p. 18)
2. As Secondness, he used the term *prehension* for "concrete fact of relatedness". He explained "that every prehension consists of three factors: (a) the 'subject' which is prehending, namely, the actual entity in which that prehension is a concrete element; (b) the 'datum' which is prehended; (c) the 'subjective form' which is *how* that subject prehends that datum". (p. 23)
3. For Thirdness, Whitehead adopted the Latin word *nexus* (plural *nexūs*), which represents an instance of connecting or binding together two or more actual entities: "Actual entities involve each other by reason of their prehensions of each other. There are thus real individual facts of the togetherness of actual entities, which are real, individual, and particular, in the same sense in which actual entities and the prehensions are real, individual and particular. Any such particular fact of togetherness among actual entities is called a 'nexus' ". (p. 20)

An actual entity can exist by itself. A prehension always involves two entities. A nexus is a bundle of two or more prehensions; it must therefore include at least three entities. The prehending entity or nexus must be physical, but the prehended entities may be physical or abstract.

Besides the three physical categories, Whitehead maintained "All else is, for our experience, derivative abstraction". He classified the abstractions in the categories of *eternal objects, propositions*, and *subjective forms*, which constitute a triad of abstract Firstness, Secondness, and Thirdness:

1. Whitehead's eternal objects correspond to Plato's forms, but with Aristotle's "correction" that the forms are derivative abstractions rather than the ultimate reality. He maintained "that an eternal object can be described only in terms of its potentiality for 'ingression' into the

becoming of actual entities; and that its analysis only discloses other eternal objects. It is a pure potential. The term 'ingression' refers to the particular mode in which the potentiality of an eternal object is realized in a particular actual entity, contributing to the definiteness of that actual entity". (p. 23)

2. A proposition, for both Peirce and Whitehead, is the predication of a form (or eternal object) as a partial description of some entity. The proposition cat (Yojo), for example, is the predication of the form named cat as "realized in a particular entity" named Yojo. A more complex proposition like ($\exists x$:mouse)chased(Yojo,x) is a combination of forms predicated of multiple entities in one statement. In Whitehead's words, "a proposition is the unity of certain actual entities in their potentiality for forming a nexus, with its potential relatedness partially defined by certain eternal objects which have the unity of one complex eternal object. The actual entities involved are termed the 'logical subject', the complex eternal object is the 'predicate'". (p. 24)

3. As abstract Thirdness, Whitehead's *subjective forms* correspond to the mediating intentions of Peirce and Husserl. He maintained "that there are many species of subjective forms, such as emotions, valuations, purposes, adversions, aversions, consciousness, etc". As a synonym for subjective form, he also used the term "private matter of fact".

Whitehead's other two categories are structural principles: his Category 7 of "multiplicities" is made up of "pure disjunctions of diverse entities"; and Category 8 of "contrasts" consists of "modes of synthesis of entities in one prehension". Whitehead said "The eighth category includes an indefinite progression of categories, as we proceed from 'contrasts' to 'contrasts of contrasts" and on indefinitely to higher grades of contrasts".

Synthesis

Besides Peirce's three-way distinction, which is relatively new in the long history of philosophy, one of the most enduring notions is the two-way distinction between what Heraclitus called *physis* [nature] and *logos* [word, reason, or speech]. The tree in Figure 1 is a synthesis of the philosophical insights ranging from Heraclitus to Peirce and Whitehead. The top symbol $\top$ is a neutral representation for the universal type; a pronounceable synonym for $\top$ is Entity. Beneath $\top$ is a two-way split between the category Physical for anything consisting of matter or energy and the category Abstract for pure information structures. The third level divides Physical and Abstract in threes according to Peirce's distinction of Firstness, Secondness, and Thirdness. The result is Whitehead's six basic categories, but with some name changes for the sake of euphony and readability.

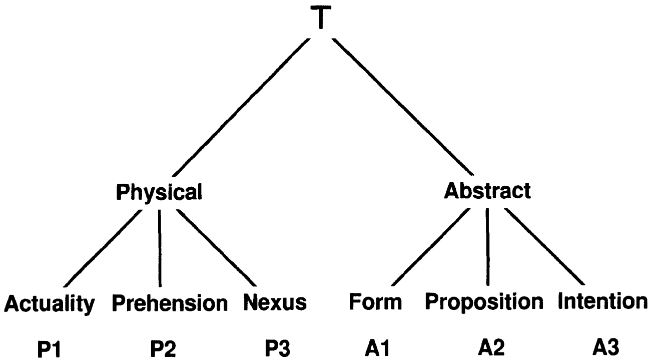

Figure 1. Top-level categories of an ontology

Each of the six categories at the bottom of Figure 1 is labeled with an English word and a two-character abbreviation, which shows how it is derived from the defining categories. For Physical Firstness, the abbreviation is P1, and the label is Actuality, which is a collective term for Whitehead's actual entities. For Physical Secondness (P2) and Physical Thirdness (P3), the labels Prehension and Nexus are taken directly from Whitehead. For Abstract Firstness (A1), Form is a shorter and more traditional label than "eternal entity". For Abstract Secondness (A2), Peirce and Whitehead both used Proposition. And for Abstract Thirdness (A3), Intention is a term that Peirce and Husserl used in approximately the same sense as Whitehead's "subjective form". To emphasize the derivation, the English label and the abbreviation can be used together; e.g., Prehension (P2) or Intention (A3).

The combinatorial method always generates highly symmetric structures, but a tree such as Figure 1 is not rich enough to display the full symmetry. By the way it is drawn, the tree imposes an ordering: it happens to show the two-way distinction as prior to the three-way distinction. Yet that choice is arbitrary, and either distinction could be placed first. Other structures, such as the graph or the matrix in Figure 2, can display the combinations without suggesting that either distinction is more fundamental.

The graph on the left of Figure 2 is generated as a product of two trees: the first tree, taken from Figure 1, has a two-way split labeled Physical vs. Abstract; the second tree is based on Peirce's three-way split. The resulting graph illustrates *multiple inheritance*, where each category on the third level inherits properties from two different categories on the preceding level. The matrix on the right of Figure 2 shows another way of representing multiple inheritance: each of the six categories inside the boxes is a combination of the distinctions listed on the top or on the left. The mathematical technique of graph theory and matrix algebra allow any number of dimensions to be represented. But as the

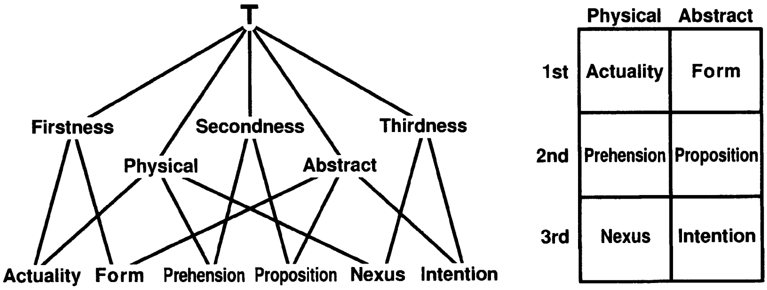

Figure 2. A graph and a matrix for displaying the categories of Figure 1

number of distinctions increases, the fine print and criss-crossing lines can make any notation unreadable. Even with computers, hypertext quickly leads to hyperclutter.

Continuants and occurrents

Whitehead agreed with Heraclitus that all things are in flux, but some things undergo rapid change, while others remain comparatively stable. To accommodate objects in a process-based ontology, he distinguished "enduring objects", which have a stable identity over some period of time, from the constantly perishing "occasions", which can be identified only by their space-time coordinates. An enduring object is called a *continuant*, and a process that does not have a stable identity is called an *occurrent.*

The distinction between continuants and occurrents depends on the time scale. On a scale of minutes, a glacier is a continuant, and an avalanche is an occurrent. But on a scale of centuries, the glacier is also a process whose structure may be radically transformed. Therefore, the distinction between continuants and occurrents must be relative to some time scale and level of detail. The changes in a person's facial features, for example, are slow enough that friends can recognize an individual as "the same" over the course of a lifetime. Yet each person gains and loses molecules with every bite of food and every breath of air. In about seven years, most of the molecules in a human body have been replaced. A person, who has a stable identity at a macro level, may be considered a constantly changing process at the molecular level.

Information is pure structure abstracted from the objects it describes and the physical medium used to record it or transmit it. A performance of a symphony is an occurrent that may last an hour, but a recording of the performance is a continuant that can preserve the information on a magnetic strip that lasts for years. The distinction of continuant vs. occurrent applies to the entities *about* *which* information is recorded and to the physical media *on which* information is stored. But in Whitehead's terms, the information itself is an eternal object that can be preserved indefinitely, provided that copies are made from time to time. Although information structures do not change, they can encode the form of either a continuant or an occurrent: a static pattern of magnetic spots on a tape may record a dynamic process, such as a movie or a symphony. Therefore, every abstract type, although unchanging in itself, can be distinguished as information about a continuant or information about an occurrent.

With the binary distinction between continuants and occurrents, the six categories at the bottom of Figure 2 are split into twelve categories in Figure 3. They are all derived by combinations of the three basic distinctions or dimensions for subdividing the universal category $\top$: Physical or Abstract (P, A); Firstness, Secondness, or Thirdness (1, 2, 3); Continuant or Occurrent (C, O). Each of the other categories is a synonym for the combination of categories from which it was derived: PhysObj, for example, could be represented by the abbreviation P1C for Physical Firstness Continuant; and Purpose would be A3O for Abstract Thirdness Occurrent. At the bottom of Figure 3, the *absurd type* $\perp$ is added as a subtype of every other type. The universal type $\top$ could be considered a synonym for the empty set of no distinctions; $\perp$ could be considered the inconsistent combination of all distinctions, PA123CO.

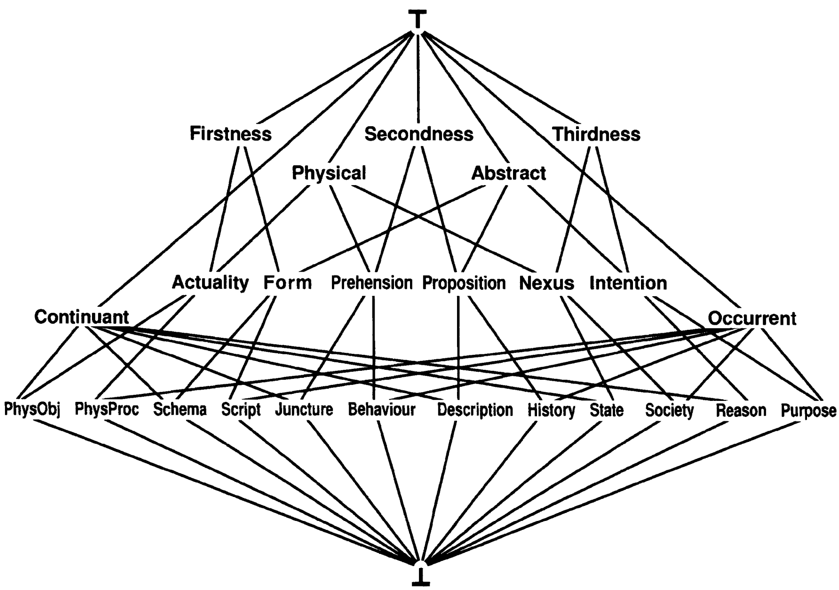

Figure 3. Lattice generated by the top three distinctions

The symmetric hierarchies generated by Leibniz's method of combination are *lattices*. When drawn in their full generality, diagrams of lattices can become cluttered with many crossing lines. To simplify the diagram, Figure 3 omits ten of the possible categories: PhysicalContinuant (PC), PhysicalOccurrent (PO), AbstractContinuant (AC), AbstractOccurrent (AO), FormalContinuant (1C), FormalOccurrent (1O), RelativeContinuant (2C), Relative-Occurrent (2O), MediatingContinuant (3C), and MediatingOccurrent (3O). If these categories were added to Figure 3, the complete lattice would contain a total of 37 distinct types, including $\top$ and $\bot$. For most applications, however, the most useful categories in Figure 3 are the central twelve, generated by one selection from each of the three major distinctions:

- PhysObj (P1C). A physical object is an actual entity (P1) considered as a continuant (C), which retains its identity over some interval of time. Although no physical entity is ever permanent, it may be stable over an interval that is short relative to its lifetime.
- PhysProc (P1O). A physical process is an actual entity (P1) considered as an occurrent (O) during the interval of interest. Depending on the time scale and level of detail, the same actual entity may be viewed as either a stable object or a dynamic process. Even a diamond could be considered a process when viewed over a long time period or at the atomic level of vibrating particles.
- Juncture (P2C). A juncture is a prehension (P2) considered as a continuant (C) over some time interval. The prehending entity of a juncture is a physical object (P1C) in a stable relationship to some prehended entity during that interval.
- Behaviour (P2O). A behaviour is a prehension (P2) considered as an occurrent (O) during the interval of interest. The prehending entity is a physical object (P1C) or a physical process (P1O) in a chaning relationship during the interval.
- State (P3C). A state is a nexus (P3) considered as a continuant (C) over some time interval. What makes a state Thirdness is the intention (A3) of some animate being who distinguishes that particular interval as significant. The animate being need not be human: it could be a cat watching a mouse or a robot waiting for a command.
- Society (P3O). A society is a nexus (P3) considered as an occurrent (O). Whitehead's notion of society is broad enough to include "regular trains of waves, individual electrons, protons, individual molecules, societies of molecules such as inorganic bodies, living cells, and societies of cells such as vegetable and animal bodies" (p. 98). Marvin Minsky's *Society of Mind* would fall within the scope of Whitehead's conception.

