NEW PERSPECTIVES IN COGNITIVE PSYCHOLOGY

THE ACT OF REMEMBERING

TOWARD AN UNDERSTANDING OF HOW WE RECALL THE PAST

EDITED BY JOHN H. MACE

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The Act of Remembering

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Preface

This volume represents the first occasion when a group of memory researchers have come together for the single purpose of addressing the problem of remembering the past, or in other words, autobiographical memory retrieval. The chapters contained herein examine involuntary and voluntary retrieval, the functions and development of autobiographical remembering, inhibitory process in autobiographical remembering, and abnormal recall processes, particularly those found in certain clinical syndromes, such as PTSD. Each chapter looks at a particular aspect of the problem of remembering, with some offering entirely novel views, and some introducing or advancing approaches for autobiographical remembering that have been successfully applied in other research domains. Regardless of the focus, the central aim of the volume is to move the science of remembering forward.

John H. Mace

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Part I

Introduction

1

The Act of Remembering the Past

An Overview

John H. Mace

One could argue that the quest to understand remembering (autobiographical memory retrieval) is central to the quest to understand autobiographical memory. One could also argue that understanding the processes of autobiographical recall might also be important to an understanding of more general cognition. For example, it is fairly easy to see how constructing a thought or solving a problem may involve many of the same mental (and perhaps neural) operations as reconstructing a past experience. While the importance of retrieval to memory and cognition has been noted by numerous other writers (too numerous to list), autobiographical memory retrieval may have a greater place in this larger aspect of the quest, given the complexity of information that has to be assembled in order to experience a memory of the past, including the knowledge, awareness, or feeling that one is "re-experiencing" a past event (Tulving, 1985).

The chapters contained in this book advance the quest to understand remembering, as they tackle many of the problems that face the science of remembering. In this first chapter, I briefly review the concept of autobiographical memory and, as this is the first chapter of a collective of works, I devote most of it to highlighting many of the major questions raised by the various authors.

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Autobiographical Memory in Brief

Although the recognition of autobiographical memory (in one form or another) has a long scholarly history in psychology and philosophy (see an excellent history in Brewer, 1986), the formal study of it is relatively recent, growing out of Tulving's (1972) introduction of the episodic/semantic memory distinction, and Neisser's (1978) plea to memory researchers to take up the study of ecologically valid forms of memory (or real-world memory phenomena). Although the terms episodic memory and autobiographical memory are often used synonymously, autobiographical memory takes in a wider range of personal knowledge forms than was originally conceived in the early views of episodic memory.

For example, autobiographical memories encompass discrete forms of abstract knowledge about the self (e.g., "knowing that I lived in Philadelphia growing up"), general or summary (i.e., repeated events) forms of personal knowledge (e.g., "my trip to London in 2005," "Sunday walks in Central Park"), and, of course, memories for discrete, specific experiences (e.g., "seeing the mummies at the British Museum during my London trip," a quintessential episodic memory; see early treatments in Barsalou, 1988; Brewer, 1986). Conway (1996, 2006) has proposed that these different forms of personal knowledge are organized in a networked fashion in a memory system that he calls the *self memory system*. In the self memory system, different forms of autobiographical knowledge are layered hierarchically, such that the most abstract forms of knowledge are at the top layer (i.e., *themes* and *lifetime periods*, such as the knowledge that one grew up in Philadelphia), with the layers of knowledge becoming relatively less abstract (or increasingly more sensory/perceptual in detail) as one moves down the hierarchy, from general forms of memories (i.e., *general events*, such as the trip to London) to specific memories (i.e., *episodic memories*, see Figure 4.1 in Conway & Loveday, chapter 4, this volume, and also discussions on theories of an additional transient episodic memory system in Conway, 2005; chapter 4, this volume; and Bluck, Alea, & Demiray, chapter 12, this volume). Whether one agrees with Conway's view or not, it seems clear that autobiographical memory takes in a number of different personal knowledge forms.

Overview of Book

In chapter 2, Ball rounds off the introductory section of this book by providing us with a comprehensive review of the various methods used to study autobiographical memory and retrieval. His review starts off with the era of Ebbinghaus, traces developments of the twentieth century, and finally culminates with the most recent developments, including methods as diverse as qualitative diary protocols and the latest imaging techniques (e.g., fMRI). The remaining chapters are separated into three main sections. I review each of these in turn.

Involuntary and voluntary remembering

The second section of this book is devoted entirely to a major subtheme which runs throughout the entire volume: involuntary remembering (spontaneous recollection of the past) and voluntary remembering (deliberate recollection of the past). Clearly an important question for any theory of retrieval to tackle, the chapters in this section exemplify the more elaborate set of questions that the involuntary/voluntary distinction in autobiographical memory has created. The treatments range from the problems of categorization (in both forms of recall), the generative retrieval model of voluntary recall, dissociations between involuntary and voluntary remembering, the larger role of consciousness in the control of retrieval, to models of involuntary and voluntary recall which derive their inspiration from more traditional laboratory approaches examining the implicit/explicit memory distinction.

In chapter 3, Mace grapples with phenomenological categorization, claiming that three categories of involuntary remembering exist (Mace, 2007b). As he argues, the three divisions of involuntary remembering might be caused by different sets of encoding or retrieval circumstances (e.g., occurring only after a traumatic experience, in one, or owing to different types of spreading activation processes in the others). However, the main thrust of the chapter is a comparison of involuntary remembering to voluntary remembering. Here, the phenomenological characteristics of involuntary and voluntary memories are compared, but mostly the focus is on similarities and differences in involuntary and voluntary retrieval. The chapter concludes with an examination of the main contrast, the involuntary/voluntary distinction, with Mace offering another categorization schema, one which places remembering phenomena along different points of a voluntary-involuntary continuum that deemphasizes or limits the role of volition. This aspect of the chapter challenges the idea that voluntary remembering can be treated as a monolithic form of recall and it also deals with the dicey concept of volition.

In chapter 4, Conway and Loveday review the generative model of voluntary recall (e.g., Conway, 2005). In their review of the model, they, too, appear to argue for a diminution of the role of volition in voluntary recall, arguing that many parts of the process are likely to be involuntary. And, while their chapter reviews the generative retrieval model, it also adds some important case data to the discussion (i.e., the case of patient CR). CR is a middle-aged woman with significant and widespread damage to the right side of her brain. While she shows many of the obvious memory disorders of an anterograde amnesic (i.e., an inability to recall the past after short periods of time), unlike most amnesics this appears to be limited to voluntary recall. So, upon questioning or self-prompting, she is unable to generate a memory of the past; however, when given very explicit cues (e.g., pictures of a past event), she is able to remember, much in the same way that one spontaneously recalls the past. Conway and Loveday use this case to make a convincing argument that CR has intact involuntary recall processes while having impaired voluntary recall processes. This is an important observation because CR's syndrome (1) supports the notion of generative retrieval; (2) supports the notion that voluntary remembering contains separate voluntary and involuntary components; and (3) strengthens the involuntary/voluntary distinction, while at the same time helping to delineate certain processes within this schema.

Talarico and Mace (chapter 5) review an interesting set of problems arising from the data produced by involuntary and voluntary memory sequencing phenomena, event cuing (a laboratory-based procedure where subjects deliberately recall memories in a sequence) and involuntary memory chaining (a naturally occurring phenomenon where involuntary memories are produced in a sequence, one of the three proposed categories of involuntary remembering). In brief, these two recall processes produce two somewhat different sets of data, each having different implications for the organization of memories in the autobiographical memory system. Talarico and Mace explore the possibility that the difference occurs as a result of biases in the laboratory procedure, thereby making the involuntary memory phenomenon the more reliable indicator. They also explore the possibility that the different patterns of results may instead be an indicator of some real differences underlying involuntary and voluntary retrieval, ones which may further our understanding of these processes.

Franklin and Baars (chapter 6) argue that spontaneous (involuntary) remembering in everyday life is a normal (functional) part of everyday cognition. Like the stream of consciousness and other forms of spontaneous cognition, they argue that rather than being merely accidental, that everyday involuntary memories play an important functional role in orientating one towards the future, solving problems, and so forth (a view which is consistent with directions being taken in involuntary memory research, e.g., Berntsen & Jacobson, 2008; Mace & Atkinson, 2009). However, their main message concerns the relationship between spontaneous memories and consciousness. Using a central tenet of Baars' (1988) global workspace theory (GWT) of conscious, the C-U-C triad, they explain how spontaneous memories (and other spontaneous processes, e.g., spontaneous problem solving) can emerge from a memory system and how this may be further explained with a computational model that has been built on GWT (LIDA-GWT).

Richardson-Klavehn's contribution (chapter 7) does not address autobiographical memory retrieval per se, it, instead, addresses retrieval on word-list memory tasks (namely the word-stem completion task). Among the topics addressed are explicit (conscious or episodic) memory retrieval and implicit (unconscious or non-episodic) memory retrieval. Within this broader context, he delineates involuntary and voluntary retrieval processes, pointing out some of the problems surrounding the use of these terms in the word-list memory arena. One problem that has arisen in that arena is the tendency for some approaches to conflate retrieval processes (involuntary and voluntary) with memory types (explicit and implicit). Richardson-Klavehn points out how such approaches have been unable to accommodate the involuntary/voluntary distinction in conscious memory, defining the concept of involuntary conscious memory (or spontaneous recollection) out of existence. Addressing the heart of this problem, Richardson-Klavehn introduces a novel retrieval architecture which can account for all variety and complexities of retrieval on word-stem tasks. This model could be important to autobiographical memory researchers, as in many ways they are facing similar problems in attempting to explain varied and complex forms of autobiographical memory retrieval. Thus in whole or in part, Richardson-Klavehn's approach to the problem of retrieval may prove useful to the science of autobiographical remembering.

Broader theoretical considerations of autobiographical remembering

Apart from the more central focus on involuntary and voluntary recall in the first main section, the second main section includes chapters which focus on broader aspects of remembering, though involuntary and voluntary remembering are also considered in some of these chapters, in some cases centrally. The topics include using the perennial notion of spreading activation to understand autobiographical remembering, understanding the important role that retrieval inhibition plays in autobiographical remembering, the importance of visual imagery, and the difficult to track but highly important questions of development and functions, respectively, of remembering.

Mace (chapter 8) examines autobiographical remembering from a spreading activation perspective. Building on a handful of different studies, he argues that the autobiographical memory system appears to be subject to different types of within and between memory systems forms of spreading activation. And, while some spreading activation processes may occur unconsciously, he also argues that some can be observed to occur in the space of consciousness (e.g., the involuntary memory chaining mentioned above). He also argues that spreading activation may account for much of everyday involuntary remembering, including involuntary remembering during voluntary remembering. And, like in semantic memory, spreading activation in the autobiographical memory system appears to subject autobiographical remembering to priming effects. He further argues that all of these processes are likely to be functional to the process of autobiographical remembering.

Pastötter and Bäuml (chapter 9) examine retrieval inhibition in autobiographical remembering. They review a fairly extensive literature on retrieval inhibition, and while most of the findings there have been generated from word-list memory paradigms, they perform the important task of drawing inferences from them with the purpose of connecting them to inhibition in autobiographical memory recall. They, too, cover voluntary and involuntary recall processes, noting, for example, that similar distinctions appear to exist in the inhibition of retrieval as it appears that memory production can be inhibited either involuntarily or voluntarily. Apart from some of the main issues surrounding the study of retrieval inhibition (e.g., the manner in which it may be carried out), their chapter also reminds us of the importance of inhibition to the understanding of autobiographical remembering and other forms of retrieval. For example, involuntary inhibition may be at work when one is trying to recall a past experience, if for no other reason than to keep irrelevent information from coming to mind. And, in some sense, inhibitory processes may be "on" and "filtering" all the time, otherwise one may be constantly bombarded by memories in everyday life (Conway & Pleydell-Pearce, 2000).

Rice (chapter 10) reviews the role of memory perspective (i.e., field, one's original viewpoint, or observer, a third-party viewpoint) and imagery in autobiographical memory retrieval. One of the important questions that she addresses is how visual imagery, most particularly perspective-based imagery, may be a determinative factor in the autobiographical memory retrieval process. Whether visual imagery or perspective per se have a causal role or not, her review reminds us of the complexity of information contained in an autobiographical memory, and the potential complexity of the retrieval processes that need to construct and bring this information to mind. Apart from this main issue, Rice also reviews how abnormal remembering in clinical syndromes (e.g., PTSD or social phobia) appears to distort visual perspective, as individuals with certain disorders tend to recall memories surrounding their condition from a third-party viewpoint.

Fivush and Bauer (chapter 11) take on the yeoman's task of tracking and explaining the development of autobiographical remembering early in the life cycle. Among other considerations, they examine neural development, as well as the role of the social and cultural factors in the development of autobiographical remembering skills. Pointing out that the development of autobiographical remembering does not terminate in childhood, they also remind us that there are other important changes taking place along the path of the lifespan (e.g., adolescence and middle age).

While three other chapters in this volume in part examine the functional considerations of remembering (chapters 3, 6, & 8, but mainly with respect to involuntary remembering), Bluck, Alea, and Demiray (chapter 12) devote their entire chapter to this cause. Looking at the problem more globally, they examine autobiographical remembering within the context of its three hypothesized functions (i.e., directive, self, and social functions; Baddeley, 1988). A central focus of their chapter is an examination of how the self memory system's (SMS, e.g., Conway, 2005) views on retrieval handle the question of function. Their take home message is that the SMS needs to do more – in particular, focus on person-environment interactions, which they view as key. While they offer this advice primarily to the SMS view, it should be noted that other approaches (present and future) may want to consider their advice.

Abnormal remembering

The last main section contains three chapters which address remembering (mostly involuntary forms) in clinical syndromes. The question of involuntary remembering in clinical syndromes (e.g., post-traumatic stress disorder) has a relatively longer history there than it has in the study of everyday normal remembering. Research in this area has developed in many ways: it has helped us to better understand the syndromes and the nature of abnormal remembering, and it has helped to inform understanding of normal remembering. The authors in this section show us how this area of inquiry continues to branch in several ways (e.g., bringing working memory into the discussion, and extending the question of abnormal involuntary remembering to depression).

Krans, Woud, Näring, Becker, and Holmes (chapter 13) review involuntary traumatic remembering in PTSD, including a comprehensive review of the different theoretical accounts of this type of remembering. Their review features a promising new information processing account recently put forward by Holmes and Bourne (2008), which argues that differential encoding (a focus more on perceptual rather than conceptual features) during the time of a traumatic event may be responsible for the development of traumatic involuntary memories. Verwoerd and Wessel (chapter 14) add another dimension to the discussion by focusing on the role of executive control (or working memory) in the production of traumatic memories in PTSD. They argue that a subset of trauma survivors develop traumatic intrusive memories because they had pre-morbid deficiencies in executive control. Williams and Moulds (chapter 15) look at involuntary remembering in depression. Their chapter reviews more recent observations that negative intrusive memories form a common part of the depressive syndrome, and that these memories share features in common with the traumatic memories of PTSD.

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2

From Diaries to Brain Scans

Methodological Developments in the Investigation of Autobiographical Memory

Christopher T. Ball

Hermann Ebbinghaus embarked on the first experimental analysis of human memory during the late 1800s that culminated in the publication of his classic text "Memory: A contribution to experimental psychology" in 1885 (translated into English in 1913). Ebbinghaus was determined to develop a research methodology for studying memory that rivaled the experimental rigor achieved by researchers in the natural sciences. His research relied for the most part on using nonsense syllables as memory stimuli. These three letter consonant-vowel-consonant combinations were chosen by Ebbinghaus because they did not appear in his native language, and consequently, he felt the nonsense syllables constituted "pure" memory stimuli. During the 1900s, memory researchers substituted nonsense syllable lists with word lists after databases became available that allowed researchers to control for confounding factors like the frequency of prior experience with a word.

The verbal learning approach has remained very popular since, but during the 1970s some cognitive psychologists began to raise concerns regarding this overreliance on memory stimuli that has little relevance to everyday, personal memories (Cohen 2008). These concerns became unified into the "everyday memory movement" that led to the first formal meeting of researchers interested in changing the focus of memory research in 1978. This conference was titled the "Practical Aspects of Memory Conference" (PAM), and the theme for this conference was to develop and report research programs that examined everyday memories and the practical aspects of such memory

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findings (Gruneberg, Morris, & Sykes, 1978). The everyday memory approach is now a strong and popular field of research that incorporates the study of many real-world memory topics, such as autobiographical memory, eyewitness memory, prospective memory, and memory training. Everyday memory researchers are faced with a difficult methodological balancing act. They want to investigate ecologically valid memory phenomena without completely sacrificing the experimental rigor provided by laboratory-based methodologies. The innovative and creative attempts by memory researchers to solve this balancing act over the past three decades are the basis of the current chapter, with a specific focus on the methodologies that have been developed to examine the retrieval of autobiographical memories.

Autobiographical memories are personal memories of past experiences that have self-relevance and that combine to form our life history. These complex memories represent the reconstruction of fragments of experience combined with our knowledge of such experiences and the knowledge of our self (Brewer, 1988; Conway, 1990). Williams, Conway, and Cohen (2008) suggest that autobiographical memories serve three functions: (1) *social* – communicating and sharing of past experiences with others, (2) *problem solving* – applying past experiences to new problem settings, and (3) *self* – past experiences provide a life-story that guides our self-goals. We are still at a fairly early stage in understanding the processing and storage of these memories when compared with other types of memories, but we have made substantial progress in this endeavor over the past three decades. The development of methods for studying autobiographical memory retrieval has been fundamental to these empirical and theoretical advancements, and further development is critically important for future progress (Baddeley, Eysenck, & Anderson, 2009).

There are two major methodological difficulties associated with the study of autobiographical memories. The first difficulty is often referred to as verifiability. How do we know if the participant is recalling a true autobiographical memory if the experimenter was not there at the time and if the participant may not even be able to distinguish their true retrievals from false retrievals? The second difficulty relates to the complexity and variety of autobiographical memories. Autobiographical memories can consist of things we have done, said, seen, heard, smelt, tasted, dreamt, and even thought. These memories can vary in distinctiveness and vividness, from mundane daily activities to significant life-changing events. Some memories are emotionally charged, but others have little emotional content associated with them. Autobiographical memories can be highly specific events, or experiences that extend over lengthy periods of time, or experiences that have been combined into one categorical representation. They can vary significantly in age from very recent memories with much of their sensory content accessible to much older remote memories that rely heavily on our autobiographical knowledge for reconstruction. Autobiographical memories can be highly rehearsed experiences or experiences that are rarely recalled. In describing the methods that have been developed by researchers to examine autobiographical memory retrieval, I will highlight how researchers have cleverly overcome these two methodological difficulties in conducting their research.

In this chapter, I will describe the methodologies developed by cognitive scientists to examine the retrieval of personal experiences from autobiographical memory. For the purposes of this review, I am focusing on methodologies developed primarily to study autobiographical memories rather than episodic memories. I will also not be describing the methodologies that have been developed to distinguish the retrieval of semantic autobiographical information, because it is still unclear whether such information is stored in autobiographical memory or semantic memory. In addition, this chapter will not be covering the variety of methodologies that have addressed the specific retrieval of highly emotional, traumatic experiences, as this would have deserved much more coverage than is possible in this chapter. If you are interested in these methodologies I would refer the reader to some excellent reviews of this important memory topic by McNally (2003), Schooler and Eich (2000), and Uttl and Seigenthaler (2006). The self-narrative is also a concept of interest to researchers collecting data on autobiographical memory. However, as self-narratives are not closely related to this chapter's focus on the retrieval of specific memories, this area of research will also not be addressed in the current review. Finally, computational models of memory have been developed by researchers and some of these models have aspects that are relevant to the retrieval of autobiographical memories (refer to McClelland, 2000; Meeter, Jehee, & Murre, 2007). However, a discussion of this theoretical approach and the methodologies involved will not be covered in this review.

Cognitive Psychology Approach

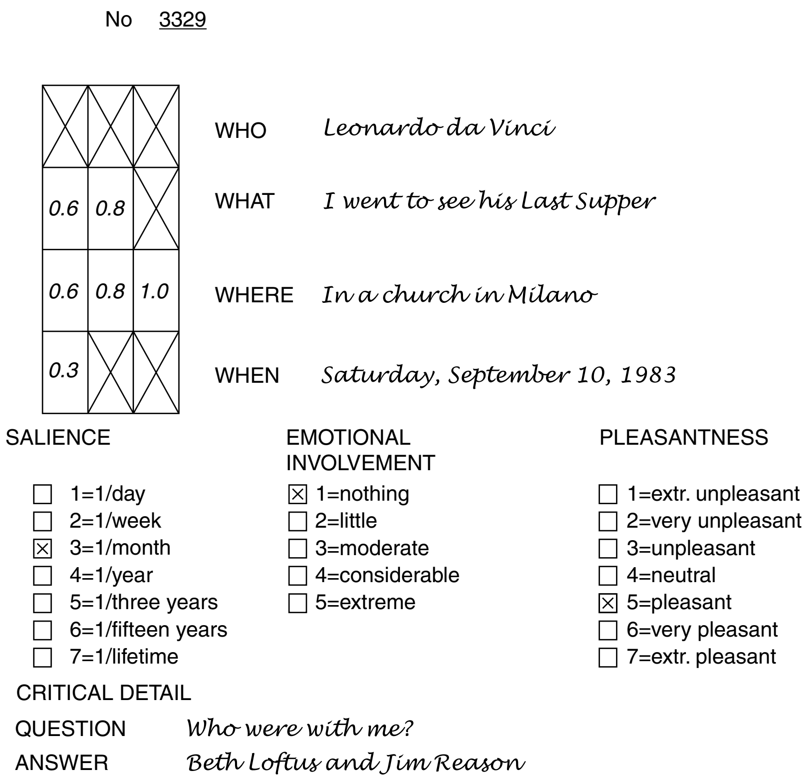
The first attempts to systematically examine autobiographical memory empirically were conducted by cognitive psychologists in the 1970s. These experimental psychologists follow a general methodological approach of testing specific research hypotheses by constructing experiments where independent variables are manipulated by the experimenter and dependent variables are recorded to test these hypotheses. The participants in their studies are usually college student volunteers who normally retrieve a small sample of autobiographical memories, and then provide self-report ratings of phenomenological characteristics associated with these memories and their retrieval. For example, when examining the influence of mood on autobiographical memory retrieval, researchers manipulate mood states (e.g., playing sad or happy music) and examine memory retrieval performance. Retrieval performance can be measured by the speed of memory retrieval and by the ratings provided by the participant of the memory's emotional content.

Diaries

One of the first approaches to studying autobiographical memories that allowed researchers to verify the validity of these events was the use of diaries. Personal experiences were recorded by the participants in a diary when the event occurred, or at least, very soon after the event occurred. The diaries provided researchers with a large database of verified autobiographical memories that could be tested at a later date. Unfortunately, the duration of data collection and the length of retention period available for testing can be limited using this longitudinal approach to studying autobiographical memory. But some exceptional individual case studies involving years of diary data have provided some important insights into the storage, retrieval, and forgetting of these personal memories over time.

The earliest attempts to collect diaries of daily personal events that extended over periods of years involved singe case studies of the researcher's own experiences (Linton, 1975, 1978; Wagenaar, 1986). These researchers vigilantly and meticulously recorded daily events that happened to them. An example of a diary entry recorded by Wagenaar is provided in Figure 2.1. The experimenter collated the diary entries in a systematic way that allowed specific research questions to be tested. For example, Wagenaar was interested in the role that retrieval cues can play when remembering past experiences. He recorded four descriptive aspects of the memory: who he was with, what he was doing, where he was, and when did it happen. He also provided ratings of each event on three phenomenological dimensions: event salience, emotional involvement, and pleasantness of event (refer to Figure 2.1). When his recall of these events was tested at a later date by his research assistant, Wagenaar was provided with one descriptive cue at a time until he could correctly recall all four aspects of the event. This testing method allowed him to evaluate which retrieval cues were best for retrieving autobiographical memories. He also examined how memory retrieval related to the phenomenological characteristics of the event. It is interesting to note that one of the first research methodologies developed by memory researchers to study autobiographical memory relied on lengthy, painstaking data collection by the researcher of their own memory – much in the same way as was conducted by Ebbinghaus during his pioneering endeavors.

A major methodological concern with diary studies conducted by researchers of their own autobiographical memory is that they introduce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X	X	X
0.6	0.8	X
0.6	0.8	1.0
0.3	X	X

WHO *Leonardo da Vinci*

WHAT *I went to see his Last Supper*

WHERE *In a church in Milano*

WHEN *Saturday, September 10, 1983*

SALIENCE
- ☐ 1=1/day
- ☐ 2=1/week
- ☒ 3=1/month
- ☐ 4=1/year
- ☐ 5=1/three years
- ☐ 6=1/fifteen years
- ☐ 7=1/lifetime

EMOTIONAL INVOLVEMENT
- ☒ 1=nothing
- ☐ 2=little
- ☐ 3=moderate
- ☐ 4=considerable
- ☐ 5=extreme

PLEASANTNESS
- ☐ 1=extr. unpleasant
- ☐ 2=very unpleasant
- ☐ 3=unpleasant
- ☐ 4=neutral
- ☒ 5=pleasant
- ☐ 6=very pleasant
- ☐ 7=extr. pleasant

CRITICAL DETAIL

QUESTION *Who were with me?*

ANSWER *Beth Loftus and Jim Reason*

Figure 2.1 An example from Wagenaar's (1986) personal diary records.

experimenter bias to the data collection. The experimenter may collect data that reflect their own research goals or expectations. One way to overcome this problem is to conduct a case study using individuals that are blind to the goals of the research. Many people enjoy maintaining diary records over the years of their life and access to these diaries can be very informing. Catal and Fitzgerald (2004) recently tested the memories of a married couple for diary entries recorded every day by the wife for a period of 20 years. Although the findings from this study replicated many results from the experimenter-based diary studies, there were some significant differences. These differences highlight a major weakness of the case study approach to diary collection in that it is difficult to generalize findings based on a single individual. For example, Wagenaar (1986) found 'where' cues to be significantly better retrieval cues than 'who' cues. However, Catal and Fitzgerald (2004) did not find a difference in the effectiveness of these two retrieval cues. They suggested that Wagenaar's data reflected his increased level of travel when compared to the married couple in their study.

One way to overcome this generalizing limitation is to collect diary data from a larger random sample of participants. Many studies have now been conducted that have collected diary data from a sample of participants over periods of time ranging from weeks to months. Participants usually record one distinctive event a day and supplement this recording with phenomenological ratings of the event. Thompson and colleagues have conducted many diary studies of this form over a number of years and now have hundreds of diaries in their impressive database of autobiographical memories (Thompson, Skowronski, Larsen, & Beiz, 1996). However, the time periods for data collection and memory testing are relatively short in these studies when compared to case studies. A study by Burt, Kemp, and Conway (2001) combines the merits of both approaches. They collected diary data for a year from 14 participants and then re-tested 11 of the participants 10 years later.

A general methodological weakness of diary studies is their reliance on self-selection of events by participants, as this may introduce a participant bias to the data collected. Participants are often asked to record a distinctive, memorable event each day and so the memories tested may not generalize to all autobiographical experiences. This bias was highlighted in a study by Brewer (1988). He required the participants in his diary study to carry electronic beepers with them each day. The beeper would sound off randomly at approximately 2-hour intervals to signal the participant to record what they were doing and thinking at the time. This naturalistic sampling of events overcomes the self-selection bias. Brewer found significant differences in the memory strength and the phenomenological characteristics of the event when comparing randomly sampled events with self-selected events.

The diary procedure was recently adapted to study an elusive memory phenomenon that was first defined by Ebbinhaus (1885) as involuntary memories. Involuntary memories are past experiences that come to mind spontaneously without a deliberate, conscious attempt by the individual to retrieve the experiences from memory. Involuntary memories occur without any forewarning and are very difficult to study. Up until the 1990s, the discussion of involuntary memories relied on anecdotal or fictional descriptions (Salaman, 1982; Proust, 1913–27). Berntsen (1996) pioneered the use of the diary method to collect involuntary memories. Participants in her research carried a diary with them as they went about their daily activities. They were required to immediately record in their diary any involuntary memories that occurred during the day. The participants only recorded a brief description of the memory at that time. Later that day or evening, participants added ratings of the memory characteristics (e.g., age of memory, emotional valence of experience) and retrieval context (e.g., attention state, emotional state) to this diary entry. A number of diary studies have now been conducted to further our understanding of this evasive memory phenomenon (Berntsen, 2009).

One weakness with diary studies is that the participant may become aware of the goals of this research through repeated recordings, and begin to record data that match these perceived goals. Ball and Little (2006) conducted a diary study to examine this concern with involuntary memory diaries. Their participants were only required to record one involuntary memory recording. After recording this memory, the participants provided additional information based on instructions enclosed in a sealed envelope. As a result of this procedure, the participants were blind to the type of information they would need to provide about the involuntary memory retrieval until they had experienced it. The findings of this study were consistent with previous diary research based on multiple diary entries.

Cue prompts

A method of collecting autobiographical memories that adds some of the experimental control that is missing from the diary methodology was first reported by Crovtiz and Schiffman (1974) and was based on the pioneering research of Galton. Cue prompts (e.g., words, phrases, categories) are presented to a participant who must retrieve an autobiographical memory that relates to this cue. This laboratory-based method of data collection allows the experimenter to test various research questions by manipulating aspects of the prompting process and context. In addition, this methodology is well suited to collecting a range of behavioral measures that relate to memory retrieval performance, such as retrieval time and memory ratings. The cue-prompt methodology has arguably become the most popular method for studying autobiographical memory. In addition, this method has important clinical applications for studying patients suffering from memory loss (Wenzel, 2005). I will now provide some research examples of how this methodology can be varied to test different types of research questions.

One simple and popular way of changing the cue-prompt task is to vary the category of cue-words used. This manipulation is fundamental to the Autobiographical Memory Test (AMT) developed by Williams and colleagues. The AMT has become a popular method for examining clinical disorders (e.g., depression, PTSD) and can even predict disorder occurrence, severity, and treatment success (Williams et al., 2007). The AMT uses 10 cue-words that relate to either positive or negative affect (e.g., sad, happy). Researchers than examine the number of specific personal events that are reported by participants to these cue words. Memory specificity has been found to vary as a function of clinical diagnosis, disorder severity, and duration (Williams et al., 2007). The cue prompts do not necessarily have to be verbal stimuli presented visually. Researchers have tested cues involving multiple sensory modalities. For example, Goddard, Pring, and Felmingham (2008) presented three different types of cues in their experiment. The first prompt was a photograph or drawing of the cue; the second type of prompt was the word that described the cue; and the third type of prompt was an odor cue.

Another experimental manipulation involves changing the information that precedes the presentation of the cue prompt. Reisser, Black, and Abelson (1985) examined the hierarchical organization of autobiographical memories by presenting a phrase before the cue word (another phrase). They compared retrieval times when general activity descriptions preceded specific action phrases and vice versa. Ball and Hennessey (2009) recently presented subliminal primes before the cue words were displayed. The masked primes consisted of words associated with categories of memories, and the cue words were either related to these categories or came from unrelated categories. Haque and Conway (2001) interrupted the retrieval process after the cue word was presented by displaying the word "REPORT" at random times while the participant was retrieving a memory. The participant was required to report what was in their mind at that time. This procedure enabled the researchers to look at the cognitive steps involved in the retrieval of autobiographical memory and especially during cue-elaboration. The retrieval context can also be varied using the cue-prompt method. Suedefeld and Eich (1995) collected autobiographical memories from participants in a sensory deprived environment as they floated on a body-temperature solution in a dark chamber that was sound attenuated.

Questionnaires

A common feature of the methodologies described so far has been the research interest in the phenomenological characteristics of the memory retrieval. These characteristics are usually recorded from the participants as ratings on a scale. However, researchers have recently attempted to provide better measurement tools for these characteristics in the form of multi-item questionnaires. Rubin and colleagues developed the Autobiographical Memory Questionnaire (AMQ) to measure recognition and sensory aspects of autobiographical memories (Rubin, Schrauf, & Greenberg, 2003; Rubin & Siegler, 2004). The AMQ consists of 19 items that measure three broad aspects of the autobiographical memory and its retrieval phenomenology: (1) recollection and belief in the accuracy of the memory (e.g., "I travel back to the time when it happened"), (2) component processes (e.g., "I can see it in my mind"), and (3) reported properties of events and memories (e.g., "It is significant for my life").

Sutin and Robins (2007) recently created the Memory Experiences Questionnaire (MEQ) that consists of 63 items which measure 10 phenomenological dimensions: (1) vividness (e.g., "My memory of this event is very vivid"), (2) coherence (e.g., "The order of events in the memory is clear"), (3) accessibility (e.g., "This memory was easy for me to recall"), (4) sensory detail (e.g., "I can bodily 'feel' myself in this memory"), (5) emotional intensity (e.g., "My emotions are very intense concerning this event"), (6) visual perspective (e.g., "I see the experience through my own eyes"), (7) time perspective (e.g., "My memory for the year when the event took place is clear"), (8) sharing (e.g., "I often share this memory with friends"), (9) distancing (e.g., "I don't have much in common with the person in the memory"), and (10) valence (e.g., "The overall tone of the memory is positive"). The MEQ has good scale reliability and factor analyses have confirmed a good fit for the proposed 10-factor model (Sutin & Robins, 2007).

Archival data

The research methodologies we have described so far have relied on a participant recalling a personal memory from the large database of experiences they have acquired throughout their life. These are usually private experiences without the experimenters present at the time they occurred. An alternative approach to studying autobiographical memory is to test an individual's memory for events that are well documented in the public domain. The researcher can now verify the accuracy of the reported memory and to accurately measure other contextual variables associated with this public event. Autobiographical memories of this form usually involve significant world events that are subject to extensive media coverage. One intriguing case study example of the archival approach was conducted by Ulrich Neisser in 1981 when he examined the recall of John Dean during the Watergate hearings. Neisser was able to evaluate the recordings of the Watergate meetings and compare them with Dean's testimony during the hearing. Another case study example was provided by Schulster (1981), who tested his own memory for 25 seasons of opera he had attended at the Metropolitan Opera in New York City. This approach is not restricted to a sole individual's memory of such events, as many individuals share memories of a significant event even if they personally did not experience it first hand. Memories of these dramatic world events were coined flashbulb memories by Brown and Kulik (1977). Autobiographical memory for a number of major events has been examined in this way, such as the *Challenger* disaster, the 9/11 terrorist attack, and the fall of the Berlin Wall (Luminet & Curci, 2009).

Cognitive Neuroscience Approach

There is no doubt that the single biggest methodological development in the past 20 years involving research on autobiographical memory (and human cognition in general) has been the development of the cognitive neuroscience approach. This research approach focuses on the brain anatomy and neural processing involved in human cognition. Originally, the neuropsychological study of autobiographical memory was restricted to detailed case studies of individuals who lost their ability to access autobiographical memories or form new memories because of brain damage. The famous case of HM is a classic example of this neuroscience approach. More recently, this approach has expanded to include new brain scanning technologies, such as EEG, PET, and fMRI. The cognitive neuroscience approach is heavily indebted to the cognitive psychology methods we have just described, because many of these tasks and measures have been incorporated into cognitive neuroscience experiments. However, many new methods have also been introduced, while other methods have been cleverly adapted to the physical constraints imposed on the participant by the brain scanning equipment.

Electroencephalogram (EEG)/Event-related potential (ERP)

One of the first procedures developed to examine brain activity during cognitive processing was the measurement of electrical activity recorded from surface electrodes placed on the participant's scalp. The electrodes record very small changes in electrical activity that researchers believe result from post-synaptic activity of pyramidal neurons in the cerebral cortex during neural transmission (Luck, 2005). The temporal resolution of the data collected is very good with millisecond accuracy. Spatial topographic analysis can also be carried out with EEG, but the spatial resolution will be dependent on the number of electrodes used in recording. Precise localization of the neural activity generating the recorded changes in electrical activity will still be difficult given the poor conductivity of the skull (Shibasaki, 2008).

The changes in electrical activity detected by the surface electrodes are in the range of micro volts, therefore considerable amplification is required to achieve a clear picture of the subtle changes in electrical activity that result. Unfortunately, this amplification process also amplifies any noise in the recording (e.g., background electrical activity, movement and eye-blink artifacts). One research design that can assist considerably in obtaining a clearer picture of the underlying brain activity involves averaging the experimental trials to remove random noise from the recordings. This is achieved by synchronizing the EEG recording with a target or response event. The resulting picture is called the evoked- or event-related-potential (ERP). Further averaging across participants of their ERPs will provide a grand-average ERP that hopefully describes a consistent pattern of neural activity.

Researchers are interested in the temporal and spatial properties of the resulting ERP waveform. The waveform will show changes in negative and positive peaks of activity at various temporal locations and which reach a maximal change at specific spatial locations of the electrodes. For example, the presentation of a cue prompt in an autobiographical memory task will first generate a positive peak about 100ms after cue presentation with maximal activity in the occipital electrodes (Dien, 2009). This peak is identified as a P100 or P1 by EEG researchers and highlights the first low-level perceptual processing of the word stimulus.

Only a few ERP studies have examined autobiographical memory retrieval. The retrieval of autobiographical memories is much slower and more variable than other types of memory retrievals, making it harder to obtain a consistent ERP pattern. ERP research requires the presentation of a large number of trials (often in the hundreds) for the averaging process to be effective, and this is a taxing experimental demand when each trial involves retrieving a new autobiographical experience. For example, Conway, Pleydell-Pearce, and Whitecross (2001) required their participants to provide memories to 78 cue words and the experiment took over three hours to complete. The data analysis from this experiment actually involved even fewer memories, as cue words came from three different categories and so only 26 retrievals were required to each cue category. The researchers then decreased this number of memories further as they tried to separate memory retrieval processing from cue-word processing by restricting data analysis to trials where retrieval times were greater than 3 seconds. This again significantly reduced the number of memory retrievals available for averaging, and unfortunately introduced a new source of retrieval variability. Longer retrieval times arguably result from additional processing of the cue word as the participant struggles to retrieve a memory, and then instigates a semantic elaboration of the cue to assist in the retrieval (Ball, Mace, & Corona, 2007).

These methodological concerns do not rule out the use of the EEG methodology when studying autobiographical memory, but suggest that EEG analysis may be best suited to experimental designs comparing qualitatively different types of autobiographical memory retrievals. For example, Magno and Allan (2007) showed how EEG analysis can be conducted to examine the role of self-processing during autobiographical memory retrieval. They manipulated self-processing by requiring their participants to recall two types of autobiographical memories: (1) memories in which they had participated (self) and (2) memories in which a friend had participated (friend). To further validate this memory distinction, the participants distinguished the phenomenological aspects of the retrieval in terms of the recollection feedback (e.g., feelings of reliving the event) associated with each memory retrieved. Half of the participants were required to retrieve personal events (autonoetic group) while the other half of the participants were required to simply recall a factual piece of autobiographical information (noetic group). Figure 2.2 illustrates the ERP data from this study, and not only highlights the increased activation in the self-processing regions of the

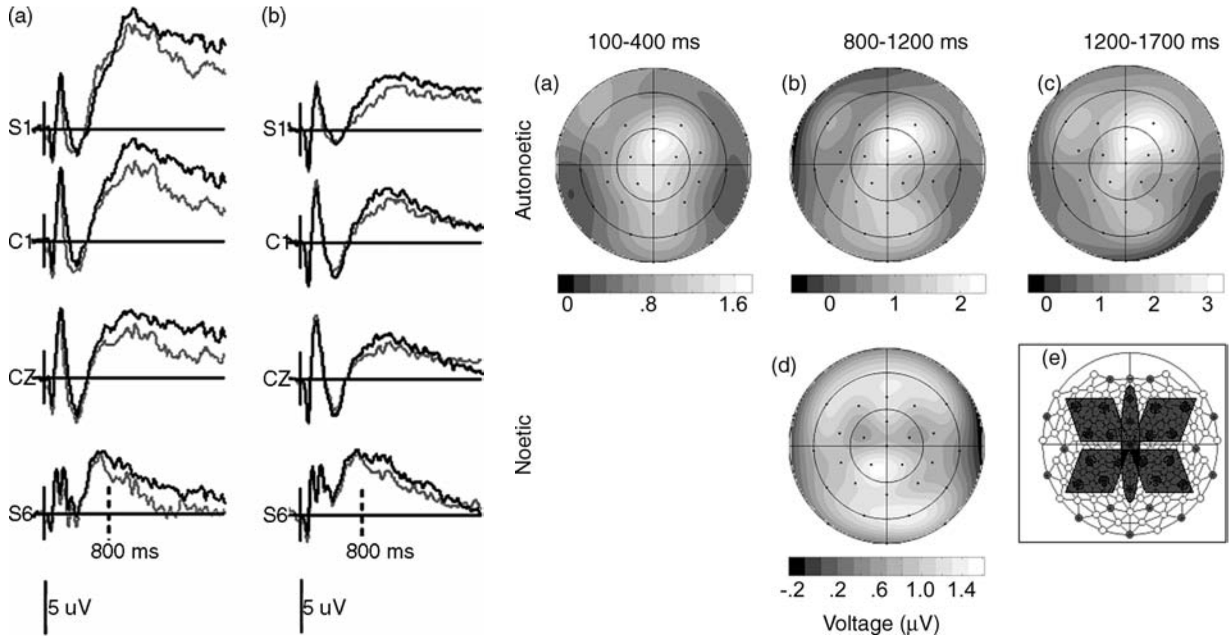

Figure 2.2 Grand-average ERP findings from the Magno and Allan (2007) study on the role of self-reference processing in autobiographical memory retrieval. Left figure highlights positive-going shift for self-related memories and this shift was greater and earlier for autobiographical memories. The right figure highlights this difference in the ERP pattern (ERP self-related content – ERP friend-related content) was primarily located just anterior and to the right of the scalp vertex across time period of the trial for the autobiographical memory retrievals (autonoetic group).

brain, but also reveals that this processing begins almost immediately after cue presentation.

Positron emission topography (PET)

Electromagnetic measures rely on the electrical and magnetic fields generated by neural activity of the brain during memory retrieval. Hemodynamic measures are based on the energy requirements of neural activity and record neural activity indirectly by measuring blood flow and metabolic changes that support these increases in neural activity. Unfortunately, these hemodynamic processes take many seconds to complete, and therefore this approach does not have the temporal resolution possible with EEG recording. However, unlike EEG recording, hemodynamic approaches can accurately record precise spatial changes (mm accuracy) in neural activity that originates from both cortical and sub-cortical regions of the brain.

Positron emission topography relies on the detection of positron emitting radiotracers that are injected into the blood supply of the participant. The tracers contain positrons that collide with local electrons and emit two photons that can be detected by the PET scanner. The regional changes in cerebral blood flow (rCBF) imposed by neural activity are recorded for analysis. Unfortunately, PET scans are quite slow, and can take more than a minute to complete one trial of recording. Consequently, PET scanning is not well suited to studying fast dynamic cognitive processes like memory retrievals. PET studies generally rely on subtractive-block designs for isolating the neural basis of cognitive processes. The subtractive design assumes a researcher can develop a variety of tasks that only differ in the cognitive processes of interest. If this can be achieved, the slow recording rate of PET scans is less of a concern because the participant is performing the same cognitive processes over and over again in each block of trials. Unfortunately, the subtractive block design is not well suited to a complex cognitive task like retrieving autobiographical memories. A popular control condition that has been used in past PET studies is simply instructing the participant to do nothing. However, it is unclear what cognitive processes are involved when a participant is told these instructions, and it is highly likely that some form of memory processing is still being performed.

One other difficulty when interpreting the findings from these PET studies involves the variety of autobiographical memory tasks that have been used. Some studies rely on interviews to collect memories at an earlier date, while others elicit memories for the first time in the scanner. Some participants simply listen to auditory descriptions of their memories, while participants in other studies have to actively retrieve a memory in response to a cue word. In some studies the participants do not make any responses

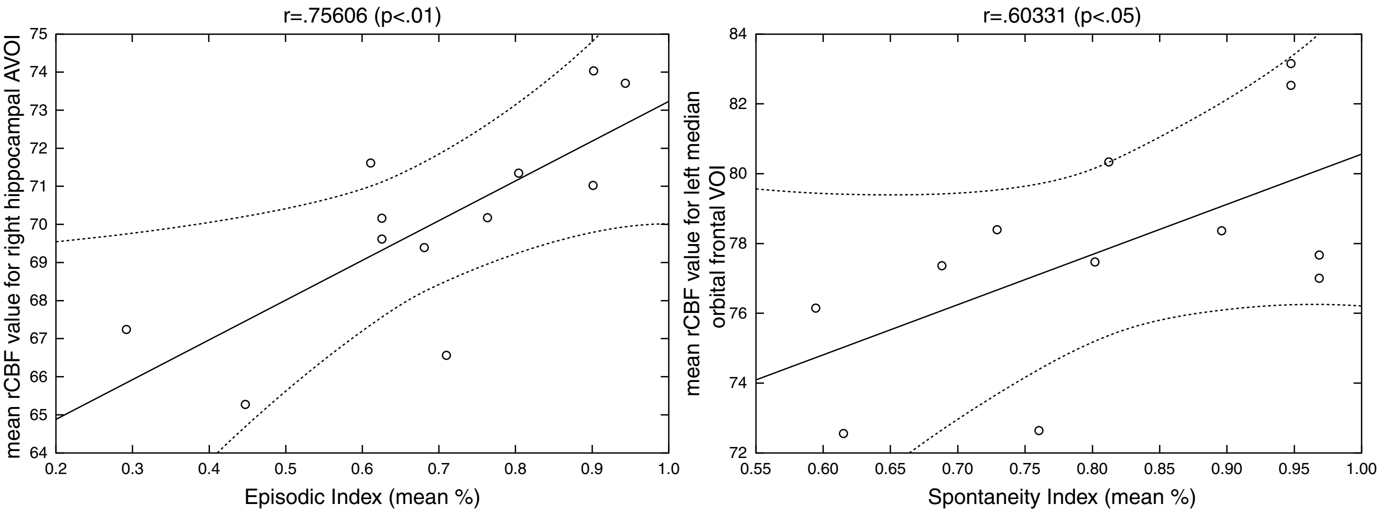

Figure 2.3 Scatterplots from the Piloino et al. (2008) PET study that reveal the correlation between rCBF values from right hippocampus areas with the episodic index (left graph) and the correlation between rCBF values from left medial orbital lobe and the spontaneity index (right graph). Each point corresponds to the data for one participant (n = 12).

to signal a memory was retrieved, while in other studies participants could be required to press a button or speak aloud a memory description. Many of the PET studies did not examine the type of memory retrieved in each block of trials, and therefore the confounding influence of such variables as emotional content and memory age could not be controlled across blocks of trials.

Piloino et al. (2008) have recently presented a methodology that may overcome some of these concerns. They used a standardized, semi-structured questionnaire (TEMPau) to prompt autobiographical memory retrievals from five time periods in the participant's life. The participant also indicated if the memory recalls involved feelings of recollection (R) or not (K). In addition, the participant rated each memory retrieved on a number of phenomenological dimensions. Ninety second scans were performed as the participant was prompted to recall a specific memory from the time period. Instead of subtracting activity recorded during a control condition from activity recorded during the experimental condition (i.e., autobiographical memory retrieval), Piloino et al. calculated two different indices to reflect the type of memory processing involved during different memory retrievals. They calculated an "episodic index" from the number of "R" responses that were provided by the participant for each life period. A "spontaneity index" was also calculated from the number of cues and encouragements the experimenter needed to provide the participants before they recalled an experience. Piolini et al. correlated these indices with activity levels recorded from different brain regions known to be involved in autobiographical memory retrieval. As expected, the episodic index correlated with activation in the right hippocampus, whereas the spontaneity index correlated with activation in the left medial orbital frontal cortex (see Figure 2.3).

Function magnetic resolution imaging (fMRI)

fMRI and event-related designs have steadily replaced the use of PET scans and block (subtractive) designs. The fMRI procedure is not as invasive as PET scanning because the magnetic field changes can be detected without injecting anything into the participant's blood system. The spatial and temporal resolution is better with fMRI, and this resolution will continue to improve as more powerful machines become available to researchers. The blood oxygenated level dependent (BOLD) system is arguably the most popular fMRI methodology. The BOLD system measures the subtle changes in microscopic magnetic fields that result from changes in the ratio between oxygenated and deoxygenated hemoglobin. It is not completely clear what underlies the relationship between the BOLD hemodynamic response and the underlying neural activity, but there does appear to be a close relationship between the two, with increases in oxygenation levels reflecting increases in neural activity (Shibasaki, 2008).

The spatial resolution of fMRI recording is related to the strength of the magnet used to detect these changes. Currently, most memory studies have involved magnets in the range of 1–3 Tesla. These magnets can detect changes in neural activity across a surface area of approximately 9–16 mm^2 with a slice thickness of 5–7 mm (usually axial slices) giving an average voxel size of around 55 mm^3 (Logothetis, 2008). Of course, each voxel still corresponds to a large number of neurons that is estimated to be around 5.5 million (2.2–5.5 × 1010 synapses, 22 km of dendrites, and 220 kms of axons) (Logothetis, 2008). The temporal resolution is still a few seconds for the hemodynamic response to reach its peak in fMRI scans, so this resolution does not rival that achieved with EEG recording (Shibasaki, 2008). The temporal resolution can be improved by reducing the number of slices when recording, but this also sacrifices the spatial resolution of data collected (Amaro & Barker, 2006).

The event-related fMRI (efMRI) research design makes use of the ERP design described previously for EEG recording. The efMRI design overcomes the difficulty of developing tasks that isolate the memory processing unique to autobiographical memory retrievals when using the subtractive-block design (Amaro & Barker, 2006). The fMRI recording is synchronized to a target event (such as a cue prompt) and recording continues for a number of seconds. Then a short delay is necessary as the scanner completes the full fMRI recording before the next trial begins.

Maguire, Henson, Mummery, and Frith (2001) conducted an efMRI study to compare brain activity for different types of memories that included an autobiographical memory, autobiographical factual information, memory of a public event, and general knowledge. They collected memories by interviewing participants five weeks before scanning took place. During the scanning, each memory was presented to the participant as a question, with some questions reflecting true memories while others were false. The question (target event) was heard through headphones and the participant had 5 seconds to respond (button press). Sixteen questions were presented in a row for each type of memory. The age of each memory retrieved was correlated with brain region activity, and the efMRI separated for the different types of memory (see Figure 2.4).

An efMRI study conducted by Daselaar et al. (2008) attempted to map the spatial-temporal dynamics of autobiographical memory retrieval using the ERP design reported by Conway et al. (2001). They time locked fMRI data analyses to the target event (cue-word presentation) and to the response event (key-press that signals memory retrieved). To overcome the variability inherent with memory retrievals of this sort, they created a time course of the processes involved and matched the brain activities in different regions to this time course (see Figure 2.5).

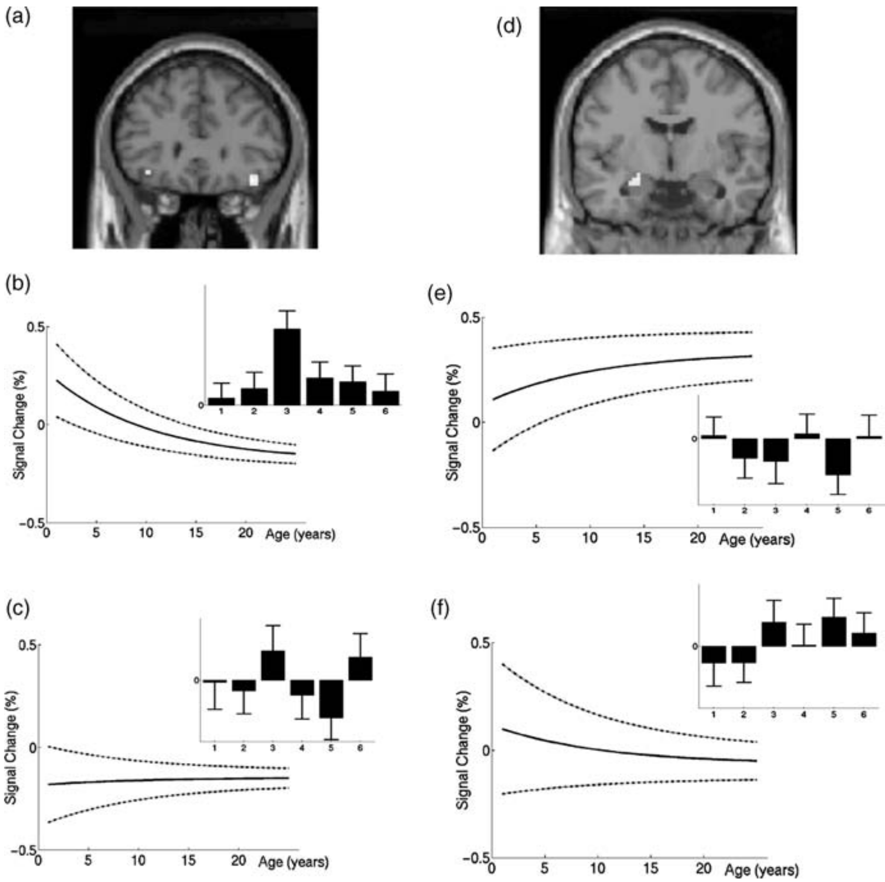

Figure 2.4 Findings from the efMRI study conducted by Maguire et al. (2001) that examined role of hippocampus in mediating retrieval of remote versus recent memories. The left figure (c) highlights the decrease in activity in ventrolateral prefrontal cortex with increasing age of memory for autobiographical memories, but not for memories of public events (d). No changes in activity were found with memory age for hippocampus regions with either type of memory retrieval (e) and (f).

Researchers have attempted to overcome the self-selection of memories by participants in brain scanning experiments. Gilboa, Winocur, Grady, Hevenor, and Moscovitch (2004) used photographs provided by the participant's friends and relatives as stimuli. The variety of autobiographical memories is also a major problem for brain scanning researchers. fMRI researchers often interview the participant before the scanning so that they have a database of memories to present during scanning. Maguire et al. (2001) over-sampled memories from their participants and collected ratings of these

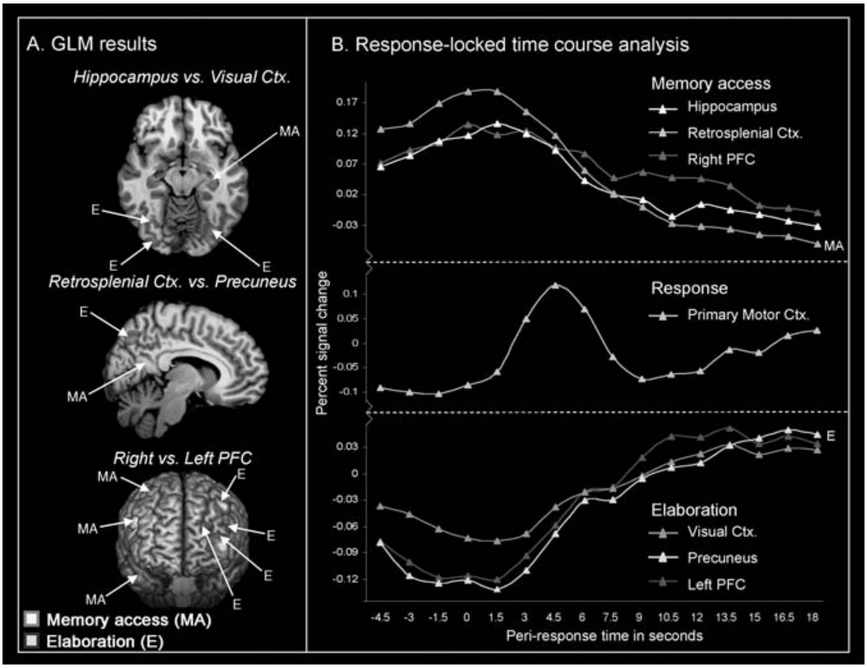

Figure 2.5 Spatiotemporal dynamics of autobiographical memory retrieval revealed by efMRI study conducted by Daselaar et al. (2008). The predicted time course for performing memory retrieval (top) compared with auditory processing of cue word and motor processing of retrieval response actually obtained (bottom). Supports time-locked analysis for target event recording of fMRI.

memories to control for confounding factors during memory selection. Unfortunately, surveying the participant at an earlier date now introduces a new methodological concern. Researchers are not sure if the memory retrieved during scanning involves the original memory or the interview when the memory was retrieved. Another problem for scanning experiments that is unique to the study of autobiographical memory is that the act of retrieving an autobiographical memory while being scanned is a new autobiographical memory in its own right. Consequently, while the participant is being scanned for memory retrievals the participant is also simultaneously being scanned for the encoding of these new events.

We also have the common methodological problem of verifying the accuracy of autobiographical memories retrieved during scanning. Different brain activations can result from “true” and “false” memories (Mitchell & Johnson, 2009). One way to overcome this concern is to combine the archival approach with fMRI scanning. For example, Campitelli and Parker (2008) examined the memories of past chess games played by two chess masters and available in the public domain. They showed the chess masters a chessboard configuration taken from one of their games or taken from someone else's games. The participant had to recognize if the chess positions came from one of his games. Although verifiability of these memory retrievals is guaranteed, there are still concerns generalizing theses types of memories to other types of autobiographical experiences.

One of the most innovative approaches to verifying the validity of memories was undertaken recently by Mendelsohn, Furman, Navon, and Dudai (2009). They filmed a participant for two days (10 hours of tape) before testing her memory of the events recorded on those days. She was scanned four months later and again one year later. The participant was tested with sentences that described true events or false events from the two days of recording and she also provided confidence judgments for her answers. The control condition involved the participant looking at scrambled static images taken from the movie and requiring a perceptual judgment to be made. Figure 2.6 highlights the differences found between correct and incorrect answers and between low to high confidence judgments.

Tests for brain damage patients

There is no doubt that much has been learnt over the years from the study of patients who have suffered some form of brain damage that has affected their ability to recall autobiographical memories or form new ones. HM is arguably the most famous case study in the history of this approach and his recent death brought to an end one of the longest, most-detailed, systematic studies of autobiographical memory ever undertaken.

The cue-prompt procedure has been used in many patient studies (see Kopelman, 1994), but the lack of standardization associated with the choice of cues can make it difficult to compare the findings from one study to the next. Another method involves recording the free recall recollections of amnesia patients and then scoring their recollections (Bayley, Hopkins, & Squire, 2003). However, a lack of standardization involving the scoring of these transcripts also makes it difficult to generalize the findings from these studies. In addition, the number of details provided by patients may not reflect the amount of information they actually hold in autobiographical memory (Kirwan, Bayley, Galván, & Squire, 2008).

Researchers working with amnesia patients have developed standardized methods for testing autobiographical memory with these individuals. The Autobiographical Memory Interview (AMI) was developed by Kopelman, Wilson, and Baddeley (1989). The AMI is a structured interview which assesses semantic autobiographical memory (Personal Semantic Schedule) and personal autobiographical memory (Autobiographical Incidents Schedule) from three life periods (childhood, early adulthood, and

FIGURE NOT AVAILABLE

Figure 2.6 Findings from the efMRI study conducted by Mendelsohn et al. (2009) that showed increased activity in regions of interest for metamemory judgments as memories confidence increases (remote memories). These regions do not vary in activity as a function of actual accuracy of memory judgment.

recent adulthood). The Autobiographical Incidents Schedule requires participants to recall specific events and is scored in terms of the richness and specificity of the detail provided for each memory. Further verification of memories is undertaken by communicating with the participant's relatives, checking medical records, and noting inconsistencies in the participant's responses. A standardized scoring system exists for the Autobiographical Incidents Schedule and it produces fairly reliable scores. The AMI has been found to accurately discriminate different types of special populations with memory problems, such as amnesia, dementia, and psychiatric patients (Koppelman, 1994).

However, Levine, Svoboda, Hay, Winocur, and Moscovitch (2002) were concerned that the AMI did not generate enough memory content from the patient. Consequently, they developed the Autobiographical Interview (AI) with the patient recalling one event description from five life periods (childhood < 11 years, teenage years (12–17), early adulthood (18–35), middle age (36–55), and year before testing). Although the AI only requires one event from each life period to be recalled, extensive prompting is provided by the experimenter to generate as much detail as possible. If participants cannot recall a specific event, they are shown a list of approximately 100 life events to help prompt recall. The experimenter also facilitates patient recall of content by providing general prompts (e.g., "Can you tell me more?") and by providing specific prompts directed at five aspects of the event recalled (event, time, location, and sensory and emotion/thought details). Patients also rate the vividness of the memory and how often they have talked about the event in the past. Each narrative of an event is segmented and coded for content and good inter-rater reliability has been reported for this coding system (Kirwan et al., 2008).

Another autobiographical memory test used with amnesia patients is the Autobiographical Fluency Test (AFT) developed by Dritschel, Williams, Baddeley, and Nimmo-Smith (1992). The AFT provides two scores: (1) personal semantic memory and (2) personal incident memory. The personal incident memory score is obtained by requesting the participant to report as many brief descriptions of specific events as possible in 90 seconds. The task is repeated three times for three different life periods.

Future Directions

Overcoming methodological limitations

Although cognitive psychologists have made important advancements in the quantitative measurement of the phenomenological aspects of autobiographical memory using questionnaires (e.g., AMQ, MEQ), the qualitative measurement of memory content and retrieval context has received less attention. Autobiographical memories are rich, complex experiences and their content can vary dramatically from a general gist of a memory to almost reliving the experience when recalled. The qualitative analysis of memory content has received some methodological attention from self-narrative researchers, but cognitive psychologists and neuroscientists have tended to rely on simple categorical assignments or ratings by independent judges (e.g., TEMPau, AMI, AI). The use and development of qualitative data analysis techniques has recently increased considerably in psychology research (Madill & Gough, 2008). Future research should be conducted using these new qualitative analysis techniques and software for examining the content of autobiographical memories and the details of the retrieval context.

Many researchers rely on the self-selection of memories by participants and the validity of these memories cannot be verified. Creative approaches to this problem have involved using photos from friends and family members (Gilboa et al., 2004), random beepers (Brewer, 1988), and day-long videotapes of a participant's activities (Mendehlson et al., 2009). One recent technological development that has the potential for researchers to randomly sample real-world memory events is the wearable digital camera, such as Microsoft's SenseCam (see Figure 2.7). The camera is worn by the individual and is fitted with a wide-angle lens that maximizes the frontal field of view. A number of sensors are built into the camera (light, body temperature, accelerometer, color) and any changes in these sensors will cause the camera to take a shot. Hundreds of shots are taken in a day, and the shots can be easily downloaded to a computer. This camera may soon include GPS and audio recording functionality that would allow even more information about a personal experience to be captured. The SenseCam data could also be synchronized to a portable, mobile physiological recorder that records psychophysiological data during an event, such as heart rate (Schama, 2009). Berry et al. (2007) recently used the SenseCam as a retrospective memory aid to help improve the autobiographical memory of a brain damaged patient.

Brain scanning methodologies each have their strengths and limitations, and many researchers are now suggesting combining brain scanning techniques. One such example is combining EEG with fMRI. The EEG-fMRI methodology allows the researcher to take advantage of EEG's superior temporal resolution in combination with the better spatial resolution provided by fMRI recording. Currently, researchers are still working on ways to resolve some technological difficulties associated with this combined approach to brain scanning (Herrmann & Debener, 2008). However, more precise spatial-temporal pictures of brain activation during autobiographical memory retrieval should be available soon.

New methodological directions

One of the most interesting recent developments in the use of neuroscience tools is the use of magnetic stimulation of the brain by locating magnets near the surface of the head at specific locations. Repetitive transcranial magnetic stimulation (rTMS) can disrupt or enhance the underlying neural activity, although most memory researchers rely on its disruptive capabilities. The use of this technique simulates a temporary brain lesion and this allows researchers to examine the causal effects a lesion at specific locations of the brain can have on retrieving memories. The design of a rTMS experiment usually involves the inclusion of a sham condition so that the participant is unaware of when rTMS is being delivered. Participants can attempt to perform the cognitive task while receiving rTMS, or they can be tested during a small period of time after the rTMS has been delivered. No studies involving rTMS and autobiographical memory retrieval have been found by the author, but similar research has successfully examined the role of specific brain regions in episodic memory retrievals (e.g., Rossi et al., 2006). A recent study that simulated semantic dementia highlights the utility of rTMS for studying autobiographical memory loss (Pobric, Jeffries, & Ralph, 2007).

Much has been learnt about autobiographical memories from the case studies of brain damaged patients. Parker, Cahill, and McGaugh (2006) recently described the case of a special woman who does not suffer from autobiographical memory loss, but rather just the opposite; she cannot forget any personal experiences. The advent of the Internet and the resulting rapid expansion of the use of web-based social media will further increase the opportunities for researchers to find other "special" memory cases, as well as help collect archival data for autobiographical memory studies. For example, experimenters could test an individual's memory for their blog or twitter entries.

Some researchers have begun to develop laboratory-based procedures for collecting involuntary autobiographical memories. One experimental approach relies on the assumption that voluntary memory retrievals may elicit additional involuntary memory retrievals through the incidental spreading of activation across the memory system (Ball, 2007; Mace, 2006, 2007). The second approach relies on the assumption that involuntary memories are more likely when a participant is performing a mundane cognitive task that encourages a diffuse attention state in the participant (Schlagman & Kvavilashvili, 2008). A laboratory-based procedure for collecting involuntary memories allows researchers to experimentally manipulate factors that could influence involuntary memory retrievals. For example, Ball (2007) manipulated the attention state of the participants in his experiment by requiring them to perform two versions of a secondary task. The further development of a laboratory method for eliciting involuntary memories will also allow researchers to conduct brain scanning studies of involuntary autobiographical memory retrievals in the future.

Although the study of autobiographical memory was late in developing, considerable progress has been made. Contemporary theories of autobiographical memory are complex and multidimensional, and these theories imply that a distributed neural network is necessary for the encoding, storing, and retrieval of autobiographical memories (Conway & Pleydell-Pearce, 2000; Rubin, 2005). The converging findings from a variety of psychological and neuroscience methodologies are critical to such theoretical developments. It is an exciting time to be an autobiographical memory researcher because the multitude of methodological tools currently available will continue to grow in number and sophistication.

Figure 2.7 Microsoft's SenseCam (wearable digital camera) and some sample shots taken by camera as a function of sensor change elicited by the wearer's movement or background change.

Figure 2.7 (*Continued*)

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Part II

Theories and Reviews of Involuntary and Voluntary Remembering

3

Involuntary Remembering and Voluntary Remembering

How Different Are They?

John H. Mace

Introduction

Volition has been a defining characteristic of remembering ever since the era of Ebbinghaus. In the opening pages of his landmark text, Ebbinghaus (1964) aptly distinguished memories that spring to mind spontaneously from those that come to mind as a function of "will," thus defining categories of recall that autobiographical memory researchers more than a century later would typically call involuntary or voluntary memories and what researchers working in other domains (e.g., with word-list memory paradigms) might call involuntary or voluntary conscious, explicit, or aware memories (e.g., Berntsen, 1996, 2009; Conway & Pleydell-Pearce, 2000; Kinoshita, 2001; Mace, 2003a, 2003b, 2005a, 2007b; Richardson-Klavehn, Gardiner, & Java, 1996; Schacter, 1987).

This chapter compares involuntary remembering to voluntary remembering. It explores how these two forms of remembering may be different and how they may be the same. Given that there has not been a great deal of research directly comparing the retrieval processes of involuntary and voluntary remembering, the ideas expressed here do not rest on a large (or firm) empirical base, but it is nevertheless hoped that they will serve as a guide for future researchers. Although the focus is on autobiographical remembering (or autobiographical memory retrieval), some of the considerations might have applications to other areas where the involuntary/voluntary distinction is an issue.

The Act of Remembering: Toward an Understanding of How We Recall the Past.

Taxonomic Differences between Involuntary and Voluntary Forms of Remembering

At the broadest categorical level, autobiographical memory researchers have distinguished involuntary remembering from involuntary remembering on the basis of retrieval intention and use of retrieval strategies (e.g., Berntsen, 2009; Conway, 2005; Mace, 2007b). However, involuntary remembering appears to have retrieval subcategories which do not exist in voluntary remembering. Elsewhere (Mace, 2007a, 2007b), I've argued that involuntary remembering can be separated into three categories: *direct involuntary remembering* (after Conway & Pleydell-Pearce's [2000] term *direct retrieval*), *chained involuntary remembering*, and *traumatic involuntary remembering*.

In the first instance, direct involuntary remembering refers to everyday situations in which cues in one's environment, for example, lead to memories of the past (e.g., Berntsen, 1996, 1998). This type of involuntary remembering is probably the most common, the most familiar, and most of us probably envision this form of it when discussing involuntary memories. In contrast, chained involuntary remembering is probably both less common and less familiar. Here, involuntary memories appear to be triggered by other involuntary memories or voluntary memories (e.g., Mace, 2005b, 2006). For example, when subjects report the occurrence of an involuntary memory in naturalistic diary studies, occasionally they report that such memory immediately leads to the production of another involuntary memory, which may in turn produce another and so forth until the process appears to terminate (e.g., Mace, 2005b, 2007a). The third instance (or category) of involuntary remembering involves the production of traumatic memories. In this retrieval instance, individuals experience traumatic involuntary memories concerning some past traumatic experience. These memories occur repetitively and this type of involuntary remembering is a defining characteristic (or central feature) of post-traumatic stress disorder.

It seems reasonable to ask if these divisions in involuntary remembering are merely the constructions of theorists or real natural categories, and if so, what causes the lines of delineation. There appears to be good reasons for believing that they are real categories, at the very least phenomenological categories, but the causes of the divisions remain to be seen.

Considering the categorization question first, as may be apparent from the foregoing discussion, it appears that these differences are natural categories as opposed to theoretical ones. Even at their most superficial levels, they appear to be different instances of remembering. In the case of direct involuntary recall, isolated cues in one's external or internal environment cause involuntary memories, while quite differently, memories appear to cause other memories in the case of chained involuntary recall. In the third category, traumatic and repetitive involuntary memories occur as a direct result of a traumatic experience. Thus, on this basis alone, they appear to warrant separation and study if for no other reason to uncover their specific functions or dysfunctions.

Concerning the question of underlying causes of the divisions, as mentioned, this is an open question. It is possible that these differences might reflect different underlying retrieval processes, or different categories of the same underlying process. For example, some traumatic involuntary memory theorists believe that different retrieval processes and mechanisms may separate normal, everyday involuntary remembering from traumatic involuntary remembering (e.g., Steel & Holmes, 2007; Krans, Woud, Näring, Becker, & Holmes, chapter 13, this volume). Involuntary memory chaining might have a retrieval basis different from direct involuntary remembering, but it is perhaps more likely that these different instances of involuntary memory production are characterized by different types of spreading activation processes (e.g., one representing spreads within the autobiographical memory system, the other representing spreads from other memory systems on many occasions: see Mace, chapter 8, this volume).

Functional Comparisons of Involuntary and Voluntary Remembering

Functional accounts of autobiographical memory have postulated three separate purposes for this memory system: directive (helping to guide future behavior), social (enhancing social cohesion among individuals), and self functions (helping to facilitate and maintain conceptualizations of the self) (see Baddeley, 1988; Conway, 1996, 2005; Bluck & Alea, 2002). While there has been little work done in the area of function with involuntary memories, one study has suggested that they may have functions which in many ways overlap with these three functions (Mace & Atkinson, 2009). It makes sense that involuntary remembering and voluntary remembering would have the same or overlapping functions, as both should be serving the larger purposes of autobiographical memory (for a more in-depth treatment of the functions of autobiographical remembering, see Bluck, Alea, & Demiray, chapter 12, this volume). However, involuntary remembering may have unique functions that voluntary remembering could not logically have.

Involuntary memory chaining, which results from voluntary memories, is a good case in point. Mace (2006) demonstrated that involuntary memory chains resulted from memories produced voluntarily on an autobiographical memory task. As virtually all of these memories were related to the targets of voluntary recall, Mace (2007a) argued that involuntary memory chaining may naturally be functional to voluntary recall, as chaining appears to be expanding the process of remembering by bringing memories to mind that had some relationship with the targets of recall. Another special function of involuntary remembering may occur when involuntary memories experienced in everyday life cause one to engage in voluntary recall. That is, frequently the experience of an involuntary memory may cause one to engage in the voluntary remembering process by elaborating further on a memory in potentially all sorts of ways (Baars, Ramamurthy, & Franklin, 2007). In this regard, involuntary remembering could be seen as serving the purpose of jump starting the voluntary remembering process, prompting one to think more about a particular situation or remember more about a particular past event. In a more traditional sense, one could look at involuntary memories as early warning devices that on occasion may signal a potential danger (e.g., Mace & Atkinson, 2009).

Comparing the Memories Generated from Involuntary and Voluntary Remembering

In attempting to predict whether involuntary and voluntary retrieval processes would produce memories with similar or different characteristics, one comes up with two conflicting answers. On the one hand, there is good reason to believe that different types of memories might be produced by involuntary and voluntary retrieval processes, as the latter should include generative/constructive processes (e.g., Conway, 2005) which might influence, bias, or add to the memory production process in some way. On the other hand, there is good reason to believe that the two retrieval processes may produce the same or similar memories as they are likely to be sampling the same autobiographical memory base. Although some differences have been reported, commonalities appear to be the trend (for a more extensive review of differences and similarities, see Berntsen, 2009).

The most consistent difference to emerge involves specific versus general memory production (i.e., memories of specific episodes, such as "sitting on the banks of the River Thames last summer," versus extended or more abstract memories, such as "my trip to London last summer"). Involuntary memories collected via naturalistic diary techniques (a method requiring subjects to record their involuntary memories as they occur in everyday life) are more likely to pertain to specific episodes than voluntary memories collected via cue-word or cue-phrase techniques (e.g., Berntsen, 1998; Mace, Atkinson, Moeckel, & Torres, in press; for more on laboratory and diary recording methods, see Ball, chapter 2, this volume). While we do not as yet understand this difference, one possible explanation is that it may simply owe to the unique (or relatively specific) cuing circumstances surrounding everyday involuntary memory recall (e.g., involuntary memories are the relatively rare circumstances where the contents of cues overlap with the contents of memories).

Another possible difference between involuntary and voluntary memories can be found when the event-cuing procedure is compared to involuntary memory chaining. In event cuing, subjects first produce a memory in response to a cue word or phrase, and then they are asked to recall a memory related to it (e.g., Brown, 2005). When these memories are compared to involuntary memory chains, general-event associations (i.e., memories connected to the same general event) occur at a much higher rate than conceptual associations (i.e., memories unconnected by a general event or other temporal connections, but instead connected by common content, e.g., same people or activities), which are the dominant form in involuntary memory chains (see Mace, 2006; for a review, see Mace, 2007a). The dissociation produced by these two memory sequencing phenomena might represent an interesting retrieval difference; however, there is also good reason to believe that it might be the result of biases inherent in the event-cuing procedure (Mace, Martin & Clevinger, 2009; for a more detailed review of the possibilities, see Talarico & Mace, chapter 5, this volume).

Turning to similarities, although initially the results were conflicting (e.g., Berntsen, 1998; Berntsen & Hall, 2004; and more recently Mace et al., in press), involuntary memories and voluntary memories appear to have the same emotional valence (see a detailed review in Berntsen, 2009). Subjects also equate involuntary and voluntary memories on vividness scales, and they feel as confident about the details of their involuntary memories as they do about their voluntary memories, rating both equally on a confidence scale (Mace et al., in press). Confidence judgments proved to be more than just subjective impressions, as corroborates (individuals who were also present in a subject's memory) had independently judged the details of subjects' involuntary and voluntary memories with equal confidence on the same scale. The Mace et al. (in press) study also showed that both involuntary and voluntary memories come with the same proportions of field (original point of view in the event) and observer (third party point of view) perspectives, and both forms of memories also showed equal and significant declines in the field perspective (or increases in the observer perspective) as the memories pertained to more remote time periods (for further discussion and original findings on memory perspective, see Nigro & Neisser, 1983; Robinson & Swanson, 1993, and also, Rice, chapter 10, this volume).

Another set of similarities concerns the age of memories produced via involuntary and voluntary retrieval processes. The reminiscence bump (i.e., a spike in memories from ages 15 to 25 in the recall protocols of older adults, e.g., Rubin, Wetzler, & Nebes, 1986), has been shown to occur with everyday involuntary memories in the same way that it manifests itself in voluntary memory production (Berntsen & Rubin, 2002; Schlagman, Kvavilashvili, & Schulz, 2007). The same study that provided accuracy data (Mace et al., in press) also showed that involuntary memories and voluntary memories were equal in age (on average pertaining to events four years old), and maintained similarities in other dimensions as the memories pertained to more remote periods.

Thus, there appears to be more similarities than differences in the memories produced by involuntary and voluntary retrieval processes. These similarities may occur only because both processes sample the same memory system, and therefore it may not be prudent to draw the inference that the two are driven by the same underlying retrieval mechanisms as well. Further, although I've not reviewed all of the dissociative findings, most of the remaining differences reported in the literature pertain to effects that memories have on the individual, and not necessarily on differences in the memories produced. For example, in comparison to voluntary memories, involuntary memories appear to have greater emotional/physical impact on individuals (e.g., Berntsen & Hall, 2004; but see Mace et al., in press, where emotional impact differences were not obtained). Additionally, older involuntary memories appear to have a greater sense of "being brought back" than older voluntary memories (Mace et al., in press). Dissociations like these may be expected with some variables as they may be caused by the unexpected nature of involuntary memories (i.e., prompted by their novelty or surprise). For these reasons, we probably cannot (and should not) draw inferences about possible differences between involuntary and voluntary memories, as these effects appear to occur after retrieval has taken place.

Comparing Involuntary Remembering to Voluntary Remembering

Involuntary and voluntary remembering are clearly delineated on the basis that memories are self-generated in one (e.g., in response to a query to remember a particular event), while they are generated unintentionally by cognitive processes in the other (i.e., by the stream of thought or perception, or even the process of remembering). Thus, by some means, we generate a sought after memory, or a memory is produced by the flow of some sort of cognitive activity (e.g., internally or externally experienced cues in the stream of thought). In this section, we'll attempt to understand these forms of remembering along two major lines: (1) the retrieval processes underlying them, and (2) their relationship with conscious processes, particularly volition or retrieval intentionality.

Retrieval processes

Voluntary remembering is generally conceived as a top-down, conceptually driven process, where one either uses a strategy (such as hierarchical memory searches) to bring a memory to mind or a simple query causes it ("What did you do last New Year's eve?"). The strategy that one chooses may be of one's own making (i.e., any number of different idiosyncratic strategies), or it may involve the more organized hierarchically driven strategy (i.e., beginning at the level of a lifetime period, moving to the general event memory level, and then culminating in a sought after specific memory, e.g., see Conway & Pleydell-Pearce, 2000; Conway & Loveday, chapter 4, this volume; and empirical support in Haque & Conway, 2001). While involuntary remembering should lack the use of mental strategies, it, too, appears to involve top-down, conceptually driven processes. Many of the cues that trigger everyday involuntary memories are abstract, such as utterances, words appearing in print, or thoughts (e.g., Mace, 2004, 2005b; Schlagman, Kvavilashvili, & Schulz, 2007). And, many of the cues which might be classified as more perceptual (or less abstract) in nature appear to have conceptual connections to the involuntary memories that they elicit (Schlagman et al., see review in Ball, Mace, & Corona, 2007). Although it might be argued that involuntary remembering involves bottom-up type retrieval processes (e.g., spreads from sensory systems to the autobiographical memory system), perhaps distinguishing it from voluntary remembering, basic sensory cues rarely trigger involuntary memories (e.g., Mace, 2004; see additional discussions on the characteristics of involuntary memory cues in Ball et al.; Berntsen, 2007, 2009). Further, these types of cues can also be used to elicit voluntary memories in the laboratory (e.g., Herz & Schooler, 2002), and while we don't have much data on voluntary remembering in everyday life, one would imagine that rememberers rarely select sensory cues as a means to recall past experiences. Thus, sensory cues seem to be unlikely pathways to memories in both involuntary and voluntary remembering.

Although we may broadly classify each instance of remembering as top down, each may represent very different types of top-down processes. For example, involuntary remembering may frequently involve top-down spreads from generic memory systems (i.e., noncontextual systems like semantic memory) to autobiographical memory (see more in Mace, chapter 8, this volume). On the other hand, voluntary remembering may almost always involve top-down processes occurring within the autobiographical memory system. Different retrieval or cue elaboration strategies in voluntary remembering could involve different types of top-down processes, and as a whole this may entail very different involvements of working memory (Baddeley, 1987, 2007), which may make for further differentiation.

For example, cue elaboration strategies (i.e., the strategies that one may use to construct a memory in response to a cue word on an autobiographical memory task or in everyday contexts, e.g., "When was the last time you went to a concert?") could vary considerably. In Conway's generative retrieval, hierarchical searches (outlined above) are directed by the working self

(Conway, 2005). Other types of retrieval strategies (i.e., any number of idiosyncratic forms which may differ from hierarchical retrieval) could involve different forms of top-down processes where different mental pathways are followed. Each of these different retrieval strategies may engage different aspects of working memory (i.e., the working self versus more generic working memory mechanisms).

In the case of involuntary remembering, if working memory is involved at all, its involvement is likely to be very different from its involvement in the voluntary remembering process. For example, working memory mechanisms may prevent involuntary memories from entering consciousness when they are irrelevant to or disruptive to task goals (Conway & Pleydell-Pearce, 2000). Such mechanisms may need to be in place as autobiographical memories, according to Conway, may be developing all the time in the background (e.g., Conway & Pleydell-Pearce, 2000; and more on the working self in Conway, 2005). There is some evidence in support of this view. Diary studies of involuntary memories show that they are more likely to occur in relaxed states of attention rather than focused states of attention (e.g., Berntsen, 1998; see more discussion in Berntsen, 2009). Using a variety of laboratory techniques, Ball and Hennessey (2009) present evidence in strong support of Conway's view on inhibition (see their study and further discussion in Mace, chapter 8, this volume).

All of this discussion, then, suggests that while involuntary and voluntary remembering can both be described as involving top-down retrieval, there may be vast differences in the kinds of top-down processes involved within and between them. This is likely to enrich the theoretical landscape in the future as we get closer to understanding these two retrieval processes.

Awareness and intentionality

With respect to the information available to consciousness, involuntary remembering and voluntary remembering appear to be roughly equivalent. Rememberers appear to be aware of the strategies that these use to bring memories to mind (e.g., Conway, 1996; Haque & Conway, 2001) and the cues that are likely to be responsible for bringing memories to mind spontaneously, as evidenced by diary reports (e.g., Ball & Little, 2006; Berntsen, 1996; Kvavilashvili & Mandler, 2004; Mace, 2004; Schlagman, Schulz, & Kvavilashvili, 2006). We also appear to be aware of our unawareness, that is, the parts of the recall process that are unconscious and unavailable to introspection (see more discussion on the phenomenological characteristics of remembering in Conway, 2007). The memories that are produced by either involuntary or voluntary recall processes appear to be of equal clarity, rememberers have the same perspectives (i.e., field or observer) in both, and so forth, as a good part of the data reviewed in an earlier section has indicated.

However, despite having the same conscious (or mental) properties, these two forms of remembering are clearly separated along an intentionality continuum. While intentionality is clearly at the heart of the distinction, it is also at the same time the murkiest part of it, as it is probably based more on beliefs about our own introspective experiences than on a firm empirical evidence base. Similar to other areas of cognition where intentional and unintentional processes were part of the focus, the basic problem lies in determining what constitutes a voluntary process and what constitutes an involuntary process. In general, there appears to be two broad schools of thought: one which prefers broader definitions of voluntary processes and narrower definitions of involuntary processes, and one which sees it exactly the other way round, with broader definitions of involuntary processes and narrower definitions of voluntary processes. My own view on the topic is a preference for the latter school of thought. And, while I sketch out this position below, I remind the reader that there is currently no sure way of testing this position (or any others) empirically. Thus, in the purest sense of the word, these views represent conjecture on my part (or anyone else's) at this point in time, though I believe most of them will ring true for many.

First, with respect to involuntary remembering, I believe that all of the processes described under this label (i.e., everyday involuntary memories triggered by cognitive processes, involuntary memory chaining, and traumatic involuntary remembering) are "purely" involuntary in that they are largely uncontrollable acts of cognition. This belief essentially rests on the broader belief that cognition is largely an involuntary, automatic, and oftentimes unconscious act (Reber, 1993; Wegner, 2002), and therefore it may be easier to identify involuntary acts than voluntary acts, though this could be debated. In contrast to this, voluntary remembering involves relatively intentional or controllable acts of recall. However, the emphasis here is on *relative*. That is, even when one believes that an act is voluntary, even introspection should lead one to the belief that most of this is uncontrollable or involuntary. For example, memories can spring to mind spontaneously and immediately upon the mere perception of a query (e.g., someone asking "When was the last time it snowed on Thanksgiving?"), or some other cue or situation that might signal that remembering should begin, without any additional mental actions, such as engaging in some sort of strategic "search" process. Acts of remembering like these might be considered weakly voluntary in comparison to others, shifting them towards instances of involuntary remembering. Stronger labels may be used for the more deliberate turning of attention towards the process of remembering, engaging in a specific mental strategy, and maintaining the focus on it or changing the strategy until a memory finally comes to mind. But even among these processes we might argue that there are gradations of deliberation, as sometimes the strategy is only to keep thinking about the problem. Whether the processes are given strong or weak labels with

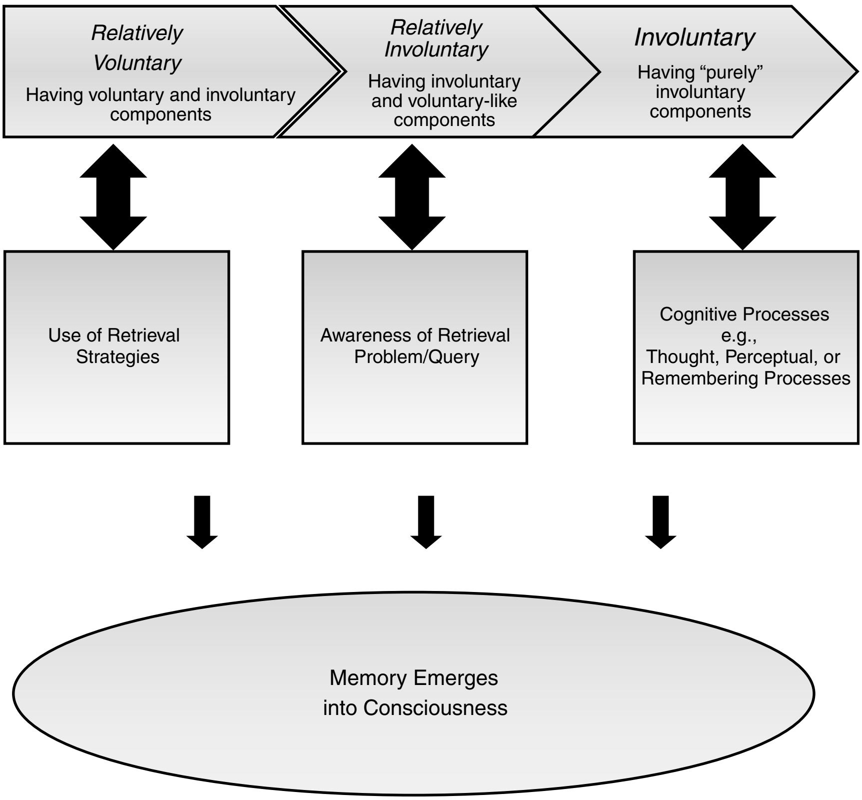

Figure 3.1 Intentionality continuum for voluntary and involuntary retrieval.

respect to volition, it appears that all other processes associated with the act of voluntary remembering are involuntary (i.e., the retrieval processes, including the memories produced and their contents). Thus, one could argue from many different perspectives that most of what goes on in voluntary remembering is involuntary.

Figure 3.1 outlines a categorization schema for involuntary and voluntary remembering along an intentionality continuum. As may be clear from the argument above, the categorical schema places a heavy emphasis on involuntary remembering processes, with a narrowing of intentionality, shifting it towards the unintentional end of the continuum. The weaker cases of volition (i.e., when the mere awareness of a query produces a memory) might be defined as instances of involuntary remembering or quasi-voluntary recall, further down the continuum toward the involuntary end. And, once again, although it cannot be stated that this labeling rests on empirical evidence, this categorical schema may prove useful to future research which attempts to delineate the different forms, even if it is only used to refute the positions contained therein or otherwise refine them.

Conclusion

This chapter has asked how different involuntary remembering is from voluntary remembering, and the answer appears to be "not that much" and "very much." Both in terms of awareness and in terms of the quality and content of the memories involved, involuntary and voluntary remembering appear to be very much alike or the same. But as noted, this may simply be because they sample the same memory system. However, there probably are differences (and perhaps many) in the types of retrieval processes that underlie them. Another dividing line separating them is intention. I have presented a voluntary-involuntary schema with the goal of drawing attention to the notion that there may levels of "volition," ranging from relatively voluntary to relatively involuntary. In terms of functions, the case for differences also appears to be strong, with involuntary remembering serving some roles that voluntary remembering could not serve, though the two should have overlapping or the same functions as well. Overall, then, it appears that involuntary remembering and voluntary remembering is a robust distinction.

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4

Accessing Autobiographical Memories

Martin A. Conway and Catherine Loveday

Intentionally retrieving memories is an effortful cognitive process that takes seconds (a long time in neural processing terms) and sometimes 10s of seconds (Haque & Conway, 2001). Intentional recall can be faster especially if the memory system is in *retrieval mode* (Tulving, 1983, 2002). For instance, during an extended conversation with another about a shared experience, memories may be primed and the retrieval processes highly active, leading to faster retrieval of memories. Nonetheless, compared to many other cognitive processes, such as lexical or conceptual processing, the recall of autobiographical memories is comparatively slow: why? Here we argue that this is because memories are *generated* from an underlying knowledge base and are *constructed* in consciousness. The sections that follow outline how the generation process takes place and what its cognitive and neural basis may be. We also describe a new patient who apparently cannot use generative retrieval but who, nonetheless, when provided with effective cues can directly access memories she could not otherwise bring to consciousness. First, however, we consider some wider aspects of memory generation.

Accessing Information in Long-Term Memory

An important principle is that of *encoding specificity* (Tulving & Thompson, 1973). Encoding specificity simply states that in order to access a memory there must be some information in the search process that corresponds to or

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which indexes information in the sought-for memory. We will refer to this as the *cue*. The effect of a cue is to cause activation in long-term memory of some specific item of knowledge. Activation then spreads to representations associated with the cue-activated item and as it spreads it dissipates (Collins & Loftus, 1975). The process of cue-activation and subsequent spread of activation is not within conscious control. It follows from this that in a fundamental sense all memory is involuntary. The information a cue makes available to consciousness may be what was expected, what was searched for, or it may not. What controls cue-activation is not known, although encoding specificity is obviously important. What can, however, be consciously and intentionally controlled is the process of cue-generation and cue-elaboration and, as we describe below, this can be used to channel activation through knowledge structures in long-term memory.

A further important distinction is that between availability and accessibility (Tulving & Pearlstone, 1966). At any given time there are a number of memories that are available and which could be accessed with an effective cue. An effective cue might emerge in the process of what we have called *generative retrieval* (Conway, 1993, 1996, 2005, 2009; Conway & Pleydell-Pearce, 2000; Conway & Piolino, 2009; Conway & Rubin, 1993; see also Moscovitch, 1995). Generative retrieval features the intentional, effortful construction of a memory in consciousness. This may involve an iterative retrieval process of cue-elaboration in which a cue is used to activate knowledge in long-term memory and the knowledge it activates is then used to elaborate and shape the cue for a further cycle of knowledge access. This procedure is iterated though until the sought-for memory is accessed or generative retrieval fails. Generative retrieval ends with what we term *direct retrieval*, that is, a cue emerges that accesses, by encoding specificity, the sought-for knowledge. Importantly, direct retrieval can occur independently of generative retrieval, but generative retrieval, when successful, always ends in direct retrieval. Generative retrieval is driven and modulated by executive control processes (often associated with activation in the left hemisphere prefrontal cortex, PFC; Cabeza & St Jacques, 2007), whereas direct retrieval occurs during knowledge access in networks in the temporal lobes and posterior regions of the brain, sometimes bilaterally and sometimes predominantly in the right hemisphere.

Direct retrieval must underlie involuntary recollection in which a cue, endogenous (e.g., an emotion) or external (e.g., something in the environment), directly activates episodic memories and related conceptual knowledge (Conway, 2005). Indeed, we have argued that the autobiographical knowledge base in long-term memory is exquisitely sensitive to cues and representations in it are probably being activated continuously during periods of wakefulness. The reason that cognition is not incapacitated by what would be floods of memories is that control processes act to keep task-irrelevant or task-neutral activated knowledge out of consciousness. Indeed, it might be the case that a general mechanism sets some comparatively high threshold of activation that has to be exceeded for memories and/or knowledge to enter a state in which they might potentially be included in conscious awareness. It is perhaps at this point that they attract intervention by control processes that then act to facilitate their incorporation into current processing and possibly consciousness or which act to keep them out of current processing and conscious awareness. It might be noted that in facilitating the integration of activated knowledge with current processing, control process must inhibit other activated and competing memories/knowledge (Racsmany & Conway, 2006). Thus, accessibility can be controlled in several ways by control processes. Availability, on the other hand, is determined by direct retrieval and cue effectiveness, which in turn is a more automatic process occurring outside executive control and outside conscious awareness.

Memory Representations

An autobiographical memory is a mental construction or pattern of activation (and inhibition) across knowledge structures in long-term memory. One recent account proposes that such knowledge structures can be highly specific sensory-perceptual-affective-conceptual (SPAC) experience-near representations (Conway, 2009). Or they can be more abstract conceptual representations of personal knowledge of ourselves, our history, and history of the time in which we live. According to this scheme, there are three types of highly specific representations of experience: *episodic elements* (EEs), *simple episodic memories* (SEMs), and *complex episodic memories* (CEMs).

Episodic elements are the most event-specific, most experience-near representations in long-term memory. They are often in the form of visual images and most of all they represent moments of experience or summaries of moments of experience, particularly and perhaps exclusively moments of conscious experience (see Moscovitch, 1995). Thus, the SPAC information that EEs contain is not a literal record of previous online processing but rather a summary of it. Importantly, EEs are usually in a *frame*. A frame is conceived of as conceptual contextualizing knowledge that organizes either a single EE or more usually a set of EEs. Thus, an EE plus conceptual context is a *simple episodic memory*. According to this view, there are two ways to access a SEM, either by a cue that corresponds in some way to the content of EEs or by a cue that accesses the frame. Intentional access of a SEM will usually be through the frame, incidental access usually through EEs, although given an effective cue, access intentionally or incidentally could be through either type of episodic knowledge or both in parallel.

The conceptual frame provides an interpretation of the EEs. An interpretation locates the EEs in a person's life and gives personal meaning to them. Because of this the conceptual frame is viewed as originating from conceptual processing systems in fronto-temporal regions of the brain. Episodic elements are viewed as the product of temporo-occipital-parietal networks. Some intriguing evidence suggests that EEs may be stored in these more posterior regions and conceptual frames in the more anterior networks. It has been found, for example, that patients with damage to posterior regions who lose the ability to generate visual images may as a secondary consequence develop amnesia in which general personal conceptual knowledge is retained while access to EEs is lost (Conway, 1996; Conway & Fthenaki, 2000; Rubin & Greenberg, 1998). Amnesia resulting from other types of brain injury (e.g., to limbic system structures) may also lead to the loss of access to EEs with preservation of access to some general personal knowledge. Taken together, these data suggest that SEMs are distributed in fairly complex ways over anterior-posterior memory networks – a finding further supported by many neuroimaging studies (for a review, see Cabeza & St Jacques, 2007).

One important property of SEMs is that they represent comparatively short time slices and any SEM will only feature a limited number of EEs. Memory for experience is, however, more complicated than this and consequently SEMs themselves may be organized into *complex episodic memories* or CEMs. Complex episodic memories consist of one or more SEMs associated with a common higher order conceptual frame. Thus, an everyday event such as a *day at work* will be represented by several SEMs, for example, images of a project meeting, talking with colleagues at coffee, organizing a meeting, lunch, etc. Episodic memory as a memory system contains then a variety of representations. Very specific representations of moments of experience, EEs, are records of SPAC processing that featured in an experience (Racsmany & Conway 2006). These EEs may be summary or representative samples of experience. For instance, a person who studied a categorized list of words might subsequently retain some summary information, *some of the words named fruits*, and perhaps the activation levels of the names of specific fruits would in the EE be determined by processes occurring during study. Added to this might be the conceptual frame *studying words I have to remember* and the EE with frame would then form a SEM. Several SEMs associated with this experience might have been constructed, possibly related to points in goal processing (e.g, switching from learning to remembering), and these might be associated with a common higher order conceptual frame or CEM, which in this example might be *when I was in the memory experiment*.