- Schema (A1C). A schema is an abstract form (A1) whose structure does not specify time relationships. Examples include geometrical forms, the syntactic structures of sentences in some language, or the encodings of pictures in a multimedia system.

- Script (A1O). A script is an abstract form (A1) that represents time sequences. Examples include computer programmes, a recipe for baking a cake, a sheet of music to be played on a piano, or a differential equation that governs the evolution of a physical process. A movie can be described by several different kinds of scripts: the first is a specification of the actions and dialogue to be acted out by humans; but the sequence of frames in a reel of film is also a script that determines a process carried out by a projector that generates flickering images on a screen.

- Description (A2C). A description is a proposition (A2) that relates some schema (A1C) to the structure of some continuant (C). A schema by itself is uninstantiated Firstness; a description is the application (Secondness) of a schema to describe an entity, either physical or abstract.

- History (A2O). A history is a proposition (A2) that relates some script (A1O) to the structure of some occurrent (O). A computer programme, for example, is a script (A1O); a computer executing the programme is a physical occurrent (PO); and the abstract information (A) encoded in a trace of the instructions executed is a history (A2O).

- Reason (A3C). A reason is an intention (A3) of some animate agent concerning some continuant (C). Unlike a simple description (Secondness), a reason explains an entity in terms of an intention (Thirdness). For a birthday party, a description might list the presents, but a reason would explain why the presents are relevant to the party.

- Purpose (A3O). A purpose is an intention (A3) of some animate agent concerning the progress of some occurrent (O). The words and notes of the song "Happy Birthday" form a script (A1O); the party-goers singing the song form a society (P3O); a description of how they sang each word and note of the song is history (A2O); and the intention (A3) that explains the overall behaviour (P2O) of the party-goers is a purpose (A3O).

Lattices of categories can be derived from the top down, as this one, or they can be derived empirically from an analysis of data. Rudolf Wille and his colleagues (Wille, 1992; Ganter and Wille, 1996) have been developing lattice techniques for formal concept analysis. Among their applications, they have used them for machine learning from examples and for classifying large volumes of data, such as the books and documents in a library. Unlike typical trees, the lattices provide a complete set of cross links for associating documents along multiple dimensions. They have been implemented in tools for data analysis and knowledge acquisition.

	Physical		Abstract	
	Continuant	Occurrent	Continuant	Occurrent
1st	PhysObj	PhysProc	Schema	Script
2nd	Juncture	Behaviour	Description	History
3rd	State	Society	Reason	Purpose

Figure 4. Matrix of the twelve central categories of Figure 3

To show the twelve central categories from a different perspective, Figure 4 arranges tham in a matrix instead of a lattice. The three rows are based on Peirce's ternary distinction, and the four columns represent the product of the binary distinction of Physical vs. Abstract with the binary distinction of Continuant vs. Occurrent. Each abstract category on the right of Figure 4 is said to *characterize* the corresponding physical category on the left: a schema characterizes a physical object; a script characterizes a physical process; a description characterizes a juncture; a history characterizes a behaviour; a reason characterizes a state; and a purpose characterizes a society. A concept such as [Cat: Yojo] asserts that the schema named by the type label Cat characterizes the physical object named Yojo. Depending on which features are highlighted, the same entity can be characterized in many different ways, as [Pet: Yojo], [Mammal: Yojo], or [FuzzyBlackEntity: Yojo]. As pure information, scripts (A1O), histories (A2O), and purposes (A3O) are static by themselves, but they may describe or determine the time sequences of dynamic processes.

Inheritance

Hierarchies like Figure 3 organize the ontological categories to make them easier for people to remember and more efficient for computers to search. They also enable properties to be inherited through the hierarchy from supertypes to subtypes. If A is a supertype of B, then every property, feature, aspect, attribute, axiom, rule, procedure, or definition that applies to A can be inherited by B. For the top-level categories in Figure 3, the following characteristics are inherited by every subtype:

- Physical: has mass or energy and a location in space-time.
- Abstract: can be communicated without transporting the matter in which it is encoded.
- Firstness: definable by a monadic predicate $p(x)$ in terms of the entity x itself (including its inherent parts and properties) and not in terms of anything external to x.
- Secondness: definable by a dyadic predicate $p(x, y)$ that relates the entity x to some independently existing entity y that is not an inherent part or property of x.
- Thirdness: definable by an n-adic predicate $p(x, y, z, \ldots)$ that relates the entity x to at least two other independently existing entities y and z where y is physical and z is abstract.

  Example: y is some animate being (human, animal, or robot) and z is, in Whitehead's terms, the subjective form according to which y interprets x.

- Continuant: definable by a predicate $p(x)$ that does not involve time or a time-like succession.

  Example: An entity of type Animal may change over time, but it can be considered a continuant because the characteristics that make it an instance of Animal are independent of time.

- Occurrent: definable by a predicate $p(x)$ that depends on time or a time-like succession.

  Example: the lifetime of an animal is an occurrent because it is definable as a time-like succession of states.

Each category in the hierarchy inherits all the properties of every category above it. An instance of Script (A1O), for example, is abstract (A); therefore, it can be communicated without transporting the matter in which it is encoded. As Firstness (1), it can be characterized by a monadic predicate $p(x)$ defined in terms of the parts and properties inherent in it. As an occurrent (O), its characteristics predicate $p(x)$ must involve time or a time-like succession. These properties of the top-level categories apply to subjects in every domain of knowledge. The mid-level categories have more specific, but still broadly applicable properties and axioms. The lowest-level categories inherit all the general knowledge from the top-level and mid-level categories, but they also have much more detailed domain-dependent properties.

3. DESCRIBING PHYSICAL ENTITIES

At the top level of Figure 3, Peirce's three-way distinction characterizes entities by objective criteria. But Peirce's trichotomy could also be used to characterize entities according to the way they are named for different purposes – in Whitehead's terms, by different *subjective forms*. The category Actuality, which includes all physical entities, is subdivided in Figure 3 by a two-way distinction into PhysicalObject and PhysicalProcess. That same category could be divided by a three-way distinction of Thing, Role, or System:

1. *Thing*. A thing is a physical entity described by the name of some abstract entity that characterizes its form. The phrase *a wooden cube*, for example, describes a thing in two ways: the noun *cube* names a geometrical form that describes its shape; and the adjective *wooden* describes the embodiment of that form as an object made of wood. Without that adjective, the word *cube* would be ambiguous, since it could refer to either an abstract form or a physical object.

2. *Role*. A role is a physical entity described by its relationship to something else. The category HumanBeing, for example, describes an entity by its form; but by role, that same entity could be described as a mother, employee, or pedestrian. Note the distinction between a role and a prehension: a prehension includes both entities in a relationship, such as the mother and the child; the role of mother, however, focuses on one entity, but describes that entity by a relationship to another. In logic, a prehension may be represented by a dyadic predicate motherOf(x, y), which explicitly refers to both entities; a role, however, is represented by a monadic predicate mother(x), which leaves the entity y implicit.

3. *System*. A system is a physical entity described according to its internal structure as a society of interacting components. As a thing, a person named Tom may be classified as a human being. By role, Tom may be classified as a father, brother, artist, or bus driver. During a medical operation, a surgeon might treat Tom as a system of bodily organs whose delicate interactions must be kept in working order. From the outside, a system may be considered a single object; internally, however, it is a nexus that encompasses multiple prehensions of its parts and subprocesses.

This three-way distinction uses Peirce's trichotomy to classify physical entities by how they are described, not by what they are. The same actual entities could occur in any or all of the three categories Thing, Role, and System. But in each of those categories, the entities would be described or conceptualized differently.

Multiple embodiments

The same abstract forms may be represented or embodied in many different physical entities. Therefore, physical objects of widely divergent natures could be characterized by the name of the same abstract form. The name of the book *War and Peace*, for example, could refer to an abstract form conceived by Tolstoy or to an embodiment of that form in a physical object made of paper and ink. When computers are used to represent such things, the number of entities, both physical and abstract, is multiplied:

- When *War and Peace* is encoded for computer processing, it becomes a pattern of bits, which is another abstract form that hardly resembles the one that Tolstoy conceived.
- When a computer programme formats the bits to recreate a humanly readable copy, the abstract pattern passes through a rapid succession of physical embodiments: reflecting spots on one disc, magnetic spots on another disc, currents flowing in transistors, pulses of light in a laser beam, electrically charged spots on a drum, and dust particles that are attracted to the drum and baked on the paper.
- Despite the profound differences between the physical embodiments, they could all be called by the name of the same abstract form, *War and Peace*. For different purposes, the same physical entity could also be described by different forms: the bound volume could be called *War and Peace* to emphasize its content, or it might be called 'a book' to emphasize its physical structure.

William of Ockham admonished philosophers to avoid multiplying entities, but computers multiply them faster than his razor can shave.

Possible confusions

For each actual entity, there are many abstract forms that could characterize it from different perspectives. In a computer, each form could be represented in different ways. A curve, for example, might be stored as a pattern of bits or as a mathematical equation. Each representation of a form could have a different name; the names could also have forms; and the forms of the names could have their own representations. A failure to distinguish these entities is a common source of bugs in computer programmes. One query system, for example, gave the following answer to a question about U.S. geography:

Q: *What is the biggest state?*
A: *Wyoming.*

Alaska is the largest state in area, and California is the largest in population.

Wyoming is not the largest by any measure, but it happens to be the last state in alphabetical order. For numbers and character strings, the system would find the largest value by comparing their names with the > operator. For states, it blindly applied the same operator to their names. But unlike numbers, states do not have names that encode their size.

The State of Wyoming, its population, and its land are physical entities; but the name of the state and the measurements of its population and land area are abstract entities. The representations of names and measurements are further abstract entities. Yet programmers sometimes ignore the distinctions and blithely define a person as a string or population as a number. In the NIAM methodology for database design (Nijssen and Halpin, 1989), the distinctions are carefully preserved: any abstract information structure that can be represented in a computer is called a *lexical object type* (LOT); and a physical entity, which cannot be stored in a computer, is called a *nonlexical object type* (NOLOT). That distinction is fundamental to knowledge representation, but the terms LOT and NOLOT show their computer bias by making LOTs primary and calling physical objects by the negative term *nonlexical.* Those terms make the information in the computer seem more real than the world outside.