The foregoing discussion presented what is essentially an encoding account of the formation of episodic memories and there can be no doubt that encoding and the environment in which it takes place is critical to the

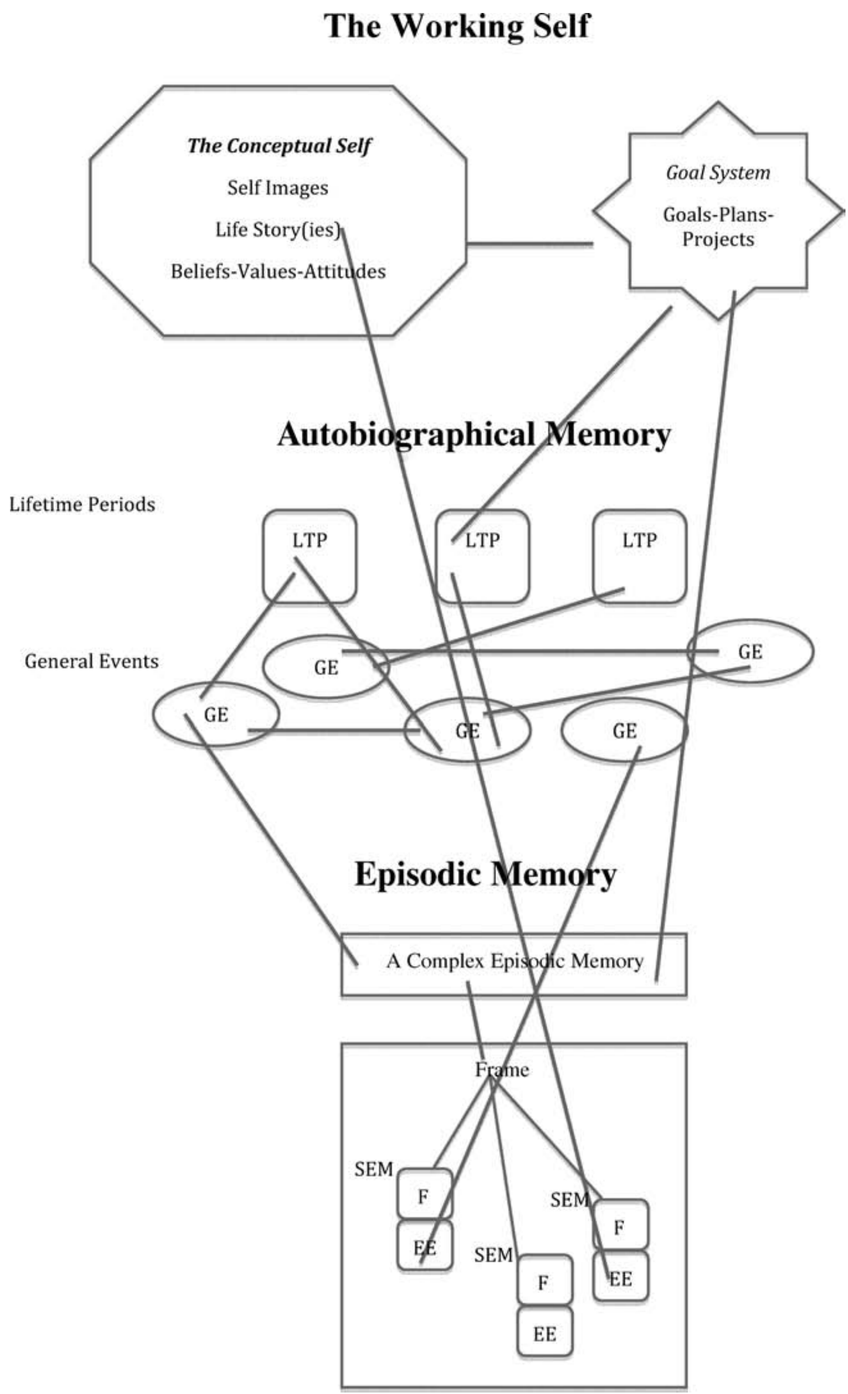

Figure 4.1 The structure of autobiographical knowledge (after Conway, 2005, Figure 2, cited with permission).

formation of episodic memories – after all, this is just what anterograde amnesics cannot do. Nonetheless, retrieval too may help shape episodic memories and influence their integration with long-term autobiographical memory knowledge structures. Accessing SEMs and CEMs may raise their accessibility and accessing their content may act to make some details more accessible than others. Another consequence of accessing some EEs in, for example, a SEM may be (episodic) inhibition of associated EEs that compete for retrieval and in this way a pattern of activation/inhibition over the content of a SEM may be shaped by retrieval/rehearsal. The same process of episodic inhibition could, of course, function at higher levels, making some SEMs, CEMs, and other autobiographical knowledge structures differentially accessible. Racsmany and Conway (2006) propose that over time the pattern of activation in a SEM becomes fixed and difficult to change. A potent cue corresponding to some aspect of an EE in a SEM might overcome lowered accessibility and lead to what might be termed a "Proustian moment" of, possibly, involuntary recall. In general, however, as the retention interval lengthens and as selective rehearsal continues, driven by the stable pattern of activation/inhibition over the contents of a SEM or CEM, the probability of finding a sufficiently specific cue, one that could perhaps reinstate some previous processing state, decreases, even possibly to asymptotic levels. By this view, although some – maybe many – EEs and other types of knowledge become in effect inaccessible, they are not lost from long-term memory and remain, in theory at least, available. The effects of retrieval, whether generative or direct, especially repeated retrieval (rehearsal), are to shape episodic memory and autobiographical knowledge into patterns of accessibility, ranging from the highly accessible to the inaccessible (but still available).

Episodic knowledge has also, however, to become integrated with autobiographical knowledge if intentionally driven access to it is to be established and subsequently maintained. Episodic knowledge that does not become integrated can only be accessed by a cue that corresponds in some way to the content or features of the episodic knowledge (e.g., a cue that maps onto the content of an EE). Figure 4.1 illustrates the integration of episodic memory with autobiographical memory and the self (for a more detailed overview of this model, see Conway, 2005; see also Conway & Pleydell-Pearce, 2000; Conway, Singer, & Tagini, 2004; for related views on the integration of memory and the self, see Rosenbaum, McKinnon, Levine, & Moscovitch, 2004; Levine et al., 1998). The central idea behind Figure 4.1 is that autobiographical knowledge (depicted under the title "autobiographical memory") forms the conceptual context for episodic memories, while the conceptual self forms the conceptual context for autobiographical knowledge. These knowledge domains are hierarchical and nested within each other by "part-of" relations. A SEM is part of a CEM, which is part of a general event, which is part of a lifetime period, which is part of the conceptual self. Knowledge structures in the autobiographical knowledge base are *partonomic knowledge hierarchies* (Barsalou, 1988; Conway & Bekerian, 1987). There are two principal forms of access to representations in this system: either by activation traversing the part-of indices of the autobiographical knowledge structures or by a cue directly activating the content of a representation (generative and direct access – Conway, 1993, 1996; Moscovitch, 1995).

Also in Figure 4.1 is a depiction of the goal system. Conway, Singer, and Tagini (2004) review this aspect of the autobiographical memory framework in detail. The goal system is considered to influence all aspects of autobiographical memory (especially retrieval) and indeed autobiographical memory as a whole can be thought of as a record of the goal system and a basis for further goal generation. Episodic memories (SEMs and CEMs) are initially a record of short-term goal processing or rather the effects or outcomes of short-term goal processing. As consolidation takes place, perhaps in part stimulated by retrieval, some episodic memories become integrated with autobiographical memory knowledge structures and access to them then becomes long term. Autobiographical memory knowledge structures are essentially about long-term goals and they provide a basis for the generation of coherent long-term goals and plans, goals and plans that extend beyond a few days. Episodic memories are particularly important because they provide the most specific evidence (images derived from experience) about recent goal processing and because of this specificity they can constrain and channel subsequent goals. A specific visual image of sending off a recently completed piece of writing may be part of the complex long-term goal of *writing a book*. This image provides the evidence, the data, that certain sub-goals have been completed or satisfied.

Retrieval takes place in this complex system as cues drive patterns of activation and inhibition. Control/executive processes gate access to activated representations and determine which states can enter consciousness. Note that, because in this model control processes cannot directly influence the spread of patterns of activation-inhibition in long-term memory knowledge structures, such patterns can nonetheless influence processing nonconsciously. Control processes can only influence which cues are to be elaborated in the cycles of generative retrieval, however, once an effective cue has entered the processing sequence, then the knowledge that then becomes potentially available to consciousness is determined solely by the effect of the cue and not by control process. On the other hand, whatever memory details eventually enter consciousnesses is, of course, modulated by control processes. This raises an interesting possibility: what if the control of retrieval was impaired such that what entered conscious could not be controlled? What would then emerge from accessed SEMs and CEMs?

Uncontrolled Direct Retrieval: A Case Study

CR is a 47-year-old mother of four who, at the age of 44, suffered a severe case of Herpes Simplex Viral Encephalitis, leaving her with significant damage to the right side of her brain, including a large portion of the medial temporal lobe extending to the fusiform gyrus, basal ganglia, the insula, and the inferior frontal lobe. CR has a profound amnesia for her 20s, 30s, and early 40s, to the extent that she is unable to recall anything about the birth or development of any of her children (Loveday & Conway, 2009). In addition she demonstrates a lesser but still significant level of amnesia for her childhood and adolescence. For example, she has relatively good personal knowledge about this time, but while she is able to recall some specific autobiographical memories, many of these appear to be well-learned stories. Those that do have the qualities of a more genuine autobiographical memory tend not to be generated spontaneously or in response to general cues, but rather they are prompted by highly specific cues. In fact, CR's family describe this period of her memory as a locked vault that can be opened but only through prompting with very specific triggers. Importantly, when these memories are accessed, they are rich in episodic SPAC details.

In terms of her current functioning, formal testing reveals that CR is of high average intelligence, with good short-term and working memory and with executive functioning that lies within the normal range. However, she shows some impairment on any recall that extends to 30 minutes or more and a very unreliable and inconsistent memory for anything that is more than three days old. For example, when asked to recall details of her son's birthday six days previously, CR stated:

> Oh well, I really can't remember very much about it . . . erm . . . I think he was around but not awake at lunchtime – I don't think he got up until later on in the afternoon. Erm . . . but I really can't remember now.

And likewise, when asked to remember an evening she had spent with her in-laws seven days earlier, she said:

> Yes – I think I had a nice time with them – yes. Erm . . . but what specifically happened – if anything – I'm not sure. I'm just trying to visualize the house and think about erm . . . perhaps I more than likely helped L in the kitchen. Erm . . . if I went for the evening I think perhaps we had all – we'd have sorted tea so it wasn't a teatime evening – I don't know perhaps we all had a glass of wine – I'm not sure. Erm . . . oh I can't be sure what happened at all – whether we sat in their new sitting room or . . . I can't visualize myself playing with the children anything in particular. Or talking to J or anything. Oh dear.

Formal assessment of her recent autobiographical memory for events of the preceding week revealed that vividness ratings and level of detail fell dramatically after three days, with the exception of very emotional, highly rehearsed events. In contrast, when CR is cued to recall a specific and discrete event from three days ago, she is able to provide a good level of detail, although this is effortful and it is interesting to note how she uses her general knowledge to construct what she believes must have happened and correct herself as she works through her memory:

> So I picked up B and E and went up to the house. We walked up – I think. Erm . . . yes I think we did 'cos I didn't need the car. No – we didn't – we drove up thinking that if it took a long time helping unload and what have you then I would at least have the car there because I had to fetch the children from the school bus stop later. Yes – so one of the things I actually did do, having parked a bit later on in the morning, was move the car because I thought when the removal van came it might block me in. So, no, I did drive up there and B and E and I went to the home, opened the front door with the keys quite happily and went in. And . . . oh . . . and one of the things that I had done when I went to get the keys in Market Deeping – which I forgot to say just now – was I had walked back through past the florist and bought a nice bunch of flowers – some roses and erm . . . other little pink and purple – freesias. And I'd also spoken to the lady there about some flowers for the Golden Wedding Anniversaries coming up next week before I left. So actually what I also did when I picked up B and E was pick up a vase because I knew that one wouldn't be unpacked and I wanted the flowers to be ready when L and J arrived as a bunch of flowers. And the other thing I bought when I was in Market Deeping in a little shop was a nice "new home" card.

What is striking about CR is the dramatic contrast between the good level of detail she can provide for her very recent memories and the complete blank she draws when asked to recall something older than a few days. Importantly, this demonstrates that CR can create new memories, unlike many anterograde amnesics, but fairly rapidly over a period of about 72 hours loses access to them. We believe that this reflects a consolidation problem in which SEMs and CEMs fail to become integrated with long-term knowledge structures (see Figure 4.1). Thus, she can recall some general aspects of events older than three days but rarely accesses SPAC episodic details and, instead, infers what most probably would have taken place. One possibility is that the large right hemisphere (RH) lesion may have compromised consolidation processes critical for later generative retrieval. By this view, left hemisphere (LH) encoding processes remain functional and temporarily maintain access to recently formed SEMs & CEMs (Nyberg, Cabeza, & Tulving, 1996). As the process of consolidation proceeds, perhaps during periods of sleep following the initial formation of

SEMs and CEMs (Racsmany, Conway, & Demeter, 2009), integration of these via RH neural networks that would link them into the pre-existing knowledge structures is not successful. Under these conditions generative retrieval which uses conceptual knowledge to probe long-term memory could not function or could only function in an attenuated form. Intriguingly, however, the SEMs and CEMs plus some of their conceptual knowledge would have been formed in posterior networks by the LH encoding processes. In principle these inaccessible memories, inaccessible to generative retrieval that is, remain available for recall, but only if an effective cue can be found.

In an attempt to by-pass CR's compromised RH retrieval networks and directly access the SEMs and CEMs she cannot generatively access we introduced her to a SenseCam, a prototype device produced by Microsoft that can be used to record and later cue memories in people with amnesia. The SenseCam is a small camera that is worn around the neck, taking a series of fish-lense color photographs in response to the movements and sensory experiences of the person wearing the device. One of the key features of the SenseCam is that it "sees" what the wearer sees and because it responds to movement and light changes it specifically records moments, however incidental, that are likely to be salient to that person. As we will see, what SenseCam does is create effective cues for memory.

We carried out an in-depth study with CR in which she was asked to record one discrete event on the SenseCam each weekday for four weeks. She was also asked to write a short account of each event in her diary to act as a control. On each weekend throughout this period, CR would attempt to recall the events of the preceding week without any help and would then be allowed to look at the pictures from the SenseCam or read the written account in her diary. A comprehensive scoring scheme was devised so that each memory could be assessed in terms of the level and type of episodic detail recognized in, or evoked by, the SenseCam and diary cues. Analysis of these results revealed that, when compared to reading her diary entries, looking at the SenseCam pictures led to a dramatic improvement in CR's ability to recall new episodic detail (i. e., details not contained within the pictures themselves). Specifically, CR produced more than four times as many episodic details and notably these memories were significantly more likely to include reference to cognitions and emotions.

What was particularly noticeable from a qualitative perspective was the nature of the retrieval process. It appeared that certain SenseCam pictures acted as powerfully effective cues to previously inaccessible SEMs and CEMs with moments of sudden illumination as the memory came flooding back to her. In fact, she herself described this as a floodgate opening. For example, when asked to recall a trip out with a friend, she was initially unable to recall any SPAC episodic details. However, as she looked at the SenseCam images, there was a moment when she was suddenly able to recall specific details about what had happened, including a conversation:

> Oh . . . yes! . . . I remembered I wanted to get some stuff for the cats – some cat biscuits – here I am in the pet shop – Pet's Parlour – Pet's Pantry – yes. I was asking her for cat . . . cat bisc . . . cat biscuits and cat lit leaves – yes I remember now that I decided to go back. Yes and we had a long chat about how much the cats loved them and I talked to her – oh yes about the scratch mat from America that we got with the corrugated card and how I put the cat lit leaves underneath it and she said she wanted to get some for her shop.

Throughout the study, these "a-ha!" or "Proustian" moments were a common feature of the memories triggered by the SenseCam images in CR. Typically, CR would begin browsing through the pictures, using the images to reconstruct the sequence of events, usually with a sense of some recognition but initially with little indication of true recollective experience. This in itself would be helpful for CR but then, almost inevitably, she would reach an image that she described as a "memory jig," which would produce an exclamation of surprise and joy followed by a clear and vivid description of what she had been doing, thinking, and feeling. The following example is taken from CR's attempt to recall a shopping trip she had made six days earlier:

> And – oh I suddenly remembered . . . yes!! – that I got my Waitrose list out on my way and on my shopping list it had said that R had asked me for some face cream from the Body Shop which I had already passed but decided that he had desperately asked me for this particular men's face cream that he needed from the Body Shop and it was on my list so I went back to the Body Shop. I knew I had time so this is me going to the Body Shop to choose – and I got the right stuff for him – the men's cream that he had asked for – I'd got it on my list and bought it for him before I then went back to Waitrose.

What was particularly notable during these recall sessions was how seemingly incidental the most effective cues were. In the following example, CR was struggling to remember anything at all about the event that she had recorded on the SenseCam, but a simple image of her filofax was enough to evoke a memory of a conversation that she'd had:

> Umm . . . I don't know . . . um . . . I'm holding something I'm not sure what I'm showing her. . .. Oh its my filofax I'm looking through for something I think? Oh, I know . . .!! We had a long discussion about the cat's flea medicine and the fact that I'd been to get them done and the lady had told me they were already covered. Yes!

These examples contrast with the relatively limited effectiveness of her written accounts in stimulating recollective experience. While the diaries were sometimes able to trigger an "a-ha!" moment, they more typically prompted quite simple descriptions that extended little beyond basic recognition. The following is taken from a visit she made to her family (the bold text indicates what was being read directly from the diary):

> **I arrived and J opened the door to me which was a nice surprise that he was up and about and confident to answer the door.** Yes I remember now him answering the door and that I was surprised and pleased. **I went in and said warm hellos to them all and then helped a little in the kitchen** . . . oh . . . **as L was starting to prepare their evening meal. R was reading stories and settling G and Z to bed upstairs.** Oh . . . **J went back to his chair to continue watching the cricket on TV** – yes I remember him watching the cricket and I sat and I think I talked a little bit about the cricket with him on and off.

As a follow-up to this case study we assessed CR's recall for each of the events she had recorded, six weeks, six months, and nine months later. Remarkably, she was able to recall a significant amount of detail for the events that she had reviewed on the SenseCam. An fMRI study also showed that while she was recalling these events there was significant widespread activation, particularly in the visual cortex (Loveday & Conway, 2009). The degree of activation was markedly higher than her attempts to recall anything else, even from the preceding day.

The interesting feature of CR is the overwhelming evidence that she does indeed store many episodic details about the events in her life, but under normal circumstances she loses access to these and therefore presents with a profound amnesia. For the most part, the episodic elements of her autobiographical memory remain locked away and yet with the right "memory jig"/effective cue she is able to have recollective experience and when this happens she describes the experience as "reliving the event." Typically, she cannot access memories, but then when viewing her SenseCam photographs she will suddenly have a Proustian moment and a flood of SPAC details from SEMs and CEMs will intrude into conscious awareness. Indeed, when this occurs we have detected uncontrolled spread of activation in the parietal, occipital, and (posterior) temporal lobes. This activation is far more extensive than that seen in intact controls recalling their own SenseCammed events.

Why is it then that the SenseCam is such an effective vehicle for CR's retrieval? Why is it so much more effective than either a written account or a set of ordinary photographs? We believe that the SenseCam offers a special type of cue that closely corresponds to the nature of SEMs: it is a visual record of short time slices, taken from the user's perspective, time compressed and fragmentary, and formed outside conscious awareness. In particular, the fish-eye lens ensures that it records a large part of the visual field, but most importantly, in contrast to a picture or a written account which both reflect a very conscious decision about what to record, the SenseCam is stimulated by changes in light or movement to record a series of incidental moments of change without any conscious intervention. In everyday life, each moment of change we experience usually represents something significant, however subtle, and our innate orienting response ensures that for the most part, these moments are accompanied by attention and awareness. It seems likely then that the SenseCam offers a unique opportunity to review a full visual record of each of the brief incidental but significant moments within an experience, thus mimicking important aspects of episodic memory and therefore acting as a highly effective cue. Indeed, so effective that even in a severely brain damaged patient these cues can by-pass dysfunctional generative processes and access SEMs and CEMs that are not integrated with the autobiographical knowledge and in this way bring about intense moments of retrieval.

Concluding Comments

Retrieval of past events is complicated and engages a neural network that is widespread throughout the cortex and mid-brain structures. The system has evolved to integrate experience-near representations, SEMs and CEMs, with more abstract, conceptual, and perhaps uniquely human knowledge. Effective cues are probably a phylogenetically older form of memory access (see Conway, 2005, 2009) and generative retrieval, on the other hand, intimately linked with consciousness as it is, a more recent development. Even in a brain that cannot use generative retrieval, effective cues continue to access otherwise inaccessible memories.

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5

Involuntary and Voluntary Memory Sequencing Phenomena

An Interesting Puzzle for the Study of Autobiographical Memory Organization and Retrieval

Jennifer M. Talarico and John H. Mace

Introduction

One of the most enduring questions about long-term memory is how such a vast quantity of information is organized for efficient and reliable retrieval. Within semantic memory, the clustering of items in category generation tasks informs our understanding of organization. Bousefield (1953) defined a cluster as "a sequence of associates having an essential relationship between its members . . . [with the] assumption that clustering is a consequence of organization in thinking and recall" (p. 229). Similarly, clustering in the recall of personal experiences can inform our understanding of autobiographical memory organization. There are two sources of clustering in the autobiographical memory literature. One is a laboratory technique known as event cueing, where subjects voluntarily generate sequences of autobiographical memories. The other is a naturally occurring phenomenon known as involuntary memory chaining, where subjects spontaneously generate sequences of autobiographical memories. While both of these clustering sources have produced internally consistent sets of results, the findings between the sources are contradictory, with the former indicating dominance for temporal associations, the latter dominance for conceptual associations among autobiographical memories.

The Act of Remembering: Toward an Understanding of How We Recall the Past.

In this chapter, we review the findings from these two different paradigms. While we attempt to reconcile the discrepant sets of data, as will become clear as the chapter progresses, a complete resolution to the problem is not at hand. However, we believe that the possible solutions present some interesting and potentially important implications for understanding autobiographical memory retrieval and organization. The chapter is divided into three main sections: (1) a review of the laboratory-based data, (2) a review of the involuntary memory data, and (3) a review of some of the ideas that may explain the differences between these two sets of data.

Laboratory Techniques Used to Study Autobiographical Memory Organization

The primary technique for examining the organization of autobiographical memory is the event-cueing procedure. Based on the Galton/Crovitz word-cue procedure (Crovitz & Shiffman, 1974), one autobiographical memory is used to cue another autobiographical memory. The generated event (cued-memory) is assumed to share key characteristics with the cueing memory provided. The candidate characteristics include those based on memory content (e.g., activity, participants, or location) and remembering process (e.g., vividness or emotional response). The prevalence of each relationship type is thought to be indicative of the organizing principles of autobiographical memory retrieval.

Autobiographical memory clusters are defined as groups of memories that are causally related, hierarchically related, or are part of the same larger story (Brown & Schopflocher, 1998a). In addition to shared theme, participants, and setting, Brown and Schopflocher's (1998a) participants also generated memory pairs that shared common activities. Furthermore, most events in the cueing-memory and cued-memory pairs were temporally proximate.

Brown and Schopflocher (1998b) demonstrated that participants' cued memories were systematically drawn from two different populations based on age. The first is a store of recent, mostly mundane, autobiographical events. The second is a store of long-lasting, more important, autobiographical events. This is consistent with the distribution of freely recalled autobiographical memories from across the lifespan (Rubin, Wetzlel, & Nebes, 1986; Rubin & Schulkind, 1997a, 1997b), but also suggests that each store may have its own organizational features.

To test the extent of this temporal structure within autobiographical memory, Brown (2005) asked first- and second-year undergraduate participants to generate autobiographical memories from either the past week, their high school years, or their grade school years in response to cue words. Subsequently, these memories were presented in a random order as cues for participants to generate personal events that were "somehow related to the cueing event" (p. 41). Events from the recent past (high school years) were most likely to elicit memories from the same cluster, significantly more so than grade school memories, with past-week memories resulting in moderately frequent recall of clustermates (not significantly different from high school or grade school). Memories within clusters from each time period were also more likely to share people and location than nonclustered memory pairs.

In addition to this temporal-cueing manipulation, Brown (2005) manipulated the instructions given to participants when recalling the event-cued memories. The first group was required to recall an event from the "same story" as the cueing event, whereas the second group was required to recall an event that was related to the cueing event in any way *except* that it was part of the same story. The final group was given standard instructions to think of the first memory that came to mind that was related in any way to the cueing event. All three instructions resulted in a replication of standard findings that within-cluster memories included the same people and location more often than nonclustered memories. "Same story" instructions lead to more frequent clustered memories and faster reaction times for clustered memories, suggesting that event clusters may be more prevalent than standard retrieval instructions indicate. Furthermore, nonclustered memories were retrieved faster with standard instructions than with "not-same story" instructions, indicating that retrieval of clustermates with standard instructions is unlikely to be due to biased search for narratively related memories in the standard design.

Fitzgerald (1980) examined the development of autobiographical memory organization by asking participants to generate memories in response to cue words and then shuffling and re-presenting those memories as cues to generate an additional autobiographical memory. He found that the most common relationships between memories were a continuation of the same ongoing event and a common theme or element shared between different events. Furthermore, younger participants (aged 13) were more likely to continue describing the ongoing event when prompted with a memory, whereas older participants (aged 19) were more likely to generate new events related in theme, participants, or setting.

Wright and Nunn (2000) expanded the original event-cueing procedures which had been limited to linking one (typically word-cued) autobiographical memory to one subsequently generated autobiographical memory to include larger groups of memories. They also examined more noncontent memory characteristics that might serve to relate autobiographical memories. Participants were presented with seven cue words to generate the initial autobiographical memory of each cluster. Those memories were then presented in series as cues for additional autobiographical memories.

The procedure was repeated until clusters of six memories apiece were generated, with the restriction that the cued memory could not be from the same day as the cueing event. Subsequent to the memory generation task, participants rated the emotionality, clarity, and importance of each memory as well as providing a date for each. Emotionality predicted importance which predicted memory clarity within event clusters, and each characteristic was more similar among events within a cluster than among events between clusters. Furthermore, their data replicated the temporal proximity findings of Brown and Schoplocher (1998b), even with the same-day restriction in place.

Instead of directly examining the relationships between memories, Odegard, Lampinen, and Wirth-Beaumont (2004) investigated the reliability of event clusters. They asked participants to generate four-memory clusters, each initiated by a word-cued memory. After a six-week delay, participants sorted their previously generated memories into event clusters. One's own memories were more reliably sorted than were other participants', but performance on both tasks was well above chance. Furthermore, the likelihood of correctly sorting an event decreased with an increasing distance between memories within the cluster. In other words, sequential memories within a cluster were more likely to be reliably sorted than were more distantly related events. When they repeated this procedure and added an additional memory generation task at the three-week mark, they replicated these findings. However, the advantage of sorting one's own memories was eliminated when participants were asked to sort into supraclusters (i.e., all memories generated in response to an initial cueing memory, regardless of if they were generated at time 1 or time 2) instead of sorting each event cluster separately, even though performance on the sorting tasks remained well above chance. Also noteworthy was the finding that cueing memories resulted in few of the same cued memories at time 1 and at time 2.

Procedurally, event-cueing paradigms offer many advantages. The cueing- and cued-memory pairs are easy to generate and the resulting data involve straightforward analysis. Cueing memories can be generated by a variety of means to explore secondary questions of memory organization (as demonstrated by Brown's [2005] time period restrictions) or the reliability of cueing-memory/cued-memory pairs (as demonstrated by Odegard, Lampinen, and Wirth-Beaumont, 2004). The procedure could also be adapted to examine the variability of cued memories that can be generated in response to the same cueing-memories, for example.

These laboratory-based memory-cued-memory procedures demonstrate that content features (e.g., people, location, event age, and event importance) are quite commonly shared among event clusters. However, the decreasing likelihood of accurate event-cluster identification with increasing distance between the to-be-sorted memory and the cluster-initiating memory found by Odegard, Lampinen, and Wirth-Beaumont (2004) could mean that the event-cueing procedure overestimates the content similarity of memories within event clusters. The ability of participants to sort other participants' memories more reliably than would be predicted by chance alone (Odegard, Lampinen, & Wirth-Beaumont, 2004) indicates that, not surprisingly, there are some inherent constraints on memory content and the relationships among memories. However, there is still room for other organizing principles. There is some indication of higher-order relationships (causal or hierarchical links) predicting recall in these data. However, when trying to examine the organizational structure of autobiographical memory, limiting stimuli to memory pairs may be too restrictive, especially given the near infinite capacity in long-term memory. The lack of recalling the same memories when provided with the same cueing event (Odegard, Lampinen, & Wirth-Beaumont, 2004) underscores the quantity of information available in autobiographical memory and the necessity of a retrieval strategy that is both reliable and flexible. The functional demands of any given retrieval situation require organizational principles that can accommodate these needs.

Involuntary Memory Chains: Naturally Occurring Indicators of Autobiographical Memory Organization?

Diary studies of naturally occurring involuntary memories have shown that these memories sometimes occur in a series (e.g., Mace, 2005). Known as involuntary memory chains, subjects in these studies report that their involuntary memories sometimes occur in a rapid stream or succession of spontaneously generated memories (i.e., one memory quickly followed by one or more memories, hence the term *memory chains*). The chains typically contain two to three memories (longer chains appear to be very rare), and it appears that some 15–20 percent of all naturally occurring involuntary memories result in a chain of memories (see Mace, 2007). Other work on the chaining phenomenon has shown that it also occurs when subjects are intentionally recalling autobiographical memories, or words from a previously studied list (Mace, 2006; Mace, Martin & Clevinger, 2009, see review in Mace, 2007). The only difference in the case of voluntary remembering is that the precipitating memory (i.e., the first in the chain) is produced intentionally while the rest of the chain occurs spontaneously, thus mimicking the phenomenon as it is observed to occur in diary studies (for more details, see Mace, 2007).

Whether they have been observed to occur on laboratory tasks of autobiographical memory or in everyday involuntary remembering, memories in these chains uniformly exhibit a relationship to one another (see Mace, 2007). Similar to event-cueing procedures, these relationships are either temporally related event clusters or they are conceptually (but nontemporally) related clusters. However, the distribution of these associations appears in stark contrast to the distributions produced by event-cueing procedures, with conceptually related clusters dramatically outstripping temporally related clusters (typically, 80 percent versus 20 percent; see Mace, 2006, and Mace, 2007, for a review of distributions found in various studies).

This dissociation between voluntary memory laboratory procedures and involuntary memory chains brings us to the obvious question: What is the cause of this difference? Although we have no definitive answers, as stated at the outset, we believe that the possible solutions could have important implications for the study of autobiographical memory organization and retrieval. We devote the rest of this chapter to the possibilities.

Explaining the Dissociation

We argue that there are two competing sets of explanations for the causes of the dissociation between the voluntary event clusters and involuntary memory chaining: (1) methodological, and (2) theoretical. The methodological account works under the assumption that the differences are merely an artifact of measurement that is produced by laboratory procedures. That is, the dissociation in question is produced by two very different sets of data, one occurring spontaneously, the other deliberately, and thus inconstancy of conditions may be in some way responsible for the differences. One logical assumption may be that involuntary memory chains represent naturally occurring, automatic spreading activation in the autobiographical memory system (see Mace, 2007, chapter 8, this volume). And, as such, one might argue that they flow along more settled lines of organization within the system, similar to the idea that semantic priming follows the organization of semantic memory. Another methodological problem to consider is that voluntary recall procedures are relatively unnatural laboratory procedures, which leaves them open to the influences of subject biases (e.g., subjects thinking that temporal associations are the best examples of related memories, or that such memories are what the experimenter is asking for). In stark contrast to these explanations, theoretical accounts work under the assumption that the dissociation represents a real difference, perhaps the function of retrieval differences or retrieval/organization interactions. As these possibilities are more complicated, we introduce them after we review data that relate to the methodological explanations.

Methodological accounts

The event-cueing paradigms described above randomize presentation of the cues within each trial. The consequence of this is that each cued memory is the result of a novel search process. The potential problem with this technique is that it may encourage more deliberative search based (i.e., top-down strategic recall) on content features than would more naturalistic retrieval of related memories in sequence which may be more open to the influence of unconscious retrieval processes and therefore better reveal the emergent structure of autobiographical memory. The traditional memory-cued memory tasks are more similar to paired-associate retrieval tasks than to the free-recall tasks in category generation used to assess the structure of semantic memory.

Another difficulty in comparing data generated by the event-cueing procedure to data generated by involuntary memory chains is that the memories from each of these occur at very different time intervals. In event-cueing, subjects first go through a list of cues, recalling a single memory in response to each. Once they finish this task, they return to the generated memories, with the instructions to recall related ones, but this is obviously occurring some minutes (or longer) after the initial memories had been generated. This is not the case in involuntary memory chains, where memories are retrieved sequentially, within seconds of one another.

Memory chaining involves the sequential generation of related memories. In an attempt to bridge the laboratory-based event-cueing paradigm with the naturalistic diary recording of involuntary memory chains, Talarico (2005) gave participants a word-cue to generate an initial autobiographical memory, and then subsequently presented each cued memory as an immediate cue for a further memory in the chain. These memory chains are more naturalistic in that they are meant to model the kind of mind-wandering reminiscence that occurs outside the laboratory when individuals recall personally experienced events, but they still occur in a controlled laboratory session that allows for the discrimination of one memory from another and for the probing of relationships among memory-cued-memory pairs.

Talarico (2005) found that memory chains generated via this technique were recalled with significantly less effort than were memory clusters generated by the same participants via a traditional event-cueing technique. However, memory chains replicated the temporal proximity overlap found in event clusters. Also, memories within both chains and clusters had significant overlap in participant, activity, and location content and were not different in the frequency of higher-order relationships (e.g., "part of the same story" and/or "causally related") found among those memories.

Mace (2006) similarly instructed subjects in the event-cueing procedure to recall memories and then immediately recall related memories, such that a memory was recalled in response to a cue and then a related memory was recalled immediately after this, making it very similar in time to involuntary memory chaining. The results generated from this approach, however, still dissociated from the involuntary memory chaining data, with the former showing significantly more event clustering than the latter.

However, it is not entirely clear what role subject bias might be playing in event cueing. In Mace's lab, different patterns of results have been observed for somewhat different subject populations. That is, relatively more mature subjects (i.e., roughly between the ages of 25 to 35) tend to show less event clustering than younger subjects (i.e., roughly 18 to 19 years of age, the typical subject pool age; Mace et al, 2009). This observation suggests that these different age groups may have different ideas about what constituted related memories. Another (not necessarily mutually exclusive) possibility is that younger subject populations may perceive the task of generating related memories as onerous and may therefore look for short cuts, such as recalling event clusters instead of conceptual clusters, whereas older subjects may be somewhat less inclined to approach the task in this manner.

To test the possibility that perceived task difficulty might influence outcomes, Mace et al. (2009) set up two event-cueing conditions: one long list containing 18 cues, representing the typical event-cueing condition which might be perceived as laborious, and one short-list condition containing four cues, representing an atypical testing condition which might be perceived as relatively easy. The results showed that subjects given the long list showed a high proportion of event clusters, comparable to other event-cueing findings. However, short-list subjects dissociated from long-list subjects, in that they showed a significantly lower proportion of event clusters, comparable to involuntary memory chains. Furthermore, an inspection of the first four pairs of memories in the long-list group did not reveal any differences from the pairs generated in the rest of the list, thus ruling out the possibility that non-event or conceptual clustering was a function of the initial memories generated on a list of any length.

In sum, it appears that inconsistencies with the methods of measurement have been ruled out as alternative explanations, although there still may be a few avenues to explore here. On the other hand, the list-length findings show that subject biases can play a large role in the data generated from the event-cueing procedure. However, there are problems with accepting this conclusion and simply dismissing the dissociation between event cueing and involuntary memory chaining as a mere methodological artifact. For example, if subjects find it easier to retrieve event-related memories, then this suggests that there is something special about them, such as there may be more of them available, or they may be more readily available or easier to produce. Consistent with an ease of production view, Brown (2005) demonstrated that retrieval time for event-related memories was faster than retrieval time for conceptually related memories. Further, it is also possible that biases work in the other direction. That is, when the task is not perceived as burdensome, subjects might feel that they have more time to look for conceptually related memories, which might be considered the better model for related memories. All of this, then, makes the prevalence of event clustering in event cueing seem like a real phenomenon, which of course implies that the dissociation between event cueing and involuntary memory chaining is still open to theoretical interpretation.

Theoretical accounts

The dissociation between event cueing and involuntary memory chaining might be based on two different factors. The main factor concerns the distribution of event-related and conceptually related memories over time. More recent memories may be more likely to be connected to other temporal events than to conceptually related events. One reason for this might be that newer memories may not have yet had the opportunity to connect to other conceptually related memories in autobiographical memory through the process of rehearsal and consolidation. However, as time goes by, these connections are made and simultaneously some of the temporal connections may be lost through the normal process of forgetting, though this part could be a small or negligible component. The result, then, is increasing conceptual connections with the passage of time (a point which seems to be supported by increased conceptual clustering in the event-cueing data generated from remote periods; Brown, 2005).

The second factor is a subject characteristic which combines with the first to produce event-clustering dominance. Younger subjects (i.e., 18 to 19) may be more inclined to recall recent memories rather than more remote memories. Thus, when these subjects use recent memories to generate related memories, they recall more temporally related memories because more of them are available, according to the theory put forth above. Hence, event clusters dominate their data, and given that most of the event-cueing data are based on subject populations from this age range, the results are skewed towards event clusters. Further support for this idea comes from the fact that the youngest subjects tested, aged 13, were the most likely to rely on temporal continuation when generating events in response to event cues (Fitzgerald, 1980).

However, this account alone probably does not entirely explain the differences between event-cueing and involuntary memory chaining, because it appears that irrespective of all of the preceding arguments, one process has a tendency to produce a set of temporal connections while the other has a tendency to produce a set of conceptual connections. If these differences are truly a function of inherent differences in the two retrieval processes, then the questions that quite logically follow are how and why. Functionally, voluntary remembering might be better served if it naturally followed temporal pathways, as temporal information frequently is a central aspect of a retrieval problem. This could be accomplished by directing the search along the targeted temporal lines, while other temporal periods are simultaneously inhibited. So, for example, when a subject first recalls a memory in response to a cue, a temporal period is selected and set and a memory from the period is produced. If the subject then uses that memory as a cue to recall a related memory, the temporal parameter remains intact (or is reinstated) and the second search produces a memory that is closely related temporally (i.e., another memory from the event cluster). If the goal is to produce a single memory, without a second search (as in the case of typical voluntary remembering), or if a memory occurs spontaneously (as in the case of everyday involuntary remembering), then additional spontaneous activations can flow along any set of connections, though it appears that conceptual flows are more likely, as indicated by the involuntary memory chaining data (Mace, 2006, 2007; Mace et al., 2009).

How are Memories Organized in the Autobiographical Memory System?

As is evident from this review, studies using event-cueing methods have suggested that event clusters are the dominant form of organization in autobiographical memory (e.g., Brown, 2005). The involuntary memory chaining data, however, suggest just the opposite (e.g., Mace, 2007). We have suggested that the two sets of data may indicate that organizational dominance depends on the way that memories are retrieved (or organization conforms to retrieval function). And we have also reviewed a way in which event age may interact with organization. While we would like to argue that these points reconcile the two sets of data such that one might reasonably conclude that conceptual and temporal connections are equal (or nearly equal) in autobiographical memory, there appear to be too many open questions and conflicting possibilities to allow for such a conclusion at this time.

Summary

We have presented paradoxical data from two different memory sequencing retrieval phenomena (one voluntary, the other involuntary), both of which rely on the assumption that cued memories easily brought to mind by cueing memories are our best representatives of naturalistic organization of autobiographical memory. The voluntary retrieval data reveal a temporal organization to autobiographical memory with event clusters formed by sequences of individual events. This kind of relationship dictates that content features of the memories will be similar and likely to include substantial thematic overlap as well. However, these seem to be a consequence of their temporal relationship in these data, not an organizing principle. The involuntary retrieval data reveal a conceptual organization of event clusters including thematically related events than may have occurred at temporally distant time points. The dissociation between these two phenomena may be indicative of different underlying retrieval processes, which has the potential of enhancing our understanding of these processes and their functions.

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6

Spontaneous Remembering is the Norm

What Integrative Models Tell Us About Human Consciousness and Memory

Stan Franklin and Bernard J. Baars

Introduction

Ever since Hermann Ebbinghaus, the scientific study of memory has focused on deliberate memorizing and recall in laboratory experiments. However, "memorizing," while experimentally convenient, is rather uncommon in everyday life (Rubin 2006). Based on some five decades of thought-monitoring studies, we know that most of our normal, spontaneous thoughts do not involve explicit recall of novel, deliberately memorized material. Rather, the spontaneous stream keeps coming back to our "current concerns," to answer the question, "What do I do next, to reach my most important goals?" The stream of thought reveals a wide range of spontaneous thoughts, perceptual experiences, unbidden memories, fantasies and feelings, reveries, emotionally toned fringe experiences, feelings of effort, familiarity and unfamiliarity, and self-evaluating thoughts (James 1890; Chafe 2000; Schooler, 2002; Epstein 2000). We can acquire memories simply by paying attention to novel and important events, with no explicit attempt to memorize them, and we constantly make use of our memory systems while acting, thinking, and coping with the challenges of everyday life. Real-life memory helps to solve real-life problems.

The Act of Remembering: Toward an Understanding of How We Recall the Past.
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Here we explore some well-established features of the stream of consciousness: spontaneous remembering, including incidental learning and problem solving, expectation-driven recall, action control, and the "availability heuristic" – the influence of conscious accessibility on judgments and decisions, spontaneous recall and problem solving (Tversky & Kahneman, 1973). These empirical phenomena emerge naturally from Global Workspace Theory as implemented in the LIDA model (see Baars, 1988, 1997, 2002; Franklin, 2001; Ramamurthy, D'Mello, & Franklin, 2006), an integrative, evidence-based computational model of cognition. LIDA has a detailed role for both conscious and unconscious processes, based on the Global Workspace Theory (Franklin 2001; Ramamurthy, D'Mello, & Franklin 2006; Baars 1988, 2002). It reveals an adaptive role for the stream of consciousness, interacting with well-established memory systems and with the external world, making constant use of declarative, perceptual, transient episodic, and procedural memory types.

A neglected scientific question is, "How do the human memory systems enable spontaneous, life-relevant retrieval of everyday information?" We explore a set of spontaneous memory retrieval phenomena, with explanations based on the LIDA-GWT model of conscious and unconscious goal-directed cognition. Following are some features of natural thinking that require explanation. Our basic message is that such spontaneous memories and thoughts comprise the normal, everyday stream of thoughts (James 1890, chap. 9; Chafe 2000; Epstein 2000; Smallwood et al., 2004). This view suggests that spontaneous thoughts are not just irrelevant "mind wandering," as some researchers suggest, but rather a highly functional, implicitly purposeful, problem-solving stream. The function of spontaneous thoughts is to solve life problems, including implicit ones.

Spontaneous thinking involves implicit problem solving

Baars (1988, 1997) has made the case that the fundamental unit of spontaneous thought is a "C-U-C" triplet, consisting of a conscious, then an unconscious, and finally a conscious stage of thought. The basic notion is that the apparently accidental quality of the free flow of conscious thoughts results from many intertwining C-U-C problem-solving threads. Notice that these triplets are not typically *labeled* as "problem solving." They are typically shaped and guided by unconscious contextual expectations and goals, and therefore they are not self-consciously labeled or identified at all in a metacognitive fashion. The trick is that apparently irrelevant thoughts, or "mind wandering," may actually be highly purposeful, life-relevant problem solving.

These three proposed stages of spontaneous problem solving, which are well known in numerous experimental problem-solving tasks, are as follows.

(1) C1. Conscious problem identification Any conscious "prime" creates expectations. That may be true for unconscious events as well. In language perception, for example, a normal sentence can be stopped in the middle, and listeners will still be able to make highly reliable predictions about the next word, and certainly about the syntactic category of that word (so-called Cloze sentences). Much the same can be said about watching a football game or perceiving any other structured activity, like listening to a song. In general, conscious events evoke numerous expectations.

Notice that when we encounter a missing word like __, we do not necessarily tell ourselves explicitly to bring it to mind. The answer simply tends to emerge in consciousness spontaneously, much like the classical Gestalt closure phenomena. Thus the brain spontaneously performs implicit problem solving *as if* it were trying to identify and answer questions.

The same thing is likely to be true of endogenous conscious events, like spontaneous thoughts, memories, images and feelings. In general, conscious primes can be considered to *present a problem* for the nervous system to solve, involving a set of predictions about what is coming next.

The next stage in problem solving is often (though not always) unconscious.

(2) U. Unconscious incubation Going back to Gestalt psychology, a number of researchers have studied unconscious or implicit problem solving. These stages of problem solving are traditionally called "incubation." We see incubation with the tip-of-the-tongue phenomenon, which has been described since William James as a silent (i.e., unconscious) anticipation of the word whose meaning we know, but whose phonological form we cannot bring to mind. Such unconscious states of expectation appear to be active, in the sense that the answer to the question – e.g., "What is the name of the flying dinosaurs?" – is being actively pursued. Thus, unconscious incubation is not merely a passive waiting for the answer to appear, but seems to involve active problem solving.

Finally, the third stage is conscious.

(3) C2. Conscious emergence of an answer In the case of the tip-of-the-tongue phenomenon we expect the answer to emerge consciously. But conscious emergence of an answer applies to a dizzying variety of problem-solving tasks. Associative memory is certainly one of those, simply because an established association allows us to present associate *A* consciously, and then expect associate *B* to emerge in consciousness. Pattern recognition and action planning show the same regularity.

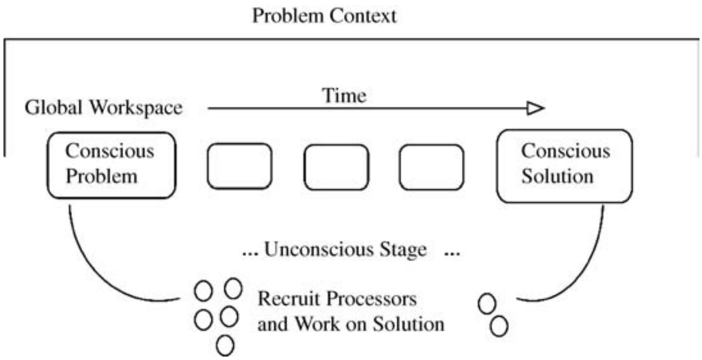

Figure 6.1 The basic C1-U-C2 triplet of spontaneous problem solving. When a subgoal is satisfied, the flow of processing can "pop the stack" to return to higher-level goals. The tip-of-the-tongue experience is the simplest example.

Very many psychological tasks reveal a Conscious-Unconscious-Conscious format, ranging from ambiguity resolution in language and perception, to visual target search, question answering, free association, decision making, action control, path navigation, and word retrieval. Each of those well-studied tasks begins with a conscious phase, a limited period of forgetting or distraction, and the spontaneous appearance of a conscious answer. In GWT the conscious moments allow collaborative interactions to occur among multiple unconscious knowledge sources, using a shared momentary memory domain called a global workspace (Baars, 1988, 2002). In the brain, unconscious knowledge sources may involve declarative or procedural memory, primed neuronal networks, or all those systems working collaboratively.

When answers are found by the automatic routines, those answers may become conscious again (C2), in a process that was traditionally called "insight." However, no profound or surprising insights are required to observe these phenomena. C1-U-C2 patterns seems to happen every minute of the waking day.

Topical threads in the flow of thought We can think of each goal-driven string of C1-U-C2 triplets as a *thread* in a set of active, intertwining threads, much like a conversation in an Internet chat room. Only a small part of each thread is articulated "in public" at any single moment. But in private, multiple threads are always busy trying to reach their goals. Like consciousness, the "Internet chat room" of the mind has quite limited capacity at any moment, and each topical thread appears and disappears in a seemingly arbitrary fashion. The apparent randomness of the free flow of thoughts is of course a common observation in psychology, going back at least to Sir

Francis Galton and Sigmund Freud; no doubt a historian could trace it back to the time of Aristotle (Crovitz, 1970).

The arbitrariness of the stream of thought is of course a central claim in Asian views of consciousness, with ancient roots expressed in Vedanta Hinduism, Buddhism, and Taoism. There, the notion of the impulsive or ungovernable mind, which is to be transcended by way of meditation and other practices, is a basic assumption for a sophisticated worldview.

In more recent times the notion of the jumpy randomness of the spontaneous stream of thought has faded in formal science, in good part because naturalistic observation of the stream of thought is methodologically difficult. It is not easy to subject spontaneous thought to experimental study. And yet, unforced thinking continues to exert a fascination. The recent discovery of endogenous "intrinsic networks" of the brain, which are only observed when a subject is freed from the usual experimental demands, is a good example (Fox, Zhang, Snyder, & Raichle, 2009).

Our working hypothesis therefore claims that the apparent arbitrariness of the stream of spontaneous thought reflects an underlying pattern; that our spontaneous thinking is guided by a multiplicity of implicit goals and challenges, driven by the most important events in life, our motivations and emotions.

As Jerome Singer has written, mental life is a continuous effort at tracking sensory inputs, cognitively organizing experiences, re-examining memories, and monitoring "a continuous set of plans and anticipations and a variety of unfinished businesses which compete for our limited attentional capacities with the demands of steering our selves through a physical and social world" (Singer, 1978). Given this framework, where does spontaneous remembering come in?

Hypothesis: spontaneous remembering is one kind of C-U-C problem solving

Spontaneous thought often seems to have many C-U-C "threads" running at the same time, much like an Internet chat discussion. But rather than involving a small group of people, each making their separate contributions, the chat room of consciousness seems to have several major "current concerns" that are touched on in an intertwined way.

Take the case of highly predictable word associations like the following:

- *Brother*: What is the first association?
- *Father*: What is the first association?
- *Up*: What is the first association?

Notice that the associate of each word seems to come to mind spontaneously, though it is always highly constrained by lexical, syntactic, and semantic regularities. The same point applies to far more complex but still predictable analogies, sentences, concepts, jokes, linguistic strings, musical phrases, and the like.

Remote associates The Remote Associates Test first devised by Mednick provides many good examples (Mednick, 1962) (http://socrates.berkeley.edu/~kihlstrm/RATest.htm):

Instruction: Think of the first word to come to mind in the blank spaces below.

1.	Shopping	Washer	Picture	_____
2.	Blank	White	Lines	_____
3.	Stick	Light	Birthday	_____
4.	Sore	Shoulder	Sweat	_____

While there are no correct answers for these items, there are very probable and often subjectively surprising associates that come to mind with a strong sense of rightness.[1]

The Mednick remote associates have been developed further in recent years to permit brain imaging over many trials. Bowden, Jung-Beeman, Fleck, and Kounios (2005) report a remarkable interaction of alpha and gamma rhythms during the unconscious incubation period (U, above), followed by the moment of conscious insight (C2, above).

Unconscious semantic inferences evoked by conscious input Information can easily be constructed to suggest false inferences, which are largely if not entirely unconscious. Thus:

The web consists of . . .
A key board is . . .

Again, there are some surprising answers, that is, answers that appear to violate the spontaneous unconscious inferences we make from these sentence fragments.[2] The effect is similar to the famous "garden path" sentences, which strongly suggest one syntactical structure, only to switch to a different one in the middle of the sentence. A sizable body of such evidence suggests that we spontaneously make unconscious inferences from a wide range of conscious events. In everyday speech, jokes, puns, analogies, and insinuations exploit this tendency.

Spontaneous problem solving is shaped by implicit motivations and emotions

What about spontaneous thought? Do we have evidence for similar C1-U-C2 phenomena there? We propose that the spontaneous stream of thought, and especially its memory component, runs very much along these lines. That is, we propose that spontaneous thought involves conscious moments that trigger unconscious inferences and problem-solving processes, which are then followed by a conscious re-emergence of related material that will tend to complete the C1 and U stages of thought.