Things and roles

In elementary logic books, English adjectives and nouns are usually translated to monadic predicates. For many common phrases, that translation produces an acceptable formula in logic:

```
a happy boy    ⇒   (∃x)(happy)(x) ∧ boy(x)).
a shaggy dog   ⇒   (∃y)(shaggy)(y) ∧ dog(y)).
a green tree   ⇒   (∃z)(green)(z) ∧ tree(z)).
```

These translations correctly imply that there is some x that is happy and a boy, some y that is shaggy and a dog, and some z that is green and a tree. But when the method is applied to all adjectives and nouns, it runs into serious difficulties. One question-answering programme used it to translate the following two sentences to logic:

```
Sam is a good musician   ⇒   good(Sam) ∧ musician(Sam).
Sam is a bad cook        ⇒   bad(Sam) ∧ cook(Sam).
```

Using those translations, the programme answered yes to all the following questions:

```
Is Sam a bad musician?
Is Sam a good cook?
Is Sam a good bad musician cook?
```

The problem is caused by the way the adjectives *good* and *bad* modify the meaning of the nouns. Unlike the adjective *happy*, which applies directly to the person, the adjectives *good* and *bad* apply to some particular role that the person may play. Sam is not being considered good or bad as a human being, but only in the role of musician or cook. This example illustrates two important points: some nouns describe an individual only with respect to a particular role; and some adjectives qualify the role, not the individual.

In terms of Peirce's categories, the nouns *boy*, *dog*, and *tree* describe the form or Firstness of a thing without regard to how it may be related to any other entities. Similar examples include *man*, *woman*, *animal*, *beagle*, and *building*. An instance of these types can be recognized by examining the form or structure of the entity without considering any external relationships or circumstances. Nouns like *musician* and *cook*, however, describe an entity by some role that relates it to something external – in this case, music or cooking. Other examples include *pet*, *teacher*, *lawyer*, *sister*, *friend*, *employee*, *pedestrian*, *dwelling*, and *landmark*. An instance of a role can only be recognized in context, sometimes by indirect means. A person might not know that he or she has assumed a new role until some time after it happens; becoming a grandfather or a prize winner, for example, may be completely unexpected.

Everything that plays a role also has a form of its own. Usually, however, things of many different forms can play the same role. The type Nail, for example, describes an object by its form – long and thin with a point at one end. A common use for a nail is to fasten things made of wood; in such a use, a nail would be a fastener. But Fastener is a role that could be played by things of many different forms, such as Nail, Tape, Hook, Button, String, or PaperClip. Although a fastener must have some form, there is no single form that every fastener must have. In some cases, the form may be predictable from the role. A pet, for example, is usually an animal in a certain role with respect to a human being. Therefore, the role of Pet suggests the form of Animal. Yet the suggestion is not a strict implication, since a robot, a human, a plant, or even a rock could play the role of Pet. By extension, it may happen that all instances of some role have the same form. But new discoveries or inventions might lead to very different forms that could play the same role. Velcro, for example, is new kind of fastener whose form does not resemble the traditional types like Nail, String, or Button.

Adjectives like *happy*, *shaggy*, and *green* describe the form of something independent of any role that may be mentioned by the noun: a shaggy dog and a shaggy pet are both shaggy in the same way, and the role of pet is independent of the shagginess. Those adjectives may be applied to role words, as in the phrases *happy musician*, *shaggy pet*, or *green dwelling*. In such combinations, the adjective describes the base entity; the role of musician, pet, or dwelling are incidental to the modifying adjective. Therefore, the adjective can be represented by a monadic predicate:

a happy musician	$\Rightarrow$	$(\exists x)(\texttt{happy})(x) \wedge \texttt{musician}(x))$.
a shaggy pet	$\Rightarrow$	$(\exists y)(\texttt{shaggy})(y) \wedge \texttt{pet}(y))$.
a green dwelling	$\Rightarrow$	$(\exists z)(\texttt{green})(z) \wedge \texttt{dwelling}(z))$.

The adjectives *good* and *bad*, however, modify the role: a good musician and a good cook are considered good only in relationship to music and cooking. Other examples include *nuclear physicist*, *former senator*, and *alleged thief.* A happy physicist is a happy person, but a nuclear physicist is not a nuclear person; a former senator is not a former person; and an alleged thief is not an alleged person and perhaps not even a thief.

Modifying the role

The simplest way to represent an adjective modifying a noun is to invent special predicates like goodMusician(x) or nuclearPhysicist(y). That method always works, but it requires a new predicate for every combination of adjective and noun. A more general approach could be based on Richard Montague's technique of treating modifiers as functions that convert one precicate into another. The adjective *good*, for example, would correspond to a function that maps the predicate musician(x) to a predicate that is equivalent to good-Musician(x):

a good musician	$\Rightarrow$	$(\exists x)\texttt{good}(\texttt{musician})\ (x)$.

This formula says that the function *good*, when applied to the predicate *musician*, generates a new predicate good(musician), which is then applied to the entity x. But this approach becomes more complicated with the sentence *Ivan is a poor choice for shortstop, but he's a good choice for catcher.* Choice is a role that implies that Ivan could be chosen for another role, Shortstop or Catcher, for which he might be good or bad. Generalizing the above representation would produce something like

a good choice for catcher	$\Rightarrow$	$(\exists x)\texttt{good}(\texttt{choice})\ (\texttt{catcher})(x)$.

This formula says that *good* is a function, which when applied to *choice* produces another function, which when applied to *catcher* generates a predicate, which is applied to x.

The representation of adjectives as functions is only a first step. It shows that an adjective modifies a noun, but it does not show how it changes the definition of the noun. In Peirce's terms, a role like *musician* or *cook* is defined by a relationship between a person and some Second, such as music or cooking. In Whitehead's terms, that "concrete fact of relatedness" is a *prehension*, which consists of three factors: (a) the prehending entity, namely the person or thing that the noun refers to; (b) the prehending entity, such as music or cooking; and

(c) the subjective form or intention, which determines how the first entity plays the music or cooks the food. An adjective that modifies such a noun could apply to any of the three factors:

- *Prehending entity.* In the phrases *happy musician, handsome cook*, and *elderly physicist*, the adjective applies directly to the entity referenced by the noun. The relationship of that individual to music, cooking, or physics remains un affected by the adjective.
- *Prehended entity.* In the phrases *nuclear physicist* and *pastry chef*, the adjective describes the prehending entity: the branch of physics or the kind of food prepared by the chef.
- *Intention.* In the phrases *good musician, former senator*, and *alleged thief*, the adjective modifies the subjective form or intention that relates the prehending entity to the music, the U.S. Senate, or the act of stealing.

In these examples, the noun implies the role, but sometimes the modifier determines the role. The Loch Ness monster, for example, lives in the Loch Ness, but the cookie monster eats cookies. Deciphering the correct relation makes natural language understanding a challenge for both people and computers.

Classifying entities by their roles

The biological classifications of plants and animals have traditionally depended on their visible form or *morphology*. Newer techniques that use DNA also classify them by form, but by their forms at the molecular level rather than the visible level. Classification by role is orthogonal to a classification by form: animals of many different forms could be pets, livestock, or vermin; plants could be crops, ornamentals, or weeds. Similar distinctions apply to artifacts and geographical features: nails and buttons could be distinguished by form or grouped together as fasteners; a river and a mountain might both be tourist attractions, while various bodies of water might be obstacles or navigable channels.

Figure 5 shows a subhierarchy under Actuality (P1) that classifies actual entities as things, roles, or systems: the category Thing describes an entity by its form or Firstness; the category Role describes an entity by some role it plays or its Secondness relative to something else; the category System describes an entity as a nexus of interacting components or Thirdness. For different purposes, the same entity could be classified in any or all of these ways. As an actual entity (P1), anything classified as an instance of Thing, Role, or System must also be an instance of Firstness according to the hierarchy of Figure 3. But the subhierarchy of Figure 5 distinguishes those instances of Firstness according to defining characteristics that may involve any of Peirce's three

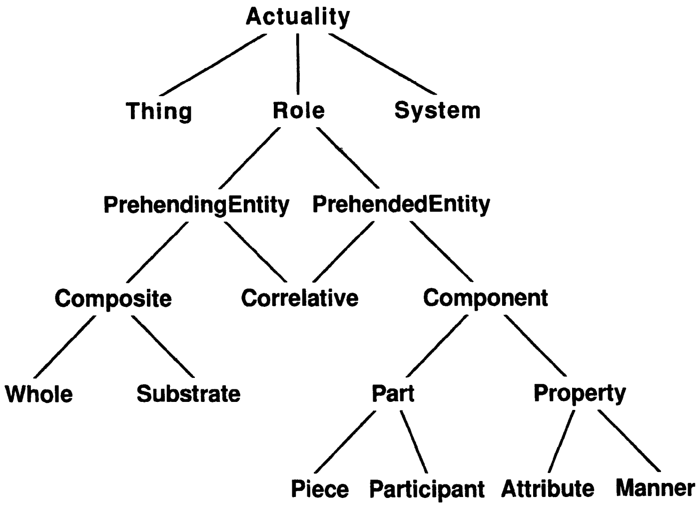

Figure 5. Classification of actual entities by role

categories Firstness, Secondness, or Thirdness.

After the three-way subdivision of Thing, Role, and System, the category Role in Figure 5 is further divided according to Whitehead's distinction of the prehending entity and the prehended entity of relationship. The distinction of *extrinsic* or *intrinsic* distinguishes the kinds of prehensions. If either entity in a prehension could disappear without affecting the form or existence of the other, the relation between them is extrinsic. If the disappearance of one entity in a prehension changes the form or even the existence of the other, the relation between them is intrinsic. That distinction generates three categories at the third level of Figure 5:

- *Composite.* An intrinsic prehending entity, called a *composite*, bears a relationship to something inherent within itself. Its subtypes are distinguished by the kind of prehension: a whole is made up of its parts; and a substrate (translated from Aristotle's word *hypokeimenon*) is the underlying material that supports properties such as size, weight, shape, or colour.
- *Correlative.* An extrinsic prehending or prehended entity, called a *correlative*, bears a relationship to something outside itself. Examples include mother and child, lawyer and client, or employer and employee. A correlative could be considered the prehending entity of one prehension or the prehended entity of the converse prehension.

- *Component*. An intrinsic prehended entity, called a *component*, bears a relationship to something in which it inheres. Its subtypes include parts, which can exist independent of the whole, and properties, which cannot exist without some substrate.

Has test

As a test for distinguishing the prehending or prehended entity, apply the pattern "X has Y" to the pair of words that describe them. If the pattern sounds normal or natural, then X is the prehending entity, and Y is the prehended entity. For example, one may say "The car has an engine" or "The car has a colour", but not "The engine has a car" or "The colour has a car". In general, composites have components, but components do not have composites. For correlatives, however, either member of the pair may be the prehending or prehended entity: a mother has a child, and a child has a mother; a lawyer has a client, and a client has a lawyer; an employer has an employee, and an employee has an employer. In general, if "X has Y" sounds natural, but "Y has X" does not, then X is a composite of which Y is a component. If both patterns "X has Y" and "Y has X" sound natural, then X and Y are correlatives.

The *has* test is not a criterion for finding relationships in the world, but a criterion for distinguishing the conceptual pattern implied by a pair of words (or by the concepts they express). Earth and sky, for example, are strongly associated, but the association between them is a physical fact, not a conceptual pattern implicit in the words *earth* and *sky*. Therefore, both patterns "The earth has the sky" and "The sky has the earth" sound odd or unnatural. If the same entities are described in different words, the *has* test may find different implicit relationships. If Sam hires his daughter Sue to work in his business, the implicit relationship depends on whether they are described as father–daughter, employer–employee, or partners.

At the fourth level of Figure 5, the two categories Composite and Component are subdivided according to the distinction of *independence* and *non-independence* (Husserl, 1900). Fred's car, for example, has parts such as an engine, wheels, doors, and tyres, which can be detached and replaced. If separated from the car, they continue to have an independent existence. But the car also has properties that cannot exist independently: size, weight, colour, shape, horsepower, fuel consumption, and sex appeal. The weight and shape may be changed by removing or replacing some of the parts, but weight and shape cannot exist without some substrate. This distinction leads to two kinds of intrinsic relations or prehensions: a whole has parts, and a substrate has properties. If Fred's car is considered a whole, its parts such as engine and tyres can be removed and continue to exist. The prehension that links Whole to Part is intrinsic, but parts can have an independent existence. The car can also be considered a substrate for properties like colour, weight, and sex appeal, but the properties cannot exist independently. The prehension that links Substrate to Property is intrinsic, but properties are not independent.

The classification of physical entities by role in Figure 5 is orthogonal to the subdivision by Continuant and Occurrent in Figure 3. Each category of Figure 5 could therefore be subdivided further as an object (Continuant) or a process (Occurrent). With that distinction, the two subtypes of Component could be divided into four:

- *Piece.* The parts of a continuant are called *pieces.* Examples of pieces include the doors and walls of a house, the states or provinces of a country, and the limbs and organs of an animal.
- *Participant.* The parts of an occurrent are called *participants.* They include the agent, patient, or recipient of an action, the flammable substance in burning, or the water that falls in a rain.
- *Attribute.* The properties of a continuant, which are usually described by adjectives, are called *attributes.* They include entities like colours, shapes, sizes, and weights.
- *Manner.* The properties of an occurrent, which are usually described by adverbs, are called *manners.* They include entities like the speed of the wind, the style of a dance, or the intensity of a sports competition.

These categories, which are defined by purely semantic distinctions, have a strong correlation with the syntactic categories of natural languages. Continuants are commonly expressed by nouns, and occurrents by verbs. Attributes are expressed by adjectives, and manners by adverbs. Participants are expressed by the *case relations* or *thematic roles* associated with verbs; they are discussed further in another paper (Sowa, 1996) and a forthcoming book (Sowa, 1999).

The English-based *has*-test for classifying prehensions can be rephrased in words related to *have* in other languages. Aristotle, in fact, discussed the various uses of the Greek *echein* [have] in the last chapter of his *Categories.* Such cross-linguistic tests, which are illustrated in many examples throughout this book, confirm the validity of Aristotle's methodology of using language structure as a guide to both metaphysical and empirical analyses. The correlations that Aristotle observed in the syntax and vocabulary of Greek have become broader and deeper as linguists have extended their analyses to more exotic languages from all parts of the world.

Representing nexūs

A nexus is an entity that prehends two or more other entities, thereby introducing further relationships between the prehended entities. An instance

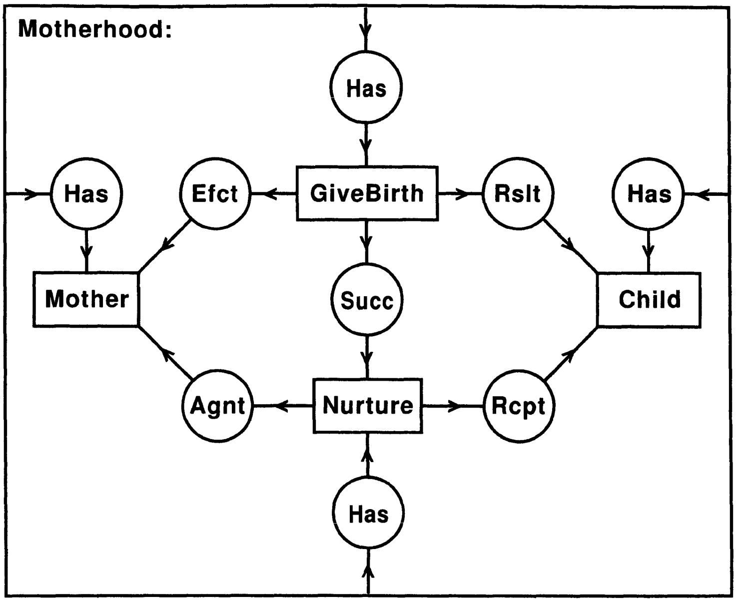

Figure 6. Representing motherhood as a nexus

of motherhood, for example, is a nexus that "has" four prehended entities: a mother, a child, an event of giving birth, and a subsequent process of nurturing. Figure 6 shows a context of type Motherhood, which contains a nested conceptual graph that describes the relationships.

Each of the four HAS relations in Figure 6 connects the Motherhood context to a concept of one of the four prehended entities. The mother is the effector (EFCT) of giving birth, and the child is the result (RSLT). Giving birth has nurturing as a successor (SUCC), which has the mother as agent (AGNT) and the child as recipient (RCPT). The distinction between agent and effector depends on whether the action is intentional. As the agent of nurturing, the mother must perform the action voluntarily; giving birth, however, is performed by an effector, who does so without a volunary decision. The nexus of motherhood in Figure 6 gives rise to correlative prehensions between the mother and the child: the mother has a child, and the child has a mother.

Intentionality

As Whitehead noted, the way a physical entity is classified depends on the intention or subjective form of some perceiving agent. A proposition, by itself, is a Secondness that characterizes some entity by some abstract form. The mental state of a person who believes or states a proposition is not involved in the proposition. An intention, however, is the mental mediation or Thirdness that directs an agent's attention to some form that characterizes some entity. In his book *Intentionality*, the philosopher John Searle began with a definition: "Intentionality is that property of many mental states and events by which they are directed at or about or of objects and states of affairs in the world".

To illustrate intentionality, Searle presented Figure 7, which agents with different intentions might interpret in different ways:

> This can be seen as the word "TOOT", as a table with two large balloons underneath, as the numeral 1001 with a line over the top, as a bridge with two pipelines crossing underneath, as the eyes of a man wearing a hat with a string hanging down each side, and so on. In each case, we have a different experience even though the purely physical visual stimuli, the lines on the paper in front of us and the light reflected from them, are constant. But these experiences and the differences between them are dependent on our having mastered a series of linguistically impregnated cultural skills. It is not the failure, for example, of my dog's optical apparatus that prevents him from seeing this figure as the word "TOOT".

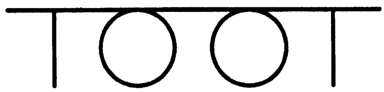

Figure 7. Searle's example of an ambiguous figure

Each interpretation of Figure 7 could be stated as a different proposition: *There is the word TOOT* or *There is a table with two balloons underneath.* In these statements, the word *there* indicates the physical entity, and the phrase following the word *is* specifies some form that is applied to the entity. But the propositions make no reference to any agent, explicit or implicit, who may believe them. A belief is intentional because it involves the agent who relates the form to the entity: *Mary believes that Figure 7 shows the word TOOT, but Bill believes that it shows a table with two balloons underneath.* The intentions of Mary and Bill are essential to their beliefs, but not to the propositions that make up the content of those beliefs.

4. DEFINING ABSTRACTIONS

At the entrance to his Academy, Plato posted the motto "Let no one ignorant of mathematics enter here". That slogan expressed his conviction that mathematics is the key to understanding all forms. As he said in the *Republic*, "the knowledge at which geometry aims is knowledge of the eternal, and not of anything perishing and transient". Today, mathematicians have defined much richer structures than the geometrical forms of Plato's time: topology and set theory of infinite structures; differential equations for representing continuous change; and computer simulations of virtual reality. Mathematical structures, which can be analysed theoretically and be represented on a computer, have the properties that philosophers from Heraclitus to Quine have postulated for the category of Form: they are abstract, independent of matter and energy, and rich enough to represent or simulate phenomena with sufficient detail to match or exceed the threshold of human perception. Virtual reality, in fact, can be precise enough to trick the human senses into interpreting the simulations as though they were real. In its full generality, mathematics is the theory of all these forms – real, imaginary, and virtual. It includes everything that can be implemented on a computer of any kind: finite or infinite; digital, analog, or neural. Plato summarized that point succinctly: "God eternally geometrizes".

Categories of form

Since forms, for both Plato and Whitehead, are eternal, mathematical objects, they do not have a location in either space or time. But they can be used to characterize physical entities that do. The distinction of Continuant vs. Occurrent divides the category Form in two: Schema includes all the forms and patterns of stable objects; Script includes all the forms of dynamically changing processes. Like read-only procedures in a computer, scripts do not change, but they can determine the flow of processes that are in constant flux. The two categories of Schema and Script can be further subdivided by the distinction of spatial vs. nonspatial. Figure 8 shows the category Form subdivided by both the temporal and spatial distinctions.

Under SpatialForm are Plato's geometrical forms, natural shapes like cats, dogs, and people, and the irregular, but systematic *fractals*, which are used to simulate trees, grass, ocean waves, and mountain ranges. Under Arrangement are mathematical structures based on relations other than space: numbers, sets, lists, vectors, matrices, and all the data structures of computer science. The Greek word for arrangement is *taxis*, and the type Arrangement includes the subtypes whose names are derived from *taxis*, including taxonomies and syntax. All the syntactic forms in natural languages, programming languages, and versions of symbolic logic are included under Arrangement. Graphic

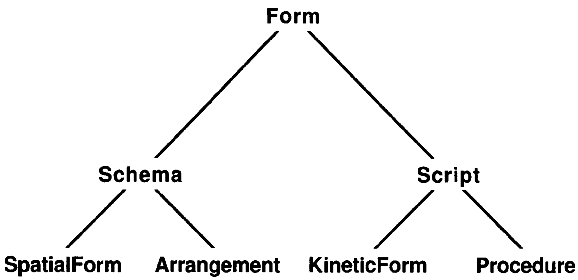

Figure 8. Temporal and spatial subdivisions of Form

languages where distance and position are significant would be under SpatialForm, but languages like conceptual graphs where the placement of the nodes is not significant would be under Arrangement.

The subtree under Script includes the forms of everything that is in flux. The type KineticForm includes the information in a reel of motion picture film or the patterns and equations for generating motion in virtual reality. The type Procedure includes computer programs, finite-state machines, and Petri nets. It also includes any time or sequence dependent specification of actions and events: robot commands, cooking recipes, musical scores, conference schedules, driving directions, and the scripts of actions and dialog in plays and movies. Scripts can also include intermediate cases, such as dance choreography or machine controls, which may mix spatial information with nonspatial instructions. Although a script is intended to represent a dynamic process, it may have static parts. In a movie film, for example, the sequence of images is a script that determines the motion, but each frame is a schema of a static image.

Monads

Everything physical must occupy some region of space and time, but abstract forms can be imagined that are smaller and simpler than anything physically possible. The geometrical *point* and the temporal *instants* are such abstractions: a point is a spatial unit that does not take up any space, and an instant is a temporal unit that takes no time. In abstract algebra, sets, groups, and rings have *elements*, which are not only undefined, but inherently undefinable primitives. When algebra is applied to some subject, the elements may be "identified" with physical things like dogs and people, but the mathematical elements by themselves have no properties other than their relationships to the set and its other elements. For procedures, the elementary units are the *transitions* between states. Like the elements of a set, the transitions of a procedure are abstract entities; they can be associated with real-world processes like baking a cake or with abstract algorithms for computing mathematical functions. Such abstractions – points, elements, instants, and transitions – are fundamental primitives that can be used to define more complex forms.

As general term for anything that has no parts, Aristotle used the word *monad* [unit]: "An indivisible quantity is called a monad if it is indivisible in every dimension and is without position; it is called a point, if it is indivisible in every dimension and has position" (*Metaphysics* 1016b24). The term Monad can therefore be used as a label for a subtype of Form that has no parts. For each of the subtypes of Form, the corresponding primitive is a subtype of Monad: a *point* is a monad of spatial form; an *element* is a monad of arrangement in sets, groups, fields, and other algebraic structures; an *instant* is a kinetic monad; and a *transition* is a procedural monad. These labels, however, are merely convenient names for talking about the primitives from which more complex forms are constructed. To say that a number, for example, is a monad of arrangement is no more enlightening than to identify it with a notch on a counting stick. The usefulness of numbers and points results from the axioms of mathematics and their implications for the more complex patterns that are constructed from combinations or primitives. When the points on a map are identified with cities and towns, the theorems of geometry and arithmetic become available for computing distances and directions.

Spatial forms

Figure 9 shows the immediate subtypes under SpatialForm. The first distinction of Continuous vs. Corpuscular divides SpatialForm according to the presence of internal boundaries that distinguish smooth stuff from lumpy or discrete things. The category Continuous is characterized by indefinite divisibility to the limits of perception by the available sense organs or measuring instruments. It may be as homogeneous as distilled water, or it may vary like the oceans, which differ in temperature and salinity from point to point. The type Corpuscular includes organisms like trees or animals, which have parts that are not completely separable, even though there are discontinuities. It also includes assemblies like Fred's car, which consists of discrete parts that can be separated and put together to make a car whose form is indistinguishable from the original.