Furthermore, we have proposed that many, if not most, spontaneous C-U-C problem solving in the stream of consciousness is guided by implicit goals and expectations ("goal contexts" in the vocabulary of Baars, 1988). The social psychological evidence for such a claim is now quite strong (e.g., Fishbach & Shah, 2006; Glaser & Knowles, 2008; Schultheiss, Jones, Davis, & Kley, 2008).

From psychological evidence to an explicit, large-scale model of cognition

The LIDA/GWT model generates hypotheses about human cognition by way of its design, the mechanisms of its modules, their interaction, and its performance. All of these hypotheses are, in principle, testable. With the advent of more sophisticated brain and behavioral assessment methods, some earlier hypotheses in this research program have been confirmed (Baars, 2002). We expect the current set of hypotheses to become directly testable with continuing improvements in cognitive neuroscience.

Every autonomous agent (Franklin & Graesser 1997), be it human, animal, or artificial, must sample its world and act on it through a sense-select-act (or stimulus, cognition, response) cycle. The LIDA/GWT model hypothesizes for us humans a complex *cognitive cycle*, involving perception, several memory systems, attention, and action selection, that samples the world at five to ten times a second. This frequent sampling allows for an exceptionally fine-grained analysis of common cognitive phenomena, including spontaneous remembering. At a high level of abstraction, these analyses support the commonly held explanations of what is generally found in studies of the explicit (i.e., conscious and reportable) components of memory processes (e.g., Tulving, 1985; Baddeley, Conway, & Aggleton, 2001). Nothing new here. At a finer-grained level, however, our analysis fleshes out these common explanations, adding detail and functional mechanisms. Therein lies the value of our analysis.

In addition, this chapter uses the word "consciousness" or "conscious cognition" to indicate a general cognitive function, much as the word "memory" has come to be used. Conscious cognition is often labeled in many different ways in the empirical literature, including "explicit cognition," "focal attention," "awareness," "strategic processing," and the like. Here we group all these specific terms under the umbrella of "conscious cognition," as assessed by standard methods such as verifiable verbal report (Baars, 1988). Global Workspace Theory proposes a single underlying kind of information processing for conscious events, as implemented in the LIDA model.

Current techniques for studying these phenomena at a fine-grained level, such as PET, fMRI, EEG, implanted electrodes, etc., are still lacking in scope, spatial resolution, or temporal resolution. PET and fMRI have temporal resolution problems; EEG is well known to have localizability difficulties; implanted electrodes (in epileptic patients), while excellent in temporal and spatial resolution, can only sample a limited number of neurons; that is, they are limited in scope. As a result, many of our hypotheses, while testable in principle, seem difficult to test at the present time. Improved recording methods are emerging rapidly in cognitive neuroscience (Sigman, Jobert, Lebihan, & Dehaene, 2007). When GWT was first proposed, the core hypothesis of "global activation" or "global broadcasting" was not directly testable in human subjects. Since that time, however, with the advent of brain imaging, widespread brain activation due to conscious, but not unconscious, processes has been found in dozens of studies (see Baars, 2002; Dehaene, 2001). We expect further improvements to make our current hypotheses testable as well.

The LIDA/GWT model has unusual breadth, encompassing perception, working memory, declarative memory, attention, decision making, procedural learning, and more. The model suggests that superficially different aspects of human cognition are so highly integrated that they can't be fully understood in a fragmentary manner. A more global view may provide an overview with surprising points of simplification when analyzing the cognitive mechanisms of spontaneous memory retrieval.

Conscious Cognition and Memory: Basic Facts to be Accounted For

Human memory seems to come in myriad forms: sensory, procedural, working, declarative, episodic, semantic, long-term memory, long-term working memory, and many others. How to make sense of all of this? And to add to the difficulty, these terms are used differently in different research traditions. Psychologists tend to use these terms to refer inferentially to systems that appear to hold memory traces and to the underlying knowledge that constitutes their contents. To computer scientists and to neuroscientists, memory refers only to the physical (not inferred) storage device. Further, in many cognitive studies, consciousness is either taken for granted or labeled with its own set of synonyms, such as *explicit cognition*, *focal attention*, and *awareness*. Yet the role of consciousness has concerned memory researchers since Ebbinghaus (1885/1964).

There is considerable evidence that people are conscious of retrieved memories in recall, but not necessarily in recognition tasks (e.g., Gardiner, Ramponi, & Richardson-Klavehn, 1998). For pioneering memory researchers like Ebbinghaus, indeed, the term "recall" meant retrieval to consciousness. The feeling of knowing that characterizes recognition is a "fringe conscious" phenomenon, that is, an event that has high accuracy but low reported conscious content (Mangan, 2001; Baars, 2002). In numerous experiments, these differences result in striking dissociations between subjective reports in "remember" vs. "know" types of retrieval.

In cognitive working memory, the active operations of input, rehearsal, recall, and report are conscious (Baddeley, 1993). The contents of working memory prior to retrieval are not. Baars and Franklin (2003) describe the way IDA, an earlier, but compatible version of LIDA/GWT, accounts for this evidence.

Novel Hypotheses from the LIDA/GWT Model

With its finer-grained model of these processes, the LIDA model (Franklin, 2000, 2001; Franklin & Graesser, 2001; Ramamurthy, D'Mello, & Franklin, 2006) of GWT (Baars, (1988, 1993, 1997, 2002) offers hypotheses that suggest a simple account of several forms of human memory and their relationships with conscious events, including spontaneous memories. Here we list, and briefly discuss, some of these relevant hypotheses.

- *The cognitive cycle*: Recall William James' claim that the stream of conscious thought consists of momentary "flights" and somewhat longer "perches" of dwelling on a particular conscious event. Such findings have been reported by neuroscientists (Halgren, Boujon, Clarke, Wang, & Chauvel, 2002; Fuster, Bodner, & Kroger, 2000; Lehmann, Strik, Henggeler, Koenig, & Koukkou, 1998; Freeman, 2003a). Much of human cognition functions by means of continual interactions between conscious contents, the various memory systems and decision making. We call these interactions, as modeled in LIDA, *cognitive cycles*. While these cycles can overlap, producing cascading processes, they must preserve the seriality of consciousness. The LIDA model suggests therefore that conscious events occur as a sequence of discrete, coherent episodes separated by quite short periods of no conscious content[3] (see VanRullen & Koch, 2003). It should be pointed out that the "flights and perches" of normal consciousness may involve numerous cognitive cycles. A problem-solving task involving inner speech, for example, may occur over tens of seconds or minutes, according to careful thought-monitoring studies.

- *Transient episodic memory*: Humans have a content-addressable, associative, transient episodic memory with a decay rate measured in hours (Conway, 2001). In our theory, a conscious event is stored in transient episodic memory by a broadcast from a global workspace. A corollary to this hypothesis says that conscious contents can only be encoded (consolidated) in long-term declarative memory via transient episodic memory.
- *Perceptual memory*: A perceptual memory, distinct from semantic memory but storing some of the same contents, exists in humans, and plays a central role in the assigning of interpretations to incoming stimuli. The conscious broadcast begins and updates the process of learning to recognize and to categorize, both employing perceptual memory.
- *Consciousness*: Conscious cognition is implemented computationally by way of a broadcast of contents from a global workspace, which receives input from the senses and from memory (Baars, 2002).
- *Conscious learning*: Significant learning takes place via the interaction of consciousness with the various memory systems (e.g., Standing, 1973; Baddeley, 1993). The effect size of subliminal learning is therefore small compared to the learning of conscious events, but significant implicit learning can occur by way of unconscious inferences based on conscious patterns of input (Reber, Walkenfeld, & Hernstadt, 1991). In the LIDA/GWT view, all memory systems represented in the model rely on conscious cognition for their updating, either in the course of a single cycle or over multiple cycles.
- *Voluntary and automatic attention*: In the LIDA/GWT model, attention is defined as the process of bringing contents to consciousness. Automatic attention may occur unconsciously and without effort, even during a single cognitive cycle (Logan, 1992). Attention may also occur voluntarily and *effortfully* in a conscious, goal-directed way, over multiple cycles.
- *Voluntary and automatic memory retrievals*: Associations from transient episodic and declarative memory are retrieved automatically and unconsciously during each cognitive cycle. Voluntary retrieval from these memory systems may occur over multiple cycles, governed by conscious goals.

GWT as a Functional Interpretation of Conscious Cognition

GWT is a cognitive architecture with an explicit role for consciousness. It makes the following assumptions:

- The brain may be viewed as a collection of distributed *specialized networks* (processors).
- Consciousness is associated with a *global workspace* – a fleeting memory capacity whose focal contents are widely distributed ("broadcast") to many unconscious specialized networks.
- Some unconscious networks, called *contexts*, shape conscious contents (for example, unconscious parietal maps of the visual field modulate feature cells needed for conscious vision).
- Such contexts may work together to jointly constrain conscious events.
- Motives, implemented by feelings and emotions,[4] can be viewed as part of *goal contexts, which are often unconscious*.
- Voluntary control employs *hierarchies of goal contexts*.

A number of these functions have plausible brain correlates, and the theory has recently gathered considerable interest from cognitive neuroscience and philosophy (Cooney & Gazzaniga, 2003; Damasio, 1989; Dehaene & Naccache, 2001; Edelman & Tononi, 2000; Freeman, 2003b;Varela, Lachaux, Rodriguez, & Martinerie, 2001).[5] For instance, Dennett (2001) notes: "Theorists are converging from quite different quarters on a version of the global neuronal workspace model of consciousness."

The LIDA Model

The LIDA model is a comprehensive conceptual and computational model covering a large portion of human cognition.[6] Based primarily on GWT (Baars, 1988, 1997, 2002), the model implements and fleshes out a number of psychological and neuropsychological theories, including situated cognition (Varela, Lachaux, Rodriguez, & Martinerie, 1991), perceptual symbol systems (Barsalou, 1999), working memory (Baddeley & Hitch, 1974; Baddeley, 1993), memory by affordances[7] (Glenberg, 1997), long-term working memory (Ericsson & Kintsch, 1995), transient episodic memory (Conway, 2001), and the H-CogAff framework (Sloman, 1999). The LIDA model is particularly compatible with the notion of grounded cognition (Barsalou, 2008). LIDA's flexible cognitive cycle has been used to analyze the relationship of consciousness to working memory at a fine level of detail, offering explanations of such classical working memory tasks as the "phonological loop" to account for the rehearsal of a telephone number (Baars & Franklin, 2003). There is evidence suggesting such a cognitive cycle from neurobiology in the form of "hemisphere-wide, self-organized patterns of perceptual neural activity" recurring aperiodically at intervals of 100 to 200ms (Freeman, 2003a, 2003b; Lehmann, Strik, Henggeler, Koenig, & Koukkou, 1998; Koenig, Kochi, & Lehmann, 1998).

Memory Systems and Terminology

In this section, we will briefly discuss the various human memory systems that will play a role in the rest of the chapter. It will be helpful to specify here how we plan to use the various terms, as there isn't always agreement in the literature. Figure 6.2 displays some of the relationships between the memory systems we'll discuss.

Sensory memory holds incoming sensory data in sensory registers and is relatively unprocessed. In addition to deriving a representation of geometric properties of the current situation, it provides a workspace for integrating the features from which representations of objects and their relations are constructed. It also sends information along the dorsal stream to facilitate the executing of actions. There are different sensory memory registers for different senses: *iconic* (visual), *echoic*, *haptic*, and likely a separate *sensory memory* for integrating multimodal information. Sensory memory has the fastest decay rate, measured in tens of milliseconds.

Working memory is the manipulable scratchpad of the mind (Miyake & Shah, 1999). It holds sensory data, both endogenous (for example, visual images and inner speech) and exogenous (sensory), together with their interpretations. Its decay rate is measured in tens of seconds. Again, there are separate working memory components associated with the different senses – the visuo-spatial sketchpad and the phonological loop, for example (Baddeley, 1993; Baars & Franklin, 2003). Also, there are long-term processing components of working memory (Ericsson & Kintsch, 1995). Baars and

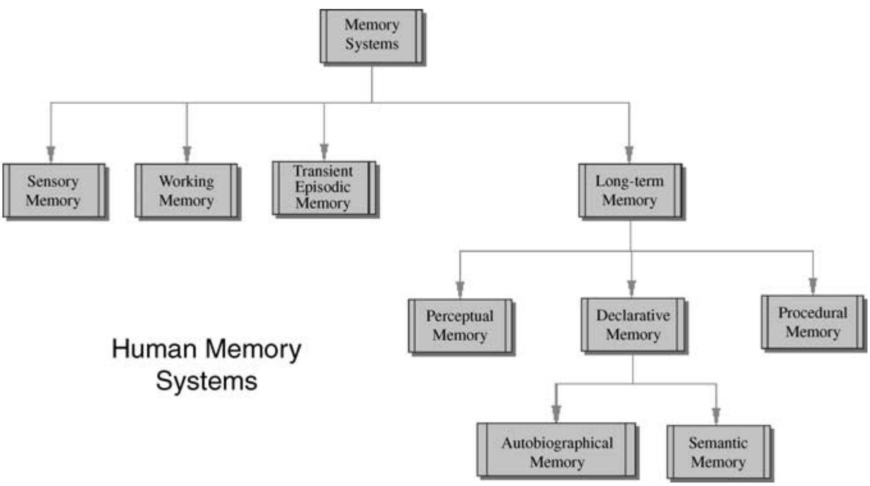

Figure 6.2 Human memory systems.

Franklin (2003) have suggested that conscious input, rehearsal, and retrieval are necessary for the normal functions of working memory.

Episodic or autobiographical memory is memory for events having features of a particular time and place (Baddeley, Conway, & Aggleton 2001). This memory system is associative and content-addressable.

An unusual aspect of the LIDA model is transient episodic memory (TEM), an episodic memory with a decay rate measured in hours. Though often assumed – Panksepp (1998) assumes a "transient memory store" – the existence of such a memory has rarely been explicitly asserted (Donald, 2001; Conway, 2001; Baars & Franklin, 2003). It will play a major role in the hypotheses about memory systems generated by the LIDA model.

Humans are blessed with a variety of long-term memory types that can decay exceedingly slowly, if at all. Memory researchers typically distinguish between procedural memory, the memory for motor skills including verbal skills, and declarative memory. In the LIDA model, declarative memory (DM) is composed of autobiographical memory, described in a previous paragraph, and semantic memory, memories of fact or belief typically lacking a particular source with a time and place of acquisition. In contrast, semantic memories have lost their association with their original autobiographical source. DM is a single system within the LIDA model. These declarative memory systems are accessed by means of specific cues from working memory. The LIDA model hypothesizes that DM decays inversely with the strength of the memory traces.

Though "perceptual memory" is often used synonymously with "sensory memory," we follow Taylor (1999) and use the term differently (see also Barsalou, 2008). Perceptual memory is a memory for individuals, categories, and their relations. The LIDA model distinguishes between semantic memory and perceptual memory (PM) and hypothesizes distinct mechanisms for each (Nadel, 1992; Franklin, Baars, Ramamurthy, & Ventura, 2005). According to the model, PM plays the major role in recognition, categorization, and more generally the assignment of interpretations, for example the recognition of situations. Upon presentation of features of an incoming stimulus, PM returns interpretations. The content of semantic memory is hypothesized to be a superset of that of PM. All this discussion essentially restates the most controversial part of our Perceptual Memory Hypothesis, the claim of distinct mechanisms for PM and semantic memory. Several types of evidence, of varying degrees of persuasiveness, support this dissociation (Franklin et al., 2005), including arguments from evolution, from developmental studies, from clinical studies of amnesiacs, and from experiments with animals with their hippocampal systems excised.

In the recognition memory literature, dual-process models have been put forward proposing that two distinct memory processes, referred to as *familiarity* and *recollection*, support recognition (Mandler, 1980; Jacoby

& Dallas, 1981). Familiarity allows one to recognize the butcher in the subway *acontextually* as someone who is known, but not to recollect the context of the butcher shop. In the LIDA model, PM alone provides the mechanism for such a familiarity judgment, while both PM and DM are typically required for recollection. Recent brain imaging results from cognitive neuroscience support a dual-process model (Rugg & Yonelinas, 2003), and so are compatible with our Perceptual Memory Hypotheses.

The LIDA Cognitive Cycle

The LIDA model and its ensuing architecture are grounded in the LIDA cognitive cycle. Every autonomous agent (Franklin & Graesser, 1997), be it human, animal, or artificial, must frequently sample (sense) its environment and select an appropriate response (action). More sophisticated agents, such as humans, process (make sense of) the input from such sampling in order to facilitate their decision making. Neuroscientists call this three-part process the action-perception cycle (Freeman, 2002). The agent's "life" can be viewed as consisting of a continual cascading sequence of these cognitive cycles. Each cycle constitutes a unit of sensing, attending, and acting.

A cognitive cycle can be thought of as a moment of cognition – a cognitive "moment." Higher-level cognitive processes are composed of many of these cognitive cycles, each a cognitive "atom." Citing evidence from Thompson, Hanes, Bichot, and Schall (1996) and from Skarda and Freeman (1987), Cotterill (2003) speaks of "the time usually envisioned for an elementary cognitive event ... about 200ms." From our cognitive cycle hypothesis, it might seem reasonable to call one such cycle an elementary cognitive event. Freeman (1999) suggests that conscious events succeed one another at a "frame rate" of 6 Hz to 10 Hz, as would be expected from our cognitive cycle hypothesis (see also Freeman, 2003c). The rate of such cycles coincides roughly with that of other, perhaps related, biological cycles such as *saccades* (Steinman, Kowler, & Collewijn, 1990), *systematic motor tremors*,[8] and *vocal vibrato* (Seashore, 1967). Could these hypothesized cycles be related to hippocampal theta waves (at 6–9 Hz) with gamma activity superimposed on them (VanRullen & Koch, 2003)?

Just as atoms are composed of protons, neutrons, and electrons, and some of these are composed of quarks, bosons, muons, etc., these cognitive "atoms" have a rich inner structure. What the LIDA model hypothesizes as this rich inner structure of the LIDA cognitive cycle will now be described. More detailed descriptions are available elsewhere (Baars & Franklin, 2003; Franklin, Baars, Ramamurthy, & Ventura, 2005).

During each cognitive cycle the LIDA agent first makes sense of its current situation as best as it can by updating its representation of its current situational model, both external and internal. By a competitive process to be described below, it then decides what portion of the represented situation is most in need of attention. Broadcasting this portion, the current contents of consciousness, enables the agent to finally chose an appropriate action and execute it. Let's look at these three processes in a little more detail. Figure 6.3 should help the reader follow the description. It starts in the upper left corner and proceeds roughly clockwise.

The cycle begins with sensory stimuli from the agent's environment, both an external and an internal environment. Low-level feature detectors in sensory memory begin the process of making sense of the incoming stimuli. These low-level features are passed on to perceptual memory where higher-level features, such as objects, categories, relations, situations, etc., are recognized. These entities, which have been recognized preconsciously, make up the percept that is passed to the workspace, where a model of the agent's current situation is assembled. (LIDA's workspace contains the preconscious buffers of working memory.) This percept serves as a cue to two forms of episodic memory, transient and declarative. Responses to the cue consist of local associations, that is, remembered events from these two memory systems that were associated with the various elements of the cue. In addition to the current percept, the workspace contains recent percepts and the models assembled from them that haven't yet decayed away.

A new model of the agent's current situation is assembled from the percepts, the associations, and the undecayed parts of the previous model. This assembling process will typically require structure-building codelets.[9] These structure-building codelets are small, special-purpose processors, each of which has some particular type of structure it is designed to build. To fulfill their task these codelets may draw upon perceptual memory and even sensory memory, to enable the recognition of relations and situations. The newly assembled model constitutes the agent's understanding of its current situation within its world. It has made sense of the incoming stimuli.

For an agent "living" in a complex, dynamically changing environment, this current model may well be much too much for the agent to consider all at once in deciding what to do next. It needs to select what portion of the model should be attended to. Which are the most relevant, important, urgent, or insistent structures within the model? Portions of the model compete for attention. These competing portions take the form of coalitions of structures from the model. Such coalitions are formed by attention codelets, whose function is to bring certain structures to consciousness. One of the coalitions wins the competition. In effect, the agent has decided on what to attend.

However, the purpose of all this processing is to help the agent decide what to do next. To this end, a representation of the contents of the winning

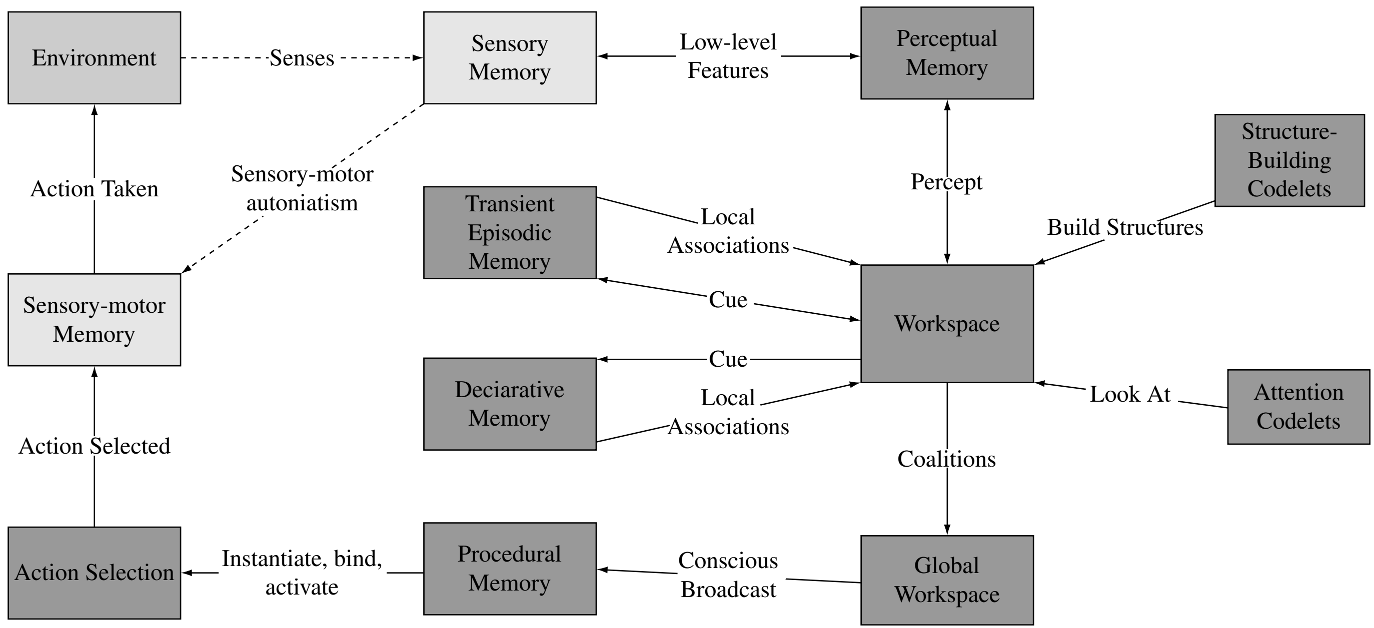

Figure 6.3 LIDA cognitive cycle diagram.

coalition is broadcast globally, effectively constituting a global workspace (hence the name Global Workspace Theory). Though the contents of this conscious broadcast are available globally, the primary recipient is procedural memory, which stores templates of possible actions, including their contexts and possible results. It also stores an activation value for each such template that attempts to measure the likelihood of an action taken within its context producing the expected result. Templates whose contexts intersect sufficiently with the contents of the conscious broadcast instantiate copies of themselves with their variables specified to the current situation. Instantiated templates remaining from previous cycles may also continue to be available. These instantiations are passed to the action selection mechanism, which chooses a single action from one of these instantiations. The chosen action then goes to sensory-motor memory, where it picks up the appropriate algorithm by which it is then executed. The action taken affects the environment, and the cycle is complete.

The LIDA model hypothesizes that all human cognitive processing is via a continuing iteration of such cognitive cycles. These cycles occur asynchronously, with each cognitive cycle taking roughly 200ms. The cycles cascade, that is, several cycles may have different processes running simultaneously in parallel. This cascading must, however, respect the way consciousness processes information serially in order to maintain the stable, coherent image of the world with which consciousness endows us (Merker, 2005; Franklin, 2005a). This cascading, together with the asynchrony, allows a rate of cycling in humans of five to ten cycles per second. A cognitive "moment" is thus quite short! There is considerable empirical evidence from neuroscience suggestive of and consistent with such cognitive cycling in humans (Massimini et al., 2005; Sigman & Dehaene, 2006; Uchida, Kepecs, & Mainen, 2006; Willis & Todorov, 2006). None of this evidence is conclusive, however.

Learning in the LIDA Model

Edelman (1987) usefully distinguishes two forms of learning, the selectionist and the instructionalist. Selectionist learning requires selection from a redundant repertoire that is typically organized by some form of reinforcement learning. A repertoire of, say, possible actions, is redundant if slightly different actions can lead to roughly the same result. In reinforcement learning (Kaelbling, Littman, & Moore, 1996) a successfully executed action is reinforced, making it more likely to be chosen the next time the result in question is needed. In Edelman's system, little-used actions tend to decay away. In contrast, instructional learning allows the learning of representations of, say, new actions, that is, actions not currently in the repertoire.

GWT postulates that learning requires only attention (Baars, 1988, pp. 213–218). In the LIDA model this implies that learning must occur with each cognitive cycle, because whatever enters consciousness is being attended to. More specifically, learning occurs with the conscious broadcast from the global workspace during each cycle. Learning in the LIDA model follows the tried and true Artificial Intelligence principle of generate and test. New representations are learned in a profligate manner (the generation) during each cognitive cycle. Those that are not sufficiently reinforced during subsequent cycles (the test) decay away. Three modes of learning – perceptual, episodic, and procedural – employing distinct mechanisms (Nadel, 1992; Franklin, Baars, Ramamurthy, & Ventura, 2005) have been designed and are in various stages of implementation. A fourth, attentional learning, is contemplated but not yet designed. We'll discuss each individually.

Perceptual learning enables an agent to recognize features, objects, categories relations, situations, etc. In the LIDA model what is learned perceptually is stored in perceptual memory (Franklin 2005b, 2005c). Motivated by the Slipnet from the Copycat architecture (Hofstadter & Mitchell, 1994), the LIDA perceptual memory is implemented as a collection of nodes and links with activation passing between the nodes. Nodes represent features, individuals, categories, actions, feelings, and more complex structures. Links, both excitatory and inhibitory, represent relations. Each node and link has both a current and a base-level activation. The base-level activation measures how useful the node or link has been in the past, while the current activation depends on its relevance in the current situation. The percept passed on to the workspace during each cognitive cycle is composed of those nodes and links whose total activation is over the threshold. Perceptual learning in its selectionist form modifies base-level activation, and in its instructionalist form creates new nodes and links. One or the other or both may occur with the conscious broadcast during each cognitive cycle.

Episodic learning refers to the memory of events – the what, the where, and the when (Tulving, 1983; Baddeley, Conway, & Aggleton, 2001). In the LIDA model such learned events are stored in transient episodic memory (Conway, 2001; Franklin, Baars, Ramamurthy, & Ventura, 2005) and in the longer-term declarative memory (Franklin et al., 2005). Both are implemented using sparse distributed memory (Kanerva, 1988), which is both associative and content-addressable and has other desirable psychological properties. In particular it knows when it doesn't know, and exhibits the tip-of-the-tongue phenomenon. Episodic learning in the LIDA model (Ramamurthy, D'Mello, & Franklin, 2004, 2005) is also a matter of generate and test, with such learning occurring at the conscious broadcast of each cognitive cycle. Episodic learning is initially directed only to transient episodic memory. At a later time and offline, the undecayed contents of transient episodic memory are consolidated (Nadel

& Moscovitch, 1997; Stickgold & Walker, 2005) into declarative memory, where they still may decay away or may last a lifetime.

Procedural learning refers to the learning of new tasks and the improvement of old tasks. In the LIDA model such learning is accomplished in procedural memory (D'Mello, Ramamurthy, Negatu, & Franklin, 2006), which is implemented via a scheme net motivated by Drescher's (1991) schema mechanism. Each scheme in procedural memory is a template for an action, consisting of a context, an action, and a result, together with a base-level activation intended to measure how likely the result would be to occur were the action taken within its specific context. Once again, the LIDA model's procedural learning is via a generate and test mechanism, using base-level activation as reinforcement, as well as through the creation of new schemes. These new schemes can support multiple actions, both parallel and sequential.

The Availability Heuristic

It is well known that people tend to overestimate the frequency of divorce if they can quickly recall instances of divorced acquaintances. This principle also applies to frequency estimates, and is referred to as the *availability heuristic* (Kahneman, Slovic, & Tversky, 1982; Fiske & Taylor, 1991).

An online demonstration of the heuristic (Colston & Walter, 2001) asks the subject to review a list of names of well-known people, one such presented at each mouse click, to see if the subject knows them. No mention is made of gender. After viewing the last name in the list, the subject is presented a forced choice as to whether he or she had seen more men's names or women's. Since the men named tended to be more famous, and hence more easily recalled, the availability heuristic would correctly predict that most subjects would claim that there were more men's names on the list. There are, in fact, 14 of each. In this section, we will analyze this task using LIDA's cognitive cycle to see what the LIDA model would predict for a human subject.

The initial instructions given to the subject comprise a text of some 37 words. To read and understand the instructions will likely occupy a subject for a few seconds and some few tens of cognitive cycles. During the last of these cycles, the gist of the meaning of the instructions will have accumulated in the appropriate preconscious working memory buffer. The conscious broadcast of these meanings will likely instantiate a goal context hierarchy for sequentially clicking through and seeing the names, noting whether they are recognized. The action chosen during this cycle will likely be a mouse click bringing up the first name.

One to three or four cycles will likely suffice for the subject to preconsciously perceive the entire name, which will have accumulated in the appropriate preconscious working memory buffer in LIDA's workspace.

Here we must consider two cases: (1) The name has been recognized during the preconscious perceptual process (see the description of perceptual memory, above), or (2) it has not. Recognition of the name John Doe has occurred if the subject can answer the question "Who is John Doe?" In the first case, after the conscious broadcast the action selection mechanism will likely choose a mouse click as an action. This would bring up another name. In the second case, a conscious goal to consult declarative memory in search of recognition would likely arise over several cognitive cycles (see the seventh major novel hypothesis on voluntary memory retrieval, listed earlier). Such a conscious goal would produce an attention codelet on the lookout for information concerning the as yet unrecognized name. In the next cycle, the name, by then located in a preconscious working memory buffer, will be used to cue declarative memory. This voluntary episodic memory retrieval process may iterate over several additional cycles, with the parts of local associations that make it to consciousness contributing to the cue for the next local associations. The subject will eventually recognize the name or will give up the effort on a subsequent cycle. In either case, the action chosen selected on this last cycle is likely to be a mouse click for the next name.

Thus the subject will work his or her way through the list of names, recognizing many or most of them but missing some. At the mouse click following the last name, a new set of instructions appears. These instructions, in 16 words, ask the subject to decide whether more men's or women's names were on the list, and to click the mouse when the decision is made. A very few tens of cycles are spent understanding the instructions.

The conscious broadcasts whose contents contain the full understanding of the instructions will likely recruit behavior codelets that instantiate a goal context hierarchy to comply. During some subsequent cycles, behaviors (goal contexts) will likely be selected that will attempt to query transient episodic memory (TEM), starting the recall process for names on the list. The behavior's codelets will write this goal to preconscious buffers of working memory (WM), where it will serve to cue local associations from TEM and declarative memory (DM). The next contents of consciousness will be chosen from the resulting long-term working memory (LTWM), a part of LIDA's workspace.

This process can be expected to continue over many subsequent cycles, with each cue from WM containing material from previous local associations from DM. Since the names were encoded in TEM as distinct events, those retrieved from TEM can be expected to appear as such in LTWM when associated with the latest cue. From there, each recovered name is likely to appear as the central content of its own coalition of that same attention and information codelets bring to compete for consciousness. Thus, the LIDA model would predict that only one name would be recalled at a time, since a single coalition must win the competition. More famous names would have their initial coalitions replaced during subsequent cycles, with expanded coalitions including information from their many local associations in DM. Thus, they would accrue an advantage in the next competition for consciousness, such that more famous names are more likely to be recalled. A name on the list could fail to be recalled for either of two reasons. First, it might not have been retrieved from TEM by any of the cues used during the process. Second, it may have been retrieved into LTWM, but decayed away before it could be part of a coalition that won the competition for consciousness.

At some point in this process, a decision as to more men's names or more women's is taken. How does that happen? Some subjects may actually instantiate a goal context hierarchy (behavior stream) that keeps separate tallies in WM of the number of men's names and of women's names recalled. These tallies are likely to be part of the conscious contents in at least some of the ongoing cycles in the process. When no more names are being recalled, a goal context (behavior) to decide is chosen. The decision is then made and, on a subsequent cycle, the mouse is clicked.

We think this is a relatively unlikely scenario, in that most subjects will not keep such explicit running tallies. Rather, they'll decide on the basis of a fringe consciousness feeling that one gender or the other has been recalled more often (Mangan, 2001). In the LIDA model, such feelings are to be implemented as fringe attention codelets. In this case, a selected behavior would give rise to two such fringe attention codelets, one for each gender. As a name from one gender is recalled, the activation of the corresponding fringe attention codelet is increased, the amount of increase biased by the activation of the recall of the name. Each of these fringe attention codelets likely enters each competition for consciousness as the process progresses. The stronger of the two will be able to win only after names are no longer being recalled; a coalition with a name to be newly recalled would simply have a higher average activation. Such fringe consciousness feelings are easily defeated.

Thus the LIDA model predicts the experienced outcome of this demonstration of the availability heuristic, and supports the commonly given, functional explanation, the availability heuristic. What the model adds is a hypothesized detailed mechanism for its functional process.

Conclusions

We have explored some of the well-established features of spontaneous remembering in the light of the LIDA/GWT model, including incidental learning and problem solving, expectation-driven recall, action control, and the "availability heuristic." Our basic message is that spontaneous remembering is a part of our ordinary stream of thought, helping us to answer the ever-present question: *What do I do next, to further my most important goals?* This view suggests that spontaneous thoughts are not just irrelevant "mind wandering," as some researchers suggest, but rather a highly functional, implicitly purposeful, problem-solving stream.

Acknowledgments

The authors gratefully acknowledge the conceptual contributions to this work made by the various members, past and present, of the Cognitive Computing Research Group at the University of Memphis, and to Uma Ramamurthy and Mathew Ventura in particular.

Notes

1. Reliably high associates to the word series are *window*, *paper*, *candle*, and *cold*, respectively.
2. 1. Tiny threads woven by a spider; 2. A wood board to hang keys from.
3. To say that conscious moments may be separated by short periods of no conscious contents does not mean, of course, that people momentarily fall asleep between conscious episodes.
4. Feelings in humans include hunger, thirst, various sorts of pain, hot or cold, the urge to urinate, tiredness, depression, etc. Emotions, such as fear, anger, joy, sadness, shame, embarrassment, resentment, regret, guilt, etc., are taken to be feelings with cognitive content (Johnston, 1999).
5. Quotes to this effect from each of these citations, and more, can be found in Baars (2002) and Franklin, Baars, Ramamurthy, & Ventura (2005).
6. At this writing the LIDA model is only partially implemented. We claim it as a computational model since each of its modules and most of its processes have been designed for implementation.
7. Gibson (1979) introduced the term *affordance*, meaning that information about the available uses of an object existed in the object itself. We are using it in the sense that the agent can derive such information from the object.
8. "In the last 15 years or so, it has become clear that the 8–12 Hz rhythmicity of physiological tremor is observed not only during voluntary movement, but also . . . during maintained posture and in supported limbs at rest (Marsden et al., 1984)" (Llinas, 2001).
9. The term codelet refers generally to any small, special-purpose processor or running piece of computer code. The concept is essentially the same as Baars' (1988) processors, Minsky's (1985) agents, Jackson's (1987) demons, or Ornstein's (1986) small minds. The term was borrowed from Hofstadter and Mitchell (1994).

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7

Priming, Automatic Recollection, and Control of Retrieval

Toward an Integrative Retrieval Architecture

Alan Richardson-Klavehn

1. Introduction

It has long been hypothesized that the astounding human capability for learning and memory is not monolithic, but instead consists of different types (e.g., Ebbinghaus, 1885/1964; for reviews, see Richardson-Klavehn & Bjork, 1988, 2002; Roediger, Marsh, & Lee, 2002; Schacter, 1987). Indeed, the distinctions between working and long-term memory, procedural and declarative memory, implicit and explicit memory, semantic and episodic memory, and familiarity and recollection are now routine. With the advent of the interdisciplinary field of cognitive neuroscience, a major goal has been to discover whether these hypothesized types of learning and memory have different neural substrates (e.g., Ghahremani and Poldrack, 2009; Henson, 2005, 2006; Paller, Voss, & Westerberg, 2009; Ranganath, 2009; Reber, 2009; Richardson-Klavehn et al., 2009; Rugg, 2009). Notably, all of these influential distinctions are defined, in part, by reference to different types of consciousness accompanying retrieval and/or encoding (Richardson-Klavehn & Bjork, 2002; Roediger et al., 2002). In cognitive neuroscience, therefore, understanding of memory, consciousness, and brain are intextricably interlinked.

The Act of Remembering: Toward an Understanding of How We Recall the Past.
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1.1. Explicit and implicit memory

Despite intensive research, none of the just-mentioned distinctions is uncontroversial (for discussion see, for example, Ranganath, 2009; Richardson-Klavehn et al., 2009). Here my main concern is the distinction between explicit and implicit memory (Graf & Schacter, 1985; see also Ebbinghaus, 1885/1964). Under the simplest definition, *explicit memory* occurs when one becomes conscious of a prior episode, and results from an act of the will, that is, voluntarily, intentionally, or via cognitive control. *Implicit memory* occurs when a past episode influences current thought or behavior without one having consciousness of that episode at the time its influence occurs. The absence of consciousness of the past in turn implies that retrieval occurs without an act of of the will, that is, involuntarily, unintentionally, or automatically. Hypotheses regarding the existence of implicit memory, thus defined, date back at least to Descartes (Schacter, 1987). The revival of the explicit/implicit distinction in the context of experimental research in the 1980s caused great excitement in the field. Such research had thus far, since its beginnings with Ebbinghaus (1885/1964), largely neglected the distinction owing to the dominance of behaviorism, which banned mental content, especially consciousness, from scientific inquiry. In stark contrast to behaviorist dogma, issues concerning consciousness were becoming amenable to experimental investigation. Most notably, the explicit/implicit distinction appeared essential to understanding memory deficits and the absence thereof in the human organic amnesic syndrome, in which explicit but not implicit memory seemed to be affected by damage to medial temporal lobe and connected limbic system structures in the brain (e.g., Graf & Schacter, 1985; Schacter, 1987). The explicit/implicit distinction was, therefore, a cornerstone of the emerging cognitive neuroscience of memory.

However, together with others (e.g., Butler & Berry, 2001; Moscovitch, 2008; Schacter, 1987; Schacter, Bowers, & Booker, 1989), I believe that the distinction between explicit and implicit memory as just defined turns out to be too simple, as is often the case with psychological dichotomies. In brief, it does not distinguish the volitional aspect of memory retrieval (whether retrieval is intended vs. unintended, voluntary vs. involuntary, or controlled vs. automatic) from the consciousness aspect (whether or not there is consciousness of prior episodes), thus failing to accommodate consciousness of prior episodes that occurs unintentionally, involuntarily, or automatically. A major thrust of my research has been to examine the respects in which the explicit/implicit distinction falls short, and their implications for the formulation of an adequate theory of memory, consciousness, and brain (see also Moscovitch, 1992, 2000, 2008). Here I integrate some of this research, address potential criticisms, and suggest that going beyond the simple explicit/implicit distinction can improve our understanding of the human retrieval architecture.

1.2. Intentional and incidental memory tests

In tandem with the revival of the explicit/implicit distinction, it became apparent in the 1980s that tests of memory routinely used in different subdomains of the field fell into two overarching classes (e.g., Richardson-Klavehn & Bjork, 1988). First, there were the traditional free recall, cued recall, and recognition memory tests, with cued recall (paired associate learning) having been the mainstay of research from around the turn of the last century (e.g., Müller & Pilzecker, 1900) until the 1960s. In these tests, research participants willfully retrieve previously learned information; that is, the test instructions refer to that information, and research participants are asked to try to retrieve it. Further, Tulving had already pointed out that, in order to achieve success on such tests when the information had been learned during the experiment itself, participants are often required to demonstrate knowledge of specific personal past episodes (e.g., Tulving & Thomson, 1973; Tulving, 1983). The material "learned" is often in fact well known to participants before the experiment (e.g., words used commonly in written and spoken language or pictures of common objects); participants have to try to produce the specific material presented during the learning episode (on recall tests), or to try to distinguish it from material that was not presented during the learning episode (on recognition tests). Success on such tests, therefore, also depends in some sense on consciousness of the learning episode. It was precisely these tests on which amnesic patients showed impaired performance, so that they were classified as *explicit memory tests* (Graf & Schacter, 1985; see also Roediger & Amir, 2005).

Second, there was a class of tests in which participants perform an ongoing task that makes sense to them based on their current base of knowledge and skills, without mental reference to previous experimental episodes being necessary (Moscovitch, 1984), such as completing a jigsaw puzzle, solving an anagram, identifying a fragmented or otherwise perceptually degraded word or picture, classifying a letter string as a word or a nonword, classifying a line drawing as a possible versus impossible object, responding with the first word coming to mind in response to a cue word or a word stem, and so forth (for more exhaustive lists, see Richardson-Klavehn & Bjork, 1988; Roediger & Geraci, 2005). Such tests nonetheless allow that performance might be influenced by previous experimental episodes. Perfomance improvements have typically been studied (but see, for example, Ikier, Yang, & Hasher, 2008, for research on performance impairments). Exposure to a word or a picture, for example, typically improves later identification or classification of that word or picture, and previously encountered words are more likely to pop up as free associates to cue words or completions to word stems than they would do in the absence of the prior encounter, a phenomenon known as *repetition priming*. Further, because the tasks make sense to participants without mental reference to previous experimental episodes, such tests also allow that the influence of these past episodes might occur without willful retrieval. The influence of the previous experimental episodes might even occur without consciousness of those episodes when the influence occurs, conforming to the simple definition of implicit memory (Section 1.1). These tests appeared to reveal striking unimpaired memory capabilities in amnesic patients, and were thus classified as *implicit memory tests* (Graf & Schacter, 1985; see also Roediger & Geraci, 2005).

Explicit and implicit tests appeared to reveal such impressively different pictures of memory that the field temporarily ignored lessons of the immediately preceding era, in which comparisons between recall and recognition tests were central. Brown (1976), for example, had commented that "the terms 'recall' and 'recognition' refer to both test situations and to memory processes. This is a potent source of confusion.... There is no necessary correlation between the formal characteristics of a test situation and the processes it evokes" (p. 1), and indeed, it became a prevailing view that recognition and recall tests did not involve fundamentally different core retrieval processes (e.g., Lockhart, Craik, & Jacoby, 1976; Tulving, 1976, 1983). Similarly, it was ultimately recognized that explicit and implicit tests do not necessarily index different underlying strategies, processes, or memorial states of consciousness (e.g., Richardson-Klavehn & Bjork, 1988). In order to avoid premature assumptions concerning the types of memory involved (e.g., the hypothetical processes of explicit vs. implicit memory), they were referred to instead as *direct* and *indirect tests* (e.g., Johnson & Hasher, 1987; Richardson-Klavehn & Bjork, 1988), or *intentional* and *incidental tests* (e.g., Jacoby, 1984; Richardson-Klavehn, Gardiner, & Java, 1996), thus emphasizing objective task and measurement characteristics.

The latter terminology, which I adopt here, parallels the distinction between intentional and incidental study tasks. In incidental study tasks, participants are asked to interact with the to-be-learned material in some way (e.g., judge it on some criterion), and are not necessarily told that the material will later be tested. Just as such study instructions do not guarantee that the participant does not try to learn, incidental test instructions do not preclude participants "catching on" to the experimenter's wish to study the influence of past experimental episodes, and engaging voluntary or controlled retrieval strategies. Further, even if retrieval is involuntary or automatic, it cannot necessarily be concluded that the participant has no consciousness of the relevant past episodes. That is, incidental tests are *capable* of revealing implicit memory (as defined in Section 1.1), but do not necessarily do so (Richardson-Klavehn & Bjork, 1988; Schacter, Bowers, & Booker, 1989).

Intentional tests are equally subject to questions concerning the variety of strategies, processes, and memorial states of consciousness that may be involved (e.g., Richardson-Klavehn & Bjork, 1988). Most relevant here, although participants may be engaging in voluntary or controlled retrieval, material from previous experimental episodes might nonetheless involuntarily or automatically pop to mind, especially when cues are provided to assist retrieval (e.g., Mace, 2007a; Moscovitch, 1992, 2000, 2008). Such involuntary or automatic retrieval might often improve performance, but might also impair performance, such as when previously encountered interfering material pops to mind, impairing voluntary or controlled retrieval of more recently encountered information (e.g., Gardiner, Craik, & Birtwistle, 1972).

In sum, the strategies, processes, and memorial states of consciousness underlying observed performance on both incidental and intentional tests require empirical verification, and cannot be assumed *a priori* (e.g., Richardson-Klavehn & Bjork, 1988; Gardiner & Richardson-Klavehn, 2000). Here I illustrate a component-process approach (Roediger, Buckner, & McDermott, 1999) to these problems, which is designed to elucidate both differences between, and similarities across, incidental and intentional tests. I argue that such an approach increases the theoretical and methodological resolution of comparisons between these test-types, and overcomes some of their potential disadvantages.

1.3. Chapter overview

I believe that a fair characterization of the field of explicit and implicit memory as it stands today is that research using intentional and incidental tests has established firm evidence for a distinction between voluntary (controlled) and involuntary (automatic) retrieval, which is critical in informing theories of memory. Whether the field has established evidence for implicit memory, as defined in Section 1.1, remains considerably more controversial (e.g., Butler and Berry, 2001; Berry, Henson, & Shanks, 2006a, 2006b; Berry, Shanks, & Henson, 2008; Kinder & Shanks, 2001, 2003; Ostergaard & Jernigan, 1993; Paller, Voss, & Westerberg, 2009; Richardson-Klavehn & Gardiner, 1995; Richardson-Klavehn, Gardiner, & Java, 1994). A corollary of this distinction between involuntary retrieval and implicit memory is the hypothesis that conscious recollection of prior episodes can occur involuntarily (as mooted by Ebbinghaus, 1885/1964).

In Section 2, I review evidence for involuntary retrieval in incidental tests, and address skeptical claims that such tests simply reveal voluntary memory retrieval in a less sensitive way than do intentional tests. In Sections 3 and 4, I review evidence that retrieval, while involuntary, can be accompanied by conscious recollection of past episodes at the time their involuntary influence occurs, a phenomenon I have termed *involuntary conscious memory* (Richardson-Klavehn, Gardiner, & Java, 1994, 1996; see also Schacter, 1987), but which I have more recently termed *automatic recollection* (Bergström, de Fockert, & Richardson-Klavehn, 2009a; Richardson-Klavehn, Gardiner, & Ramponi, 2002; see also Moscovitch, 1992, 2000, 2008), to reinforce the distinction between the volitional aspect of retrieval, or cognitive control of retrieval, and the extent to which retrieval is accompanied by conscious recollection of contextual details of past episodes. As part of this evidence, in Section 4, I consider models that postulate two retrieval processes that correspond to the constructs of explicit and implicit memory as defined in Section 1.1, and thus do not accommodate automatic recollection. I review evidence that one version of these models, which postulates that explicit and implicit memory are independent processes, produces estimates of automatic retrieval that in some situations systematically underestimate automatic retrieval, and in other situations are uninterpretable, both of which are predicted if automatic recollection occurs. In Section 5, I suggest that a heated controversy that arose in the context of these two-process models, namely the debate between direct retrieval (independence) and generate-recognize (redundancy) models of explicit and implicit memory, is an artificial one that does not arise when automatic recollection is considered, and show how elements of both models can co-exist within a sketch of a hierarchical cascaded retrieval architecture, and its interaction with working memory and attention, that accommodates automatic recollection, while also providing a principled account of dissociations between, and parallel effects across, intentional and incidental tests.

I cannot review the vast literature on implicit and explicit memory, which now includes a burgeoning literature on brain activity (e.g., Henson, 2003; Schacter, Wig, & Stevens, 2007; Paller, Voss, & Westerberg, 2009; Richardson-Klavehn et al., 2009). Neither can I review the expanding literature on involuntary conscious recollection in normal and clinically disturbed autobiographical memory, mainly exemplified by naturalistic studies (e.g., Mace, 2007b). This chapter is, rather, a personal perspective within a laboratory-memory-task context.

2. Evidence for Automatic Retrieval in Incidental Tests

Initial research comparing intentional and incidental tests revealed striking *dissociations*, meaning that these test-types responded differently to experimental manipulations and participant variables (e.g., Richardson-Klavehn & Bjork, 1988; Roediger & McDermott, 1993; Schacter, 1987). Unfortunately, in much of this research the difference between the tests in terms of instructions was confounded with other differences, such as the type of retrieval cues (e.g., entire words on a recognition memory test vs. words with deleted letters on a word fragment completion test, e.g., Tulving, Schacter, & Stark, 1982; or entire words on a recognition memory test vs. briefly flashed words on a perceptual identification test, e.g., Jacoby & Dallas, 1981), thus limiting conclusions that could be drawn about differences in the types of memory tapped by the two kinds of test (e.g., Ryan & Cohen, 2003). Indeed, it was shown experimentally that the intentional/incidental variable was not necessarily responsible for the dissociations, because differences in retrieval cues could create dissociations between different intentional tests, and between different incidental tests (e.g., Blaxton, 1989).