Whether something is considered an unstructured collection or a structured assembly depends on some agent's intention (A3). Fred's car in working order is a highly structured assembly. But if the parts were disassembled and spread out on Fred's lawn, it would be called a collection. Yet if the parts were arranged to spell the name "FRED", they would again form an assembly, although not one that could be used for transportation. Conversely, if Fred's car were towed to the junk yard, the junk dealer might consider it a collection, even though the parts were in the same order they had been while it was still running. This example raises the question of whether a collection is tangible (physical) or intangible (abstract). The answer is that the types in Figure 9 are abstract information structures that belong under Form (A1). Those forms, however, can be used to characterize physical entities such as a car. A collection of physical entities (P1) is also a physical entity (P1). The assertion that the parts of Fred's car form a collection, however, is a proposition (A2). An explanation of why the parts of Fred's car were assembled in the form of his name is a reason (A3C).

Hierarchies of theories

Each of the four subtypes of Form at the bottom of Figure 8 is described by theories taken from a different branch of mathematics. Geometry in all its variations is the theory of SpatialForm; discrete mathematics, as expressed in

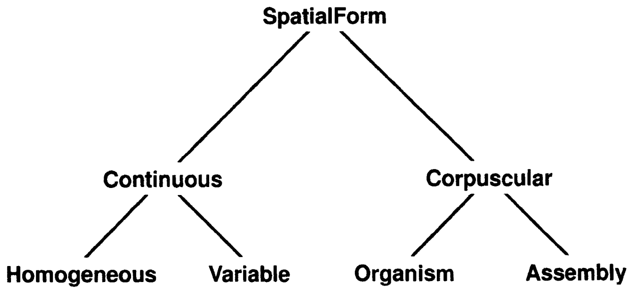

Figure 9. Hierarchy of spatial forms

algebra, logic, set theory, graph theory, and formal grammar, describes the types of Arrangement; calculus and differential equations with their applications to mechanics and fluid dynamics are the theories of KineticForm; and the theories of computer science, such as Turing machines, automata theory, and programming language semantics, are the theories of Procedure.

Figure 10 shows a hierarchy of mathematical theories. Each theory is a *generalization* of the ones below it and a *specialization* of the ones above it. The top theory contains all *tautologies* – all the logically true propositions that are provable from the empty set. Each theory below Tautologies is derived from the ones above it by adding new axioms; its theorems include all the theorems inherited from above plus all the new ones that can be proved from the new axioms or from their combination with the inherited axioms. Adding more axioms makes a theory larger, in the sense that it contains more propositions. But the larger theory is also more specialized, since it applies to a smaller range of possible models. This principle, which was first observed by Aristotle, is known as the *inverse relationship between intension and extension*: as the meaning or *intension* grows larger in terms of the number of axioms or defining conditions, the extension grows smaller in terms of the number of possible instances. As an example, more conditions are needed to define the type Dog than the type Animal; therefore, there are fewer instances of dogs in the world than there are animals.

Just below Tautologies are four theories named Asymmetry, Transitivity, Reflexivity, and Symmetry. Each of them includes all tautologies; in addition, each one has a single new axiom for a single dyadic relation. The theory named PartialOrdering has two axioms, which it *inherits* from the theories of Asymmetry and Transitivity. The theory named Equivalence inherits the three axioms of Transitivity, Reflexivity, and Symmetry. PartialOrdering has two subtheories for Trees and Lattices, which have a common subtheory named LinearOrdering, which has subtheories for Integers and Sequences. The theory

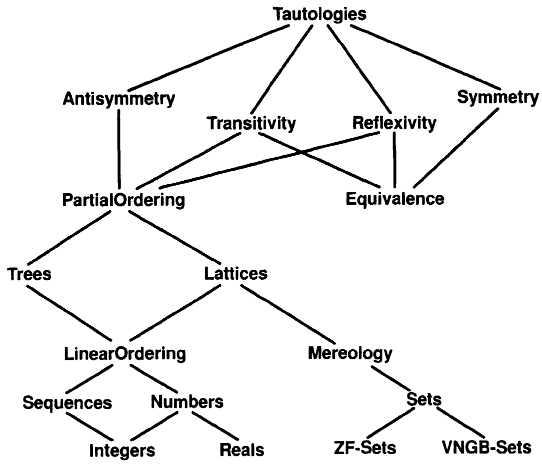

Figure 10. A generalization hierarchy of theories

of Lattices has a subtheory named Mereology, which is the theory of parts and wholes. Mereology, in turn, has a subtheory named Sets, which has subtheories named after the mathematicians who developed them, such as Zermelo Fraenkel (ZF set theory) and VonNeumannGödelBernays (VNGB set theory). The theory of Tautologies can also be called the *universal theory* because, like the empty set from which it is derived, it is true of everything.

Figure 10 is just a small extract from the infinite lattice of all possible theories. It shows a few of the more elegant theories that mathematicians like to study, but the infinite lattice contains enough theories to axiomatize all the computer programs that have ever been written or ever will be written by humans, robots, compilers, and AI systems. Besides the elegant theories, the lattice contains truly "ugly" theories for the poorly designed and undebugged programs that even their authors would disown. It contains theories for both Richard Montague's high-powered formalisms and Roger Schank's scruffy programs. Even though Schank argues against the use of logic and formalization, his programs still have an axiomatization somewhere in the infinite lattice. To complete the lattice, the type InconsistentTheory could be added at the bottom; it would inherit all axioms and be true of nothing.

Theories as forms, propositions, or intentions

In logic books, the word *theory* is used as a synonym for the *deductive closure* of a set of axioms. That term emphasizes the Firstness of a collection of formulas: it treats them as strings of symbols manipulated by rules that depend only on syntax, not on meaning. In empirical sciences, however, a theory has applications (Secondness) and explanatory power (Thirdness). Which aspect of theory is being considered determines how the hierarchy of theories in Figure 10 would be classified:

1. If the applications are ignored, Figure 10 would represent a hierarchy of deductive closures (Firstness). The formulas of each theory are abstract patterns that characterize some Form (A1); the word *formula*, in fact, is a Latin word meaning "little form". Theories of static structures are schemata, and theories of time or time-like sequences are scripts.

2. If the formulas of a theory are treated as summaries of observed data (Secondness), but without any consideration of their predictive or explanatory power (Thirdness), then the theory could be considered an instance of Proposition (A2). If the same theory is applied to many different physical entities, each application would be a separate instance of Proposition.

3. In the empirical sciences, a theory must be applicable to some domain (Secondness), and the deductive steps between the formulas must serve as an explanation (Thirdness) of the corresponding cause and effect relationships. As Thirdness, an explanation always involves an Intention (A3) or three-way relationship of the scientist, the theory, and the data. The same forms (A1) may be applied to different physical entities (P1). The differential equation for an oscillator, for example, may be applied to a radio circuit, a sound wave, or the springs in a car's suspension; each application would be a different Proposition (A2). For an application (Secondness) to provide an explanation (Thirdness), some agent must have an intention (A3) to use the formulas (A1) as an explanation of the physical phenomena (P1).

A theory, by itself, is pure form (A1). The classification of a theory by Firstness, Secondness, or Thirdness depends on the intentions of some human being who is applying it. This trichotomy is based on the same principles as the subdivision of the category Actuality (P1) as Thing, Role, and System.

Figure 11 shows how an abstract form (or a model in Tarski's sense) relates a theory to some aspect of the world. On the left is a collection of formulas, which serve as the axioms for some theory. In the middle is a graph structure, which represents for form (A1) of some mathematical model. On the right is a picture of the world, some aspect of which is characterized by the model. The relationship between the theory and the model is *denotation*: every axiom and theorem of the theory should have denotation true in terms of the model. Yet even at best, a model is only an approximation to the real world.

The value of an approximation depends on purpose: a model that is adequate for one purpose could be completely inappropriate for another. Various physical objects, for example, might be considered spherical, but with

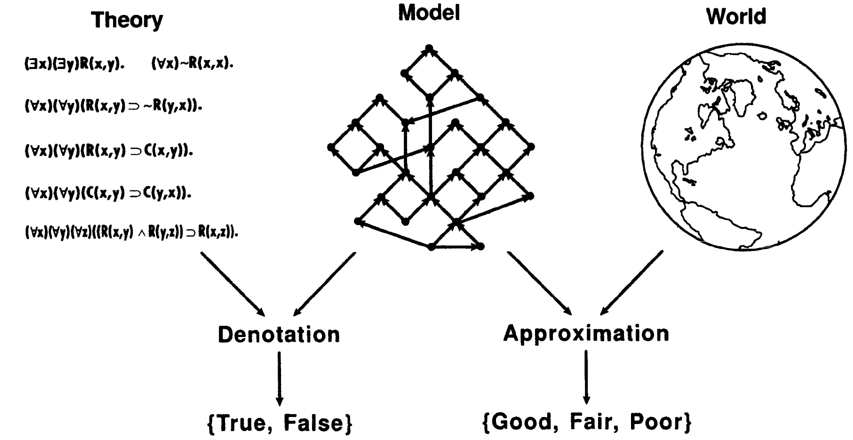

Figure 11. Relating a theory to a model of the world

different criteria of accuracy: slight imperfections are much more serious in a ball bearing than a meatball. For different purposes, a single object could be considered to have different shapes. A boulder might be treated as a sphere for computing its approximate speed in rolling down a mountain, but a stonemason might consider it block-like when building it into a wall. Denotation is the Secondness that evaluates the truth of a theory in terms of a model. With different models, the equations for a sphere could be true of the boulder, the meatball, and the ball bearing. Intention is the Thirdness that evaluates the usefulness of the model for the purpose of some agent. A stonemason, a chef, and a machinist have different purposes, hence different models and different criteria for what is considered spherical.

5. PHILOSOPHY, LINGUISTICS, AND WORLD KNOWLEDGE

The ontological categories discussed in this paper are based on philosophical distinctions. As a second source for categories, the vocabularies of natural languages contain thousands of words that people have found useful for referring to the things, events, and properties that arise in everyday life. As a third source, empirical classification in every branch of science, business, and politics supply a broad range of things that people talk about or, in Quine's sense, refer to with quantified variables. In developing his ontology, Aristotle made use of all three sources. He invented logic and metaphysics; he was a pioneer in analyzing the syntax and semantics of natural language; and he painstakingly studied, dissected, and classified the thousands of plants, animals, and artifacts brought back from the known (or conquered) world by his patron and former pupil, Alexander the Great. Although Aristotle'e empirical results are now obsolete, his methodology is still a paradigm of how ontology should be done: a systematic correlation of top-down reasoning with bottom-up empirical studies, reconciled with the forms of expression in logic and natural languages.

As theory and empirical evidence accumulate, new distinctions may be added, and old distinctions may be deleted. The combining rules can always generate a new hierarchy, but it might not have the full symmetry of Figure 3. What breaks the symmetry are the *constraints* that rule out certain combinations. Logical constraints are the strictest ones; they rule out provably impossible combinations such as the round square. Physical constraints, which can rule out logical possibilities such as flying horses or insects as big as elephants, depend on the current state of science. It is logically possible that new principles might be discovered that would allow combinations that are today considered unlikely or physically impossible. Other combinations, such as unicorns, are logically and physically possible, but the course of evolution has bypassed them. An ontology may include them for completeness: it should allow new branches to sprout for combinations that might be discovered on some distant planet, in some scientist's laboratory, or in some author's vivid imagination.

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JACEK JADACKI

ON FORMS OF OBJECTS

1. Thirty years ago in Cracow, Ingarden wrote: "I wish to make myself aware of certain difficulties encountered by the theory so that I can find the ways and means to overcome them".[1] The intentions of this paper are very similar. I am far from being a 'skeptische Hochmut' in approaching the problem of forms of objects in the work some scholars, recognizing it as a scholastic pseudo-problem, bereft of topical interest. But I must also admit I am unacquainted with the minimalistic humility according to which I should consider this problem as one of irresolvable mysteries of the world.