2.1. The retrieval intentionality criterion

A major advance in this respect was the *retrieval intentionality criterion* proposed by Schacter, Bowers, & Booker (1989). They argued that intentional and incidental tests must present identical retrieval cues, with only the instructions differing. If the tests then respond differently to experimental manipulations or participant variables, this difference can only be attributed to a difference in retrieval volition or intention created by the different test instructions. The word-stem-completion paradigm became popular in this regard because it allows the same word-stem cues (e.g., *EMP*____, *OFF*____) to be used, either with instructions to try to complete the stems with words from a previous study episode (intentional version), or with the first word coming to mind (incidental version). In the latter case, the measure of interest, repetition priming, is the difference between the likelihood that particular experimenter-selected target words (e.g., *EMPRESS*, *OFFICER*) are used as responses when those target words have been encountered in a previous study episode, compared with when they have not. This repetition priming is typically assessed within participants by including stems corresponding to both studied and nonstudied target words within the test list, and counterbalancing across participants which target words are previously studied (e.g., in the example above, some participants might study *EMPRESS*, and others *OFFICER*, thus allowing comparison of the likelihood that these words pop to mind with and without prior study). The stems corresponding to nonstudied target words are also included on the intentional test and provide a baseline measure to assess the likelihood that participants guess during their attempts to retrieve studied words.[1]

When these procedures equating test cues are followed, striking dissociations between intentional and incidental tests do in fact persist. A case in point is the effect of level of processing at study, which is one of the strongest, most stable, and well-replicated effects in all of the literature using intentional tests (e.g., Craik, 2002; Lockhart, 2002). Intentional stem-completion tests are no exception, with substantial level-of-processing effects typically being observed. Most relevant here, there are substantial performance advantages at test for prior semantic or meaning (i.e., deep) over prior phonemic or sound (i.e., shallow) study processing at study (e.g., Richardson-Klavehn & Gardiner, 1996, 1998; Richardson-Klavehn et al., 1999; see also Craik, Moscovitch, & McDowd, 1994). In matched incidental stem-completion tests, by striking contrast, the effect of the same study manipulation on later repetition priming can be completely absent, despite there being substantial repetition priming following both deep and shallow study processing. (LOP is henceforth used as an abbreviation for level of processing.)

The results from the incidental tests in the studies just cited are summarized in Table 7.1, which involved a total of 112 incidental test participants and revealed a mean LOP effect on later repetition priming of zero, despite the use of exactly the same experimental conditions (i.e., the same test lists, study lists, study conditions, and retention intervals) as in the intentional tests in these studies, with only the test instructions differing between the test groups (for similar results, see Craik et al., 1994). According to the logic of the retrieval intentionality criterion, such dissociations from intentional test performance demonstrate that the repetition priming observed in the incidental tests reflected involuntary or automatic retrieval of studied words.

Table 7.1 Mean priming of word-stem completion in incidental tests following deep (semantic) and shallow (phonemic) study processing in four experiments, and mean priming across experiments, weighted by the 112 individual participants (n = number of participants contributing to means) in a meta-analysis reported in Richardson-Klavehn et al. (1999). Priming was computed for each participant as the proportion of target words used to compete stems of studied words minus the proportion of target words used to complete stems of nonstudied words. Data from Richardson-Klavehn and Gardiner (1996) are averaged over study modality (visual vs. auditory), which did not interact with level of processing at study (for the separated data, see Table 7.4)

		Study condition		
Experiment	*n*	*Semantic*	*Phonemic*	*Difference*
Richardson-Klavehn and Gardiner (1996)	16	.17	.17	.00
Richardson-Klavehn & Gardiner (1998, Experiment 1)	24	.22	.21	–.01
Richardson-Klavehn & Gardiner (1998, Experiment 2)	48	.19	.19	.00
Richardson-Klavehn, Clarke, & Gardiner (1999)	24	.18	.19	.01
Mean	*112*	*.19*	*.19*	*.00*

Given the reasonable assumption that the intentional test instructions engaged voluntary or controlled retrieval, given that the intentional tests showed substantial LOP effects, and given that the intentional and incidental tests differed *only* in test instructions, repetition priming in the incidental tests would have had to show LOP effects if that priming had reflected voluntary or controlled retrieval. That is, if the incidental test participants had spontaneously turned the incidental tests into intentional tests, despite the instructions to respond with the first words coming to mind, their performance would have had to resemble that of the intentional test participants.

In two of the studies included in Table 7.1 (Richardson-Klavehn & Gardiner, 1998; Richardson-Klavehn et al., 1999), response times in the incidental tests (measured on a test-list-wise basis, because the tests were written) were somewhat faster than response times in additional control tests in which the participants had received no prior study list, and were thus constrained to respond with the first word coming to mind. These results concur with the occurrence of involuntary or automatic priming in the incidental tests. The retrieval intentionality criterion, and the convergent response-time data, nonetheless only permit the conclusion that retrieval in the incidental tests was involuntary or automatic, not the stronger conclusion that retrieval in the incidental tests was unaccompanied by conscious recollection of prior episodes, a point I reinforce in Section 3. First, however, I address some skeptical arguments.

2.2. LOP effects on priming:

Voluntary contamination versus lexical processing hypotheses

Small LOP effects on priming in incidental tests have been ubiquitous in other studies and have sometimes been significant individually (e.g., Toth, Reingold, & Jacoby, 1994; for meta-analyses, see Brown & Mitchell, 1994; Challis & Brodbeck, 1992), and these results have been taken to indicate that the retrieval intentionality criterion cannot be met in respect of LOP manipulations, and that there has been widespread contamination of incidental tests by voluntary or controlled retrieval (Toth & Reingold, 1996; Toth et al., 1994). Whereas such effects may indeed reflect contamination in some studies, it is now, however, apparent that such effects partly reflect the widespread use of graphemic (visual) tasks in the shallow study condition that permit extremely superficial processing, in contrast to the phonemic (sound) shallow processing task used in the studies in Table 7.1. In one of those studies, Richardson-Klavehn and Gardiner (1998, Experiment 1) explicitly contrasted graphemic (counting enclosed spaces within the letters of words), phonemic (counting syllables in words), and semantic (judging pleasantness of words) study tasks, within the same groups of intentional and incidental test participants, and found that the graphemic study task produced a substantial deficit in priming in the incidental test relative to the phonemic and semantic tasks (mean priming of .12, .22, and .21, respectively). The graphemic study task also produced much worse performance than the phonemic and semantic study tasks on the intentional test (mean recall corrected for baseline guessing of .06, .28, and .53, respectively).

Had only the graphemic and semantic tasks been used, as in the majority of studies in the literature (see Brown & Mitchell, 1994), the intentional and incidental tests would not have been dissociated, the retrieval intentionality criterion would not have been met, and the voluntary contamination hypothesis would have been plausible. However, within the same incidental test participants, and with test cues corresponding to items in the three study conditions randomly intermixed in the test list, the phonemic and semantic study tasks produced very similar priming (see also Table 7.1), so that the incidental and intentional tests were nonetheless dissociated, and the retrieval intentionality criterion was nonetheless met, within the same sets of intentional and incidental test participants. The deficit in priming for the graphemic task could, therefore, not reflect voluntary contamination, but instead appeared to reflect a deficit in lexical ("whole-word") processing during the graphemic study task, whereby participants were not attending to the words as lexical units, and these words were less likely to be later primed. Consistent with this hypothesis, participants reported "not looking at the words themselves" while performing the graphemic study task, even though they performed that task accurately.

To test this hypothesis, Richardson-Klavehn and Gardiner (1998, Experiment 2) replicated the priming deficit for graphemic study processing compared with phonemic and semantic study processing (mean priming of .09, .19, and .18, respectively), but further found that introducing the additional requirement to make a lexical decision (word vs. nonword) on each studied item into all three study tasks completely eliminated this deficit in priming following graphemic study processing (mean priming of .21), while leaving priming following phonemic and semantic processing unaffected (mean priming of .18 and .19, respectively). The results thus confirmed the lexical-processing-deficit hypothesis and, by additive/interactive factors logic, demonstrated that the phonemic and semantic study tasks already involved the requisite lexical processing to produce full repetition priming of around .20. These results, coupled with the absence of a priming difference between phonemic and semantic processing, support the theoretical conclusion that involuntary or automatic retrieval in word-stem completion is driven by the perceptual-lexical rather than the semantic level of memory representation (see also Craik, Moscovitch, & McDowd, 1994; Richardson-Klavehn & Gardiner, 1996, 1998; Richardson-Klavehn et al., 1999).

I will re-emphasize this point about the lexical, but not semantic, basis of priming in word-stem completion at a number of later points, because it is critical to my theoretical arguments in Section 5. The main point here, however, is that the retrieval intentionality criterion can be met given study tasks that guarantee lexical processing.

2.3. The response bias hypothesis of dissociations

A second skeptical argument that might undermine the conclusions I have drawn concerns possible differences in response bias between intentional and incidental word-stem-completion tests (e.g., Reingold, 2003; Reingold & Toth, 1996; Toth, Reingold, & Jacoby, 1994; see also Ryan & Cohen, 2003). Intentional tests are very often conducted with instructions not to guess with words believed nonstudied, whereas incidental tests are, by definition, conducted with instructions to respond with the first word coming to mind. The result is that, for stems corresponding to nonstudied target words, the baseline likelihood of responding with the experimenter-selected target words can differ considerably across the tests, often being lower for the intentional than the incidental test. The response bias argument is that the dissociations are an artifact of this baseline difference, so that dissociations between incidental and intentional tests should no longer be observed when baselines are matched. Such an argument would undermine the claim that the incidental tests provide useful measures of involuntary or automatic retrieval.

This hypothesis has, however, now been addressed in a number of experiments that have employed both intentional tests, with instructions not to guess, and modified intentional tests, which allow participants to respond with the first item coming to mind when they cannot retrieve a studied target word, thus equating the nonstudied baseline with the nonstudied baseline in the incidental tests. These modified intentional tests are known as *inclusion tests* and are henceforth referred to as such (see Sections 3–5). Substantial LOP effects are still observed in inclusion tests (Richardson-Klavehn & Gardiner, 1995, 1996, 1998; Richardson-Klavehn, Gardiner, & Ramponi, 2002; see Tables 7.2–7.4), and performance in inclusion tests still clearly dissociates from performance on incidental tests as a function of LOP at study, assuming the use of phonemic and semantic study tasks (Richardson-Klavehn & Gardiner, 1996, 1998; see Tables 7.1 & 7.4). Moreover, the response bias hypothesis cannot easily account for situations in which LOP effects on priming in incidental tests are completely absent (Tables 7.1 & 7.4), but instead implies that these effects should simply vary in size depending on the baseline. The response bias hypothesis of the dissociations I review here has, therefore, been roundly dismissed.

2.4. Statistical power and single dissociations: The importance of reversed associations

A third skeptical argument relies on the fact that the dissociations between intentional and incidental tests that I have described involve accepting the statistical null hypothesis of no effect of LOP for the incidental tests. This absence of an effect could simply reflect a lack of statistical power (e.g., Dunn, 2003; Dunn & Kirsner, 1988, 2003; Ostergaard & Jernigan, 1993; see also Buchner & Brandt, 2003). A corollary of the statistical power argument is the argument that the dissociations I have highlighted thus far are *single dissociations* (Dunn & Kirsner, 1988) – that is, cases where an experimental or participant variable affects one test (the intentional test) and not another test (the incidental test) – and that such dissociations are consistent with a single psychological process. Formally speaking, that is indeed the case: the test showing no effect could just be on the flat part of a monotonically positive or monotonically negative function linking the efficiency of a single underlying psychological process (or resource) to performance in the two tests (Dunn, 2003; Dunn & Kirsner, 1988, 2003; Shallice, 1988).

Our data, however, militate strongly against these arguments. First, with the 112 participants included in Table 7.1, statistical power to detect very small effects of LOP on priming approached unity (see Richardson-Klavehn, Clarke, & Gardiner, 1999). Second, the incidental tests in Richardson-Klavehn and Gardiner's (1998) experiments did show statistically significant priming deficits for graphemic study processing compared with phonemic and semantic study processing, showing that these tests were not simply statistically insensitive. Third, and most convincingly, we have found (Richardson-Klavehn et al., 1999) that intentional and incidental word-stem completion tests can simultaneously show, within the same sets of intentional and incidental test participants, and within the same randomly intermixed set of test items, (1) a single dissociation as a function of LOP at study, (2) a *crossed double dissociation* (Dunn & Kirsner, 1988), in which an experimental manipulation influences the tests in opposite ways, and (3) a *parallel effect* (Richardson-Klavehn & Bjork, 1988), in which an experimental manipulation influences the tests similarly. The conjunction of crossed double dissociation and parallel effect consistitutes a *reversed association* (Dunn, 2003; Dunn & Kirsner, 1988, 2003), which is formally incompatible with a single memory process underlying performance in the two tests (Richardson-Klavehn et al., 1999, 2009). The reversed association, because it involves both tests showing statistically significant effects, also demonstrates that the single dissociation within the same participants and tests as a function of LOP at study did not reflect a lack of statistical power.

The data of Richardson-Klavehn et al. (1999) are germane to later arguments, so I describe them in detail. Randomly assigned intentional and incidental test groups were contrasted, the word-stem test cues corresponded to both studied and nonstudied words, and the constitution of the test list (cues and sequence) was identical across groups. Prior to these tests, words were studied under three conditions. Participants either generated words from incomplete sentences together with the first letter of the target words, which virtually guaranteed successful generation, and said the target words aloud (Generate condition), read visually presented target words and made a judgment concerning the pleasantness of each word's meaning (Read-Semantic condition), or read visually presented target words and counted the syllables that each word contained (Read-Phonemic condition). Study condition was manipulated within subjects within each test group, with a blocked and counterbalanced order, and the order of the cues corresponding to the three types of studied words within the test list, as well as of the cues corresponding to nonstudied words, was block-randomized and then held constant.

The results are shown in Figure 7.1, in which priming in the incidental test group (i.e., the likelihood of producing target words in the incidental test for stems corresponding to studied target words minus the corresponding likelihood for stems corresponding to nonstudied target words) is plotted against corrected cued recall in the intentional test group (i.e., the likelihood of responding with studied target words minus the likelihood of guessing with nonstudied target words). The critical reversed-association data pattern is that the Generate condition produced better performance than the Read-Phonemic condition in the intentional test, but worse performance than the Read-Phonemic condition in the incidental test (i.e., a crossed double dissociation indicated by the filled arrow in Figure 7.1), and that the Read-Semantic condition produced better performance than the Generate condition in both tests (i.e., a parallel effect indicated by the unfilled arrow in Figure 7.1). It therefore appears impossible to construct a monotonically positive or a monotonically negative function relating the efficiency of a single underlying memory process to performance in the two tests. The data also show a single dissociation as a function of LOP at study, in that the Read-Semantic condition produced better performance than the Read-Phonemic condition in the intentional test, but very similar priming in the incidental test (the two data points to the right of Figure 7.1; see also the incidental test data from this experiment in Table 7.1). This conjunction of crossed double dissociation and single dissociation occurred despite the tests involving identical physical retrieval cues and differing only in the instructions to participants, and thus meet the retrieval intentionality criterion, strongly suggesting that performance in the incidental test reflected involuntary or automatic retrieval, despite the simultaneous occurrence of a parallel effect across the tests within the same participants.

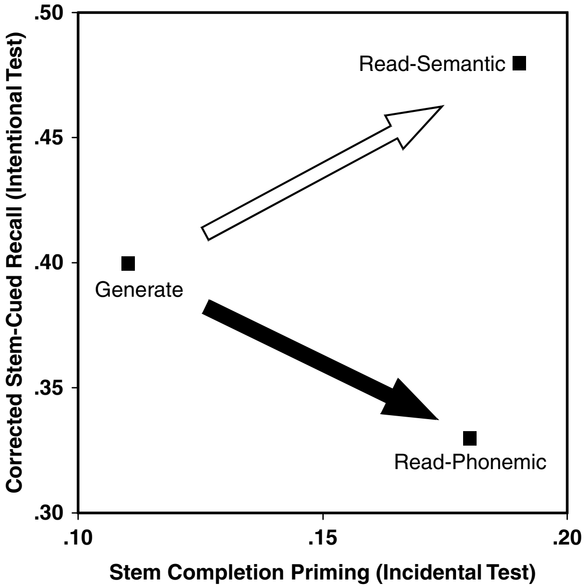


Figure 7.1 A reversed association between memory tests presenting identical word-stem retrieval cues and differing only in instructions (after data presented in Table 1 of Richardson-Klavehn, Clarke, & Gardiner, 1999). Proportion stem-cued recall, corrected for baseline guessing, in the intentional test group is plotted against proportion priming in the incidental test group (following Dunn & Kirsner, 1988). Study condition (Generate, Read-Phonemic, Read-Semantic) was manipulated within subjects within each test group. The positive association between the tests is indicated by the unfilled arrow; the crossed double dissociation between the tests is indicated by the filled arrow. All differences between study conditions within each test were statistically significant, except for the difference in priming between the Read-Semantic (.19) and Read-Phonemic conditions (.18) in the incidental test, and significant priming was observed compared to the non-studied baseline in all study conditions in the incidental test. The same reversed association pattern occurs with data uncorrected for baseline performance (the baseline correction subtracts a constant within each test), and when performance in the Generate condition is not conditionalized on successful generation at study (conditionalized data are shown).

Our substantive interpretation of these data is that voluntary or controlled retrieval, as engaged by the intentional test, benefits from prior processing of semantic information, thus producing advantages for the Generate and Read-Semantic study conditions over the Read-Phonemic condition. By contrast, priming in the incidental test was insensitive to prior processing of semantic information (as indicated by the very similar priming for the Read-Semantic and Read-Phonemic conditions), but rather benefited from match in sensory modality between study and test, thus producing priming advantages for the

Read-Semantic and Read-Phonemic conditions over the Generate condition. The Generate condition did nonetheless produce significant priming compared to the nonstudied baseline. The results again suggest that involuntary or automatic retrieval in word-stem completion reflects a combination of perceptual and more abstract lexical, but not semantic, memory representations, owing to the absence of a priming advantage for the Read-Semantic over the Read-Phonemic condition in the incidental test (see also Craik, Moscovitch, & McDowd, 1994; Richardson-Klavehn & Gardiner, 1996, 1998). The priming in the Generate condition, which, by the arguments just given, cannot be attributed to contamination by voluntary or controlled retrieval, appears not to be directly due to the semantic processing that occurred at study in that condition, but rather due to the participants having spoken and heard the words at study. In other words, that priming represents an involuntary or automatic cross-modal priming effect (see also Craik et al., 1994; Richardson-Klavehn & Gardiner, 1996). I return to this assertion in Section 4. The parallel advantage for the Read-Semantic over the Generate condition in the incidental and intentional tests appears to reflect a modality-match advantage for involuntary or automatic retrieval, which plays a role in performance not only in the incidental but also in the intentional test, in the latter driving conscious recollection upwards. I return to this assertion in Section 5.

The experiment of Richardson-Klavehn et al. (1999), and those of Richardson-Klavehn and Gardiner (1998) reviewed in Section 2.2, exemplify a more general research strategy of seeking simultaneous dissociations between, and parallel effects across, intentional and incidental tests, via the use of a greater number of study conditions than were used in earlier research, which improves the theoretical resolution of intentional/incidental test methodology, and concurrently addresses concerns such as possible voluntary contamination of incidental tests, response bias, and statistical power (see also Gardiner, Richardson-Klavehn, Ramponi, & Brooks, 2001; Ramponi, Richardson-Klavehn, & Gardiner, 2004, 2007; Richardson-Klavehn et al., 2009). They also represent a component-process approach (e.g., Roediger, Buckner, & McDermott, 1999), in which processes common to, and not only different between, intentional and incidental tests are specified, addressing concerns about the "purity" of incidental and intentional tests as measures of underlying strategies, processes, and memorial states of consciousness (Section 1.2). I take up this component-process approach again in Section 5.

3. Retrieval Control versus Conscious Recollection of Prior Episodes

Thus far I have argued that recent research using incidental and intentional tests of memory has remedied certain methodological limitations of earlier research and thus provided firm evidence that retrieval can take voluntary/controlled and involuntary/automatic forms. I re-emphasize, however, that these data do not necessarily support the conclusion that involuntary or automatic retrieval occurs without consciousness of the relevant prior experimental episodes, which would conform to the simple definition of implicit memory in Section 1.1. Here I extend this caveat by reviewing data showing formally that differences in retrieval volition or control are causally responsible for the dissociations between intentional and incidental tests reviewed in Section 2, and not necessarily differences in conscious recollection of prior episodes, and that involuntary or automatic retrieval can indeed be accompanied by conscious recollection.

3.1. Automatic retrieval versus implicit memory

Initial clues were revealed by the results of Richardson-Klavehn, Gardiner, and Java (1994) and Richardson-Klavehn, Lee, Joubran, and Bjork (1994), which were surprising in certain aspects. In the latter article, reporting three experiments, we employed recognition memory tests and perceptual identification tests (identification of briefly flashed words), and a study manipulation analogous to the generate-read manipulation in Richardson-Klavehn, Clarke, and Gardiner (1999; see Figure 7.1), in which words were either heard and processed deeply (Auditory-Deep condition), or seen and processed shallowly (Visual-Shallow condition). When the perceptual identification tests were conducted with incidental test instructions (i.e., "Simply identify these briefly flashed words"), this study manipulation produced a crossed double dissociation between recognition memory and priming of perceptual identification (i.e., Auditory-Deep > Visual-Shallow for recognition memory and Visual-Shallow > Auditory-Deep for perceptual identification priming; see also Jacoby, 1983, for a similar data pattern). We further showed that this crossed double dissociation only occurred when the perceptual identification test was conducted with incidental test instructions. When, in other randomly assigned perceptual identification test groups, participants were asked to use their memory for studied items to help them identify the test items (an intentional perceptual identification test), priming in the Auditory-Deep condition increased, whereas priming in the Visual-Shallow condition was unaffected, such that the recognition and perceptual identification tests were no longer dissociated, but instead showed a parallel effect (i.e., Auditory-Deep > Visual-Shallow). This reversed association was confirmed by a nonparametric analysis of the ordinal arrangement of population means for the two study conditions across experiments, which formally demonstrated that a difference in retrieval volition or control was responsible for the crossed double dissociation between the recognition memory and incidental perceptual identification tests, and that the crossed double dissociation was not entirely accounted for by differences in the physical test cues (cf. Blaxton, 1989). These data are also, according to the logic of reversed association (e.g., Dunn, 2003; Dunn & Kirsner, 1988, 2003), formally inconsistent with a single memory process (see Section 2.4, Figure 7.1, and Richardson-Klavehn et al., 1999, 2009).

Moreover, to our surprise, the vast majority (46) of the 48 participants in the incidental perceptual identification tests were aware, as reported in a systematic post-test questionnaire, that the perceptual identification test had included previously studied words, although the experimenter had not informed them of this fact prior to the test, and although their test performance exhibited the striking dissociation from both intentional perceptual identification test performance and recognition memory test performance. In the experiment by Richardson-Klavehn, Gardiner, and Java (1994), we obtained analogous test-awareness results in a word-stem-completion paradigm: that is, all 24 incidental test participants were aware that they had been responding with previously studied items, although the presence of word stems corresponding to studied items had not been mentioned to them prior to the test. Their test performance nonetheless demonstrated no significant effect of LOP at study on priming, in contrast to the performance of intentional test participants, who showed the traditional strong advantage for deep over shallow processing at study with the same word-stem test cues, suggesting that the performance of the incidental test participants primarily reflected involuntary or automatic retrieval.

These data, taken together, suggested that it might be possible to obtain an item-by-item measure of conscious recollection during an incidental test, without inducing the incidental test participants to contaminate the test with voluntary or controlled retrieval of studied words. We confirmed this hypothesis in two further word-stem-completion experiments (Richardson-Klavehn & Gardiner, 1995, 1996). Inclusion test participants were asked to complete stems with a studied word wherever possible, but with the first word coming to mind if they were unable to retrieve a studied word (thus equating the nonstudied baseline with the baseline in the incidental test; see Section 2.3). Incidental test participants were asked to respond with the first word coming to mind. In both tests, however, participants additionally indicated, after completing each word stem, whether their completion was studied or was a new, nonstudied, word. The experiments replicated the dissociation between intentional/inclusion tests and incidental tests as a function of LOP at study discussed in Section 2 (portions of the incidental test data from Richardson-Klavehn & Gardiner [1996] were included in Table 7.1), and just mentioned with respect to Richardson-Klavehn, Gardiner, and Java (1994), suggesting that repetition priming in the incidental test groups reflected involuntary or automatic retrieval. Therefore, asking the incidental test participants to report whether or not each completion was studied did not induce them to contaminate the test with voluntary or controlled retrieval of studied words.

Although priming was very similar following deep and shallow study processing, incidental test participants were much more likely to report conscious recollection for words previously given deep processing than for words previously given shallow processing, and following deep study processing they recollected that the majority of their completions were studied words. (Table 7.4 shows in full the inclusion and incidental test data from Richardson-Klavehn and Gardiner [1996] in a different context.) These results show that it is the way in which retrieval is initiated in response to the test cues (i.e., whether or not a voluntary or controlled strategy for retrieving studied words is engaged), rather than the state of consciousness with respect to past episodes, that is causally responsible for the impressive dissociations between intentional and incidental tests reviewed here and in Section 2, and which provide strong evidence that retrieval can be involuntary or automatic.

It can of course be objected that, in the experiments with "online" tests for consciousness of study-list membership (Richardson-Klavehn & Gardiner, 1995, 1996), the incidental test participants would not have been conscious of responding with studied items if the experimenter had not asked them to report that consciousness for each completed item. In other words, the experimenter added an intentional recognition test to an incidental test. The point of fact is correct, but the objection misses two critical points:

(1) The data are akin to an existence proof that inducing consciousness of study-list membership on an item-by-item basis during an incidental test does not have to contaminate that test with voluntary or controlled retrieval of studied words in response to the test cues. Priming can still reflect involuntary or automatic retrieval even when such consciousness is induced.

(2) The data show that it is *possible* that participants spontaneously consciously recollect prior episodes (involuntary conscious memory, or automatic recollection) during performance of incidental tests, without contaminating those tests with voluntary or controlled retrieval, although they do not *prove* that such spontaneous conscious recollection occurs. The data could of course have turned out differently (i.e., that inducing conscious recollection produced contamination by voluntary/controlled retrieval), which could have falsified the concept of involuntary conscious memory or automatic recollection in incidental tests.

In sum, these data, despite their limitations, go some way beyond the traditional definitions of explicit and implicit memory (Section 1.1). For example, it was long assumed after the advent of research using implicit memory tests (Section 1.2) that the nature of such tests (i.e., the presence of retrieval cues corresponding to studied items) must be concealed from participants in order to prevent "conscious recollection of prior study episodes." This assumption was false and rested on a confusion between "conscious recollection" defined as voluntary or controlled retrieval and "conscious recollection" defined as consciousness of prior episodes, the latter being compatible with involuntary or automatic retrieval. Indeed, purer involuntary or automatic retrieval may result from incidental test instructions that mention the possibility of responding with studied items, but request that participants nonetheless respond with the first items coming to mind (e.g., Gardiner, Richardson-Klavehn, Ramponi, & Brooks, 2001; Ramponi, Richardson-Klavehn, & Gardiner, 2004, 2007; Richardson-Klavehn, Gardiner, & Java, 1996).

3.2. Brain-activity evidence

The distinction between retrieval volition and memorial awareness (e.g., Richardson-Klavehn, Gardiner, & Java, 1994, 1996), or between retrieval control and conscious recollection of episodes (e.g., Richardson-Klavehn, Gardiner, & Ramponi, 2002), has also received support from functional brain imaging. Using a variant of the paradigm of Richardson-Klavehn and Gardiner (1995, 1996) just described, Schott et al. (2005) used functional magnetic resonance imaging (fMRI) to show that similar brain regions, notably areas of parietal cortex associated with successful retrieval of prior episodes, were hemodynamically activated at retrieval when participants were conscious of responding with studied items, whether the test instructions were inclusion or incidental. Priming-related hemodynamic deactivations in ventral visual stream areas associated with stimulus identification (e.g., Schacter, Wig, & Stevens, 2007) also did not interact with test instructions. Instead, activity in right frontal regions associated with control of episodic retrieval was influenced by inclusion versus incidental test instructions. Under the alternative hypothesis that conscious recollection of prior episodes is coextensive with voluntary or controlled retrieval, as implied by the simple definition of explicit memory (Section 1.1), activity in these frontal control regions should not have dissociated from activity in regions associated with conscious recollection of prior episodes. And according to the simple definition of implicit memory (Section 1.1), priming-related brain activity should have been more apparent when there was less evidence of voluntary or controlled retrieval as indexed by right frontal brain activity. These predictions from the traditional definitions of explicit and implicit memory were, however, not supported. The results thus illustrate how brain-activity data can assist in resolving issues in cognitive theory by disconfirming and not only confirming theoretical viewpoints (Henson, 2005, 2006; Richardson-Klavehn et al., 2009). As commented in Section 3.1, the data could have turned out differently. Related brain-imaging data are reported by Hall, Gjedde, and Kupers (2008; Hall, 2007), who found, using positron emission tomography (PET), that certain brain areas associated with conscious recollection of prior episodes were actually more active during incidental than during intentional testing. By contrast, right frontal areas associated with control of retrieval were more active during intentional than during incidental testing.

Further relevant results concern the null effect of LOP at study on later word-stem-completion priming reviewed in Sections 2 and 3.1. Schott, Richardson-Klavehn, Heinze, and Düzel (2002), using electroencephographic (EEG) measurements during the study phase of their experiment, showed that the neurocognitive processing predictive of later word-stem-completion priming was much earlier, peaking at 400 milliseconds (ms) after word onset, than the neurocognitive processing differences associated with LOP (semantic vs. phonemic), which peaked at around 1000 ms after word onset, and began after the priming-related processing had peaked. These neurocognitive processing differences were also distributed differently on the scalp, with priming-related activity being centrally distributed and LOP-related activity being frontally distributed. Further, using magnetoencephographic (MEG) measurements during the study phase of the same experiment, Düzel et al. (2005) showed that alpha and gamma oscillatory activity predictive of later word-stem-completion priming was already apparent during the time window of word identification (i.e., 100–300 ms after word onset), and localized this activity to ventral visual stream areas known to support word identification (see Schott et al., 2006, for fMRI data localizing priming-related activity at encoding to similar areas). The timing and localization of the relevant electromagnetic activity was not influenced by LOP (semantic vs. phonemic). Taken together, these results concur strongly with the dissociations between incidental and intentional tests as a function of LOP at study (semantic vs. phonemic) reviewed in Sections 2 and 3.1 (see also Tables 7.1 and 7.4), and with the assertions concerning the role of perceptual-lexical but not semantic processing in involuntary/automatic priming of word-stem completion made in Section 2, which are taken up again in Section 4 and especially Section 5.

4. Automatic Recollection and Two-Process Models of Explicit and Implicit Memory

The concept of involuntary conscious memory (e.g., Ebbinghaus, 1885/1964; Richardson-Klavehn, Gardiner, & Java, 1994, 1996) or automatic recollection (Richardson-Klavehn, Gardiner, & Ramponi, 2002) appears incontrovertible in everyday life and experience, and many lay people are surprised when I tell them that there are scientists (e.g., Reingold & Toth, 1996) who doubt that conscious recollection of prior episodes can occur involuntarily or automatically. Everyone has experienced suddenly coming to think about a past episode or episodes without having intended to think back to the past. Indeed, such instances of apparently spontaneous or automatic stimulus-driven conscious recollection of episodes are common in everyday life, as indicated by naturalistic studies (see Berntsen, 2007, and other contributions to Mace, 2007b). Moreover, in depressive and post-traumatic stress disorders, the problem is precisely that unpleasant and often highly vivid personal episodic memories are automatically retrieved despite the sufferer not wishing to retrieve them (e.g., Steel & Holmes, 2007). The concept of automatic recollection is also a cornerstone of research on retrieval inhibition, which examines the impact of directly avoiding or otherwise overriding (via the retrieval of other material) such automatic recollection on the future accessibility of the avoided episodic memories (e.g., Anderson & Green, 2001; Anderson et al., 2004; Bergström, Velmans, de Fockert, & Richardson-Klavehn, 2007; Bergström, de Fockert, & Richardson-Klavehn, 2009a, 2009b; Depue, Curran, & Banich, 2007; Wimber et al., 2008). Finally, as mentioned in Section 1.2, proactive interference, in which retention of current information is impaired by previously studied information, can sometimes reflect undesired automatic recollection of the previously studied information, and inability to distinguish it from the current information during retrieval (e.g., Gardiner, Craik, & Birtwistle, 1972).

However, as discussed in Section 3.1 in relation to "online" measures of conscious recollection during incidental tests (Richardson-Klavehn & Gardiner, 1995, 1996), directly (experimentally) demonstrating involuntary conscious memory or automatic recollection during incidental test performance is difficult. Such attempts may always founder on the objection that the participant would not have experienced conscious recollection of the episode or episodes in question if the experimenter had not asked them to think about it, either before or after the memory test. Phenomena that are difficult to observe are nonetheless not necessarily inaccessible to scientific inquiry, as demonstrated, for example, by the success of research in physics that postulates particles that cannot be directly observed, but whose existence is inferred from phenomena that are amenable to observation. In the current case, another approach is to formalize the simple distinction between explicit and implicit memory in a quantitative model that does not incorporate involuntary conscious memory or automatic recollection, and to see how this model fares. If the results from the model deviate systematically from reality, or the model cannot be realistically applied to relevant data, the results provide evidence for a phenomenon that is itself difficult to observe directly. (See, for example, Bergström, Velmans, de Fockert, & Richardson-Klavehn, 2007; Bergström, de Fockert, & Richardson-Klavehn, 2009a, 2009b; Hall, Gjedde, & Kupers, 2008; for another approach, in which brain-activity patterns act as markers for conscious recollection; for discussion, see Richardson-Klavehn et al., 2009.)

4.1. The process-dissociation procedure

The model I have considered in this case is incorporated in the process-dissociation procedure suggested by Jacoby and colleagues (e.g., Jacoby, 1998; Jacoby, Toth, & Yonelinas, 1993; Toth, Reingold, & Jacoby, 1994). This model incorporates two quantitative parameters: C is the probability of controlled, conscious memory. A is the probability of automatic, unconscious memory. The model thus explicitly equates consciousness of prior episodes with the engagement of cognitive control (or voluntary retrieval), and the absence of such consciousness with the absence of cognitive control (or involuntary retrieval). The psychological meaning of these parameters therefore corresponds very closely with the traditional simple definitions of explicit and implicit memory (Section 1.1). There is no parameter in the model corresponding to involuntary conscious memory or automatic recollection.

The process-dissociation model can be applied in a variety of task paradigms, but here I will again be concerned with word-stem completion, because it permits a comparison (e.g., Toth et al., 1994) with results from incidental tests of word-stem completion, as mainly reviewed up to now. With word-stem test cues, the process-dissociation model prescribes a comparison of two kinds of test instructions (e.g., Jacoby, 1998). In the inclusion test, participants are to try to recollect a studied completion for each word stem and to overtly complete the stem with that word; if they cannot recollect a studied completion they are to complete the stem with the first word coming to mind. In the exclusion test, participants are to try to recollect a studied completion for each word stem (exactly as in the inclusion test), and if they can do so, to replace that completion with a different, nonstudied, completion as their overt response; if they cannot recollect a studied word, they are to complete the stem with the first word coming to mind. Inclusion and exclusion trials are typically intermixed randomly in the test sequence, with a cue as to whether to include or exclude preceding each word stem.

The process-dissociation model is then mapped onto performance in these tests. In the inclusion test, both C and A push studied words out as overt behavioral responses. The probability of responding with a studied word in the inclusion test can therefore be expressed as $C + A\,(1 - C)$. This equation assumes that C and A are independent forms of memory: that is, either C operates, A operates, both C and A operate together, or neither C and A operate. The fourth case corresponds to unsuccessful retrieval when the test cue corresponds to a studied item, under the assumption that *C* and *A* reflect a tendency to respond with a studied item created by the study episode, and occurs by definition when the test cue corresponds to a nonstudied item. In the exclusion condition it is assumed that if *C* operates, the participant suppresses the studied word and responds with a different word: therefore, they will only respond with a studied word when *A* operates but *C* does not operate, so that the probability of responding with a studied word in the exclusion test can be expressed as $A\ (1 - C)$. The equations for the two tests differ only in *C*: therefore, subtracting observed exclusion from observed inclusion performance, expressed as proportions of stems completed with studied words, estimates the probability of *C*. The probability of *A* is then estimated by dividing the observed exclusion proportion by $(1 - C)$. This calculation corresponds algebraically to adding the joint probability of *C* and *A* to the observed exclusion proportion to estimate *A* (i.e., $A = \text{Exclusion} + CA$), because, under the independence assumption, when *C* and *A* co-occur, the participant is assumed to omit the automatically retrieved studied words from their overt responses on exclusion trials.

4.2. Dissociations between intentional/inclusion and incidental tests:

Direct retrieval (independence) vs. generate-recognize (redundancy) models

The *C* and *A* parameters, thus defined, are meant to provide estimates of the probability of conscious and unconscious memory. However, because no distinction is made between state of consciousness with respect to prior episodes, and retrieval volition or control, these parameters are also meant to provide estimates of voluntary or controlled versus involuntary or automatic retrieval. The parameters of the model definitionally rule out the possibility that involuntary or automatic retrieval can result in consciousness of a prior episode, as asserted with the concept of involuntary conscious memory or automatic recollection. It is only when, under the independence model, *C* and *A* co-occur, that involuntary or automatic retrieval can be accompanied by consciousness of a prior episode, but because *C* also represents the probability of voluntary or controlled retrieval, such co-occurrence must imply that voluntary or controlled retrieval operates. Therefore, at least at face value, the independence model implies that, if there is any conscious recollection of prior episodes during an incidental test, that test must be contaminated by voluntary or controlled retrieval of studied items in response to the test cues (as implied, for example, by the attempt to account for involuntary conscious memory or automatic recollection in terms of the independence model in Reingold & Toth, 1996). This implication is inconsistent with the data discussed in Section 3.1 showing that involuntary/automatic retrieval in incidental tests is perfectly compatible with participants reporting that they are responding with studied items (e.g., Richardson-Klavehn & Gardiner, 1995, 1996; see also Table 7.4).

In order to account for such incidental test data within the process-dissociation framework, therefore, it must be assumed that participants can change the way the constructs in the two-process model operate, that is, that they can change from an independence model, in which *C* and *A* both begin to operate immediately and independently on presentation of the test cue, to a generate-recognize model in which *A* operates first in response to the test cue, and *C* then operates on the product of *A* (e.g., Jacoby & Hollingshead, 1990). Such a model is known as a redundancy model, because *C* becomes a subset of *A* (i.e., the probability of *C* cannot exceed the probability of *A*), and thus *C* is not independent of *A* (e.g., Jacoby, 1998; Reingold & Toth, 1996). If automatic unconscious retrieval, *A*, is uninfluenced by LOP at study, and controlled conscious retrieval, *C*, only operates on words retrieved via automatic unconscious retrieval, such a generate-recognize model could potentially account for our demonstrations (Section 3.1; Richardson-Klavehn & Gardiner, 1995, 1996) that priming in an incidental test shows no LOP effect, but that participants' consciousness of responding with studied items is much greater following deep than following shallow study processing. Indeed, it has sometimes been suggested that we (e.g., Richardson-Klavehn, Gardiner, & Java, 1994, 1996) have proposed a two-process generate-recognize model (e.g., Reingold & Toth, 1996; Roediger, Marsh, & Lee, 2002).

We have not, however, proposed a generate-recognize model, because the concept of involuntary conscious memory (e.g., Richardson-Klavehn, Gardiner, & Java, 1994, 1996) or automatic recollection (Richardson-Klavehn, Gardiner, & Ramponi, 2002) implies that retrieval cues can not only result in involuntary or automatic retrieval as evidenced in priming, but can simultaneously trigger involuntary or automatic conscious recollection of episodes (see also Moscovitch, 1992, 2000, 2008). Our viewpoint thus questions both the direct retrieval (independence) and generate-recognize (redundancy) two-process models of implicit and explicit memory (Richardson-Klavehn et al., 2002). The generate-recognize model, for example, does not explain how incidental test participants spontaneously become conscious of responding with studied items, even when the experimenter has not informed them in advance of cues corresponding to studied items, and even though their performance demonstrably reflects involuntary/automatic retrieval (Section 3.1; Richardson-Klavehn, Gardiner, & Java, 1994; Richardson-Klavehn, Lee, Joubran, & Bjork, 1994). In the generate-recognize model, as in the direct retrieval model, conscious recollection of episodes is still a voluntary or controlled process. It is this very assumption that I question, together with the sequentiality assumption that automatic generation temporally precedes conscious recollection. Sections 4.5 and 5.2 to 5.4 consider other limitations of generate-recognize models.

4.3. Consequences of automatic recollection for the process-dissociation procedure

Most critical here, however, is whether the process-dissociation (direct retrieval independence) model of explicit and implicit memory, applied to inclusion and exclusion tests, provides plausible estimates of the effect of critical experimental variables on estimates of automatic retrieval. If the traditional conceptions of explicit and implicit memory, which the direct retrieval independence model formalizes, exhaust and correctly classify the kinds of memory that can operate in word-stem completion, the model should produce sensible results. However, if there is involuntary conscious memory or automatic recollection in response to test cues, and if participants follow the inclusion and exclusion test instructions, items thus retrieved will be included in inclusion test responses and excluded from exclusion test responses. Therefore, the *C* parameter, which is meant to index only controlled conscious memory, should be contaminated by automatic recollection, and the *A* parameter should fail to index automatic recollection, and systematically underestimate automatic retrieval (e.g., Richardson-Klavehn & Gardiner, 1996; Richardson-Klavehn, Gardiner, & Java, 1994, 1996). My contention is that such systematic underestimates of automatic retrieval have now been frequently enough observed to falsify the model, including under conditions in which the published boundary conditions for the application of the process-dissociation independence equations (e.g., Jacoby, 1998; Reingold & Toth, 1996) have been fully met, thus providing evidence for automatic recollection, and the need to go beyond two-process models of explicit and implicit memory, whether two-process direct retrieval (independence) models or two-process generate-recognize (redundancy) models.

4.4. The elusiveness of null effects of LOP on estimates of automatic retrieval

As a first test case, I examine the effect of LOP of studied items on word-stem completion, which has featured prominently thus far. In a sense, the effect or non-effect of this variable is the gold standard. Proponents of the process-dissociation procedure shared the assumption that a pure measure of automatic retrieval in word-stem completion should be uninfluenced by LOP at study, because they argued that when advantages of deep over shallow study processing on priming in incidental word-stem-completion tests are observed (as are also observed in intentional/inclusion tests), they reflect contamination by voluntary or controlled retrieval of studied items (e.g., Toth & Reingold, 1996; Toth, Reingold, & Jacoby, 1994). Accordingly, it was reported that estimates of automatic retrieval (*A*) from the process-dissociation procedure in word-stem completion showed no effect of LOP at study; only estimates of controlled retrieval (*C*) were larger for deep than for shallow study processing (Toth et al., 1994, Experiment 1). However, in two large-scale experiments (Richardson-Klavehn, Gardiner, & Ramponi, 2002), which took every possible precaution to ensure that the process-dissociation procedure had been implemented according to the prescriptions of the originators of that procedure (e.g., Jacoby, 1998), and which included a direct replication of the procedures of Toth et al. (1994, Experiment 1), we found that estimates of automatic retrieval (*A*) were either uninterpretable, or were systematically lower following deep compared with shallow study processing even when the published boundary conditions for application of the process-dissociation equations (e.g., Jacoby, 1998) were met. Table 7.2 shows these results, together with the results of Toth et al. (1994, Experiment 1).

Our Experiment 1 was designed as an "improved" version of the Toth et al. (1994) experiment, in that it used the "direct retrieval" instructions recommended by Jacoby (1998), which are to treat both inclusion and exclusion trials as a cued recall test before responding (Section 4.1). These instructions are designed to ensure that the *C* parameter is identical on inclusion and exclusion trials, which is an assumption of the process-dissociation equations, and to avoid participants adopting a generate-recognize strategy, which is a strategy of responding with the first word coming to mind, and including that word on inclusion trials if it happens to be a studied word, and excluding that word on exclusion trials if it happens to be a studied word. This strategy violates the assumption that *C* and *A* begin to operate independently on presentation of a test cue, and instead makes *C* redundant with *A* (Section 4.2). Toth et al. (1994, Experiment 1), by contrast, used direct retrieval instructions on inclusion trials, and "creativity" instructions on exclusion trials, which were to treat those trials as a creativity test and respond only with nonstudied words. Other procedural differences between experiments were minimal (e.g., the precise method for assigning studied items to inclusion and exclusion trials) and should not have influenced the results.

Indeed, as Table 7.2 shows, nonstudied baseline performance and inclusion test performance were highly comparable across the experiments. We nevertheless failed to reproduce two critical aspects of the Toth et al. (1994, Experiment 1) results. First, estimates of automatic retrieval (*A*) following deep study processing were below the nonstudied baseline (computed by averaging the nonstudied baseline scores for the inclusion and exclusion tests; see Jacoby, 1998; Jacoby, Toth, & Yonelinas, 1993; Toth et al., 1994). This nonstudied baseline estimates the probability of responding with target words in the absence of prior study. Therefore, estimates of automatic retrieval should never be below this nonstudied baseline, which would nonsensically correspond to negative memory. Our estimates of automatic retrieval following deep study processing were therefore uninterpretable. The difficulty occurred because participants were too good at excluding studied words with the exclusion instructions following deep study processing, resulting in low exclusion proportions, and because the automatic retrieval parameter is calculated as $A = \text{Exclusion}/(1 - C)$, and is therefore strongly dependent on the level of exclusion performance. Second, whereas Toth et al. (1994, Experiment 1) reported a significant advantage for deep over shallow study processing in their incidental test (i.e., with instructions to respond with the first word coming to mind), which they attributed to contamination by controlled or voluntary retrieval, we found only a small nonsignificant effect of LOP at study on priming in our incidental test, which we would have expected in view of the fact that the shallow processing task used by Toth et al. (1994) was a low-level graphemic task (i.e., counting vowels in common with the previous study-list word), and which, as previously reviewed here, we would not necessarily attribute to voluntary contamination of the incidental test (Section 2.2; Richardson-Klavehn & Gardiner, 1998).

In our Experiment 2 we changed *all* aspects of the experimental procedure, including the test instructions, so as to be identical to those used by Toth et al. (1994, Experiment 1), including some details concerning assignment of studied items to inclusion and exclusion test trials not published in their original article, and doubled the participant count to 48 across Experiments 2a and 2b. Performance was again comparable to that in Toth et al. (1994, Experiment 1), and this time the floor effect on exclusion performance and estimates of automatic retrieval (A) following deep study processing disappeared, so that these estimates were interpretable, but they were still lower following deep than following shallow study processing, and did not exceed the nonstudied baseline following deep study processing, which would imply no automatic retrieval following deep study processing (Table 7.2). This result does not make sense in view of the results from comparable incidental tests, which lead one to expect similar automatic retrieval following deep compared with shallow study processing (Table 7.1, Section 2.1), or a small advantage for deep over shallow study processing, if graphemic and semantic study tasks are used (Table 7.2, Section 2.2).

Our Experiment 2 also contained other test conditions to provide evidence concerning the basis of exclusion performance with the Toth et al. (1994) creativity exclusion instructions. In Experiment 2a, following a procedure recommended by Jacoby (1998), a further group of 24 participants were

Table 7.2 Mean proportions of word stems completed with target words and mean estimates of controlled and automatic retrieval in Richardson-Klavehn, Gardiner, and Ramponi (2002, Experiments 1 and 2) and Toth, Reingold, and Jacoby (1994, Experiment 1)

		Studied		
Test	*Estimate*	*Deep*	*Shallow*	*Nonstudied*
Richardson-Klavehn, Gardiner, & Ramponi (2002, Experiment 1): Direct retrieval instructions				
Incidental		.51	.49	.34
Inclusion		.58	.50	.31
Exclusion		.06	.34	.31
	Controlled	.52	.16	
	Automatic	.10 (.18)	.41 (.40)	
Toth, Reingold, & Jacoby (1994, Experiment 1): Creativity exclusion instructions				
Incidental		.51	.45	.30
Inclusion		.60	.47	.29
Exclusion		.33	.43	.26
	Controlled	.27	.03	
	Automatic	.42 (.45)	.45 (.44)	
Richardson-Klavehn, Gardiner, & Ramponi (2002, Experiment 2a & 2b): Creativity exclusion instructions				
Inclusion		.58	.48	.33
Exclusion		.21	.38	.31
	Controlled	.38	.10	
	Automatic	.30 (.34)	.44 (.44)	
Richardson-Klavehn, Gardiner, & Ramponi (2002, Experiment 2a): Remember-know instructions				
Inclusion		.62	.54	.36
"Remember"		.53	.10	.01
"Know"		.07	.18	.07
"New"		.03	.27	.29
	Exclusion	.09	.44	.35
	Controlled	.53	.10	
	Automatic	.18 (.23)	.49 (.48)	
Richardson-Klavehn, Gardiner, & Ramponi (2002, Experiment 2b): Strict creativity exclusion instructions				
Inclusion		.60	.48	.31
Exclusion		.13	.35	.30
	Controlled	.48	.12	
	Automatic	.21 (.27)	.41 (.42)	

treated identically to the 48 participants in the direct replication of Toth et al. (1994, Experiment 1), but received direct retrieval inclusion instructions on all test trials, and classified each completed word as "remember" (meaning they recollected the specific contextual details of the study episode), "know" (meaning the word was familiar in the experimental context, but they did not specifically recollect studying it), or "new" (meaning the word elicited no experience of memory) (for details concerning "remember" and "know" judgments, see Gardiner & Richardson-Klavehn, 2000). Exclusion performance is then estimated by subtracting the proportion of "remember" judgments from the overall inclusion proportion, under the assumption that the *C* parameter reflects words that are specifically consciously recollected as studied, and that the *A* parameter reflects both words that are familiar in the experimental context and words that elicit no experience of memory (Jacoby, 1998). Whereas overall performance for this group was similar to that for the group in the direct replication of Toth et al. (1994, Experiment 1), estimated exclusion performance following deep study processing was lower, and estimates of automatic retrieval (*A*) in that condition were below the nonstudied baseline and uninterpretable, as in Experiment 1 (Table 7.2). This result provided initial evidence that participants receiving the creativity exclusion instructions in the direct replication of Toth et al. (1994, Experiment 1) might, on exclusion trials, not be fully following the instructions to exclude words that they consciously recollected as studied.

In Experiment 2b, a further group of 24 participants were treated identically to the 48 participants in the direct replication of Toth et al. (1994, Experiment 1), with the addition of one sentence to the creativity exclusion instructions stressing that when they were only able to recollect a studied word, and could not think of an alternative, nonstudied, completion, they were to pass and not respond with the studied completion. Despite their

Note: Means in parentheses were computed excluding participants with exclusion proportions of zero (floor effects) in the deep study condition. Richardson-Klavehn, Gardiner, and Ramponi (2002, Experiment 1) employed the direct retrieval (cued recall) inclusion and exclusion instructions recommended by Jacoby (1998) (n = 24), and the incidental test instructions employed by Toth, Reingold, and Jacoby (1994, Experiment 1) (n = 24). Richardson-Klavehn et al. (2002, Experiment 2) employed (1) a direct replication of Toth et al.'s (1994) Experiment 1 using direct retrieval inclusion instructions and "creativity" exclusion instructions (n = 48), (2) an inclusion test with direct retrieval (cued recall) instructions and instructions to classify each completed word as "remember" (recollected), "know" (familiar but not recollected), or "new" (nonstudied), as recommended by Jacoby (1998), with exclusion scores being estimated by subtracting the proportions classified as "remember" from the inclusion proportions prior to model estimation (n = 24), and (3) a direct replication of Toth et al.'s (1994) Experiment 1 using direct retrieval inclusion instructions and "creativity" exclusion instructions, with the addition of one sentence to the exclusion instructions stressing that participants were to pass on exclusion test trials if they were only able to think of a studied completion (n = 24).

performance being again generally comparable to the participants in the direct replication, these participants also showed lower exclusion scores and lower (below baseline, and therefore uninterpretable) estimates of automatic retrieval following deep study processing, thus producing additional evidence that the participants in the direct replication may have been responding on exclusion trials with words that they consciously recollected having studied.

Consistent with this evidence, we were only able to find a null effect of LOP on estimates of automatic retrieval in our Experiment 2b by separating out 13 of the 24 participants in the direct replication of Toth et al. (1994, Experiment 1), who, in a systematic post-test interview used only in Experiment 2b (the interview responses being quantified by two blind raters), admitted not to have followed the exclusion instructions carefully, and some of whom admitted knowingly responding on exclusion trials with items they recollected having studied, despite the instruction to exclude studied words from their overt responses. Table 7.3 shows the results of the 24 participants in the direct replication group in Experiment 2b as a function of interview responses. The performance of the lax participants violates the assumption that items retrieved via controlled conscious retrieval (C) do not appear as responses in the exclusion test, given by the equation Exclusion = A (1 – C). Thus this replication of Toth et al. (1994,

Table 7.3 Mean proportions of word stems completed with target words and mean estimates of controlled and automatic retrieval as a function of blind-rated post-test interview responses in Richardson-Klavehn, Gardiner, and Ramponi (2002, Experiment 2b, direct replication of Toth, Reingold, and Jacoby 1994, Experiment 1). Means in parentheses were computed excluding participants with exclusion proportions of zero in the deep study condition

		Studied		
Test	*Estimate*	*Deep*	*Shallow*	*Nonstudied*
Careful excluders (n = 11)				
Inclusion		.55	.45	.35
Exclusion		.14	.33	.29
	Controlled	.40	.12	
	Automatic	.20 (.24)	.38 (.37)	
Lax excluders (n = 13)				
Inclusion		.61	.44	.31
Exclusion		.29	.33	.27
	Controlled	.32	.10	
	Automatic	.40 (.43)	.39 (.39)	

Experiment 1) ironically only occurred under conditions that violate a core assumption of the process-dissociation procedure. This result inevitably raises the question of whether participants in that earlier study may have been responding with consciously recollected words on exclusion trials.

The results that we did consistently obtain (i.e., uninterpretable estimates of automatic retrieval following deep study processing, or lower estimates of automatic retrieval following deep than following shallow study processing), including under conditions that closely followed the prescriptions for the use of the process-dissociation procedure (Jacoby, 1998), and a direct replication of Toth et al. (1994, Experiment 1), are exactly those that would be predicted if automatic recollection plays a role in performance in word-stem completion. Recall that in "online" measures in incidental tests, participants were more likely to be conscious that they were responding with studied items following deep than following shallow study processing, although the priming they displayed did not show an influence of LOP (Section 3.1; e.g., Richardson-Klavehn and Gardiner, 1996; see also Table 7.4). This finding suggests that automatic recollection should be more likely following deep than following shallow study processing, and therefore that the process-dissociation procedure should underestimate automatic retrieval to a greater extent following deep than following shallow study processing even when the boundary conditions for the application of the process-dissociation equations (Jacoby, 1998) are fully met (as observed in our direct replication of Toth et al.'s 1994, Experiment 1), or that estimates following deep processing should be below the nonstudied baseline and uninterpretable (as observed in our other experimental conditions), so that the equations cannot meaningfully be applied.

4.5. Automatic recollection and generate-recognize models, Part 1

As previously noted, the process-dissociation equations are held to be inapplicable if participants adopt a generate-recognize strategy of responding with the first words coming to mind, emitting these words on inclusion trials, and omitting these words on exclusion trials if they are recognized as studied. Such a strategy is held to yield two behavioral "signatures" (e.g., Jacoby, 1998). First, inclusion test performance resembles incidental test performance (as indicated, for example, by the absence of an LOP effect; see Table 7.1), because participants are responding with the first words coming to mind. Second, baseline responding with nonstudied target words is lower on exclusion trials than on inclusion trials, because such a strategy leads participants to exclude words that are familiar in the experimental context but not specifically recollected as studied, and because some nonstudied target words elicit such feelings of familiarity (Jacoby, 1998). This conclusion follows because participants are generating the first word coming to mind, and the fluency that sometimes accompanies generating is held to cause such feelings of familiarity (Jacoby, 1998). As shown in Table 7.2, however, there is no evidence whatsoever of these signatures in the data of Richardson-Klavehn, Gardiner, and Ramponi (2002).

The remember-know instructions used in our Experiment 2a also provide important information in this regard. The "remember" (specifically consciously recollected) and "know" (familiar in the experimental context) false alarm proportions for nonstudied target words were .01 and .07, respectively (Table 7.2). If our participants had been excluding on the basis of familiarity, therefore, baseline differences between inclusion and exclusion proportions of around .08 would have been expected. Instead, subtracting the "remember" proportions from the inclusion proportions to estimate exclusion performance in Experiment 2a resulted in quite accurate predictions of the very small baseline differences and of the exclusion proportions following deep study processing in Experiment 1 and in the "strict creativity" group in Experiment 2b, suggesting that participants in these experiments were excluding words they specifically recollected having studied and only these words, and further suggesting that the participants in the direct replication of Toth, Reingold, and Jacoby (1994, Experiment 1) in Experiments 2a and 2b were responding with recollected words on exclusion trials corresponding to items previously deeply processed.

Richardson-Klavehn et al. (2002) also reported extensive individual-difference analyses of post-test interview responses and test performance measures, none of which provided any support for the hypothesis that failure to find invariance of estimates of automatic retrieval as a function of LOP at study reflected a generate-recognize strategy. For example, smaller LOP effects on inclusion performance were not associated with lower exclusion performance following deep study processing. If anything, the results suggested precisely the opposite: it was the lax excluders in Experiment 2b (Table 7.3), whose automatic retrieval estimates replicated the invariance as a function of LOP at study reported by Toth et al. (1994, Experiment 1), for which post-test interview responses could be taken to indicate a generate-recognize strategy. These participants not only reported sometimes knowingly responding with recollected words on exclusion trials, but also making exclusion "mistakes" by responding with studied words prior to recognizing them.

It would of course be possible to counter with the argument that our participants used a generate-recognize strategy despite the absence of its signatures, just because their automatic retrieval estimates (*A*) were not invariant as a function of LOP at study (except of course for the lax excluders in Experiment 2b). That argument would, however, be deeply problematic.

First, as reviewed in Section 4.6, other experimental variables have been found by proponents of the process-dissociation procedure to influence automatic retrieval estimates (*A*) in word-stem completion, with estimates in some study conditions not exceeding the nonstudied baseline, and these results would then have to be taken as reflecting an inappropriate generate-recognize stategy. More generally, any unexpected pattern of automatic retrieval estimates could be explained away as reflecting an inappropriate but unobservable test strategy, rendering the scientific value of the approach questionable.

Second, if participants can show significant LOP effects in inclusion tests (as in all of the Richardson-Klavehn et al. [2002] experiments, including for the lax excluders in Experiment 2b; see Tables 7.2 & 7.3) despite using a generate-recognize strategy, the basis within the process-dissociation framework for explaining dissociations between intentional/inclusion and incidental word-stem-completion tests disappears (Section 4.2). LOP effects are thought to occur when participants use a direct retrieval strategy, and not to occur when participants use a generate-recognize strategy (e.g., Jacoby, 1998; Reingold & Toth, 1996), the latter being the basis for explaining the finding that the performance of incidental test participants can reflect involuntary or automatic retrieval, but that they can be conscious that they are responding with studied items (Section 3.1; Richardson-Klavehn & Gardiner, 1995, 1996; see also Table 7.4). If not, a generate-recognize model might be applied to all aspects of word-stem completion, including intentional/inclusion test performance (e.g., Bodner, Masson, & Caldwell, 2000; Jacoby & Hollingshead, 1990). For example, one might attempt to explain dissocations between intentional/inclusion tests and incidental tests via the number of generate-recognize cycles involved in producing responses. The very basis for the direct retrieval independence model is then undermined.

Moreover, I agree with the proponents of the process-dissociation procedure (e.g., Reingold & Toth, 1996) that a generate-recognize approach is not to be favored, because it postulates that retrieval cues can never directly cue episodic memory traces, as well as for the reasons given in Section 4.2, and for further reasons given in Sections 5.2 to 5.4. Together with the proponents of the direct retrieval (independence) model, I want to retain, in a modified form, the notion that cues (e.g., word stems) can directly cue episodic memory traces. I question, however, whether such direct cueing must involve controlled or voluntary retrieval, as assumed in the direct retrieval independence model. Re-emphasizing an earlier point, the notion of involuntary conscious memory (Richardson-Klavehn, Gardiner, & Java, 1994) or automatic recollection (Richardson-Klavehn et al., 2002) questions the very assumption that two processes, of automatic unconscious retrieval (*A*), and conscious controlled retrieval (*C*), are theoretically sufficient, regardless of how the relationship between these processes is conceived (independence or redundancy), and postulates instead that direct cueing of episodic memory traces can occur involuntarily or automatically (see also Moscovitch, 1992, 2000, 2008). I take this point up again in Section 5, in which I argue that elements of both generate-recognize and direct retrieval models can co-exist in a retrieval architecture that accommodates involuntary/automatic recollection.

4.6. Automatic retrieval from generating at study, and automatic cross-modal retrieval

A second important testing ground regarding automatic recollection and the process-dissociation procedure concerns the effect of generating items from semantically related cues at study on later automatic retrieval. Toth, Reingold, and Jacoby (1994, Experiment 2) reported, using the inclusion and exclusion instructions and the process-dissociation equations, that automatic retrieval (*A*) was greater when items were read at study than when items were generated aloud at study from semantic cues and not seen. Controlled retrieval (*C*), by contrast, was greater when items were generated at study than when they were read. This result mimics the results of Richardson-Klavehn, Clarke, and Gardiner (1999) described in Section 2.4 (Figure 7.1, Table 7.4), the results of Richardson-Klavehn, Lee, Joubran, and Bjork (1994) described in Section 3.1, and those of Jacoby (1983). However, Toth et al. (1994, Experiment 2) found no evidence of automatic retrieval (*A*) following generating at study, compared with the nonstudied baseline. They concluded that where significant priming from prior generation at study is observed in incidental tests, it must reflect contamination by voluntary or controlled retrieval (see also Toth & Reingold, 1996). This conclusion is at variance with the findings of Richardson-Klavehn et al. (1999) described in Section 2.4 (Figure 7.1, Table 7.4). Our participants showed significant priming from generating at study in an incidental word-stem-completion test (Generate condition), despite their performance conforming completely to the retrieval intentionality criterion as indicated by an LOP manipulation within the same participants and test list (no priming difference between Read-Semantic and Read-Phonemic conditions), and despite priming showing a reversed association from intentional test performance. To attribute the priming we found following generation at study to voluntary contamination of the incidental test, one would have to argue that incidental test participants were able to determine which of the randomly intermixed test cues corresponded to Generate items and which corresponded to Read-Semantic items, and selectively contaminate the former but not the latter (see also Gardiner, Richardson-Klavehn, Ramponi, & Brooks, 2001; Ramponi, Richardson-Klavehn, & Gardiner, 2004, 2007; Richardson-Klavehn & Gardiner, 1998). Consistent with our argument that priming from prior generating can be involuntary/automatic, such priming has also been observed despite amnesia induced by the drug midazolam as measured with intentional tests (Hirshman, Passannante, & Arndt, 1999).

In contrast to the conclusions drawn from the process-dissociation model, the notion of automatic recollection (Richardson-Klavehn, Gardiner, & Ramponi, 2002) would suggest exactly that the semantic processing that occurs during generation at study, while not directly responsible for priming following that generation (which depends on modality-independent lexical processing; see Section 2.4 and Richardson-Klavehn & Gardiner, 1996; Richardson-Klavehn et al., 1999), forms the basis for later automatic recollection for previously generated items, leading to a systematic underestimate of automatic retrieval following generation at study when the process-dissociation procedure is applied, exactly as was reported by Toth et al. (1994, Experiment 2). It is important to note that this underestimation occurs when performance has met the boundary conditions for the application of the process-dissociation equations (Jacoby, 1998; Reingold & Toth, 1996; Toth & Reingold, 1996; Toth et al., 1994), and that inverse relationships between controlled retrieval (*C*) and automatic retrieval (*A*), and estimates of automatic retrieval *A* not exceeding baseline following some study conditions (i.e., generating at study), have not been taken to indicate the use of inappropriate generate-recognize strategies.

The third test case concerns cross-modal priming. In experiments examining modality match between study and test, Jacoby, Toth, and Yonelinas (1993) reported that estimates of automatic retrieval (*A*) in word-stem completion were above baseline only when modality matched between study and test (visual, visual) and not when it mismatched (auditory, visual). The conclusion was, as in the case of priming from generating at study, that involuntary or automatic retrieval in word-stem completion is completely modality-specific, so that cross-modal priming in incidental tests of word-stem completion must reflect contamination by voluntary or controlled retrieval of studied words (see also Toth & Reingold, 1996). This conclusion, however, conflicts with data from participants with the organic amnesic syndrome. These participants can exhibit unimpaired levels of cross-modal repetition priming in incidental word-stem-completion tests, in conjunction with impaired cross-modal performance in intentional/inclusion word-stem-completion tests (Graf, Shimamura, & Squire, 1985; Verfaillie, Keane, & Cook, 2001), strongly suggesting that cross-modal priming can be involuntary or automatic. Further, experiments by Craik, Moscovitch, and McDowd (1994) and Richardson-Klavehn and Gardiner (1996) with healthy participants found significant cross-modal priming in incidental tests of word-stem completion under conditions in which performance met the retrieval intentionality criterion (i.e., a significant effect of LOP at study on cross-modal performance in intentional/inclusion tests, but no effect of LOP at study on cross-modal performance in incidental tests), strongly implying that the cross-modal priming was involuntary or automatic. The results from the latter study, which I address in detail in Section 5, are shown in Table 7.4. In that study, we also replicated the results of Jacoby et al. (1993) showing no transfer of the automatic retrieval parameter from the process-dissociation equations across sensory modalities (data not shown).

The data reviewed here, therefore, again show systematic deviations of the automatic retrieval estimates from the process-dissociation procedure from the results of uncontaminated incidental tests (i.e., underestimates of automatic retrieval), despite the published boundary conditions for the use of the process-dissociation equations (Jacoby, 1998) being met. The argument is once again that the concept of involuntary conscious memory (Richardson-Klavehn, Gardiner, & Java, 1994) or automatic recollection (Richardson-Klavehn et al., 2002) can make sense of these systematic discrepancies. The automatic recollection construct implies progressing beyond two-process models of explicit versus implicit memory, whether direct retrieval (independence) or generate-recognize (redundancy) models, because neither of these models incorporates a parameter whereby conscious recollection occurs involuntarily/automatically.

5. Beyond Two-Process Models of Explicit and Implicit Memory:

Toward an Integrative Retrieval Architecture

> To recollect a recent event consciously, a memory trace must be reactivated via the hippocampal component. This occurs when an an external or internally generated cue automatically triggers the hippocampal index and interacts with a memory trace. The product of that interaction is delivered to consciousness. Once initiated, ecphoric processes are rapid, obligatory, informationally encapsulated, and cognitively impenetrable. We are aware only of the input to the hippocampal component and the shallow output from it. Thus, we remember countless daily events without intending to remember them. Memories may "pop" into mind much as preattentive perceptual stimuli "pop out" of their background. Just as it would be maladaptive to have a perceptual system that is too much under our control and subject to our motivations and expectancies, so it would not be useful to have a memory system that relies on our intentions to remember. (Moscovitch, 1992, p. 260)

5.1. Automatic recollection in inclusion and intentional tests

I begin with data providing further suggestive evidence concerning automatic recollection (Table 7.4). These experiments (Richardson-Klavehn & Gardiner,

Table 7.4 Top panel: Mean proportions of word stems completed with target words as a function of level of processing (semantic vs. phonemic) and modality (visual vs. auditory) at study in inclusion and incidental tests in Richardson-Klavehn and Gardiner (1996), with absolute mean proportions of stems completed with words judged as studied in parentheses. Bottom panel: Analogous data from intentional and incidental tests in Richardson-Klavehn, Clarke, and Gardiner (1999).

	Level of study processing		
Study modality	*Semantic*	*Phonemic*	*Nonstudied*
Richardson-Klavehn & Gardiner (1996): Inclusion test (n = 16)			
Visual	.47 (.43)	.36 (.11)	
			.21 (.02)
Auditory	.41 (.33)	.31 (.11)	
Richardson-Klavehn & Gardiner (1996): Incidental test (n = 16)			
Visual	.43 (.34)	.42 (.07)	
			.20 (.00)
Auditory	.32 (.22)	.33 (.12)	
Richardson-Klavehn, Clarke, & Gardiner (1999): Intentional test (n = 24)			
Visual (Read)	.59	.44	
			.11
Auditory (Generate)	.51		
Richardson-Klavehn, Clarke, & Gardiner (1999): Incidental test (n = 24)			
Visual (Read)	.51	.50	
			.32
Auditory (Generate)	.43		

1996; Richardson-Klavehn, Clarke, & Gardiner, 1999) both incorporated deep (semantic) and shallow (phonemic) study conditions, and conditions in which sensory modality matched versus mismatched between study and test. In the former case, the manipulation was of visual versus auditory presentation at study. In the latter case, the manipulation was of generating words from semantically related cues (incomplete sentences) at study and saying the words aloud versus reading visually presented words. The subsequent word-stem-completion tests were conducted visually.[2]

The Richardson-Klavehn and Gardiner (1996) study employed inclusion and incidental test instructions, and in both tests participants reported whether or not each completed word was from the study list, or a new nonstudied word. As previously reviewed (e.g., Sections 2.1, 2.3, 3.1, & 4.6, Table 7.1), the word-stem-completion proportions showed an advantage for deep over shallow study processing in the inclusion test, but priming in the incidental test showed no such effect, permitting the conclusion that priming in the incidental test reflected involuntary/

automatic retrieval. This interactive pattern as a result of test instructions applied both in the cross-modal and the within-modal conditions, suggesting that cross-modal priming did not reflect contamination by voluntary/controlled retrieval (Section 4.6; see also Craik, Moscovitch, & McDowd, 1994). The incidental test data also show that participants can be conscious that their completions are studied, particularly following deep study processing, without that consciousness inducing them to adopt a voluntary/controlled retrieval strategy (Sections 3.1 & 4.2).

More critical here, however, is that there was an overall main effect of modality match between study and test, with stems being more likely to be completed with studied words when modality matched than when it mismatched, and that this effect did not modify the interaction between test instructions and LOP at study. This pattern strongly suggests that the modality match effect was an influence on involuntary or automatic retrieval in both tests, by the logic of additive/interactive factors, together with the finding that performance in the incidental test reflected involuntary/automatic retrieval, as indicated by the absence of an LOP effect on priming in that test (for convergent data and theoretical arguments, see Habib & Nyberg, 1997; Roediger & McDermott, 1993). Most notably, the advantage of modality match for stem completion in both tests was accompanied by increased consciousness of study-list membership following deep study processing, but not following shallow study processing. In the latter case, the increased studied completions with modality match were words believed nonstudied. The results, therefore, suggest that involuntary/automatic retrieval, as exemplified here by the advantage of modality match over mismatch for stem-completion performance, can drive conscious recollection of study-list membership when participants have encoded the appropriate semantic information at study.

In as yet unpublished research, I have replicated the inclusion test data of Richardson-Klavehn and Gardiner (1996) in a brain imaging study with a very large number of test items (1,200), with the vast majority of participants showing the critical data pattern. In other unpublished purely behavioral research, participants made a "remember" versus "know" versus "guess" versus "nonstudied" judgment (Gardiner & Richardson-Klavehn, 2000) on their stem completions rather than a simple studied/nonstudied judgment. A "remember" judgment means that participants consciously recollect specific contextual details of the study episode, such as what they were thinking at the time they studied the item (Sections 4.4 & 4.5; Gardiner & Richardson-Klavehn, 2000). In inclusion ($n = 25$) and incidental ($n = 23$) tests as used in Richardson-Klavehn and Gardiner (1996), following deep (semantic) study processing, the modality-match advantage was observed in both tests (mean advantage = .10, averaged across tests and LOP), and in both tests drove "remember" judgments upwards, with 83 percent of the stem-completion advantage for match over mismatch being accompanied by an increase in “remember” judgments, and 0 percent of that advantage being accompanied by an increase in “nonstudied” judgments. By contrast, following shallow (phonemic) study processing, the modality-match advantage drove “nonstudied” judgments upwards, with 0 percent of the stem-completion advantage for match over mismatch being accompanied by an increase in “remember” judgments, and 88 percent of that advantage being accompanied by an increase in “nonstudied” judgments. The results suggest that the modality-match advantage, while an involuntary/automatic retrieval effect, drives increased conscious recollection of the specific contextual details of previous episodes, but only when semantic information has been previously encoded to support such conscious recollection.

Confirming this reasoning, in the same experiment, an intentional test conducted with strict instructions not to guess with nonstudied words ($n = 24$; nonstudied baseline proportion = .04) showed an advantage of modality match over mismatch for overt stem-completion performance only following deep (semantic) study processing, but not following shallow (phonemic) study processing. Presumably, modality match did not lead an increased number of studied words to be emitted following shallow study processing because such words were not specifically consciously recollected as studied. The latter results add evidence that conscious recollection can be driven by priming when appropriate, semantic, information has been previously encoded, even when participants do not guess with the first words coming to mind.

The data from Richardson-Klavehn, Clarke, and Gardiner (1999) in Table 7.4 make a similar point, again using an intentional test in which participants were instructed not to guess. LOP (Read-Semantic vs. Read-Phonemic) dissociated the intentional and incidental tests, with an LOP effect in the former but not the latter, and the tests also showed a crossed double dissociation (Generate > Read-Phonemic for intentional, and Read-Phonemic > Generate for incidental), supporting the conclusion that priming in the incidental test, including priming from generating, was involuntary or automatic (Sections 2.4 & 4.6, Figure 7.1). For current purposes, however, the critical result is that the tests also showed a parallel effect, that is, the Read-Semantic condition produced higher stem-completion performance than the Generate condition in both tests. This effect appears to reflect match in sensory modality between study and test in the Read-Semantic condition and not the Generate condition, so that both tests displayed a parallel effect of modality match on involuntary or automatic retrieval of studied words. In the intentional test, this involuntary or automatic modality-match advantage appears to have driven increased conscious recollection, because intentional test participants were instructed not to guess, and because their baseline guessing proportion for stems of nonstudied words was quite low.

5.2. Automatic recollection and generate-recognize models, Part 2

Because the modality-match effects on the intentional/inclusion tests in the studies just reviewed were evidently effects on involuntary or automatic retrieval, one might attempt to interpret these data in terms of a generate-recognize (two-process) model of implicit and explicit memory (e.g., Bodner, Masson, & Caldwell 2000; Jacoby & Hollingshead, 1990), which postulates that retrieval in intentional/inclusion tests is always initiated with involuntary or automatic retrieval, which is then followed by voluntary or controlled conscious retrieval (e.g., Reingold & Toth, 1996). However, together with proponents of the direct retrieval (independence) two-process model (e.g., Jacoby, 1998; Reingold & Toth, 1996; Toth, Reingold, & Jacoby, 1994), I believe that the simultaneous dissociations between the intentional/inclusion and incidental tests as a function of LOP at study suggest that participants were *initiating* retrieval differently in these tests, for two main reasons.

First, data regarding reaction times (RTs) in relation to LOP effects in intentional/inclusion word-stem-completion tests appear inconsistent with a generate-recognize model. For example, Schott, Richardson-Klavehn, Heinze, and Düzel (2002), using an inclusion test, found that RT, measured test-item by test-item, was faster for studied target words previously studied with deep (semantic) processing than for words previously studied with shallow (phonemic) study processing (mean proportion of stems completed with recollected targets: Deep = .65, Shallow = .35; mean RT: Deep = 1549 ms, Shallow = 1841 ms; these RTs include the time to complete the stem and make a studied/nonstudied judgment on the completion). Because these study conditions produce very similar priming (e.g., Tables 7.1 & 7.4, Figure 7.1), and thus similar levels of automatic generation, a generate-recognize account would apparently have to postulate that the additional studied target words achieved as completions following deep compared with shallow study processing in intentional/inclusion tests, and following deep processing in intentional/inclusion tests compared with in incidental tests (Table 7.4, Figure 7.1), result from additional generate-recognize cycles. The RT results suggest precisely the opposite, namely that conscious recollection is more fast and automatic (i.e., apparently directly cued) following deep than following shallow study processing in inclusion tests (see Dewhurst & Conway, 1994, and Gardiner, Ramponi, & Richardson-Klavehn, 1999, for converging evidence regarding fast and automatic conscious recollection following deep study processing). Intentional/inclusion test instructions, compared with incidental test instructions, lengthen overall response times in word-stem completion when they are measured on a test-list-wise basis rather than test-item by test-item (e.g., Richardson-Klavehn & Gardiner, 1995, 1996, 1998; Richardson-Klavehn, Clarke, & Gardiner, 1999), but this lengthening is primarily attributable to trials on which studied words cannot be retrieved. In the Schott et al. (2002) study, for example, mean RTs to complete stems of previously deeply and shallowly processed words with nonstudied words judged nonstudied (i.e., when no studied completion was retrieved) were 2893 and 2872 ms, respectively (see Schott et al., 2005, 2006, for convergent RT data). Anticipating Sections 5.3 and 5.4, it is the *strategy* of voluntary or controlled retrieval that is sometimes slow and effortful; retrieval processes during voluntary or controlled retrieval strategies can nevertheless be fast and automatic if appropriate episodic information exists in memory.

Second, and equally important, as pointed out by Reingold and Toth (1996), participants in intentional/inclusion word-stem-completion tests consistently retrieve more studied target words than do participants given explicit generate and recognize instructions, even when the cues permit only a single completion-word, which rules out participants employing iterative generate-recognize cycles to achieve more studied words (Jacoby & Hollingshead, 1990). These data, therefore, provide strong evidence of direct cueing in word-stem completion. If, however, stems cue episodic memory traces for studied words directly in intentional/inclusion tests, the problem arises of how an effect on involuntary or automatic retrieval, namely the advantage for modality match over mismatch between study and test, simultaneously drives conscious recollection of studied words upwards following deep (semantic) study processing, rather than simply driving the proportion of studied words believed nonstudied upwards. A similar problem arises in conceptually cued recall tasks, in which variables that increase involuntary/automatic conceptual priming also drive conscious recollection of episodes in cued recall upwards, even when cued recall participants are instructed not to guess with nonstudied words (e.g., Ramponi, Richardson-Klavehn, & Gardiner, 2004, 2007). I now sketch a component-process retrieval architecture that provides one possible solution of this apparent problem, without postulating a generate-recognize model.

5.3. Priming, automatic recollection, and control of retrieval:

Sketch of a hierarchical cascaded retrieval architecture and its interaction with attention

I believe that the data just reviewed regarding modality and LOP effects provide a clue as to how to progress beyond two-process models of explicit and implicit memory, whether generate-recognize (redundancy) or direct retrieval (independence) models, while incorporating insights from both, and at the same time naturally accommodating automatic recollection. That is, I suggest that word-stem completion provides a test situation in which *certain elements of* a generate-recognize model might plausibly play a role in retrieval processes, *together with certain elements of* a direct retrieval model, which postulates direct cueing of episodic memory traces. When one considers the retrieval situation more mechanistically, and does not restrict one's thinking to two processes (i.e., *C* and *A*) that exhaust the kinds of memory that exist, it can be seen that elements of the two models could co-exist in a unifying retrieval architecture that accommodates automatic recollection, while also providing a principled account of dissociations between incidental and intentional/inclusion tests, as exemplified by LOP effects, and parallel effects across those tests, as exemplified by modality-match effects. The key feature of the architecture is that retrieval processes, which *always* run off automatically, including up to the episodic level of memory representation, are explicitly distinguished from retrieval control processes, and how these respond to test instructions. In the two-process models, by contrast, distinctions regarding hypothetical retrieval processes (i.e., *C* and *A*) are confounded with distinctions regarding cognitive control (i.e., retrieval strategies).

The architecture tentatively proposed here is an extension to word-stem completion of the more general proposals of Moscovitch (e.g., 1992, 2000, 2008) regarding the brain structures and processes involved in priming, conscious recollection of specific episodes, and control of memory retrieval. Like those proposals, the suggested architecture is an instance of the components-of-processing framework (e.g., Roediger, Buckner, & McDermott, 1999), in that it postulates some processes that are common to incidental, inclusion, and intentional stem-completion tests, and others that differ (see also Ramponi, Richardson-Klavehn, & Gardiner [2004, 2007] for a similar approach to conceptually cued retrieval). It also draws upon and generalizes within the cognitive domain the recent neurocognitive distinction between top-down (goal-directed or controlled) attention to memory contents and bottom-up (captured) attention to memory contents during memory retrieval (e.g., Cabeza, 2008; Cabeza, Ciaramelli, Olson, & Moscovitch, 2008; Ciaramelli, Grady, & Moscovotch, 2008). Finally, the work of Nelson and colleagues (e.g., Nelson, Fisher, & Akirmak, 2007; Nelson, McKinney, Gee, & Janczura, 1998; Nelson, Schreiber, & McEvoy, 1992; see also Kinoshita, 2001) is relevant in that it has addressed the role of automatic processes at encoding and retrieval in tasks involving conscious recollection of prior episodes, and represents a components-of-processing approach that emphasizes similarities between retrieval processes in incidental and intentional memory tests. The architecture suggested here is a tentative sketch aimed at addressing the data patterns reviewed in the current chapter (especially Table 7.4), and owing to space limitations I cannot consider all relevant previous work.

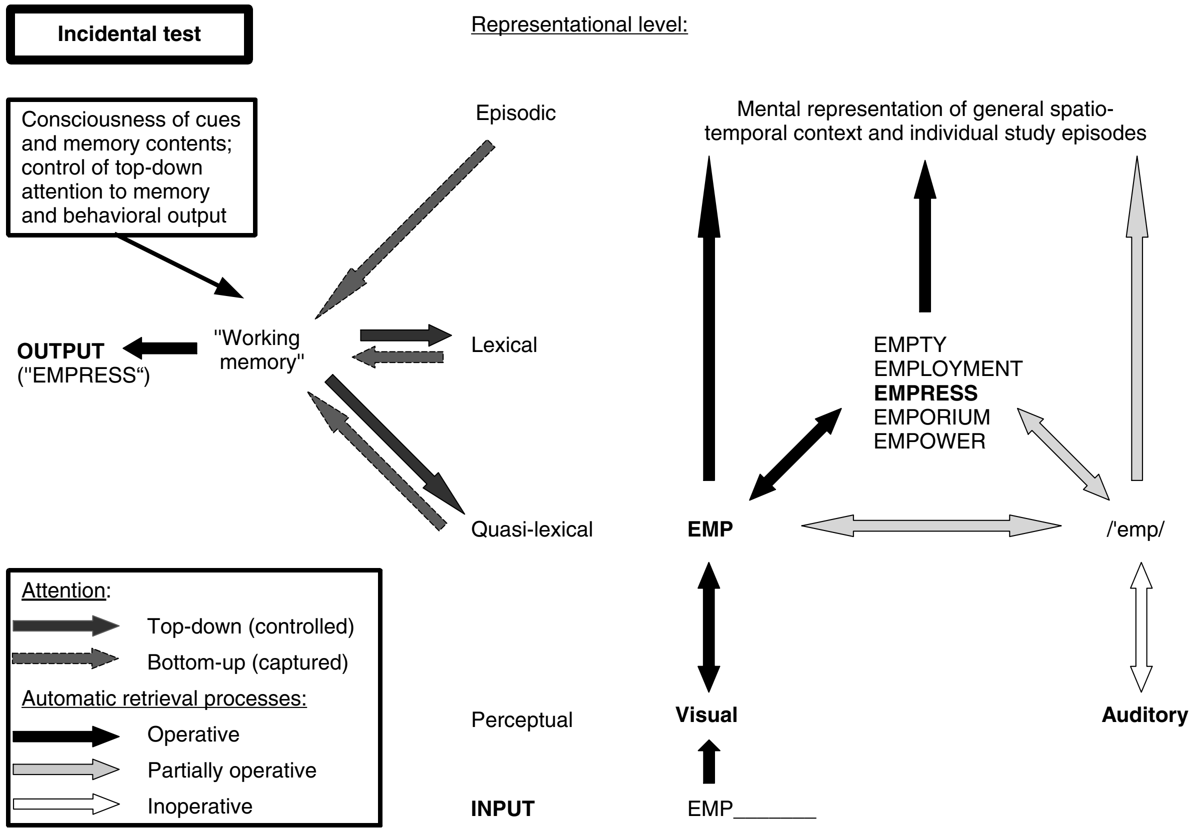
In word-stem completion, the concept of direct cueing of episodic memory traces must apparently have its limits. It seems implausible to suppose that the presentation of a word stem can directly cue episodic memory traces without the participant first having formed a quasi-lexical representation of the word stem. That is, representations of individual letters in the word stem are highly unlikely to cue memory for whole words, without the participant integrating these letters. That having been conceded, it is, further, implausible to suppose that the quasi-lexical representation of the stem does not automatically activate various potential completions to the stem in "permanent" lexical memory (e.g., as strongly implied by the research of Nelson and colleagues just cited, both with respect to stem-cued and conceptually cued memory retrieval; see also Kinoshita, 2001), and that the activation of this set of potential completions does not constrain access to episodic memory traces in some way. This constraint sounds like that in generate-recognize models of implicit and explicit memory (e.g., Jacoby & Hollingshead, 1990; Reingold & Toth, 1996), because the "search set" in memory, and the behavioural output, is restricted by the correspondence of the cue with pre-existing "permanent" memory representations. However, this restriction is an intrinsic property of word-stem completion: the participant is ultimately forced to respond with a word that fits the word-stem cue, or not respond at all, whether their test instructions are incidental, intentional, or inclusion.

The key to going beyond the generate-recognize model is, however, the notion of cascaded processing (e.g., McClelland, 1979), which postulates that processing at higher levels of representation in a cognitive hierarchy starts (in real time) before processing at lower levels is complete, and may to all intents and purposes start immediately upon the commencement of processing at lower levels, subject to the constraints of neural conduction velocities. Activation of various potential completions in "permanent" lexical memory, as postulated in the generate-recognize model, does not, therefore, preclude either the quasi-lexical representation of the word stem simultaneously beginning to cue episodic memory traces "higher up" in the cognitive system, as is supposed in direct retrieval models, or the partial, as yet incomplete, activation of the whole-word representations simultaneously feeding upwards in the system to cue such episodic memory traces. Therefore, despite the intrinsic limitation of the search set and the behavioral output by the word-stem cue, and the activation of a set of potential completions, the notion of cascaded processing means that it is not necessary for a whole word to arrive in consciousness as a result of an involuntary or automatic retrieval process (priming) and then (sequentially) be recognized via a voluntary or controlled retrieval process, as postulated by the generate-recognize models. In this sense, in a hierarchical cascaded retrieval architecture, direct cueing of episodic memory traces, as in direct retrieval models, could occur not only via quasi-lexical representations of word-stems but also via partially activated lexical representations of whole words that are not yet available to consciousness.

Such a conception provides a basis for understanding how automatic recollection might occur. A word-stem cue that corresponds to a previously studied word could "drive its way" up through the cognitive system to the episodic level of memory representation rapidly and automatically, on its way creating an automatic tendency to respond with that word (priming) at the lexical level of representation, while automatically and perhaps even simultaneously activating an episodic memory trace that supports conscious recollection for the previous occurrence of that word, even when controlled retrieval processes are not engaged, such as in an incidental test that is uncontaminated by voluntary or controlled retrieval (e.g., Tables 7.1 & 7.4, Figure 7.1). The consciousness that the word has been studied can arise together with the involuntary or automatic tendency to produce that word (priming) and may not be distinguishable from it with respect to the subjective experience of the participant.

The proposed retrieval architecture is sketched in Figure 7.2, with respect to priming and automatic recollection in an incidental test of word-stem

Figure 7.2 Sketch of a hierarchical cascaded retrieval architecture as operating in an incidental test, in which participants follow instructions to complete word stems with the first words coming to mind. The hierarchy of memory representations in which retrieval processes operate is shown to the right of the figure. Processing of the word stem proceeds rapidly and automatically up the hierarchy to the episodic level of representation via cascaded resonance processes. Bidirectional arrows connect representations in which the perceptual-lexical memory traces supporting priming operate. Illustrated is a situation in which study and test were both visual, but there is some cross-modal transfer to the auditory modality (gray arrows). The word *EMPRESS* has been visually studied, and presentation of the retrieval cue *EMP____* preferentially elicits resonance in the lexical representation for *EMPRESS* compared to lexical competitors (i.e., priming), causing preferential resonant input for that word to the episodic level. To the left of the figure are working memory and retrieval control processes. Top-down attention is focused at the quasi-lexical and lexical levels of representation, so that readout into working memory from the lexical level of representation controls monitoring and responding (i.e., *EMPRESS* is the first word to spring to mind and be verified as a legal response). The feed-up resonant input to episodic representations from the quasi-lexical and lexical representations nevertheless causes selective resonance in the episodic representation for the prior occurrence of *EMPRESS*, given that appropriate (typically, semantic) information was previously encoded about that word, leading to readout of information concerning the study episode for *EMPRESS* into working memory via bottom-up attention (i.e., automatic recollection) that does not influence overt stem-completion responding. For further details, see text.



Incidental test
Representational level:
Consciousness of cues and memory contents; control of top-down attention to memory and behavioral output
Episodic
Mental representation of general spatio-temporal context and individual study episodes
OUTPUT
("EMPRESS")
"Working memory"
Lexical
EMPTY
EMPLOYMENT
EMPRESS
EMPORIUM
EMPOWER
Quasi-lexical
EMP
/'emp/
Attention:
Top-down (controlled)
Bottom-up (captured)
Automatic retrieval processes:
Operative
Partially operative
Inoperative
Perceptual
Visual
Auditory
INPUT
EMP______

completion. I now describe in more detail the premises of the architecture. The right part of the figure schematically displays the memory representations in which retrieval processes operate, which are arranged in a hierarchy from perceptual representations (i.e., representations of letter features and letters), quasi-lexical representations (i.e., representations of word stems), and lexical representations (i.e., representations of whole words), to episodic representations, with the latter being responsible for the ability to consciously recollect the episode of having studied a word. Throughout this hierarchy, retrieval occurs automatically when memory representations with feature overlap with the input from lower levels resonate with that input (e.g., Lockhart, Craik, & Jacoby, 1976; Ratcliff, 1978; Richardson-Klavehn & Bjork, 2002). "Activation" of memory representations is shorthand for this resonance and does not mean spreading activation. In one retrieval route, resonance of the quasi-lexical representations created by the perceptual processing of the word-stem cue directly elicits resonance in episodic representations; in the other parallel route, resonance of the quasi-lexical representions elicits resonance in a candidate set of lexical representations, whose resonance in turn evokes resonance in episodic representations. These resonance processes spread up the hierarchy rapidly and automatically to the episodic level via cascaded processing, regardless of the participant's retrieval strategy (as manipulated via incidental vs. inclusion vs. intentional test instructions). That is, with respect to memory representations and retrieval processes, there is no distinction between controlled and automatic retrieval, contrary to the two-process models of explicit and implicit memory, which conflate distinctions concerning retrieval processes with distinctions concerning control of retrieval.

Involuntary or automatic priming is viewed as reflecting memory traces for lexical and perceptual, but not semantic, information, consistent with data concerning the basis of word-stem-completion priming reviewed previously (e.g., Sections 2, 3.2, & 4.6, Tables 7.1 & 7.4, Figure 7.1). Such perceptual-lexical memory traces influence the relative degrees of resonance of the representations of the set of candidate lexical responses that are evoked by the perceptual processing of the word-stem retrieval cue, so that lexical representations corresponding to previously studied words can be primed relative to other lexical representations. In the example in Figure 7.2, the word *EMPRESS* has previously been studied, and its lexical representation resonates most to the cue *EMP*____ in comparison with those of other lexical candidates. In the absence of prior study of *EMPRESS*, the lexical representation for *EMPLOYMENT* might be the one resonating most to the word-stem input. The modality-specificity of involuntary or automatic priming in word-stem completion (e.g., Table 7.4, Figure 7.1) is accounted for by the separation of representations into visual and auditory modalities at the perceptual and quasi-lexical levels of representation, so that the memory traces underlying priming are in part modality-specific. There is, however, cross-talk between modalities at the quasi-lexical and lexical levels of representation (as illustrated by the gray links in Figure 7.2), allowing for automatic cross-modal priming (Sections 2.4 & 4.6, Table 7.4). Most critical for a principled account of the data in Table 7.4, however, are the following. The feed-up resonant input to the episodic level of representation (1) will often be "stronger" from a primed lexical representation (i.e., the representation of a studied target word) than from other lexical representations resonating to the word-stem retrieval cue, although feed-up input will occur for other lexical representations resonating to the cue (2) will be of the same "strength" from primed lexical representations whether previous study processing leading to priming was deep (semantic) or shallow (phonemic), and (3) will be "stronger" from a primed lexical representation when modality matches between study and test than when it mismatches, independent of LOP at study. "Strength" here refers only to the extent to which the feed-up resonant input unambiguously indicates the studied target word relative to other lexical representations resonating with the cue.

Conscious recollection of study episodes reflects automatic resonance of episodic memory representations with the feed-up input from quasi-lexical and lexical representations that resonate with the word-stem retrieval cue. Thus, conscious recollection always reflects automatic or obligatory retrieval processes (e.g., Moscovitch, 1992, 2000, 2008), in contrast to two-process models of explicit and implicit memory (both direct retrieval and generate-recognize versions), which view conscious recollection as reflecting voluntary or controlled retrieval processes, and only priming as reflecting involuntary or automatic retrieval processes. Processing of meaning is typically critical for the encoding and later conscious recollection of episodes (e.g., Craik, 2002; Lockhart, 2002), and is thought to produce distinctive episodic memory traces (e.g., Fisher & Craik, 1977; Lockhart, Craik, & Jacoby, 1976). Thus, episodic representations resulting from deep (semantic) study processing are likely to resonate *selectively* with the feed-up input (e.g., Eysenck, 1979; Fisher & Craik, 1977; Lockhart et al., 1976; Nairne, 2002; Richardson-Klavehn & Bjork, 2002), whereas episodic representations resulting from shallow (phonemic) processing are likely to suffer interference from the resonance of other episodic representations with the feed-up input. The "signal-to-noise ratio" of the automatic episodic retrieval process will, therefore, typically be higher for episodic representations resulting from deep compared with shallow study processing.

The left part of Figure 7.2 depicts cognitive control processes that interact with the automatic cascaded retrieval hierarchy just outlined. Consistent with recent neurocognitive thinking, "working memory" is viewed as an emergent property of an interaction between attention and the hierarchy of long-term memory representations (e.g., Postle, 2009; Ranganath, 2009), and is here used as a shorthand for consciousness of retrieval volition or intention, retrieval cues, and long-term memory readout, the latter possibly controlling behavioral output, depending on retrieval volition or intention, and on retrieval monitoring processes. In regard to the interaction between working memory and long-term memory representations, a distinction is made between top-down and bottom-up attention, in a cognitive generalization of the neurocognitive proposals of Cabeza and colleagues (Cabeza, 2008; Cabeza, Ciaramelli, Olson, & Moscovitch, 2008; Ciaramelli, Grady, & Moscovitch, 2008) regarding top-down versus bottom-up attention to episodic memory representations. Bottom-up attention involves attentional capture by the content of long-term memory representations, which corresponds to readout from those representations into working memory. In the current generalization, it involves readout from quasi-lexical, lexical, and episodic representations and results in consciousness of word stems, lexical responses (whole words), and previous episodes of studying words, and is involuntarily or automatically captured by this readout. Top-down attention involves goal-directed interaction with memory representations, monitoring of memory outputs in relation to these goals, and control of overt responses, and is allocated according to retrieval volition or intention (i.e., to respond with the first words coming to mind, or to respond with studied words), which is also represented in working memory.

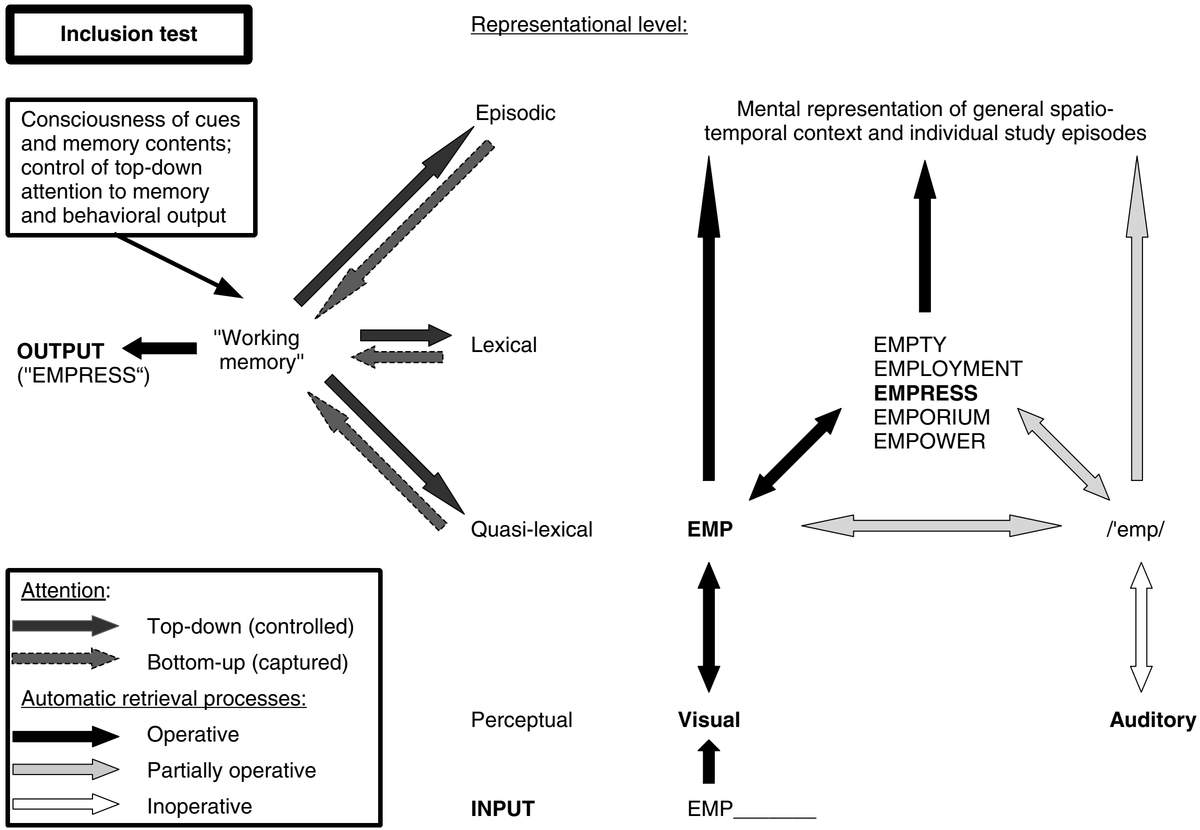
In contrast to the situation in two-process models of explicit and implicit memory, cognitive control, or top-down attention, is not a property of retrieval processes themselves, but is viewed as always present regardless of whether the test is incidental, inclusion, or intentional (e.g., Gardiner, Richardson-Klavehn, Ramponi, & Brooks, 2001; Richardson-Klavehn, Gardiner, & Ramponi, 2002). In incidental tests, assuming participants follow the instructions, the focus of top-down attention is exclusively on quasi-lexical and lexical memory representations. That is, the participant's goal is to complete the word stem in working memory with the first possible completion that is read into working memory from the lexical level of representation via bottom-up attention. A critical assumption is that the relative degrees of resonance of the lexical representations in response to input from the quasi-lexical (i.e., word-stem) level are not subject to influence by top-down attention. That is, these representations are, in this respect, cognitively encapsulated (modular) and immune to top-down influence (e.g., Moscovitch, 1992, 2000, 2008; Tulving & Schacter, 1990). Assuming incidental test participants do not switch top-down attention to episodic memory representations (which corresponds in the architecture to engaging voluntary or controlled retrieval of previously studied words), their responses will be solely determined by the relative degrees of resonance of the lexical representations of words that are potential completions to the word-stem, which will reflect the memory traces underlying involuntary or automatic priming, be independent of LOP at study, and will be greater when modality matches between study and test than when it mismatches. Thus it is a postulate of the current formulation that top-down attention to a particular level of memory representation is necessary in order for the readout from that level of representation into working memory via bottom-up attention to cause overt stem-completion responses. This postulate includes the notion of retrieval monitoring to check that the readout meets task goals (e.g., in the case of an incidental test, that a word is a legal response to a stem).