2. I state to begin with:

(1) For every x: x is an object iff for a certain P: Px.

Formula (1) is gaining increasing acceptance.[2] It is remarkable that reists, who also assume this formula, at the same time deny the thesis that, for example, properties belong to objects.[3] As Ajdukiewicz writes, the opponents of reism would appeal to the fact that we cannot predicate properties only upon things, whereas reists would deny this fact.

Can the controversy "be settled within ordinary language?"[4] Reists, at bottom, can only make use of the semantic postulate that an object is a body;[5] therefore (according to another postulate) it is something inert.

Let us consider the question more closely. Let us contrast, in particular, the following words from natural language: 'thing', 'event', 'change', 'state', 'property', 'relation', 'set', 'part'. These words do not have precise senses,[6] but I shall try to compare them within the bounds of their sharpness.

I would first point out that some of these words can be multiplied; natural languages allow us to talk about properties of properties, properties of properties of properties; about relations between relations; about sets of sets; about parts of parts, and so on. It is inadmissible, however, to talk about things of things, or about events of events. The question of the admissibility of talking about changes of changes, and about states of states, is rather vague. Let us agree that:

L. Albertazzi (ed.), Shapes of Forms, 341–359.

(2) For every x and y: x is a property of y iff y is the subject of x.

(3) For every x, y, and z: x is a relation between y and z iff y and z are members of x.

(4) For every x and y: x is a set containing y iff y is an element of x.

(5) For every x and y: x is a part of y iff y is a complex including x.

My first remark is that properties can be subjects of properties, relations can be members of relations, sets can be elements of sets, and parts can be complexes of parts. Secondly, multipliable terms can be linked together and they can also be added to the remaining terms. Let us call this phenomenon 'interpredicativity'. It is admissible to talk about properties of relations, sets, and parts, as well as about properties of changes and states, and about properties of things and events. We can talk about relations between properties, between relations, between sets, and between parts, as well as about relations between things and between events. It is admissible to talk about sets of properties, relations, and parts, as well as about sets of things, and events, and changes, and states. We can probably also talk about parts of properties, about parts of sets, about parts of things, and about parts of events, as well as of changes and states, but hardly about parts of relations.

The terms 'change' and 'state' can be also added to at least some of the remaining terms. Thus it is admissible to talk about changes in properties, relations, parts, and things, but hardly in sets and events; and it is more difficult to talk about states of properties and of relations. I doubt whether it is admissible to talk about states of sets, but we can certainly talk about states of parts.[7] Using the convention introduced above, as well as accepting the view that things, events, changes, states, properties, relations, sets, and parts are in any case objects, my second remark is that all objects can be subjects of properties, members of relations, and elements of sets; on the other hand, only some objects can be complexes of parts. Similarly, we cannot say about each object that it undergoes changes or that it is *in* a certain state (of affairs).

3. Do any ontic relations correspond to the above syntactic relations between terms? If so, the view is inescapable that we can distinguish two separate forms of objects: the form of things and events, on the one hand, and the form of properties, relations and sets on the other. Following Aristotle and from his standpoint, let us call[8] objects of the second form 'accidents' (or 'fortuities'). We now have:

(6) For every x: x is substantial iff it is not the case that for a certain y: x is an accident of y.

(7) For every x: x is accidental iff for a certain y: x is an accident of y.

The possibilities of multiplication and interpredicativity are not the only pecularities of accidents. All accidents are also reducible (contextually) one to another. Let us suppose that A is in relation S to B. If so, A has a certain property: the property of being in relation S to B. And if so, A belongs to a certain set: the set of objects having the property of belonging to this set. Then A, since it has the property of belonging to a certain set, is in a certain relation to B: the equality relation in respect of belonging to the set to which B also belongs. This reducibility also finds expression on logico-philosophical grounds in identifying properties and relations with respective sets. Is, consequently, the operation of distinguishing properties, relations, and sets among accidents a purely verbal operation?

Let us now consider the status of changes and states (of affairs). 'Change of x' means, in the first sense, the same as 'replacing' (in a certain time) one property of x with another one; it means, in the second sense, the same as 'replacing' alone. We use the word 'change' in this latter sense when we say, for example, that a movement (of any body) is a change of locality (of this body). Likewise 'state of x' denotes, in the first sense (let us call it 'the position sense'), keeping (in a certain time) a property of x; it denotes, in the second sense (let us call it 'the attributive sense'), keeping (in a certain sense) property of x – that is, something, in which, as Stonert says,[9] a given thing is present. Kotarbiński was probably aware of this polysemy when he identified states of affairs and changes (processes) either with the fact *that* things happen in such-and-such a way, and with the fact *that* they change in such-and-such a way,[10] or – correspondingly – with the manner *how* things happen and *how* they change.[11] Wolniewicz points out a certain bisemy in the expression 'state (of affairs)' which has its roots in the following amphibology: the idea here can be not only of a state of x (or a state in which x is present) but also of a state of x's (or a mutual configuration of many things),[12] that is, maintaining a certain relation between x's. He proposes paraphrasing the second sense with the aid of the phrase 'that there is so-and-so'.[13]

Every change is a certain 'position' state.[14] Whereas the latter is a certain event, an 'attributive' state is a certain property. Not every property, of course, is an (attributive) state; only a relatively unstable property is involved. Thus extratemporal properties (if such properties exist) do not constitute states. Ingarden also draws a distinction here, although he does so in a different way: "Zustand muss mehr oder weniger dürnd sein" but it must be something (in Ingarden: "der Gesamtbestand") that has been created "in dem Gegenstande durch einen Vorgang".[15] Similarly, not every event is a change; solely events able to happen only in a certain place come into play here, and thus extra-spatial events (if they exist) are not changes. Let us suppose that a meditative thin man is walking. We shall say, that the thinness is his *property*; but that he is in the *state* of meditation, and that he undergoes a certain *change* (here of locality). When something rots, we can say that it undergoes a certain *change* (i.e., rotting), that it is in a certain *state* (i.e., of rotting), and that it has a certain *property* (i.e., of rotting). When somebody is irritated, we can say that he is in a certain *state* (i.e., of irritation), that he has a certain *property* (i.e., of irritation or, better, of being irritated) but we cannot say that he undergoes a *change*. When something is green, we can say that it has a certain *property* (i.e., of green), but we cannot say that it undergoes a certain *change*, or that it is in a certain *state*. Moreover, when something rots, when somebody is irritated, or when something is green, we can say, that this object belongs to a certain *set* (i.e., of rotting, irritated, or green objects respectively). But when a certain object is a man, we do not say that this object *as such* undergoes a certain *change*, or that it (*as such*) is in a certain *state*, or that it (*as such*) has a certain *property*. Thus it is possible for the form of accidental objects (i.e., accidents) to be reduced to objects of one kind, say to sets.

4. I have ranked things and events among substances, and I should leave it at that.[16] But we may enquire as to whether the reduction outlined for accidents can be performed with substantial objects as well.

We may therefore ask whether things can be reduced to events, or vice versa. It seems that the pair part-comple*x* could be a mediator in both cases. Thus, correspondingly, the term 'thing' would mean the same as 'comple*x* of events' ("Verband von Sachverhalten"[17]) or 'part of an event', and the term 'event' would mean the same as 'complex of things' or 'part of thing'. Assuming that complexes of events, and parts of events, are events by themselves, and also that complexes of things, and parts of things, are also things, we may talk about only two ontic forms: events (or things), and sets (or properties, or relations).

It would be different if things were reduced to events (or vice versa) by means of the element set pair. Czeżowski mentions such a procedure. Things ("individuals enduring in time") are thus sets of events ("momental individuals"), and the latter, as "objects of higher logical order",[18] are not events.

To assess the admissibility of such a "clean-shaven picture of reality", as Russell described it,[19] we should make a prior choice as to the specific explication of the terms 'thing' and 'event', because they are far from being precise in natural languages. Arbitrary decisions are not permitted here. Some authors answer the question of what 'things' and 'events' are by indicating –not so much by ostension[20] as by exemplification with verbal aids – the required objects. However, these exemplifications, as well as the comments appended to them, are rather imprecise.

5. Let us consider *things*. Things are tables, stones, trees, houses, men. Socrates is certainly a thing, but what is this object 'Socrates'? Grzegorczyk proposes the following quasi-grammatical criterion: things are identical with "designates of the majority of nouns".[21] But this criterion is of no avail here; after all, grammarians generally answer the question 'what is noun?' by saying that it is the name (first of all) of things. Let us assume for the sake of simplicity that, for example, Socrate's birth is his 'going away from nothingness', and that his death is equivalent to his 'full annihilation' (this assumption is, of course, far

from correct). In every period of his life, Socrates has various properties, including various states and changes. Let us ignore the fact, again for the sake of simplicity, that he is also (willy-nilly) the member of various relations. Is Socrates (i) the 'residuum' that remains after separating these properties, or (ii) this 'residuum' with all these properties, or (iii) this 'residuum' only with these ('essential') properties, which are not states? The following counterintuitive consequence militates against version (i): all sentences which state something true about Socrates would be synthetic theses (after all, would such a 'naked' Socrates be an object at all?). Version (ii) has the equally counterintuitive consequence that all true sentences about Socrates would be analytical theses.

Events are generally identified with "a given occurrence of a phenomenon here: of a property *in specie* in a given object and at a given time",[22] or with "the fact that an individual located in a determinate place and time has [. . .] a certain property"[23] or, more generally, with the fact that a certain thing has a property (or that some relations occur between some things)[24]. Matters stand in this way according to Ajdukiewicz and Stonert. States of affairs (of the 'position' kind) and changes are – it will be remembered – only some types of such events. But according to Kotarbiński, who sometimes identifies events and states,[25] events are in principle either states (static events) or changes (kinetic events).[26] We read in Augustynek of identifying events and changes (processes).[27] According to Russell – who, after all, uses the term 'fact' – events "consist always of relations between parts of a whole or qualities of single things [. . .]. It is convenient to use the word 'fact' to express the analysed connection of the parts rather than the complex whole that they compose".[28] Some authors give grammatical criteria for eventness or factuality as well. Moore, for example, writes: "I am going [. . .] to use the name 'facts' simply and solely as a name for [. . .] the kind of things which we express by phrases beginning with 'that' ".[29] Wolniewicz distinguishes events (states of affairs) from facts, the latter being "existing states of affairs",[30] or rather "existence of states of affairs", that is, what is stated by a true sentence.[31] On the other hand, according to Ingarden, events are identical with "das Ins-Sein-Treten eines Sachverhalts"[32] and these states of affairs can be "handlungsmässigen" or "eigenschaftlichen".[33]

In these circumstances, many scholars give the technical sense of the word 'event', without looking at its current use in natural languages. For Wójcicki, for example, events are "momental sections of a thing",[34] whereas for Reichenbach, "individuals [. . .] are space-time coincidences and do not endure".[35] In Popper, an event is not "a complex, or perhaps a protracted, occurrence, whatever ordinary usage may suggest" but a class of occurrences. Thus, for example, the fact that a glass of water has just been upset – that is, a certain occurrence – belongs to the fact consisting in "upsetting of a glass of water" as to a certain event.[36]

I would add that processes (changes) are sometimes reduced to events[37] or to (momental) states of affairs[38] as sets (or complexes) of these events or states of affairs, partly ordered by the relation of anteriority.

6. Looking for objects to which all remaining ontic forms can be reduced is not the same as looking for basic (atomic) objects.

I assume:

(8) For every x: x is atomic iff it is not the case that for a certain y: $y = x$, and y is a part of x.

(9) For every x: x is molecular iff for a certain y: $y = x$, and y is a part of x.

The division of objects into atomic and molecular is probably feasible within the realm of substances, and certainly within the realm of accidents. Russell identifies molecular objects with facts. He writes: "facts [...] are whatever there is except what (if anything) is completely simple".[39] Rather unexpectedly, Wittgenstein calls objects 'things', thus fulfilling convention (8). Wolniewicz identifies Wittgensteinian things with material points, while also noting that the Wittgensteinian criterion "does not imply [...] individuality (concreteness) of his objects".[40]

It is worth stressing that if the search for individual (atomic) objects does not involve partitioning (isolating parts) but abstracting (isolating accidents), this imposes the condition of lack of accidents, of properties in particular, upon atomic objects, thereby giving rise to the paradoxical situation in which atomic objects – under (1) – are not objects at all.