However, critically, because episodic memory traces automatically resonate with the feed-up input from the quasi-lexical and lexical levels of representation, memory representations for previous study episodes can nevertheless capture bottom-up attention (i.e., their content can be read out into working memory), but without determining overt stem-completion responding in the incidental test. As previously stated, because resonance of episodic representations occurs in cascade with resonance at the perceptual, quasi-lexical, and lexical levels of representation, this consciousness could occur simultaneously with the consciousness of a candidate lexical response in terms of the participant's subjective experience. The automatic resonance of episodic representations with the feed-up input and the readout into working memory via bottom-up attention are consistent with the data reviewed in Section 3.1 (see also Table 7.4, and Richardson-Klavehn & Gardiner, 1995, 1996), which show that incidental test performance can reflect involuntary or automatic retrieval, as evidenced by no effect of study LOP on priming, but that participants can be conscious that they are responding with studied words, with this consciousness being much more likely following deep (semantic) than following shallow (phonemic) study processing. Thus, automatic recollection during incidental test performance, its greater likelihood following deep study processing, and the absence of its causal influence on overt responding with stem-completions, fall naturally out of the automatic cascaded retrieval processes and the way in which the control processes (intentions) that allocate top-down attention to memory representations interact with them.[3]

The assumption that a set of lexical candidates, and not just the lexical candidate resonating most in response to the word-stem cue, send feed-up resonant input to the episodic level of representation, renders it possible that an incidental test participant responds overtly with the word resonating most to the retrieval cue at the lexical level of representation (i.e., the first word coming to mind), but that they involuntarily or automatically consciously recollect that another completion to the word-stem was actually presented at study. This situation could occur when the study episode did not override a strong normative tendency to respond to the word-stem cue with a word that was not studied (e.g., in relation to Figure 7.2, the lexical representation for *EMPLOYMENT* might resonate more to the cue *EMP*____ than the lexical representation for *EMPRESS*, even though *EMPRESS* was studied, such that the participant emits *EMPLOYMENT*, but consciously recollects having studied *EMPRESS*). This property in part underlies the increased output of studied words in intentional/inclusion tests compared with incidental tests, particularly following deep (semantic) study processing, and is accentuated by the direct feed-up input from quasi-lexical representations (word stems) to the episodic level, as detailed next.

Figure 7.3 depicts an inclusion test (e.g., Table 7.4, top panel), in which participants are instructed to try to respond with studied words, but if they cannot, to use the first words coming to mind. These instructions are assumed to result in the spreading of top-down attention to the episodic level of representation, which corresponds to a voluntary or controlled strategy for retrieving studied word-stem completions. Top-down attention remains allocated to the quasi-lexical level because, regardless of retrieval volition or intention, the participant needs to attend to the word-stem cues in a goal-directed way. It also remains allocated to the lexical level, because participants need to respond with the first legal response coming to mind if they are unable to retrieve a studied word. That is, for simplicity, I do not consider possible top-down attention switching processes between episodic and lexical representations (and on reflection it seems an open question as to whether top-down attention is switched or spread in inclusion tests). For current purposes, it is sufficient to assume that if readout from the episodic level of

Figure 7.3 Sketch of a hierarchical cascaded retrieval architecture as operating in an inclusion test, in which participants attempt to complete each word stem with a studied word, but if they cannot, complete the stem with the first word coming to mind. The same automatic retrieval processes operate as in an incidental test (Figure 7.2), but top-down attention is spread to the episodic level of representation, corresponding to a voluntary or controlled strategy for retrieving studied words, allowing readout from episodic representations into working memory via bottom-up attention to control monitoring and overt responding, and leading to the output of studied words as stem-completions, particularly following deep (semantic) study processing, that would not be primed in an incidental test. Additionally, framing of the general spatiotemporal context of study-list presentation in working memory pre-sensitizes episodic representations, particularly those resulting from deep (semantic) study processing, so that less feed-up resonant input from the quasi-lexical and lexical levels to the episodic level is required for episodic readout. Despite the allocation of top-down attention to the episodic level of representation, retrieval processes responsible for episodic readout remain automatic and can be influenced by priming at the lexical level of representation via feed-up resonant input. Top-down attention is also directed at the lexical level of representation to cover occasions when no episodic readout occurs, in which case responses are determined by the relative degrees of resonance of lexical representations (i.e., the participant responds with the first word coming to mind). For further details, see text.


Inclusion test
Representational level:
Consciousness of cues and memory contents; control of top-down attention to memory and behavioral output
Episodic
Mental representation of general spatio-temporal context and individual study episodes
"Working memory"
OUTPUT
("EMPRESS")
Lexical
EMPTY
EMPLOYMENT
EMPRESS
EMPORIUM
EMPOWER
Quasi-lexical
EMP
/'emp/
Attention:
Top-down (controlled)
Bottom-up (captured)
Automatic retrieval processes:
Operative
Partially operative
Inoperative
Perceptual
Visual
Auditory
INPUT
EMP_______

representation occurs, it controls overt stem-completion responding, but that if it does not occur, readout from the lexical level of representation controls overt stem-completion responding. As is the case during incidental test performance, episodic representations receive feed-up input from the quasi-lexical representation of the word stem and from relevant whole-word lexical representations, creating the possibility that the same processes underlying priming and automatic recollection in an incidental test influence overt stem-completion behavior. Words thus retrieved can pass the monitoring check for study-list membership imposed by the allocation of top-down attention to the episodic level of representation.

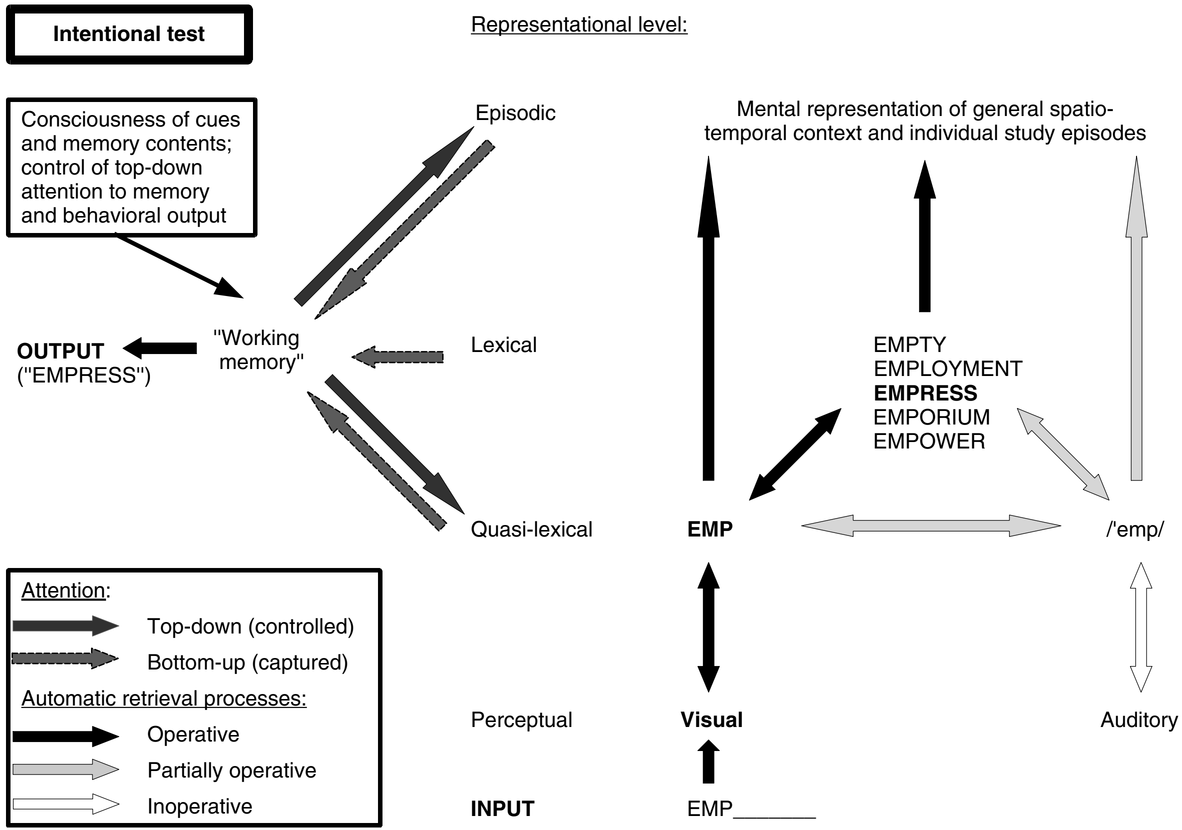
However, as previously reviewed, (1) inclusion test instructions result in the ouput of additional studied words as stem-completions compared with incidental test instructions, and this additional output is greater following deep (semantic) than following shallow processing (put the other way round, inclusion tests show LOP effects, but incidental tests do not; e.g., Tables 7.2–7.4); and (2) this additional access to studied stem-completions following deep (semantic) study processing is unlikely to reflect additional generate-recognize cycles following deep (semantic) compared with shallow (phonemic) study processing, but instead appears to result from direct and automatic cueing of episodic memory representations, because it occurs rapidly and automatically as evidenced by RTs, and because it occurs for word stems only permitting of one completion (Section 5.2).

The architecture accounts for this additional access to studied completions during inclusion testing without postulating a generate-recognize model in two ways. First, the focus of top-down attention at the episodic level of representation permits episodic readout into working memory via bottom-up attention to control overt stem-completion responding. Such episodic readout is more likely from episodic representations that resulted from deep compared with shallow study processing owing to the uniqueness assumption previously discussed. Further, critically, such readout is possible for words that are not primed at the lexical level (i.e., that are not the candidate lexical representation resonating most to the word-stem cue), because resonance from a set of lexical candidates feeds up to the episodic level, and because there is direct feed-up input from quasi-lexical representations (i.e., representations of word stems) to the episodic level. Second, the initial interaction of top-down attention with the episodic level of representation created by the inclusion test instructions leads to a mental framing of the general spatiotemporal study-list context in working memory, which in turn creates partial resonance in relevant episodic memory representations for the study presentations of individual words (i.e., "sensitizes" those representations), rendering the selective resonance with the feed-up input from the quasi-lexical and lexical level more likely to result in readout from the mental representation of a specific study episode into working memory. Because episodic memory representations that resulted from deep (semantic) study processing are more likely to have a unique connection to the general spatiotemporal context of study-list presentation (e.g., Eysenck, 1979; Fisher & Craik, 1977; Lockhart, Craik, & Jacoby, 1976; Ramponi, Richardson-Klavehn, & Gardiner, 2004, 2007), these representations benefit most from this pre-sensitization by top-down attention, enhancing LOP effects on readout from episodic representations into working memory, and on overt stem-completions.

Figure 7.4 depicts an intentional test with instructions not to guess with nonstudied words (e.g., Table 7.4, bottom panel). The situation is similar to that for inclusion test instructions, except that top-down attention is removed from the lexical level of representation, because participants are no longer responding on some trials with the first word coming to mind (i.e., words believed nonstudied) when they do not consciously recollect a studied stem-completion. That is, if automatic episodic readout into working memory via bottom-up attention does not occur, but automatic readout from a lexical representation into working memory via bottom-up attention occurs (corresponding to the stem eliciting a word believed nonstudied), such words are not emitted as overt stem-completion resonses because they fail to pass the monitoring check imposed by the allocation of top-down attention to the episodic level of representation. Nevertheless, in an intentional test, as in inclusion and incidental tests, priming, when it occurs at the level of quasi-lexical and lexical representations, will enhance feed-up input regarding the studied target word to the episodic level of representation and will drive overt stem-completion performance upwards assuming that appropriate information (i.e., semantic information) has been encoded to support episodic readout into working memory (i.e., conscious recollection of study-list membership). That is, priming can still directly and automatically drive such conscious recollection, even when participants are not responding with the first words coming to mind (i.e., words believed nonstudied) when they cannot consciously recollect a studied word.

The architecture has now hopefully been sketched sufficiently to see how it could provide a principled account of the data regarding LOP and modality effects on incidental, inclusion, and intentional word-stem-completion tests considered in Section 5.1 (Table 7.4, Figure 7.1). Modality match between study and test increases involuntary or automatic priming at the lexical level of representation regardless of LOP at study. When modality matches, there will also simultaneously be less ambiguous feed-up resonant input regarding the studied target word to the episodic level of representation from the quasi-lexical and lexical levels compared to when modality does not match, regardless of LOP at study, potentially allowing episodic representations to be more frequently automatically elicited and read out into working memory in the case of modality match. The effect of the increased feed-up input with modality match, however, depends on the informational content of the memory representations at the episodic level. Episodic memory representations formed during deep (semantic) study processing are more likely to resonate selectively with this increased feed-up input with modality match than those formed during shallow (phonemic) study processing and to be read out into working memory via bottom-up attention. Thus, in incidental and inclusion tests (in which participants are permitted to respond with words believed nonstudied, corresponding to the allocation of top-down attention to the lexical level of representation), modality match will elicit more studied words as overt stem-completions overall, regardless of LOP at study. However, modality match will only elicit more words consciously recollected as studied following deep (semantic) study processing and not following shallow (phonemic) study processing, as is illustrated in the top panel of Table 7.4 (and as discussed in Section 5.1 regarding unpublished data concerning "remember" and "nonstudied" responses in incidental and inclusion tests). In an intentional test with strict instructions not to guess with nonstudied words (corresponding to the removal of top-down attention from the lexical level of representation), the increased feed-up input to the episodic level with modality match, while independent of LOP at study, will only be apparent in overt stem-completions (i.e., will only elicit more studied completions) following deep (semantic) processing at study, and not following shallow (phonemic) study processing, because participants do not emit completions believed nonstudied (as discussed in Section 5.1 regarding unpublished data). In all cases, because the influence of modality match is a feed-up effect from the quasi-lexical and lexical levels (i.e., reflects the same processes underlying priming), the beneficial effect of modality match on readout of episodic representations following deep study processing should should not exceed its impact on priming, as is suggested by the data in Table 7.4, allowing for noise in the data.

Figure 7.4 Sketch of a hierarchical cascaded retrieval architecture as operating in an intentional test, in which participants attempt to complete each word-stem with a studied word, and do not guess with words believed non-studied. The same automatic retrieval processes operate as in an inclusion test (Figure 7.3), but top-down attention is removed from the lexical level of representation. Thus, readout from lexical representations into working memory via bottom-up attention cannot determine responses (i.e., the participant does not respond with the first word coming to mind), with monitoring and responses being wholly determined by readout from episodic representations. Despite the use of a voluntary or controlled retrieval strategy, corresponding to the allocation of top-down attention to the episodic level of representation, retrieval processes responsible for episodic readout remain automatic and can be influenced by priming at the lexical level of representation via feed-up resonant input. For further details, see text.



Intentional test
Representational level:
Consciousness of cues and memory contents; control of top-down attention to memory and behavioral output
Episodic
Mental representation of general spatio-temporal context and individual study episodes
OUTPUT
("EMPRESS")
"Working memory"
Lexical
EMPTY
EMPLOYMENT
EMPRESS
EMPORIUM
EMPOWER
Quasi-lexical
EMP
/'emp/
Attention:
Top-down (controlled)
Bottom-up (captured)
Automatic retrieval processes:
Operative
Partially operative
Inoperative
Perceptual
Visual
Auditory
INPUT
EMP_______

Top-down attention to the episodic level of representation in inclusion and intentional tests produces more overt studied stem-completions following deep (semantic) compared with shallow (phonemic) study processing under cross-modal as well as within-modal cueing conditions, creating the dissociations from incidental tests as a function of LOP at study (Table 7.4), which occur regardless of modality match between study and test (Table 7.4, top panel). Both the LOP and modality-match effects are therefore accounted for in a unified way without generate-recognize assumptions, or the assumption that additional generate-recognize cycles lead to the additional output of items deeply (semantically) processed at study, consistent with the RT data previously reviewed, showing faster responding at test after deep (semantic) than after shallow (phonemic) study processing (Section 5.2). Instead, LOP effects, like modality-match effects, always reflect automatic or obligatory retrieval processes (e.g., Moscovitch, 1992, 2000, 2008).

In terms of the sketched architecture, therefore, "automatic recollection" refers to automatic readout from episodic representations owing to feed-up input from quasi-lexical and lexical representations, which can occur even when readout from the lexical level of representation controls overt responding, as in an incidental test that is uncontaminated by voluntary or controlled retrieval. "Controlled recollection" refers to top-down attention to the episodic level of representation, which involves (1) control of overt responses by automatic readout from episodic representations for studied words that are not primed at the lexical level of representation, and thus would not appear as responses in an uncontaminated incidental test, and (2) presensitizing of specific episodic representations due to framing of the general spatiotemporal study-list context in working memory, further enhancing automatic readout from episodic representations, and thus further enhancing responding with studied words. However, in terms of the sketched architecture, these terms are actually misnomers, because regardless of how episodic readout occurs, the underlying retrieval processes are always automatic or obligatory. The participant is conscious only of their retrieval volition or intention (i.e., the level of representation to which top-down attention is directed), the retrieval cue, the readout from automatic retrieval processes via bottom-up attention, and their behavioral response, and not of whether the contents of their consciousness arose via "automatic recollection" or "controlled recollection."

There would be many other ways of constructing such retrieval architectures (e.g., Baars, Ramamurthy, & Franklin, 2007), and the plausibility of the sketched architecture awaits explicit quantitative modeling, with many details to be resolved. My intention with this sketch, however, is simply to show that theorizing need not be bound into debates between simple two-process models of explicit and implicit memory, namely direct retrieval (independence) and generate-recognize (redundancy) models of automatic unconscious and controlled conscious retrieval processes (see also Ratcliff [1978] concerning how such theoretical dichotomies can hamper theorizing). In terms of the sketched architecture, such debates no longer arise. Concepts regarding cognitive control of retrieval are explicitly separated from concepts regarding retrieval processes, and automatic retrieval processes akin to direct retrieval processes (i.e., direct cueing of episodic memory representations by word stems and by lexical candidates not yet available to consciousness), and akin to generate-recognize processes (i.e., evocation by word stems of a set of lexical candidates in "permanent" lexical memory) can co-exist, and are not necessarily mutually exclusive alternatives, as conceived within the two-process approach (e.g., Reingold & Toth, 1996). Furthermore, in the current sketch, contrary to the two-process approach, cognitive control of retrieval (top-down attention) always operates: it is where it is directed in the hierarchy of memory representations that creates dissociations between incidental tests and intentional/inclusion tests.

5.4. Relationship to previous work on memory systems and on retrieval monitoring

Space does not allow me to consider the relationship between the current sketch and all relevant previous work, but some brief comments are required. There is a clear correspondence between the constructs tentatively proposed here and those in Moscovitch's (e.g., 1992, 2000, 2008) neuropsychologically inspired theory of the organization of memory, which distinguishes systems underlying priming, located in the anatomical areas that subserve perception and stimulus identification, a hippocampally mediated episodic memory system, and frontally mediated strategic processes. Most notably, Moscovitch views the systems underlying priming as being cognitively encapsulated (modular), and episodic memory retrieval from the hippocampal system as being obligatory in response to retrieval cues, permitting automatic recollection, with the latter postulate placing his views at stark variance with two-process models of explicit and implicit memory (hence the quotation from Moscovitch [1992] commencing Section 5). The current proposals could, like Moscovitch's, be neuroanatomically instantiated (see Düzel et al., 2005; Richardson-Klavehn et al., 2009; Schott et al., 2005, 2006), but I have focused at the cognitive level here. Additionally, the current ideas focus closely on the word-stem completion task, and attempt to provide an explicit account of how processes underlying priming can directly drive conscious recollection in that task using the notion of cascaded retrieval processes, whereas Moscovitch's framework is much more general in scope and has only recently explicitly addressed possible interactions between priming and conscious recollection (Moscovitch, 2008; see also Note 3).

Finally, a postulate of Moscovitch's framework is that the hippocampal episodic memory system, like the brain systems underlying priming, is "informationally encapsulated and cognitively impenetrable; we have no direct access to the intermediate processes between encoding and retrieval, nor any way to influence their operation" (Moscovitch, 2008, p. 66). Here, as one of two mechanisms accounting for dissociations between incidental tests and intentional/inclusion tests without generate-recognize notions, I have suggested that top-down attention to the episodic level of representation results in readout of a mental representation of the general spatiotemporal study context into working memory, which pre-sensitizes specific episodic representations, modulating their automatic response to feed-up input from the processing of retrieval cues for specific items. This notion is not inconsistent with Moscovitch's hippocampal modularity postulate if the response of specific hippocampal episodic representations to input from general context cues is still viewed as modular and automatic but below a threshold for episodic readout. Moreover, the pre-sensitization notion is consistent with Moscovitch's recent writings on the interaction of top-down and bottom-up attention with the medial temporal lobe (MTL) memory system (the attention-to-memory model of parietal lobe function; e.g., Cabeza, Ciaramelli, Olson, & Moscovitch, 2008; Ciaramelli, Grady, & Moscovitch, 2008), because top-down attention, as instantiated by dorsal parietal cortex activity, "maintains retrieval goals, which modulate memory-related activity in the MTL" (Cabeza et al., 2008, p. 620).

With respect to this attention-to-memory (AtoM) model (Cabeza, 2008; Cabeza et al., 2008; Ciaramelli et al., 2008), I have borrowed the cognitive concepts of top-down and bottom-up attention from that model, and made use of the assertion that these forms of attention can be independent cognitive dimensions (Cabeza et al., 2008), but generalized them within the cognitive domain to attention not only to episodic memory representations, but also to representations of word-stem retrieval cues (quasi-lexical representations) and lexical representations. The AtoM model is a theory of fronto-parietal interaction with the MTL in relation exclusively to attention to episodic memory retrieval, whereby a dorsal fronto-parietal network is involved in top-down attention to episodic memory (e.g., *retrieval mode*; Tulving, 1983), and a ventral fronto-parietal network is involved in bottom-up attention to episodic memory (e.g., consciousness of retrieval success and failure). The current cognitive extension has no such neuroanatomatical implications, although it might be a source of hypotheses.

In agreement with proponents of direct retrieval models of explicit and implicit memory (e.g., Reingold & Toth, 1996), I have asserted that accounting for dissociations between intentional/inclusion and incidental tests requires the assumption that participants *initiate* retrieval differently in response to retrieval cues in these test-types, which is implemented in the sketched retrieval architecture in terms of changes in the allocation of top-down attention. This assertion should not be taken to imply that retrieval monitoring processes (e.g., Burgess & Shallice, 1996; Cabeza, 2008; Cabeza, Ciaramelli, Olson, & Moscovitch, 2008; Ciaramelli, Grady, & Moscovitch, 2008; Moscovitch, 1992, 2000, 2008; Norman & Bobrow, 1979; Rugg & Wilding, 2000; Shallice, 2001; Williams & Hollan, 1981) do not also differ across the test-types (see Schott et al. [2005] for relevant brain-activity evidence in a contrast of incidental and inclusion word-stem-completion tests). The interaction of top-down and bottom-up attention with memory representations and with working memory in the sketched architecture is viewed as incorporating such retrieval monitoring processes (e.g., checking that a potential response is indeed a legal completion to a stem in an incidental test, or checking that a potential response is indeed a study-list word in intentional/inclusion tests).

However, I emphasize that the monitoring processes envisaged here could be "one shot" interactions, and do not necessarily have to involve iterative processing suggestive of generate-recognize cycles (see also Lockhart, Craik, & Jacoby, 1976). I have argued that sequential generation-recognition as a theory of the retrieval architecture itself, and the retrieval processes that operate within it, does not accommodate automatic recollection, and does not provide a convincing account of LOP effects and the absence thereof on retrieval of studied words in word-stem-completion tests (i.e., dissociations between tests), or a unified account of these dissociations and of simultaneously observed parallel effects across these tests on the retrieval of studied words (such as that produced by modality match). Nor does it provide a plausible account of accompanying response-time data. The limitations of generate-recognize ideas as general theories of memory retrieval, and not just as theories of implicit and explicit memory, must also be noted (e.g., Nelson, Fisher, & Akirmak, 2007; Tulving & Thomson, 1973; Tulving, 1976, 1983; Watkins & Gardiner, 1979). As reviewed here with respect to word-stem completion (Section 5.2), these limitations include participants often being able to recall information that they cannot generate and recognize. The current sketch therefore attempts to account for retrieval processes and attentional control processes during incidental, inclusion, and intentional test performance without generate-recognize notions.

In contrast, the way in which accounts of retrieval monitoring often describe memory search, especially effortful (voluntary, controlled) memory search in everyday memory situations, in terms of mental framing of retrieval cues and monitoring of memory outputs, which lead to mental re-framing of the retrieval cues and new memory outputs, and so forth, is often highly suggestive of iterative generate-recognize cycles (e.g., Cabeza, Ciaramelli, Olson, & Moscovitch, 2008). In this respect, it should be noted that the current sketched architecture does not rule out iterative strategic processing in inclusion and intentional tests, which could consist of two types. There could be cyclic interactions with episodic representations via the top-down/bottom-up attention "loop," as envisaged by Cabeza et al. (2008), which would correspond to an "intelligent" generate-recognize strategy. There could also be a "stupid" generate-recognize strategy, which would correspond to top-down attention to lexical representations, readout from a lexical representation into working memory via bottom-up attention such that the participant is conscious of a legal completion-word, which then cues episodic representations via top-down attention – thus bypassing the direct connections in the architecture from quasi-lexical and lexical representations to episodic representations – then the readout from a further lexical representation should recognition fail, and so forth. If generation-recognition of either type is involved, however, it is a *strategy* not a retrieval process (see, for example, Tulving, 1976), and as discussed with respect to RTs and LOP effects (Section 5.2), seems to occur only after direct and automatic retrieval processes fail to elicit conscious recollection of studied words.

6. Conclusion

In the current chapter I have argued for the theoretical importance of distinguishing consciousness of memory in the sense of control of retrieval or retrieval volition from consciousness of memory in the sense of conscious recollection, or awareness, of specific prior episodes. I have argued that the field has established firm evidence for involuntary or automatic memory retrieval, but not necessarily for implicit memory, defined as involuntary or automatic memory retrieval that is also unaccompanied by conscious recollection of the prior episodes whose influence is apparent, with the validity of the latter construct remaining controversial (e.g., Butler & Berry, 2001; Berry, Henson, & Shanks, 2006a, 2006b; Berry, Shanks, & Henson, 2008; Kinder and Shanks, 2001, 2003; Ostergaard & Jernigan, 1993; Paller, Voss, & Westerberg, 2009; Richardson-Klavehn & Gardiner, 1995; Richardson-Klavehn, Gardiner, & Java, 1994). The distinction between control and consciousness is, therefore, critical to a balanced perspective on what has been accomplished with scientific rigor concerning explicit and implicit memory since the reintroduction of consciousness as a subject of inquiry into experimental memory research in the 1980s, and on what remains to be accomplished. As Roediger and Geraci (2005) comment, "the problem does cut to the core of measuring the construct of implicit memory" (p. 145).

Consistent with a distinction between involuntary or automatic retrieval and implicit memory, I have reviewed evidence that involuntary or automatic retrieval can be accompanied by conscious recollection of prior episodes, and have suggested that accommodating automatic recollection in theorizing, rather than binding theorizing into a debate between simple two-process models of explicit and implicit memory, can lead to an improved understanding of the architecture of retrieval processes that unifies the apparently conflicting models. I have sketched one such possible architecture, which describes how working memory and attention interact with cascaded automatic long-term memory retrieval processes that underlie both priming and conscious recollection. Such a theoretical perspective, which clearly distinguishes processes of control of memory retrieval from retrieval processes (see also Moscovitch, 1992, 2000, 2008), could further our understanding of the relationship between memory, consciousness, and brain, and our understanding of impairments of memory in normal aging, and in memory-disordered populations.

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Notes

1. The reader may question why such a simple verbal task is the focus of so much attention in this chapter. The answer is that such tasks provide a testbed in which irrelevant variables can be brought under excellent experimental control, but in which general scientific questions can nevertheless be asked. Similarly, research with animals has led to important advances in understanding the cellular basis of memory formation and storage in humans (e.g., Kandel, 2001). I hope I succeed in establishing here that important scientific questions about the organization of human memory retrieval and its relation to consciousness can be addressed even within this apparently restricted task context.
2. Auditory word-stem-completion tests show clear advantages for auditory over visual study presentation (e.g., Schacter & Church, 1992). Thus the effect under study here is one of modality match between study and test, and not an overall advantage for visual over auditory study presentation. An auditory testing condition was therefore omitted from the current experiments for reasons of experimental economy.

3. In the current chapter, I do not consider claims that automatic activation of episodic memory representations that support conscious recollection can causally constrain overt responding in incidental tests that are not contaminated by voluntary retrieval strategies (e.g., Kinoshita, 2001; Moscovitch, 2008), because the data reviewed here (e.g., Section 3.1, Tables 7.1 & 7.4) do not require such a conclusion.

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Part III

Broader Issues in the Science of Remembering

8

Understanding Autobiographical Remembering from a Spreading Activation Perspective

John H. Mace

Introduction

In its basic theoretical form, spreading activation is the notion that an activated memory (e.g., a concept in semantic memory, *Doctor*) will spread to and activate other related or associated memories contained within a network of memories (e.g., another concept in semantic memory, *Nurse*). Well accepted by many in cognitive psychology and other fields (e.g., neuroscience), spreading activation has been around for some 40 years, and it has served a number of areas rather well, accounting for many findings in various memory and production systems (such as semantic memory priming, speech production, and connectionist models of learning and memory, e.g., Anderson, 1983; Collins & Loftus, 1975; Dell, 1986; McClelland & Rumelhart, 1981). However, spreading activation has not received the same level of attention or investigation in autobiographical memory as it has in many other areas.

This chapter is concerned with spreading activation in the autobiographical memory system. The main focus is to identify, describe, and categorize the different ways in which spreading activation may affect memories within the autobiographical system, activate or be activated by memories in other

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systems, and surface into consciousness or remain unconscious only to dissipate or affect subsequent memory formations. One proposition being put forth here is that much (if not all) of involuntary remembering is the result of uncontrolled (or dis-inhibited) spreading activation in the autobiographical memory system. Another proposition is that spreading activation is functional to autobiographical remembering, particularly when it results in relevant involuntary memories during the process of voluntary recall, directly enhances voluntary memory production, or in some other way helps one to remember a relevant past experience in a particular situation or context. In many ways, this proposition is similar to the functional accounts of spreading activation in other memory and production systems (e.g., semantic memory or speech production).

Apart from these considerations, this chapter was written with a number of goals in mind. While a number of studies and theorists have in one way or another used spreading activation (most notably Conway and colleagues, e.g., Conway & Bekerian, 1987; Conway & Pleydell-Pearce, 2000), the concept has not been as fully worked out or pursued in autobiographical memory research as it has in other areas (e.g., semantic memory). Thus, one goal of this chapter is to encourage more systematic investigations of spreading in autobiographical memory.

The chapter is divided into four main sections. The first provides a theoretical outline for the nature of spreading activation in autobiographical memory, the second section reviews the studies supporting these claims, the third examines the functional significance of spreading activation to autobiographical remembering, and finally the fourth main section explores some unanswered questions, pointing to directions for future theories and research.

The Nature of Spreading Activation in Autobiographical Memory

Spreading activation has gone through a number of different conceptualizations over the years, ranging from theories where memories are represented by single nodes in a semantic network, with spreading flowing among them (Collins & Loftus, 1975), to views where memories are represented as patterns of activations spread over many units (or neurons), where the units (or distributed representations) are linked to others in the network (e.g., neural network models, such as those proposed by McClelland and colleagues, e.g., McClelland & Rumelhart, 1981). Although network models are probably best positioned to account for the complex set of phenomena that one sees in autobiographical remembering, as no final consensus has been reached on the exact nature of spreading activation, I avoid taking a position on its basic architecture. Instead, I work under the basic assumption that

Table 8.1 Major characteristics of autobiographical memory spreading activation

1. Directions of spreading activations
Within-systems spreads: Activations spread among memories within the autobiographical memory system.
Across-systems spreads: Activations spread from or to memories in other memory systems (e.g., semantic memory).
2. Products of spreading activation
The products of spreading activation may remain unconscious until they dissipate or effect cognitive activity.
The products of spreading activation surface into consciousness where they are experienced as memories. The spreading activation cycle continues in consciousness until it dissipates.
3. Spreading activation is obligatory
Every time a memory is activated, it spread activates other memories that it is networked with.

spreading activation exists in some real form, rather than as a metaphor only, and that the basics of it involve patterns of activation among information and memories which causes spreads to other memories or information that are similar, related, associated, or connected in some way. Beyond this basic consideration, the view being put forth here argues that spreading activation in autobiographical memory has three major characteristics: (1) concerns the types of memories involved in spreads, (2) concerns the relationship that activations have with consciousness, and (3) concerns the automatic nature of spreading activation.Table 8.1 lists all of the major points of these characteristics, and I review them in detail below.

Concerning the first characteristic, the types of memories involved in spreading activation, I propose that there are two types of system-based directional spreads. The first type is labeled *within-systems spreads*. This is the quintessential model of spreading activation where a memory in the system (in this case autobiographical) spreads to another similar or related memory within the system. Here, activation may move along temporal lines, conceptual lines, or from specific to general autobiographical memories (e.g., Conway & Pleydell-Pearce, 2000). The second type of spread is *across-systems spreads*. Here, generic memories (noncontextualized information, such as a semantic memory) spread from another memory system to memories in the autobiographical memory system. Examples of these types of spreads may be commonly found in everyday involuntary memories, where concepts have been shown to frequently trigger memories (e.g., Mace, 2004; Schlagman, Kvavilashvili, & Schulz, 2007). Elsewhere (Mace, 2007b), I have called these activations semantic-to-autobiographical spreads; however, it should be noted that this concept should not be limited to the semantic memory system or to the notion that information would flow in only one direction (e.g., semantic to autobiographical).

The second characteristic concerns the relationships that spreading activation has with consciousness. Sometimes the products of spreads (e.g., an activate memory) never enter consciousness, or if they do, the rememberer is unaware of how they may be connected to a previous event. This category of spreading activation is the classic sort, the type that presumably underlies semantic priming on lexical decision tasks. I call these *unconscious activations*, because the rememberer is unaware that one memory has activated another because the process either never surfaces into consciousness or if it does, the rememeber is unable to see any connections because the product (or memory) is experienced sometime later (hours or days), or he or she is unaware of the activating memory or prime. In contrast, *conscious activations* are like free associations, in that most of these products enter consciousness immediately as a series of connected memories, thus giving the rememberer the potential of seeing the connections between events (Ball, 2007; Mace, 2005b, 2006). Involuntary memory chaining (Mace, 2007a), where one involuntary memory prompts another, is a good example of a conscious activation (this phenomenon is discussed in several places throughout this chapter and also in chapter 3).

There may be a number of reasons why some activations may become conscious while others remain unconscious. One possibility is that in some cases activations may be too weak (or incomplete) to enter consciousness, while in other cases they may be strong and complete enough to become conscious. Another possibility is that inhibitory mechanisms might sometimes block activations from entering consciousness when they are either irrelevant or disruptive to the cognitive environment or task (e.g., Conway & Pleydell-Pearce, 2000). Obviously, these are not mutually exclusive explanations, and one might imagine that at times strong activations might be blocked because they are irrelevant to the current situation, while at other times relevant activations may not come into consciousness because they were not strong enough.

The last (or third) characteristic of spreading activation in autobiographical memory concerns its obligatory nature. According to the view being presented here, spreading activation is obligatory such that every time a memory is activated it will spread to additional memories, although they will not always become conscious, as noted above. This point can be found in semantic priming literature, where spreading activation theorists seemed to have reached the consensus that activations in the semantic system are automatic. One might also imagine that this type of automaticity is a basic property of neural networks, a point that Anderson (1983) seemed to have raised more than two decades ago.

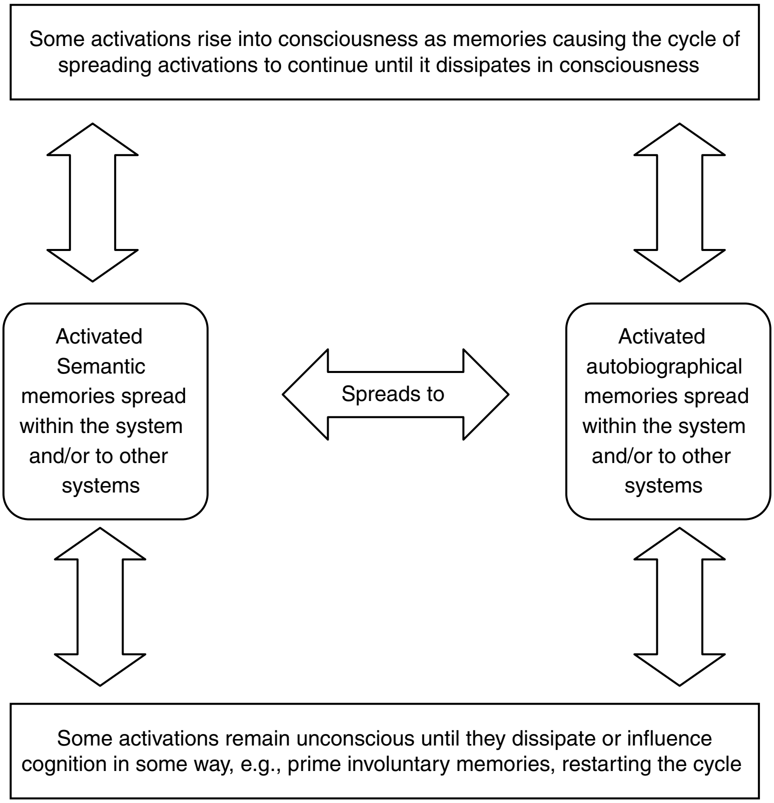

Figure 8.1 Activation processes in and between autobiographical memory and semantic memory.

To conclude this section, Figure 8.1 illustrates how activation processes can occur in and between autobiographical and semantic memory. However, it should be further emphasized that autobiographical memories can have connections with other memory systems. Involuntary memory research bears this out, as involuntary memories seem to be triggered by virtually any type of experience (e.g., from related conceptual information to sensory or motor experiences). The figure also illustrates how activations can surface into consciousness or remain unconscious until they dissipate or affect cognitive activity (e.g., the production of an involuntary or voluntary memory). Another point to emphasize here is that activation cycles can and probably do occur continually, cycling in and out of consciousness, producing continual cycles.

The effects of spreading activation on autobiographical remembering

The spreading activation approach predicts that certain effects and phenomena should be observed in autobiographical remembering. For example, autobiographical memories should be subject to priming effects such that prior activations should frequently influence autobiographical remembering in one way or another. While priming might enhance voluntary memory retrieval (e.g., by increasing the likelihood that a target memory is produced), priming effects may be more determinative and more likely to occur with everyday involuntary memories, accounting for many (or all) of this sort of autobiographical memory production. However, spreading activations also make some strong predictions about what should occur during voluntary remembering.

For example, the obligatory nature of spreading activation asserts that voluntary memory recall should abound with spreading activations (Mace, 2006, 2007a). Given the potential relevance of spread activated memories in this sort of cognitive activity, many of these memories should reach consciousness, and thus voluntary remembering should cause different sorts of involuntary remembering processes to occur (i.e., involuntary memory chaining and direct involuntary remembering, reviewed later), with some of these processes continuing after one has stopped trying to recall the past, resulting in residual processes like priming, and incubation-like retrieval processes, such as spontaneously remembering an event that would not come to mind earlier. Although at first blush this may seem to suggest that voluntary remembering is a sloppy, uncontrolled process, there may be great benefits gained by this sort of slack in the process. I explore this notion in a later section that addresses the functionality of spreading activation in autobiographical memory.

Studies Supporting Spreading Activation and Its Effects on Autobiographical Remembering

Although the literature is rather thin at this point in time, what does exist provides rather good evidence that spreading activation occurs in the autobiographical memory system and that it effects autobiographical remembering in a number of different ways (e.g., by priming voluntary memory production, etc.). In this section, we'll review the data that support these points, as well as point out how and where they support the characteristics of spreading activation enumerated above.

Unconscious activations and priming effects in autobiographical memory

The priming paradigm has been used extensively in many different areas of memory research (e.g., implicit memory and semantic memory; for reviews, see Richardson-Klavehn & Bjork, 1988; Roediger & McDermott, 1993). Although only a handful of studies have used priming paradigms in autobiographical memory (e.g., Ball & Hennessey, 2009; Conway & Bekerian, 1987; Mace, 2005b; Reiser, Black, & Abelson, 1985), these studies have provided some good evidence that priming phenomena and some of the theoretical explanations associated with them (in particular, spreading activation) can be extended to autobiographical memory.

Among the first of these, Reiser, Black, & Abelson (1985) primed autobiographical retrieval on an autobiographical memory task by presenting cues immediately before subjects were asked to recall personal memories. The cues consisted of activity and action statements (e.g., "going to the cinema," "finding a seat"), and they found that retrieval times for autobiographical memories were significantly decreased when these conditions were compared to unprimed conditions. Reiser et al.'s results indicated that the autobiographical memories recalled by subjects had been primed (or pre-activated) by the presentation of activity cues, and they interpreted these effects with a spreading activation model. Although Conway and Bekerian (1987) were unable to replicate Reiser et al.'s results in a subsequent study, they found that other types of conditions had primed autobiographical memory production. Using somewhat broader cues pertaining to more extended events such as lifetime periods (e.g., "school days," "university") and general events (e.g., "holiday in Italy"), they found that primes containing these more global forms of information had significantly decreased retrieval times when subjects were recalling specific memories in response to cue words or phrases. Thus, even though Conway and Bekerian were unable to replicate Reiser et al.'s results, they showed that primes containing larger autobiographical information had primed more specific autobiographical information (personal memories related to the larger knowledge structures, like "school days"). And while they, too, interpreted their results from a spreading activation perspective, this study was also important in that it suggested an inherent organizational schema for the autobiographical memory system.

This organizational schema consisted of lifetime knowledge structures (i.e., extended event periods, such as *when I was at university*, or *lived in New York City*), general event knowledge structures (i.e., less extended periods, such as *my trip to Italy or London last summer*, *bike rides on Sundays*), and specific (or episodic) knowledge structures (i.e., the least extended event period, such as *seeing the Egyptian mummies at the British Museum*, *having a flat tire*, representing the concept of episodic memories; see Conway, 1996, 2005). Important to the discussion here, Conway argues that spreading activation can flow between and within these structures. He also argues that such activations are likely to occur continuously as a result of various cognitive activities (perhaps representing the involuntary/obligatory claim presented above); however, inhibitory mechanisms may prevent these memories from entering consciousness most of the time because they are irrelevant to task goals or goals of the self (Conway, 2005).

In a recent study, Ball and Hennessey (2009) found evidence of such inhibitory processes, while at the same time also providing more evidence of autobiographical memory priming. Combining subliminal priming techniques with the negative priming paradigm (where priming is evidenced with inhibitory rather than facilitative effects), they showed that affect-laden memories were primed with subliminal primes (affect-associated cue words), but that these memories were also inhibited when they were inconsistent with the goals of the memory task. Similarly, in their second experiment, they showed that the same pattern of priming and inhibitory effects could be obtained with lifetime period memories (i.e., pertaining to early or late childhood).

The results of Ball and Hennessey (2009) are important because they make a good case for the existence of inhibitory mechanisms in the autobiographical memory system. Conway's (e.g., Conway & Pleydell-Pearce, 2000) theory concerning inhibitory processes is important to the view being put forth here because it explains why a system which may be continuously active does not result in continuous (or near continuous) memory production. Such an account, then, explains why the obligatory principle in spreading activation does not always result in memory production and why, for example, involuntary memories may occur at different rates in different circumstances. We'll return to this point later in our discussion.

While the studies reviewed thus far have all demonstrated priming (or unconscious activations) by showing that primes will enhance retrieval or cause inhibitory effects, other studies have demonstrated priming by showing that fully activated memories would have an effect on the type of memories that a rememberer would produce at some later point (e.g., when encountering a cue in everyday life or a cue in an autobiographical memory task).

The first study to do this established a link between reminiscing (voluntary remembering in the laboratory) and everyday involuntary remembering (Mace, 2005b). In this study, subjects kept a diary of their daily involuntary memories for two weeks while they were also required to come into the laboratory for voluntary memory sessions on one or more occasions. In the laboratory sessions, subjects recalled memories from their years in high school or memories from the past year or some other circumscribed temporal period. At the completion of the diary recording phase, the diaries were inspected for memories from the various time periods. The results showed that subjects had experienced significantly more involuntary memories from the temporal period that they were asked to remember in the laboratory than relevant control subjects, thus establishing that the involuntary memories had been primed by their previous voluntary recall activities. The results also showed that none of the primed memories were repetitions of any of the memories previously recalled in the laboratory sessions, thus indicating that the priming was of the associative type, representative of spreading activation.

More recently in our lab, we used a variant of this approach to see if voluntary remembering could be primed by prior autobiographical memory activations (Mace, Folkers, & Clevinger, in preparation). In the first of a series of experiments, subjects were asked to recall memories from their elementary school days, grades 1–5. Following this activity they were engaged in a cue-word autobiographical memory task, with instructions to recall memories from their past generally, noting the first memory coming to mind. Similar to Mace (2005b), the results showed subjects primed with the prior elementary school recall session had recalled more memories from this part of their lives than relevant controls. Previous studies using word-list memory paradigms have also suggested that previously activated memories (words on the study list) may in some cases directly prime the voluntary recall of other words on the study list (e.g., Mace, 2005a).

Conscious activations:

Within and between systems spreads

There are a number of involuntary memory phenomena that suggest that the products of spreading activation on occasion immediately enter consciousness (Ball, 2007; Mace, 2005b, 2006, 2009). As discussed above, these activations have conscious characteristics like free associations, in that they occur successively and the links between them may be readily apparent to rememberers and third parties.

A prime example of this appears in the production of involuntary memories in everyday circumstances. Diary studies of naturally occurring involuntary memories show that involuntary memories are sometimes retrieved as a sequence of memories (e.g., Mace, 2005b). Known as involuntary memory chaining (Mace, 2007a), this type of involuntary remembering is characterized by the activation of one memory leading to the activation of one or more additional memories, all occurring in quick, rapid succession. So, for example, an involuntary memory of visiting the British Museum in London might trigger a memory of visiting the Natural History Museum in New York, which might in turn trigger another related memory, all occurring within seconds of one another. Rememberers experience these memories as connected, not only because they emerge into consciousness within the same space of time, but also because they appear to be associated (or linked) in some meaningful way (i.e., either temporally or conceptually related).

The most common type of association (or spread) to appear in involuntary memory chains has been labeled conceptual associations. Here, memories in a chain are related by some common content (e.g., involving the same people, location, objects, activities, and a variety of idiosyncratic connections). While some of these associations may be related at temporal levels, too, the clearest form of temporal association has been labeled general-event associations, consistent with Conway's 1996, 2005 general event notion. Here, the memories in a chain are typically episodes from the same general event period (such as *my trip to London last summer*). Somewhat less common to appear in this category of involuntary memory chains are associations which appear to spread from larger to smaller memory structures (i.e., or vice versa). Perhaps still linked at temporal levels of organization, here more global general memories (such as *my trip to London* or *Sunday bike rides*) lead to specific memories (*visiting the British Museum*, *having a flat tire*). Involuntary memory chains have also been observed to flow in the opposite direction (i.e., from specific to general; for more on involuntary memory chains and the associations found in them, see Mace, 2007a).

These many different manifestations of associative spreads in involuntary memory chains are consistent with Conway's (e.g., Conway & Pleydell-Pearce, 2000) proposal that spreading activation in autobiographical memory will flow along the lines of its organizational structures, following many different and varying pathways. They are also obviously consistent with the basic view being put forth here, which is that spreading activation will follow basic patterns of associations and similarity, much like and similar to the basic principle hypothesized to occur in semantic memory.

Another type of involuntary memory phenomenon is also indicative of conscious activations, but in this case they appear to represent semantic-to-autobiographical spreads or across systems spreads. Ball (2007) introduced a free association procedure which was designed to elicit involuntary autobiographical memories in the laboratory. In this procedure subjects were asked to provide a series of continuous free associations in response to a single word (i.e., concrete nouns such as "coffee" or "popcorn"). The results of this procedure showed that while subjects responded with a series of semantic associates (e.g., "coffee" led to "hot," "caffeine," "awake"), frequently (on some 86 percent of the trials) they responded with autobiographical memories in their strings of associations (e.g., "awake" led to "*time when I drank a lot of coffee that kept me awake and so I went for a run*"; "hat" led to "clothing," "apparel," "top-hat," "*top-hat sign seen when driving to supermarket*"). It is important to note that the methods used in this approach took great care to eliminate (or minimize) the possibility that subjects had intentionally recalled these memories, and Ball also provided measures which suggested that the memories did occur spontaneously (for more details, see Ball, 2007).