7. I shall further distinguish between the division of objects into substantial and accidental, on the one hand, from the division of objects into autonomous and heteronomous on the other.

I assume:

(10) For every x: x is autonomous, iff it is not the case that if for a certain y: $y = x$, then for a certain z: $z \neq x$.

(11) For every x: x is heteronomous, iff if for a certain y: $y = x$, then for a certain z: $z \neq x$.

These formulae are explications of the phrases: 'primary existence', 'independent existence', 'existence in abstraction from anything', and respectively: 'existence in something',[41] 'existential dependence'.[42]

If things are complexes of events, then things are heteronomous objects. Are events therefore autonomous? Reichenbach claims that if things appear to be 'classes of events', then "for physics, events are more fundamental units than things".[43] Since Russell *conceives* "each event as occupying a finite amount of space-time and as overlapping with innumerable other events which occupy partially, but not wholly, the same region of space-time",[44] then, according to this *assumption*, no event is autonomous.

Similarly, if events are complexes of things, then events – and not things – are heteronomous objects. However, we should not jump to the conclusion that consequently only things are autonomous. On the contrary, everything goes to show that they are heteronomous as well.

8. I now assume:

(12) For every x and y: x is separated from y iff for a certain z: $z \neq x,y$, and z is between x and y.

(13) For every x and y: if x or y is subjected to suitable forces, then x is separable from y iff x (not being separated from y before the action of these forces) becomes separated from y.

(14) For every x: x is concrete, iff for a certain y: x is separable from y.

(15) For every x: x is abstract iff for every y: it is not the case that x is separable from y.

One needs, of course, to establish whether this separation of objects consists of either a spatial or a temporal separation, or in both (and one must also establish what is to be the level of magnitude), or in something else (the term 'separation' should be, in any case, understood in such a way that abstracting – that is, mentally isolating the properties in any object – is not denoted by the term). In the first three cases, abstract objects would be heteronomous as well; on the other hand, concreteness would exclude neither autonomy nor heteronomy.

9. The opposition concretes-abstracts is sometimes characterized not by means of separability but of separation. To prevent possible misunderstandings, I shall talk in these cases of isolated and connective objects. Thus we have:

(16) For every x: x is isolated iff for every y: if $y \neq x$, then x is separated from y.

(17) For every x: x is connective iff for a certain y: $y \neq x$, and it is not the case that x is separated from y.

All isolated objects are, of course, concretes, but some concretes may be connective. Likewise, all abstracts are connective, but some connective objects can be concretes.

Quine is against identifying concretes with objects that are "continuous in geometrical shape"; he points to the fact that, for example, "the territory of the United States including Alaska is discontinuous, but it is none the less a single concrete object; and so is a bedroom suite, or a scattered deck of cards".[45] Reichenbach goes further by saying that, according to the spirit of natural languages, "the furniture of a certain house is not an individual, but a class of individuals". Earlier he defines 'individual' as "something occupying a continuous and limited part of space and time" and therefore as something that we would determine as just an "isolated object".[46] Material concretes, constituting 'equipment' of the world, are characterized according to formula (16) by Czarnocka. Given a denotative definition of 'concretes',[47] she indicates bodies as well as waves and fields, since she views bodies as being "concentrated in a part of space, close – in general – nubbles of a matter, conformed in any manner, and having positive mass".[48] This would imply that the world, at least in spatial terms, has 'grainy' structure: these 'grains' (of various 'plies') – by storing phaso-complexes divorced from one another by portions of space(-time)[49] would be merely concretes. As Russell succinctly put it, the universe would be "all spots and jumps".[50]

10. I shall now distinguish the pair: concreteness-abstractness from the pair: intelligibility-incompatibility.

I assume:

(18) For every x: x is intelligible iff it is not the case that for a certain P: Px, and it is not the case that Px.

(19) For every x: x is incompatible iff for a certain P: Px, and it is not the case that Px.

If we impose no further restrictions on intelligible and incompatible objects, we cannot beforehand exclude that divisions of objects into intelligible and incompatible objects, on the one hand, and into concrete and abstract objects on the other, are logically independent.

11. The division of objects into concrete and abstract is frequently connected – or confused – with the divisions of objects into individual and universal, on the one hand, and into particular and general objects on the other. Kotarbiński claims that universals are kinds of abstracts,[51] whereas Augustynek simply *consciously defines* abstracts with universals[52] and then identifies the latter with sets.[53] Similarly, Quine identifies abstracts with universals, but in regarding sets to be universal objects, he does not identify the former with the latter.[54]

I assume:

(20) For every x: x is individual iff for a certain P: Px, and for every y: if Py, then $x = y$.

(21) For every x: x is universal iff for every P: if Px, then for a certain y: Py, and $x \neq y$.

The difference between individuals and universals is clearly set out by Metallmann:

If we describe two 'equal' buttons successively in two long strings of sentences [...] of such a kind that every sentence distinguishes suppose one property of the object, then sentences, different as to the contents, will always show up besides identical sentences among these series of sentences, on the condition of sufficiently long description. [...] Only universal objects can be mutually identical, i.e., such that whatsoever can be said about one of them, can be also predicated about any other ones.[55]

The distinction expressed by formulae (20) and (21) can be carried out on the ground of objects characterized in formula (15) as abstracts: these (properties, in particular) happen to be either individual or universal. When Ajdukiewicz refers to "a property which at a certain time be an attribute of this or that object, but can also not be its attribute at another time" as a "phenomenon". And when he contrasts these "general entities" with realized properties,[56] he is drawing the distinction between individual and universal abstracts mentioned above. We should bear in mind, however, that "by a 'phenomenon' we usually mean the same as by an 'event'"[57] or – in traditional terminology – something that is observable (see below). In any case, as Reichenbach points out, "sometimes events are important units also for the purposes of daily life".[58]

12. I assume:

(22) For every x: x is particular iff for every P: Px, or it is not the case that Px.

(23) For every x: x is general iff it is not the case that for every P: Px, or it is not the case that Px.

Formulae (22) and (23) are explications of the distinction between objects "which are indeterminate from any possible point of view" and objects either having "in their content [...] their own elements" or being "entirely indeterminate in their various directions", that is, possessing "points of indeterminateness". Ingarden calls the former "individual objects" and the latter "ideal"[59] or "(pure) intentional objects".[60] Formula (22) is not, of course, identical with Kotarbiński's assumption that "every object has either a certain property or its negation".[61] Formula (22) thus describes only particular objects. Metallmann writes:

The description of such an object with the aid of individual sentences, enumerating its properties one by one, is strictly speaking never exhaustive [...]. Thus, in everyday life, as well as in scientific practice, the description of an object is always executable, because [...] we break it off at the moment that appears advisable for us. But during the evolution of science [...] the number of possible aspects of the 'very' object is, in principle it appears, unlimited.[62]

Metallmann calls such an object 'concrete' and not 'particular'. In contrast to the description of *particularia*, the description of *generalia* "can be performed by means of the finite and, in general, small number of properties and relations.[63] According to Wolniewicz, precisely this opposition is hidden beneath the terms 'concrete' and 'abstract' in the Hegelian tradition.[64]

It is rather surprising that things – as objects with these properties only, which are not states (and with the omission of the relations in which these objects enter) – are general (as well as heteronomous and, probably, abstract) objects.

Note that under assumption (23) we have:

(24) It is not the case that for every *P*: *Px*, or it is not the case that *Px* iff for a certain *P*: it is not the case that (*Px*, or it is not the case, that *Px*) iff for a certain *P*: it is not the case that *Px*, and it is not the case that it is not the case that *Px*.

Now, there are two possibilities. If we adopt the principle of non-contradiction (in a certain form):

(25) It is not the case that it is not the case that *p*, iff *p*,

then we obtain:

(26) For a certain *P*: it is not the case that *Px*, and it is not the case that it is not the case that *Px* iff for a certain *P*: *Px*, and it is not the case that *Px*.

Thus generality is identified with incompatibility. This is *inter alia* the standpoint of Kotarbiński (who previously identifies *generalia* with *universalia*).[65] On the other hand, if the principle of non-contradiction of the form (25) is not accepted, then the difference between generality and incompatibility will consist in the fact that the former is ascribed to objects, so that a certain property is neither possessed nor non-possessed, whereas the latter is ascribed to objects, so that this property is possessed as well as non-possessed. Ingarden states that "das Prinzip der ausgeschlossenen Dritten und das Prinzip des Widerspruchs, in ontologischer Deutung ihre Geltung bezüglich der *Ideengehalte* verlieren",[66] and thus are characteristic of ideal objects.

However, apart from the interpretation, *generalia* – in the light of formula (23) – cannot be identified with sets (in the sense of set-theory); what is more, it seems that no set is a general object. Formula (22), of course, does not exclude that some *particularia* are intelligible, whereas the others are incompatible.

13. Two other distinctions interfere, generally speaking, with the distinctions discussed above: the division of objects into material and general, and the division of them into real and non-real.

I assume:

(27) For every x: x is material iff for a certain y: y is a place-moment, and x is at y.

(28) For every x: x is ideal iff it is not the case that for a certain y: y is a place-moment, and x is at y.

Kotarbiński initially grants that 'material' means the same as "extensive *and* inert at the same time".[67] However, he provides neither examples of objects which are extensive but not inert, nor examples of objects which are inert but not extensive. He then identifies materiality with temporality, spatiality (extension in breadth, length and depth) and resistance.[68] In the end, "everything which is temporal and spatial and physically defined – for instance, physically influencing something else" is material.[69] On the other hand, Moore understands by 'material object' something that "is situated somewhere or other in space",[70] thus ignoring its temporal localization and also whatever is not "a mind, nor an act of consciousness".[71]

How have concreteness and materiality an affinity for each other? If the introductory condition of the formula (13) concerns a certain material operation, then concretes, as well as abstracts, will be material objects. We can hardly talk about the separation of ideal objects one from the other, since they are *ex definitione* out of space-time. But if (particular) concretes are expected to be simply separated one from another, and (particular) abstracts are expected to be unseparated one from another by a certain portion of space-time, then we cannot exclude that some material objects will be concrete, that some of them will be abstract, and that all ideal objects will be abstract. As Quine notes, "having a bit of imagination [...] we can extend the notion of physical [here: material] objects [...] over physical processes, and events, dealing with them in common with bodies".[72] According to Wolniewicz, every event is a material object; in any case, it is "always localized in time". "On the other hand, the contents of the word 'event' do not imply [...] definitely *existence* [here: objectivity; see below]".[73]

Formulae (18) and (27) show that we should not follow the widespread practice[74] of definitionally identifying intelligibility and materiality. On the other hand, these formulae do not exclude that *de facto* the class of real objects is identical with the class of material objects. The definitional reduction of reality to materiality (or vice versa) should, of course, be distinguished from the identification of reality – or physicality – with possession of spatio-temporal localization using the respective meaning-postulate, as done (for reality) by Carnap, Ajdukiewicz and Strawson,[75] and (for physicality) by Quine.[76]

The question arises as to whether the so-called 'universe' fulfils the condition indicated by formula (27). Augustynek claims that it does not fulfil it, saying that "in relation to the world as a whole, there is no sense to talk about spatio-temporal localization; what is the temporally and spatially external object which would be the fiducial point of localization of the world?"[77] Thus, if the possibility of referring to something external is the "immanent property of localization", then the formula (27) should read:

(29) For a certain y: y is a place-moment, and x is at y – or for a certain z: z is a part of x, and z is at y.

14. I assume:

(30) For every x: x is real iff for a certain y: $y \neq x$, and x acts upon y.

(31) For every x: x is non-real iff for every y: if $y \neq x$, then it is not the case that x acts upon y.

Augustynek appeals to (physical) action when he characterizes material objects. His definition runs as follows:

(32) For every x: x is material iff for a certain y: $y \neq x$, and x acts upon y – or for a certain y and a certain z: $y,z \neq x$; y, z are parts of x, and y acts upon z.[78]

In Ingarden, the condition of reality is causal action;[79] a condition which is entailed by determination:

(33) For every x: x is determined iff for every y: $y \neq x$ and x is causally conditioned by y.

(34) For every x: x is a-causal iff for every y, if $y \neq x$, then it is not the case that x is causally conditioned by y.

Independently of whether we define 'reality' by 'determination', it seems that the following difficulty arises. If we agree that the range of variable y is the set of real (as opposed to determined) objects, then we must also use the above formula to decide whether, in a given case, we are dealing with any object at all. Thus using this formula implies a *regressus ad infinitum*.

Somehow or other, the division of objects into concrete and abstract, and the division of them into real and irreal, are mutually independent on the ground of such an approach.

15. The pair 'concretes–abstracts' is sometimes compared not only with ontic terms, but also with epistemic ones: first of all with the pair 'observable–noumenal'.

I assume:

(35) For every x: x is observable iff for a certain y: y is a place-moment

and for every z, if z cognitively intends towards y, then z recognizes x.

(36) For every x: x is noumenal iff for every y and z: if y is a place-moment and z cognitively intends toward y, then it is not the case that z recognizes x.

Nothing, of course, can be forejudged about the relation of observability and concreteness before we have specified what is the type of cognitive act mentioned in formulae (35) and (36). For this purpose we can write, for example:

(37) For every x and z: z recognizes x iff x acts upon the receptors of z, and z realizes that x acts upon the receptors of z.

It would be necessary to impose upon z the condition of normality (not yielding to delusions) and, probably, credibility (veracity). What is to be our foundation when we admit of the given epistemic operation, or when we reject the others?

Let us suppose that this problem is decided in such a way that observation is limited to extraspection and introspection. If we now assume that we are entitled to talk responsibly only about objects that are observable (in such a way), then for the time being we shall have no grounds for admitting the view that some material objects are simultaneously incompatible. Nor could we responsibly decide, respectively, about the concreteness and intelligibility of ideal objects as simultaneously noumenal ones.

16. I assume:

(38) For every x and z: x is observable for z iff for a certain y: y is a place-moment, and if z cognitively intends towards z, then z recognizes x.

We may now characterize the pair intercognitivity and monocognitivity (or in z: intersubjectivity and monosubjectivity).[80]

(39) For every x: x is intercognitive iff for every y: x is observable for y.

(40) For every x: x is monocognitive iff for every y and z: if x is observable for y, and x is observable for z, then $y = z$.

Formula (40) is usually enriched by the condition that x should stand in a determined relation to y ($= z$). Ajdukiewicz expresses this condition by stating that "psychical phenomena can be perceived only by one person, namely the person experiencing these phenomena". He calls this property "intrasubjectivity".[81] However, only mental objects are monosubjective, and one should distinguish between the monosubjectivity (here: monocognitivity) of these phenomena and their mentality.

I assume:

(41) For every x: x is extra-mental iff it is not the case that if for a certain y: $x = y$, then for a certain z: z consciously experiences x.

(42) For every x: x is mental iff if for a certain y: $x = y$, then for a certain z: z consciously experiences x.

Ajdukiewicz recognizes conscious experiencing (the contents of consciousness) as only *one* of characteristic properties of mental objects.[82] His understanding of 'objectivity' (here: 'extramentality') can also be interpreted as follows:

(43) For every x: x is extramental iff it is not the case that for a certain y: y consciously experiences x.

Ajdukiewicz thus states that phenomena are objective (here: extramental) iff "they are never contents of consciousness and they can exist independently of the consciousness of anybody".[83]

If we agree that only experiences are given in introspection, then mental objects – according to formula (42) – are abstracts. The hypothesis that there are also mental concretes (for example, 'minds') is much more doubtful than the hypothesis that some objects are mental concretes.

17. The need (and the possibility) of distinguishing between empiricism and fiction arises here.

I assume:

(44) For every x: x is empirical iff for a certain y: y is observable and x acts upon y.

(45) For every x: x is fictitious iff it is not the case that for a certain y: y is observable, and x acts upon y.

Formula (42) is sometimes given as explication of the term 'reality'.[84] Assumption (44) is not the formal obstacle – after specifying what an action is – against assuming that empirical objects contain not only some observable objects but also some noumenal objects (namely the *designata* of theoretical terms). After all, we can impose upon empirical objects the condition of being in the part-complex/whole relation to them, instead of the condition of acting upon observable objects.

18. I assume:

(46) For every *x*: *x* is objective iff for a certain *P*, exactly one possibility is realized: either *Px*, or for a certain *y*: *y* thinks that *Px*.

(47) For every *x*: *x* is subjective iff for every *P*: *Px* iff for a certain *y*: *y* thinks that *Px*.

One can subject formulae (46) and (47) to 'de-psychologization' (only partial) and express them as follows:

(48) For every *x*: *x* is objective iff for every *P*, exactly one possibility is realized: *Px*, or for a certain *y*: *y* describes the fact that *Px*.

(49) For every *x*: *x* is subjective, iff for every *P*: *Px*, iff for a certain *y*: *y* describes that *Px*.

Here the *y*-s are not only people but also sentences, and definitions in particular.

Formulae (46) and (48) will probably be more intuitive if the right-hand argument of the equivalence is stated in the following manner:

(50) For a certain *P*: *Px*, and it is not the case that for a certain *y*: *y* thinks (resp. describes the fact) that *Px*; or it is not the case that *Px*, and for a certain *y*: *y* thinks (resp. describes the fact) that *px*.

Note the intention of this formula: namely to state that something "exists *objectively* i.e., independently of a given cognitive subject"[85] or that its "existence is not necessarily conditioned by a thought".[86]

Subjectivity is matched, of course, by heteronomy, but they are not identical, which is hardly suggested by those scholars who "regard matter as self-subsistent".[87] Moreover, one should remember that instead of objectivity and subjectivity, frequent mention is made of reality and ideality[88] or of reality and fiction.[89]

Let us call all objective objects simply 'objects', and all subjective objects 'quasi-objects'. Two distinctions – between concreteness-abstractness and extramentality-mentality – seem to be made, strictly speaking, only among objects: quasi-objects are at most quasi-concrete or quasi-abstract, and quasi-extramental or quasi-mental. Secondly, only objects can be observable or material, although some of them are probably noumenal or ideal. Thirdly, all objects are empirical or individual. Fourthly, all quasi-objects are noumenal or ideal. Thus we cannot claim that the differences between observability and noumenality are not "ontologically essential".[90] On the other hand, it is true that ontological forms are not identical with epistemological forms. "Objects perceived in different ways need not belong to different ontological categories".[91] Fifthly, only quasi-objects can be fictitious or universal, though some of them are probably empirical or individual. Thus, since only (individual or universal) fictions are incompatible, only quasi-objects possess the property of incompatibility.

19. It only remains to consider the question whether concretes and abstracts exist, or more generally whether the objects distinguished in formulae (1)–(50) exist.

I am dubious of the view that existence is not a property, since it is not backed by adequate arguments. An answer to the question 'which objects exist?' should be preceded by an answer to the question 'which intuitions ought to be preserved?'. It seems to me that the following statement comes closest to the intuitions of common sense:

(51) For every x: x exists iff x is objective.

Existence would not be a property only if it had to be something identifiable with no property from among properties characterized in this paper. But then the question of what exists would be *questionae gustuum* and not *questionae fact*.

20. The problem of ontological forms puts us to a great deal of trouble not so much because scholars differ on accepted solutions as because we do not exactly know what these differences consist of.[92]

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NOTES

[1] Ingarden 1964, 97.
[2] Kotarbiński 1931,70; Augustynek 1984, 3.
[3] Kotarbiński 1931, 73; 1930–1931, 200.
[4] Ajdukiewicz 1934a,107
[5] Kotarbiński 1929, 55.
[6] Even serious philosophical texts inexactly talk about 'properties', 'relations', 'dispositions', 'events', etc., or about 'properties', 'relations', 'states', 'processes', etc. See, e.g., Kotarbiński 1931, 74; Ajdukiewicz 1948, 69.
[7] Augustynek discusses this possibility: see Augustynek 1975, 131.
[8] Kotarbiński 1929, 40.
[9] Stonert 1964a, 169.
[10] Kotarbiński 1954, 395.
[11] Kotarbiński 1935, 118–19.
[12] Wolniewicz 1968, 95.
[13] Wolniewicz 1968, 319.

[14] Stonert 1964a, 169.
[15] Ingarden 1947, 224.
[16] Strawson 1959, 15. In truth, one talks here about things and events as concretes.
[17] Ingarden 1948, 284.
[18] Czeżowski 1951, 162.
[19] Russell 1959, 66.
[20] Augustynek 1984, 4.
[21] Grzegorczyk 1959, 10.
[22] Ajdukiewicz 1965, 163.
[23] Ajdukiewicz 1934b, 90.
[24] Stonert 1964b, 53.
[25] Kotarbiński 1954, 396.
[26] Kotarbiński 1929, 51.
[27] Augustynek 1975, 95.
[28] Russell 1959, 151.
[29] Moore 1953, 298.
[30] Wolniewicz 1968, 122–3.
[31] Wolniewicz 1968, 97.
[32] Ingarden 1947, 216.
[33] Ingarden 1948, 315.
[34] Wójcicki 1972, 21.
[35] Reichenbach 1947, 267.
[36] Popper 1934, 89.
[37] Augustynek 1975, 73.
[38] Quine 1950, 67.
[39] Russell 1959, 151.
[40] Wolniewicz 1968, 78.
[41] Ajdukiewicz 1949, 78, 84.
[42] Augustynek 1975, 133.
[43] Reichenbach 1947, 267.
[44] Russell 1959,20.
[45] Quine 1950, 69.
[46] Reichenbach 1947, 266.
[47] In truth, Czarnocka talks about physical individuals (as well as about empirical or real individuals), but we can interpret her statements as concerning concretes alone, since she contrasts these physical individuals with properties, processes and events.
[48] Czarnocka 1986, 14.
[49] We should probably agree with Kotarbiński that 'empty fragments of space' cannot be concretes: see Kotarbiński 1935, 118.
[50] Russell 1931, 98.
[51] Kotarbiński 1954, 359.
[52] Augustynek 1975, 64.
[53] Augustynek 1984.
[54] Quine 1937–1950, 114–15, 128.
[55] Metallmann 1939,24, 27.
[56] Ajdukiewicz 1965, 163.
[57] Kotarbiński 1929, 79.
[58] Reichenbach 1947, 267.
[59] Ingarden 1947, 40–41.
[60] Ingarden 1948.1, 219.
[61] Kotarbiński 1949, 422.
[62] Metallmann 1939, 24.
[63] Metallmann 1939, 27.
[64] Wolniewicz 1968, 202.
[65] Kotarbiński 1920,14.
[66] Ingarden 1948.1, 242
[67] Kotarbiński 1931, 71.
[68] Kotarbiński 1935, 118.
[69] Kotarbiński 1949, 426; cf. also Augustynek 1984, 5.

[70] Moore 1953, 128.
[71] Moore 1953, 131.
[72] Quine 1977, 81.
[73] Wolniewicz 1968, 58 ff.
[74] See, e.g., Augustynek 1975, 135.
[75] Carnap 1935,21; Ajdukiewicz 1949, 79; Strawson 1959, 29–30.
[76] Quine 1977, 81.
[77] Augustynek 1984, 5.
[78] Ibid.
[79] Ingarden 1947, 109–10.
[80] Ingarden 1948, 2, 4.
[81] Ajdukiewicz 1938, 157 ff.
[82] Ajdukiewicz 1938, 158.
[83] Ibid.
[84] Moore 1953, 229.
[85] Augustynek 1975, 18.
[86] Ajdukiewicz 1923, 99.
[87] Russell 1959, 51.
[88] Kotarbiński 1929, 401; Ajdukiewicz 1949, 79.
[89] Moore 1953, 211.
[90] Czarnocka 1986, 119, 121.
[91] Czarnocka 1986, 124.
[92] For detailed discussion of these problems see Augustynek, Jadacki 1993.

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