Ball's (2007) data make a compelling case for the notion that semantic memories have links to autobiographical memories and therefore spreading activation can occur between these two systems. Spreads between autobiographical and semantic memories may occur commonly both at unconscious levels and at conscious levels in everyday life. One way in which this type of spreading activation may commonly manifest itself is in the production of everyday involuntary memories, where conceptual cues (and other types of cues that could be deemed as semantic) appear to frequently cause involuntary memories (e.g., Mace, 2004, 2005; Schlagman, Kvavilashvili, & Schulz, 2007; for a review, see Ball, Mace, & Corona, 2007)

For example, frequently subjects in diary studies report that some type of conceptual cue (reading the name "Michael Palin" in a magazine or hearing someone say the word "sushi") triggers a personal memory with the concept (having seen the comic on stage or having sushi for the first time). These involuntary memory retrievals might be produced as a result of the type of between systems spreads that Ball's (2007) data argue for. Perhaps the most compelling argument for this can be found in involuntary memory productions whose cues are best deemed as semantic associates, because they themselves played no direct role in the original experience. For example, a subject in a diary study noted that seeing a Brazilian flag had prompted a memory of being with her Brazilian friends (see further discussion in Ball, Mace, & Corona, 2007). It was clear from her description that the flag was neither present (i.e., perceived) nor had it served any other sort of role (e.g., was talked about) in the event being remembered. Thus, this type of example seems to be indicative of a semantic-to-autobiographical memory spread, where the concept of Brazil spread to a personal memory with Brazilians because it had associative links, much like that seen in Ball's (2007) free association data.

Cue and memory relationships like these are common in everyday involuntary memories, accounting for nearly a third of all productions (e.g., Schlagman, Kvavilashvili, & Schulz, 2007). They make a strong case for the notion of across-systems spreads, and they may well indicate that much of everyday involuntary memory production may be accounted for by this type of retrieval, or spreading activation, process.

Voluntary remembering and involuntary remembering: Obligatory, automatic spreads

As reviewed above, voluntary recall produces priming affects which can affect later autobiographical memory recall (e.g., Mace, 2005b). This is consistent with the notion that spreading activation is an automatic, obligatory process that will occur once a memory has been activated in the system. According to this principle, conscious activations, like chaining, should also occur as a result of voluntary recall. Indeed, there is evidence that involuntary memory chaining occurs when subjects are recalling personal memories and when they are recalling a list of previously studied words (Mace, 2006, 2009). Particularly relevant to the discussion here is the evidence obtained in a study involving an autobiographical memory task (Mace, 2006).

In this study subjects were engaged in an autobiographical memory task, in which they were to use phrases such as *being at a party* to recall memories from their high school lifetime period. Subjects were instructed to give brief descriptions of their voluntary memories, and also to note and give descriptions of any involuntary memories that they might experience during the task, specifying what they thought had brought them to mind. To rule out the possibility that memories claimed to be involuntary were in fact voluntary, two independent measures were used: general-event memory associations (as discussed above) and specific versus general memory production (i.e., episodic versus general memories, such as *my trip to London*, as discussed above). In the case of specific memory measure, past research had shown that when involuntary memories collected via diary methods are compared to voluntary memories collected via cue-word methods, involuntary memories show a significantly higher proportion of specific memories relative to general memories (e.g., Berntsen, 1998). Regarding the general-event measure, involuntary memory chains show significantly lower proportions of general-event associations compared to voluntary memory laboratory procedure known as event-cueing, where subjects are asked to recall memories related to memories they had previously recalled. Thus, to allow for these comparisons, a separate group of subjects was treated to the event-cueing procedure.

The results of the study showed that subjects treated to the regular autobiographical memory task had indicated that they had experienced involuntary memories when they were recalling memories from their high school days. Furthermore, they also indicated that the majority of these memories (94 percent) were triggered by a preceding voluntary memory (i.e., those that they had generated in response to the phrase cues), as opposed to some other or unknown cueing source. A more fined-grained analysis showed that voluntary memories had triggered involuntary memories some 40 percent of the time. When these memory chains were analyzed for association type, a very small proportion of them involved general-event associations, and thus the proportion of general-event associations to conceptual associations appeared to be very much like those reported for involuntary memory chains produced in diary studies (see Mace, 2007a). When these relative proportions were compared to the relative proportions found in the event-cueing group, the event-cueing group showed a much higher proportion of general-event associations, differing significantly from the involuntary memory chains reported in the standard autobiographical memory task group. In addition, when the involuntary memories were analyzed for specific memory production and compared to voluntary memories, the involuntary memories showed a significantly higher proportion of specific memories, and thus this measure as well as the general-event association measure, dissociated involuntary memory retrieval from voluntary memory retrieval.

Elsewhere (Mace, 2007a), I have argued that in addition to chained involuntary memory recall, more direct forms of involuntary memory recall (i.e., cued based) should also occur when one is in voluntary recall mode (or retrieval mode; Tulving, 1983). According to the view advocated in this chapter, voluntary remembering sets up a number of conditions that should make this occur. That is, typically, when a rememberer is engaged in voluntary remembering, the system is abuzz with spreading activation and these activations should be at their strongest at this point in time. Further, because one is in voluntary recall mode, inhibitory mechanisms should be relaxed, as memories are more likely to pass their "filters," given their potential relevance to the situation (the chaining data reviewed above seem to support this claim, as chaining occurred at a rate of some 40 percent in voluntary remembering, in comparison to some 15 percent in everyday involuntary remembering: see Mace, 2007a). All of this, then, should increase the likelihood that rich cueing environments (like autobiographical memory tasks) should cause direct involuntary remembering (i.e., more so than in other circumstances). Although the evidence supporting this point is only suggestive at this time, much of what does exist makes a rather compelling case for this position.

For example, Haque and Conway (2001) measured how long it took to form a memory in response to word cues (such as *Chair*), and they found that on occasion subjects reported that they had formed a specific autobiographical memory in as little as two seconds. The authors argued that such fast retrieval times probably represented instances of direct involuntary memory retrieval (i.e., cue words had involuntarily triggered a memory before voluntary recall processes got started). More indirect evidence can be found in a report by Gardiner, Ramponi, and Richardson-Klavehn (1998). In their study, subjects in word-list memory tasks indicated that words seen on a prior study list, similar to the cue words used in autobiographical memory tasks, sometimes spontaneously evoked autobiographical memories, thereby suggesting that similar retrieval is likely to occur in autobiographical memory tasks. However, perhaps the best set of indirect evidence comes from a recent study which used a laboratory paradigm to elicit involuntary memories (Schlagman & Kvavilashvili, 2008). Schlagman and Kvavilashvili presented subjects with various arrays of stimuli (e.g., a pattern of black horizontal or vertical lines), which had word phrases (such as *relaxing on a beach*) embedded within them. Subjects were instructed that their main task was to report changes in the stimulus array (i.e., when a vertical line pattern appeared), but also they should report any task-unrelated thoughts that they might have (e.g., daydreams memories, including spontaneous memories, etc.). The results showed subjects reporting the experience of involuntary memories, most of which were triggered by the phrases (some 93 percent). In addition, these memories dissociated on various measures from a comparable set of voluntary memories in ways similar to the results reported in Mace (2006). Thus, these results provided good indirect evidence that direct involuntary remembering occurs on voluntary memory tasks because Schlagman and Kvavilashvili's task had conditions which overlapped with the conditions of voluntary recall tasks (namely, the use of phrase cues).

Considering the Functional Nature of Spreading Activation in Autobiographical Memory

In addressing the functional role of spreading activation in cognition, Anderson (1983) wrote that it is "the 'energy' that runs the 'cognitive machinery'. Activation spreads through the declarative network along paths from original sources to associated concepts. A piece of information will become active to the degree that it is related to current sources of information. Thus, spreading activation identifies and favors the processing of information most related to the immediate context (or sources of activation)." Statements like Anderson's underscore much functional thinking about spreading activation, where theorists in many areas of research have come to see it having an important facilitory role in the processing and production of knowledge. One might apply this same sort of functional thinking to autobiographical remembering and imagine that spreading activation has the function of putting autobiographical memory into a ready-state so that it may process and produce relevant information, perhaps for as long as days.

Spreading activation may be functional to voluntary remembering in a number of ways. For example, it might increase the likelihood that a target is found as a result of a direct search. This could occur as a result of processing that took place during the voluntary recall process, or as a result of processing that took place hours or days ago. The involuntary memory chains that occur during voluntary recall should also serve the process, in that they will either produce additionally relevant conceptually or temporally related memories or more information about targets. Indeed, it is possible that involuntary memory chains may at times unearth the sought after information when the target was in error or under some other set of circumstances. One could also advance similar arguments for any direct involuntary remembering that might occur in voluntary recall mode (see further discussion in Mace, 2007a).

In everyday involuntary remembering the functional benefits of spreading activation are a bit more difficult to see at this point, as research into involuntary memory is still a relatively new endeavor. However, we might be able to imagine a few scenarios in which functional cases can be made. If, for example, many (or all) of one's involuntary memories are related to previous primes (e.g., the cognitive activity of the last minutes, hours, or days), then spreading activation would play a functional role here, as it would keep everyday involuntary memory production in line with (and presumably relevant to) recent cognitive activity and personal preoccupations (see discussions in Berntsen, 2007, 2009; Mace, 2005b; Mace & Atkinson, 2009). On the other hand, one could imagine that there are many different types of benefits associated with spreads to and from autobiographical memory and other memory systems in everyday life. For example, there may be many times when semantic information should (or needs to) spread to autobiographical information, and one might argue that much (if not all) of everyday involuntary remembering represents cases like this. Autobiographical to semantic (or other memory systems) spreads may be functional to general cognitive processing, including perceptual enhancement. There is some evidence of this, as involuntary conscious memory processes have been shown to facilitate priming on semantic and perceptual implicit memory tasks (e.g., Mace, 2003a, 2003b, 2005a). Clearer pictures should emerge on functions like this and the others discussed as involuntary memory researchers make advances in techniques for recording and observing everyday involuntary memories.

Concluding Comments:

Additional Questions, Reflections, and Future Directions

In this chapter, I have reviewed how spreading activation might give rise to involuntary memories, facilitate voluntary recall through priming, and additional involuntary memory recall processes. I have also reviewed how some of the products of spreads may surface immediately, up to days later, or not at all. I've categorized activations as conscious or unconscious to reflect that the rememberer may be aware or unaware of the connections between activated memories, asserting that in the case of more long-term activations (or priming effects) they are much less likely to be conscious. Additionally, I've argued that spreads are obligatory, but that they may also be blocked when they are not functional to the situation, adopting Conway's view on inhibition (e.g., Conway & Pleydell-Pearce, 2000). I have also argued that spreads in autobiographical memory can occur in multiple and varied ways (e.g., among specific memories or between specific and general memories, adopting and expanding on views expressed in Conway, 2005; Conway & Pleydell-Pearce, 2000), and also that spreads can occur between memory systems (e.g., from semantic to autobiographical).

It makes sense that spreading activation would follow along the lines of the varied, elaborate, and complex organization of memories in the autobiographical system. Such elaborate and complex connections would optimize a rememberer's ability to find a particular piece of information or information related to it. It also makes sense that semantic memories would have connections to autobiographical memories, allowing for spreads to occur to and from generic memories to personal memories. While we don't know much about the functional significance of these types of connections, one could imagine that there are benefits in everyday cognition of having generic memories spread to related personal memories, and perhaps vice versa. And, although I've emphasized this connection between semantic and autobiographical memory throughout this chapter, I should once more emphasize that autobiographical memory probably has two-way connections with other generic types of memory systems.

It also seems that not all spreads are full memory-to-memory spreads. For example, some of the cues that are found to trigger involuntary memories are probably too specific (or idiosyncratic) to represent generic information. In these cases a piece of information overlapping with a memory (in other words, a fragment of a memory) may cause spreading which ultimately culminates into the activation of a full blown memory. Indeed, much of direct voluntary remembering might represent this type of spreading activation process (e.g., a cue elaboration strategy spreads directly to a memory that it best captures; see Conway & Pleydell-Pearce [2000], who argue that all generative, voluntary retrieval culminates in such direct, involuntary retrieval), and such spreads probably embody the concept of content addressability.

Future work should probably be directed towards these additional questions. Also, as is clear by the small number of studies reviewed here, more work is needed on the various points raised throughout this chapter (e.g., on involuntary memory chaining, on involuntary remembering occurring during voluntary remembering, on functions, such as the role of activations between memory systems, etc). Also important to the framework being put forth here is Conway's view on the workings of inhibitory mechanisms. His view accounts well for why the products of spreading activations do not occur all the time, explaining why, for example, different rates of involuntary memory chaining occur under different circumstances (e.g., everyday involuntary remembering and voluntary remembering). Because such a view brings good functional sense to the spreading activation framework, it is important that future work is directed toward it, as well as other views which similarly look for functional explanations. However, we should also consider the possibility that some spreading activations, involuntary memories, are sheer accidents of production, like slips of the tongue or even mind pops (involuntary semantic memories; see Kvavilashvili & Mandler, 2004). Being able to identify these situations may help us to understand the circumstances and ways in which productions are functional.

In conclusion, I've presented a view which extends the spreading activation model to the autobiographical memory system and the processes of retrieval within it. This approach extends, adds to, and benefits very much from ideas put forth by Conway and colleagues (e.g., Conway, 1996, 2005; Conway & Pleydell-Pearce, 2000). As such it should function well within his framework. The approach presented here may also function within the context of Rubin's (2006) basic-systems model of episodic memory, work with Barsalou's (1999) perceptual symbol systems theory, and certainly with the relatively more traditional approaches to memory systems (e.g., Schacter & Tulving, 1994; Tulving, 1985).

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9

Retrieval Inhibition in Autobiographical Memory

Bernhard Pastötter and Karl-Heinz T. Bäuml

Introduction

Autobiographical memory (AM) retrieval is a complex process that involves the processing of episodic, semantic, and emotional information with strong personal relevance (Conway & Williams, 2008). It can be either a voluntary process, like in constructive memory search (Schacter & Addis, 2007), or an involuntary process, like in the case of memory intrusions of emotionally unpleasant or traumatic events (Berntsen, 1998). Voluntary retrieval of AMs is effortful and slow, i.e., it takes time to consciously retrieve a specific AM. In contrast, involuntary retrieval is fast and spontaneous, i.e., an AM intrudes without any conscious or deliberate attempt to retrieve it.

Voluntary retrieval of an AM requires constructive memory search (Cabeza & St Jacques, 2007; Schacter & Addis, 2007). For example, try to remember the last time you went to the movies. Unless this was very recently, you will actuate a protracted, time-consuming memory search to retrieve the appropriate information. You may more or less voluntarily search for the memory within an associative network of complex AM information, including episodic, semantic, and emotional representations. Doing so, retrieval success will depend strongly on the search path or retrieval route that, voluntarily or involuntarily, is selected (see Mace, chapter 3, this volume). In the first step, episodic retrieval cues (e.g., you remember a specific movie you went to with your friend Julia), semantic cues (e.g., you think of people munching popcorn), or emotional cues (e.g., you bring to mind that movies

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always make you cry) may be generated. Then, on the basis of the generated cues, a targeting search path will be constructed to recall the relevant information.

During such memory search, cueing most likely elicits not only relevant information, i.e., information pointing to the target memory, but elicits also irrelevant information that points to nontarget memories. Retrieval of a specific AM thus may fail because irrelevant information is sampled instead of relevant ones. Crucially, to overcome interference of irrelevant information and prevent spurious recall, inhibitory processes may operate to reduce the accessibility of irrelevant information and enhance that of the relevant one (for reviews, see Anderson, 2003; Bäuml, 2008; Bjork, 1989). To date, the idea that inhibition is involved in AM retrieval lacks basic research. The investigation of AM retrieval with experimental paradigms in which the action of inhibitory processes has been suggested, therefore, is eligible. Such research is raring to go (Barnier et al., 2007; Barnier, Hung, & Conway, 2004; Joslyn & Oakes, 2005; Wessel & Hauer, 2006).

While AM search often happens voluntarily, recall of past events may also happen involuntarily. This is particularly the case for emotional events that are recalled more vividly, with greater contextual detail, and with greater recollective experience than emotionally neutral memories (Buchanan, 2007). These recall characteristics may be desirable for pleasant AMs, they are less desirable, however, for involuntary retrieval of unpleasant memories. Traumatized and depressed people often suffer from involuntary retrieval of distressing memories they are unable to forget (see Williams & Moulds, chapter 15, this volume). These "flashback" memories can lead to strong memory disturbances in traumatized individuals with posttraumatic stress disorder (PTSD), characterized by intrusions of highly emotional memory fragments and the inability to voluntarily recall other important aspects of the trauma, often at the same time.

Intrusions and amnesia may be related in PTSD, because unwanted traumatic "flashbacks" may interfere with and thus impair deliberate recall of other aspects of the trauma. In addition to processes like interference and blocking, ineffective retrieval inhibition of highly emotional aspects of the traumatic event may play a role in trauma-related memory disturbances as well. The idea that inefficient cognitive control is involved in PTSD is an interesting proposal for clinical psychology (see Verwoerd & Wessel, chapter 14, this volume). Therefore, the investigation of memory disorders in PTSD with experimental paradigms in which inhibitory processes are likely to play a crucial role is eligible. Recently, first steps were taken to investigate the role of retrieval inhibition in PTSD (for a review, see Geraerts & McNally, 2008).

The chapter begins with an introduction of commonly used experimental paradigms in research on retrieval inhibition in episodic memory. Basic behavioral findings and the role of emotion in these paradigms will be reviewed. After summarizing recent physiological findings in the study of retrieval inhibition, neural substrates of AM retrieval will be addressed. Comparing the results from the two lines of studies, we will conclude that inhibitory processes may play a crucial role in AM construction and the suppression of unpleasant or traumatic AMs. Inhibitory control in AM retrieval thus may be an important piece of the puzzle towards an understanding of how we recall the past.

Experimental Paradigms for the Study of Inhibitory Processes

In the following, we summarize findings from three experimental paradigms in which the action of inhibitory processes has repeatedly been suggested: retrieval-induced forgetting, directed forgetting, and think/no-think impairment. Whereas retrieval-induced forgetting reflects unintentional forgetting, directed forgetting and think/no-think impairment reflect intentional forms of forgetting. In retrieval-induced forgetting, the selective retrieval of previously encoded information has been shown to impair later recall of related material without an explicit intention to forget (Anderson, Bjork, & Bjork, 1994). In directed forgetting and think/no-think impairment, it has been found that the explicit instruction to forget or to stop thinking of previously encoded information can lead to intentional forgetting of target material (Anderson & Green, 2001; Geiselman, Bjork, & Fishman, 1983). In all these cases, the action of retrieval inhibition, involuntarily or voluntarily, has been suggested to serve the goal-directed use of human memory (Bäuml, Pastötter, & Hanslmayr, 2010).

Retrieval-induced forgetting

Involuntary retrieval inhibition has been examined in the retrieval-practice paradigm (Anderson, Bjork, & Bjork, 1994). In this paradigm, effects of selective retrieval of a subset of previously studied items on later memory performance for the retrieved and nonretrieved items are examined. When using verbal material, participants often study categorized item lists (e.g., FRUIT-*apple*, FRUIT-*banana*, DRINK-*soda*) and then repeatedly practice half of the items from half of the categories using a word-stem completion task (e.g., FRUIT-*ap*____). Following this retrieval-practice phase and a subsequent distractor task, participants' recall performance is tested on a final memory test. The typical finding on this test is that recall of practiced items (*apple*) is enhanced and recall of unpracticed items from practiced categories (*banana*) is impaired, relative to control items from unpracticed categories (*soda*). The impairment in recall of the unpracticed material is referred to as retrieval-induced forgetting (RIF).

RIF has been observed in free and cued recall tests (e.g., Anderson, Bjork, & Bjork, 1994; Macrae & MacLeod, 1999), in item and category recognition tests (e.g., Hicks & Starns, 2004; Spitzer & Bäuml, 2007, 2009), and in implicit memory tests, like lexical-decision tasks and other conceptual implicit memory tests (e.g., Perfect, Moulin, Conway, & Perry, 2004; Veling & van Knippenberg, 2004). In addition, RIF has been found in so-called independent-probe tests in which retrieval cues are used at test that had not been presented in any previous phase of the experiment (e.g., Anderson & Spellman, 1995; Aslan, Bäuml, & Pastötter, 2007). RIF is not restricted to verbal material and has been observed with various stimuli and experimental settings, including visuospatial material (Ciranni & Shimamura, 1999), eyewitness event memory (Saunders & MacLeod, 2002), foreign language acquisition (Levy, McVeigh, Marful, & Anderson, 2007), and AM retrieval (Barnier, Hung, & Conway, 2004; Wessel & Hauer, 2006).

RIF is not restricted to episodic memories but affects semantic memories as well. Bäuml (2002) provided evidence that RIF may be the result of semantic generation. After the study of a list of category exemplars, participants generated new, previously not presented exemplars of the studied categories. On the final memory test, such semantic generation caused episodic forgetting of the originally studied items. Johnson and Anderson (2004) then extended the finding by showing that selective retrieval can induce semantic forgetting. After generating exemplars of a category, participants' ability to recall a semantically related item on a free-association test was impaired. This suggests that not only episodic memories, but also semantic memories, can be subject to RIF.

RIF is a retrieval-specific effect (Anderson, Bjork, & Bjork, 2000; Bäuml, 2002; Ciranni & Shimamura, 1999). Only retrieval (FRUIT-*ap*____), but not relearning (FRUIT-*apple*), of a subset of previously studied items can induce forgetting of the not-reprocessed material. The idea is that during attempts to selectively retrieve target information, the representation of related unpracticed information is involuntarily inhibited to reduce interference, impairing memory performance of the unpracticed items on the final test (Anderson, 2003). Instead of deactivating any particular retrieval route between the interfering items and their cue(s), involuntary retrieval inhibition is suggested to affect the representation of the unpracticed item itself (Anderson & Spellman, 1995; Spitzer & Bäuml, 2007), causing a recovery problem for the inhibited item (Bäuml, Zellner, & Vilimek, 2005). Following Tulving and Pearlstone's (1966) terminology, RIF thus may be regarded as a form of item unavailability rather than item inaccessibility (Bäuml, 2007, 2008).

Directed forgetting

Voluntary retrieval inhibition has been examined in the directed forgetting (DF) paradigm in which participants are cued to intentionally forget previously studied material. Two methods have been used in the literature to induce directed forgetting: the list method (Bjork, LaBerge, & LeGrand, 1968) and the item method (Muther, 1965).

In list-method directed forgetting (LM-DF), participants study two lists of items and, after study of List 1, are cued to either forget or continue remembering this list before studying List 2. On a later memory test, forget-cued participants typically show impaired recall of List-1 items and improved recall of List-2 items, compared to remember-cued participants; the two effects are referred to as List-1 forgetting and List-2 enhancement. In item-method directed forgetting (IM-DF), participants study a single list of items and the presentation of each single item is followed closely by a cue to either remember or forget the item. On a later memory test, in which participants are asked to recall all of the previously presented items, to-be-remembered items are typically better memorized than the to-be-forgotten items.

Whereas IM-DF is present in recall tests, recognition tests, and even implicit memory tests, LM-DF is present in recall tests only and is absent in recognition and implicit memory tests (e.g., Basden & Basden, 1996; Basden, Basden, & Gargano, 1993; Davis & Okada, 1971; MacLeod, 1989, 1999). DF effects are present irrespective of output order of to-be-remembered and to-be-forgotten information (e.g., Geiselman, Bjork, & Fishman, 1983; Zellner & Bäuml, 2006), indicating that the forgetting does not reflect effects of blocking or output interference at test (see Bäuml, 2008). DF is also a fairly general phenomenon and has been observed with verbal (e.g., Geiselman et al., 1983; MacLeod, 1999), visual (e.g., Basden & Basden, 1996), and autobiographical material (e.g., Barnier et al., 2007; Joslyn & Oakes, 2005). Crucially, DF is not the result of demand characteristics, because it was found to be still present if money was offered to participants as reward for each recalled to-be-forgotten item (MacLeod, 1999).

With respect to theoretical explanations of DF, it has repeatedly been suggested that retrieval inhibition offers the best account of LM-DF, but that a selective rehearsal account provides the best explanation of IM-DF (Basden, Basden, & Gargano, 1993; Bjork, 1989). In LM-DF, the proposal is that, by inhibiting List-1 items, the forget cue deactivates retrieval routes to List-1 items, thus making them less accessible on a subsequent recall test. Being less accessible, List-1 items are also less likely to interfere with List-2 items, which simultaneously improves access to List-2 items (e.g., Geiselman et al., 1983; for a noninhibitory account, see Sahakyan & Kelley, 2002, or Sheard &

MacLeod, 2005). The loss of accessibility via retrieval inhibition seems to affect the whole List 1 rather than single items (Kimball & Bjork, 2002). Accordingly, when participants alternately learn items intentionally and incidentally and are instructed to forget the intentionally learned items, incidentally learned List-1 items are just as well forgotten as the intentionally learned items (Geiselman et al., 1983). Following Tulving and Pearlstone's (1966) terminology, LM-DF thus seems to be due to a loss of accessibility via retrieval routes to List 1 rather than a reduction in items' availability (Bäuml, 2008).

In IM-DF, the dominant theoretical view is the selective rehearsal account, according to which participants fail to adequately encode to-be-forgotten items because they terminate rehearsal in response to the forget cue. As a consequence, these items receive less rehearsal than to-be-remembered items, which can account for the observed IM-DF effects in both recall and recognition tests (e.g., Basden, Basden, & Gargano, 1993; MacLeod, 1999). The selective rehearsal account arose from behavioral research. Recent physiological examinations of IM-DF, however, suggest that inhibitory processes may contribute to the forgetting as well (e.g., Wylie, Foxe, & Taylor, 2008).

There is strong evidence from both behavioral and physiological studies that IM-DF is due to differences in processing at the time the cue to remember or forget is presented. In contrast, in LM-DF, the presence of a forget instruction has been shown to be not sufficient to produce List-1 forgetting, but is effective only if there is additional List-2 encoding (Pastötter & Bäuml, 2007). The crucial role of postcue encoding has also been shown when dividing participants' attention during List-2 encoding by means of a secondary task which reduces List-1 forgetting (Conway, Harries, Noyes, Racsmany, & Frankish, 2000), and when increasing the amount of List-2 encoding which increases List-1 forgetting (Pastötter & Bäuml, 2010). In line with a recent physiological finding (Bäuml, Hanslmayr, Pastötter, & Klimesch, 2008), LM-DF thus is suggested to be initiated during postcue encoding.

Think/no-think impairment

A third form of intentional forgetting is think/no-think (TNT) impairment (Anderson & Green, 2001). The TNT paradigm is a memory adaptation of the go/no-go task, which is typically used to study control of prepotent motor responses. Initially, participants study several cue-target pairs (e.g., coffee-table) and are trained to answer with the appropriate target upon presentation of its cue. After training, participants engage in a TNT task in which they are instructed to either repeatedly retrieve (think) or actively suppress retrieval (no-think) of a target at its cue presentation. On a cued-recall test on the targets, memory performance is typically enhanced for the think items and impaired for the no-think items, relative to baseline items that are neither remembered nor suppressed during the TNT phase.

TNT impairment was found both when the original cue (e.g., Anderson & Green, 2001; Depue, Banich, & Curran, 2006) and when semantically related independent probes were provided in explicit memory tests (e.g., Anderson & Green, 2001; Anderson et al., 2004). However, no studies have yet been reported examining TNT impairment in recognition or implicit memory tests, at least when comparing performance of target items to an appropriate baseline condition (see Marx, Marshall, & Castro, 2008, for speeded recognition data without baseline reference). Importantly, TNT impairment has also been found when money was offered to participants as reward for each recalled no-think item (Anderson & Green, 2001). Thus, TNT impairment should not be the result of demand characteristics.

Anderson and Green (2001) argued that TNT impairment is caused by active retrieval suppression of no-think items (for a noninhibitory account, see Bulevich, Roediger, Balota, & Butler, 2006, or Hertel & Calcaterra, 2005). According to the inhibitory account, during no-think trials, the memory representation of the targets is reduced so that later accessibility of the targets is lowered regardless of which cue is provided and which retrieval route is used. According to this view, no-think trials affect the items' later availability; the impairment, therefore, should be observable across a wide range of memory tests, including recall tests, recognition tests, independent-probe tests, and even implicit memory tests. Currently, the evidence for TNT impairment is restricted to cued recall and independent-probe tests, awaiting further tests of the inhibition proposal using recognition and implicit memory tests.

In the TNT paradigm, retrieval suppression is suggested to build up slowly and, therefore, repeated TNT trials are necessary to effectively suppress retrieval of no-think targets (Depue, Curran, & Banich, 2007). Indeed, most TNT studies suggest that the forgetting in this paradigm typically arises only if the number of TNT trials is fairly high (>10 trials) and does not arise if the number of such trials is relatively low (<5 trials; Depue et al., 2006).

Emotion and Retrieval Inhibition

Prior research has shown that emotion guides human judgment and cognitive processing (for a review, see Clore & Huntsinger, 2007). In particular, emotion can affect the retrieval of AMs (for a review, see Buchanan, 2007). This influence is exerted at either a state-specific level, i.e., retrieval of emotionally neutral events in a specific affective state, or an item-specific level, i.e., retrieval of a specific emotional event in a neutral state. Thus, with respect to the role of emotion in retrieval inhibition, two related but separate questions arise. The first question is whether the affective state experienced during retrieval inhibition modulates the forgetting. The second question is whether the forgetting differs for emotional and nonemotional contents.

Affective state

In RIF, the first question has recently been addressed by Bäuml and Kuhbandner (2007). They examined how affective states experienced during retrieval modulate RIF by inducing positive, negative, and neutral moods immediately before the retrieval-practice phase. Their results showed that repeated retrieval did not cause forgetting of nonretrieved items when participants were in negative moods, whereas when subjects were in positive or neutral moods, reliable RIF was found. The absence of RIF in negative moods is consistent with the view that negative moods induce predominantly item-specific processing, i.e., processing of items by their features and distinctive qualities (e.g., Clore & Huntsinger, 2007). Because item-specific processing reduces interference from related information, retrieval inhibition should be reduced and RIF be eliminated, which is exactly what the data showed.

In LM-DF, Bäuml and Kuhbandner (2009) examined how affective states modulate intentional forgetting. On the basis of the finding that the mechanism(s) underlying LM-DF operate(s) during List-2 encoding (Bäuml, Hanslmayr, Pastötter, & Klimesch, 2008; Pastötter & Bäuml, 2007, in press), positive, negative, and neutral moods were induced immediately before List-2 encoding. The forget instruction caused List-1 forgetting when participants were in neutral or negative moods, but did not cause forgetting when participants were in positive moods. The absence of List-1 forgetting in positive moods is consistent with the view that positive moods induce spreading activation processes (e.g., Clore & Huntsinger, 2007), which may lead to reactivation of List-1 items during List-2 encoding and thus may eliminate the LM-DF effect.

No studies have yet been reported examining the role of mood in IM-DF and TNT impairment.

Emotional content

The question whether inhibitory forgetting differs for emotional and nonemotional contents has been addressed in RIF studies (e.g., Barnier, Hung, & Conway, 2004; Kuhbandner, Bäuml, & Stiedl, 2009), LM-DF studies (e.g., Barnier et al., 2007; Wessel & Merckelbach, 2006), and IM-DF studies (e.g., Korfine & Hooley, 2000; McNally, Metzger, Lasko, Clancy, & Pitman, 1998). All of these studies suggest that the forgetting is present and comparable in amount for positive, negative, and nonemotional contents. These findings arose for both simple word lists and AMs.

In contrast, in the TNT paradigm, Depue, Banich, & Curran (2006) showed that item material with negative content produces stronger TNT impairment than nonemotional material. This finding is consistent with the view that emotional material is more accessible than nonemotional material (Hamann, 2001) and thus more susceptible to mechanisms of voluntary retrieval suppression. No item material with positive content was included in this study. Marx, Marshall, & Castro (2008) compared the effects of positive and negative content as well as the effect of high and low arousal in TNT impairment. TNT effects were strongest for highly arousing positive material and lowly arousing negative material. These results partly deviate from the results of Depue et al. (2006), possibly because Marx et al. compared recall of no-think items directly with recall of think items, rather than with baseline items. Still, the findings suggest that retrieval of emotional information can be more easily suppressed than retrieval of nonemotional information.

Neural Substrates of Retrieval Inhibition

Physiological studies in the domain of cognitive control have shown that two prefrontal cortex (PFC) regions play a fundamental role in guiding behavior when interference occurs. Whereas the anterior cingulate cortex (ACC) is suggested to detect interference between competing responses (Botvinick, Cohen, & Carter, 2004), the right lateral prefrontal cortex (LPFC) is meant to resolve interference by inhibiting irrelevant responses (Aron, Robbins, & Poldrack, 2004). Thus, interference detection in the ACC is thought to implement cognitive control mechanisms exerted by lateral PFC. Recent physiological research in memory retrieval has in fact implicated PFC regions in the suppression of irrelevant information to guide access to relevant memories. These and related findings are reviewed next.

Retrieval-induced forgetting

Prior behavioral work suggests that RIF affects the availability of the non-practiced information via involuntary retrieval inhibition (Anderson, 2003; Bäuml, 2008). The findings of recent physiological studies examining the neural correlates of RIF during the retrieval-practice phase (Johansson, Aslan, Bäuml, Gäbel, & Mecklinger, 2007; Kuhl, Dudukovic, Kahn, & Wagner, 2007; Wimber, Rutschmann, Greenlee, & Bäuml, 2009) and the final testing phase (Spitzer, Hanslmayr, Opitz, Mecklinger, & Bäuml, 2009; Wimber, Bäuml, Bergström, Markopoulos, Heinze, & Richardson-Klavehn, 2008) support this inhibitory account of the forgetting.

Because RIF is a recall-specific effect (e.g., Ciranni & Shimamura, 1999), the neural correlates of RIF can be examined by comparing the (inhibitory) retrieval-practice condition with a (noninhibitory) relearning condition, thus isolating the putative inhibitory component. Johansson, Aslan, Bäuml, Gäbel, and Mecklinger (2007) used this rationale and analyzed event-related brain potential (ERP) components in an electroencephalogram (EEG) study. The authors found an early onsetting and sustained increase in prefrontal ERP positivity during retrieval practice compared to relearning. Because prefrontal positivity was predictive of RIF, the activity was suggested to reflect the differential involvement of involuntary retrieval inhibition in retrieval as compared to relearning.

Wimber, Rutschmann, Greenlee, and Bäuml (2009) used functional magnetic resonance imaging (fMRI) to investigate the neural processes underlying RIF. Following the same rationale as Johansson, Aslan, Bäuml, Gäbel, and Mecklinger (2007), brain activity between a retrieval-practice and a relearning condition was compared. Selective retrieval was associated with increased brain activity in the hippocampus, the posterior temporal and parietal association cortices, and the dorsolateral prefrontal cortex (DLPFC). Again, the prefrontal brain activity was predictive of later RIF, albeit negative in direction. The authors suggested that the negativity of the correlation may be due to the multiplicity of retrieval-practice trials. According to this view, successful retrieval inhibition on early practice trials may reduce the need for inhibitory control on subsequent practice trials and thus exhibit an overall decrease of inhibition-related activation over the whole retrieval-practice phase.

Kuhl, Dudukovic, Kahn, and Wagner (2007) directly compared brain activity between a first and a third retrieval practice trial to test for decreases in inhibitory control demands. Consistent with the Wimber, Rutschmann, Greenlee, and Bäuml (2009) interpretation, they found that repeated retrieval was accompanied by reduced brain activity in the ACC and the right lateral PFC. Prefrontal brain activity was predictive of later RIF which increased with reduced prefrontal activation across repeated retrieval attempts. Thus, RIF seems to be mediated by activations in anterior cingulate and lateral prefrontal activity, indicating interference and inhibition.

Recent studies also examined the neural substrates of RIF on the final memory test when the impairment should be observed. An fMRI study by Wimber et al. (2008) showed that RIF is reflected by an increase in left prefrontal brain activity. More precisely, RIF was specifically related to activation in the left anterior ventrolateral prefrontal cortex (VLPFC; but see Kuhl, Kahn, Dudukovic, & Wagner, 2008), a brain region that has been suggested to subserve selective retrieval of weakened memory representations stored in temporal regions (Badre & Wagner, 2007). Consistently, Wimber et al. (2008) observed a functional coupling of left anterior VLPFC with the posterior lateral temporal cortex. The finding that RIF is modulated by activity in these brain regions supports the view that RIF reflects retrieval inhibition directly affecting the memory representation of unpracticed items.

Spitzer, Hanslmayr, Opitz, Mecklinger, and Bäuml (2009) examined the effects of prior retrieval practice on evoked ERPs and oscillatory power measures during a final recognition test. Whereas ERPs are phase-locked to stimulus onset, oscillatory power measures pick up dynamic changes of brain activity nonphase-locked to stimulus onset. Spitzer et al. found that RIF was characterized by reduced amplitudes of the P2 ERP component at frontal electrode sites, reduced theta power (4 to 7 Hz) at distributed sites, and reduced gamma power (60 to 85 Hz) at occipital sites. Because theta power has been suggested to reflect – among other things – items' memory strength and occipital gamma power the activation of sensory memory networks, these results suggest that RIF leads to a deactivation of items' memory representations and a weakening of the material's sensory representation.

In sum, during retrieval practice, selective retrieval of the relevant information is facilitated by inhibiting the interfering irrelevant information as revealed by modulations of brain activations in the ACC, right lateral PFC, and the hippocampus. On the final test, RIF then is related to activation of the left VLPFC functionally coupled with temporal cortex activation, suggesting that involuntary retrieval inhibition directly affects unpracticed items' representations. The latter conclusion is further supported by results from EEG studies.

Directed forgetting

While LM-DF has been studied extensively in behavioral research (Bäuml, 2008; MacLeod, 1998), little effort has yet been made to understand the underlying physiological mechanisms. To date, the only physiological study relating LM-DF to brain activity was conducted by Bäuml, Hanslmayr, Pastötter, and Klimesch (2008), who measured participants' electrophysiological activity and investigated the effects of the forget cue on brain oscillations.

On the basis of the behavioral finding that List-2 encoding is a necessary precondition for LM-DF (Pastötter & Bäuml, 2007, in press), Bäuml, Hanslmayr, Pastötter, and Klimesch (2008) recorded EEGs during study of List-2 items, analyzing oscillatory brain activities. They found two effects of the forget cue in the alpha frequency range (11–13 Hz): a reduction of alpha phase coupling between electrode sites, which was related to List-1 forgetting, and an increase of alpha power, which was related to List-2 enhancement. Because phase coupling between electrode sites is regarded as a measure of the synchrony between distant neural assemblies (e.g., Lachaux, Rodriguez, Martinerie, & Varela, 1999) and coherent firing between distant neuronal populations has been regarded as a mechanism subserving binding processes (e.g., Miltner, Braun, Arnold, Witte, & Taub, 1999), the decrease in alpha phase coupling could reflect the unbinding of List-1 items and the deactivation of the retrieval routes to List-1 items. Because results from recent studies suggest that alpha oscillations serve as an active inhibitory filter for the brain (e.g., Klimesch, Sauseng, & Hanslmayr, 2007), the finding of the effect in the alpha frequency range supports the view that DF is mediated by inhibition.

It has recently been argued that LM-DF might be noninhibitory and be caused by an internal context change (Sahakyan & Kelley, 2002). The context-change account of LM-DF claims that the forget cue induces a change in participants' internal context, which should impair List-1 recall due to a mismatch between encoding and retrieval context. Examining oscillatory brain activity in the context-change paradigm, however, it was recently found that oscillatory activities in the context-change paradigm differ largely from those in LM-DF (Pastötter, Bäuml, & Hanslmayr, 2008), thus indicating that the LM-DF effects do not reflect the result of an internal context change.

In IM-DF, the original view has been a strengthening view according to which to-be-forgotten and to-be-remembered items differ in the degree to which they are rehearsed and strengthened during encoding (MacLeod, 1998). However, recent imaging and electrophysiological studies which examined brain activity during encoding (Paz-Caballero, Menor, & Jiménez, 2004; Wylie, Foxe, & Taylor, 2008) and retrieval (Nowicka, Jednoróg, Wypych, & Marchewka, 2009) suggest that inhibitory processes may also contribute to IM-DF.

At the encoding stage, Paz-Caballero, Menor, and Jiménez (2004) examined ERPs at the time of cuing participants to either remember or forget words on a trial-by-trial basis. They found enhanced early prefrontal positivity but decreased late parietal positivity in response to the forget cue (for the latter finding, see also Paller, 1990). The prefrontal effect of cueing was related to subsequent forgetting of items in a recognition task. Due to the frontal location of the effect, the early positivity was suggested to reflect some form of voluntary encoding suppression of to-be-forgotten items. Similar in procedure, Wylie, Foxe, and Taylor (2008) examined brain activity associated with IM-DF in an fMRI study. They found a network of brain regions more activated when participants received a forget instruction compared to when they received a remember instruction. In this network, the right VLPFC was most active for to-be-forgotten items that were not recognized on the subsequent recognition task, indicating that this brain region is specific to successful intentional forgetting of items.

At the retrieval stage, Nowicka, Jednoróg, Wypych, and Marchewka (2009) investigated changes in electrophysiological brain activity. Analyzing ERPs during recognition of previously learned to-be-remembered and to-be-forgotten items, they found a typical left parietal old/new effect for to-be-remembered items reflected by enhanced positivity for correctly recognized old items compared to new items (Rugg & Curran, 2007). The old/new effect was absent for to-be-forgotten items that were recognized despite the prior forget instruction (see also Ullsperger, Mecklinger, & Müller, 2000). More important, missed to-be-forgotten items yielded a left parietal ERP component that was more negative-going compared to correctly rejected new items and was suggested to reflect effective retrieval inhibition of to-be-forgotten information.

Together, recent physiological findings suggest that both LM-DF and IM-DF may be mediated by inhibitory processes, preventing the to-be-forgotten items from being remembered. In LM-DF, the forgetting has been found to be related to a reduction in alpha phase coupling which was interpreted as evidence for inhibition of retrieval routes to to-be-forgotten information. In IM-DF, cueing to forget an item is accompanied by an increase in right prefrontal brain activity, which may reflect active suppression of items' further processing. During retrieval, the availability of the to-be-forgotten information then is reduced and retrieval is inhibited as reflected by reduced parietal brain activation.

Think/no-think impairment

Behavioral research on TNT impairment has shown that the instruction to avoid recollection of target material can impair its subsequent memory performance. This detrimental effect has been suggested to arise from voluntary retrieval suppression (Anderson & Green, 2001). Two recent fMRI studies and an ERP study examining brain activity in the TNT phase underpin the role of inhibitory processes in TNT impairment (Anderson et al., 2004; Depue, Curran, & Banich, 2007; Hanslmayr, Leipold, Pastötter, & Bäuml, 2009).

Anderson et al. (2004) contrasted brain activity between think and no-think trials. They found that various prefrontal regions, including the ACC and bilateral DLPFC and VLPFC, were more activated in suppressing retrieval in no-think trials than in achieving memory retrieval in think trials. At the same time, hippocampal and left parietal activations were reduced in no-think trials compared to think trials. Both prefrontal cortical and hippocampal activations predicted the magnitude of subsequent forgetting. These findings suggest that voluntary retrieval suppression is an active process that recruits prefrontal brain regions to avoid conscious recollection elicited in the hippocampus.

Depue, Curran, and Banich (2007) used unpleasant stimuli that have been shown to have a larger impact on TNT impairment than nonemotional stimuli (Depue, Banich, & Curran, 2006). Using a baseline reference, they related brain activity with either the think or no-think condition. Whereas right DLPFC and VLPFC showed an increase in activity during no-think trials, activity in the hippocampus and the amygdala was decreased in the no-think condition (and increased in the think condition) compared to the baseline reference. Crucially, prefrontal and hippocampal activity were found to predict TNT impairment.

Hanslmayr, Leipold, Pastötter, and Bäuml (2009) compared ERP waveforms between the first and the second half of no-think trials and identified a decrease in positivity over right frontal and left parietal electrode sites predicting later TNT impairment. In particular, to investigate anticipatory effects of TNT impairment, Hanslmayr et al. presented the TNT instruction prior to the memory cue allowing participants to prepare for memory suppression. Interestingly, a decrease in positivity was already found at TNT instruction before presentation of the memory cue and this anticipatory ERP effect predicted both the later memory cue ERP effect and TNT impairment. Therefore, the anticipatory effect was suggested to reflect top-down control preparing for retrieval suppression.

Together, neuroimaging in the TNT phase suggests that the volition to avoid conscious recollection of both emotional and nonemotional information recruits prefrontal brain regions which are known to impose cognitive control by inhibitory mechanisms. Retrieval suppression of the no-think information is mediated by right prefrontal regions, down-regulating the activity in the hippocampus and the amygdala. ERP investigation suggests that items' memory representations can be affected via anticipatory retrieval suppression to keep unwanted memories from entering consciousness.

Neural Substrates of AM Retrieval

AM retrieval has been related to processing in a distributed neural network, including the PFC, the medial temporal lobe, and posterior regions (for a review, see Maguire, 2001, or Svoboda, McKinnon, & Levine, 2006). Because AMs usually are recalled with a sense of reliving and emotional intensity, brain regions involved in sensory and emotional processing are typically related to AM retrieval as well (Cabeza & St Jacques, 2007). In this section, we address physiological findings in AM construction and the retrieval of unpleasant AMs. Thereafter, we will discuss the possible role of retrieval inhibition in constructive AM search and the suppression of unpleasant AMs.

AM construction

AM retrieval is a constructive process (Schacter & Addis, 2007), in which relevant information is widely distributed across the brain and has to be bound together to form a coherent memory. Two consecutive processes of AM retrieval may be distinguished. Initially, a search process is activated to access a specific memory. Then, after recovery of the memory, an elaboration process is activated to maintain and elaborate the selected information. The access process includes attempts to reactivate relevant information as well as emotional processing and top-down control that guides the search. The elaboration process involves vivid imagery as well as controlled attentional and working memory operations to keep the selected information in mind for elaboration.

Brain regions that are mostly involved in constructing AMs are the hippocampus, the amygdala, the ACC, and both right and medial PFC regions (Daselaar et al., 2008). Hippocampal activity is suggested to be strongly modulated by prefrontal activations, which are assumed to guide conscious recollection of information mainly represented in posterior regions by top-down control on the hippocampal binding process (Hassabis & Maguire, 2007; Schacter, Addis, & Buckner, 2007). In PFC, different subregions implement different functions in cognitive control. The proposal is that the ACC detects interference (Botvinick, Cohen, & Carter, 2004) and integrates emotional processing (Burianova & Grady, 2007), the right LPFC exerts inhibitory control (Aron, Robbins, & Poldrack, 2004), and the medial PFC contributes to self-referential processing (Gusnard, 2005). With respect to emotional intensity of AMs, Greenberg et al. (2005) found a high correlation of amygdala and right VLPFC activity, suggesting a strong interaction between emotional processing and AM construction.

Daselaar et al. (2008) examined brain activity during AM access and elaboration using fMRI. Participants were asked to provide a memory of a specific past event in response to a generic cue word. Imaging showed that the initial accessing of AMs engaged the hippocampus, the retrosplenial cortex, right and medial PFC regions, and the ACC. In contrast, subsequent elaboration recruited the visual cortex, the precuneus, and left PFC regions. Daselaar et al. also examined emotion- and reliving-modulated brain activity. For this purpose, participants rated the emotional intensity an AM actually induced and how much they felt they were reliving the initial event again. Emotion-modulated activation was observed in the amygdala and the frontopolar cortex. Reliving-modulated activation was observed in the visual cortex, right inferior PFC, and the anterior and posterior cingulates. Interestingly, whereas emotion-related areas were selectively activated during initial memory search, reliving-related areas were selectively activated during AM elaboration.

During AM retrieval, autobiographical information dynamically interacts with episodic and semantic information within a network of long-term memory representations (Conway & Pleydell-Pearce, 2000; Conway & Williams, 2008). The question of how AM retrieval overlaps with episodic and semantic memory retrieval has recently been addressed by Burianova and Grady (2007), examining brain activations that are common or unique to autobiographical, episodic, and semantic memory search. Despite some differences in activated brain regions among the three memory types, their results provide evidence for a common temporo-frontal retrieval network involving left and right VLPFC as well as the hippocampus – brain regions that have also been associated to involuntary and voluntary retrieval inhibition. Accordingly, Burianova and Grady (2007) suggested that AM retrieval engages inhibitory processes that may be similar to episodic and semantic memory retrieval.

Together, physiological findings suggest that AM construction is related to a distributed neural network including frontal and medial temporal regions. In part, prefrontal brain activations may reflect inhibitory processes in the service of successful AM construction. At the end of the chapter, we will discuss the possible role of retrieval inhibition in AM retrieval. Before doing so, we address the neural substrates of emotional AMs, with the focus on unpleasant events.

Retrieval of unpleasant AMs

The retrieval of emotional AMs recruits the same regions that are involved in the retrieval of nonemotional AMs, along with a set of additional regions typically associated with emotional processing, including the amygdala and medial PFC. Within this network of brain regions, the retrieval of emotional AMs seems to be primarily related to interactions between the hippocampus, the amygdala, and the PFC. Thereby, whereas the medial PFC is more involved in the retrieval of pleasant AMs, findings from both neuropsychology and neuroimaging suggest that the amygdala is involved mainly in the retrieval of unpleasant AMs (for a review, see Buchanan, 2007).

Neuropsychological research has shown that patients with amygdala damage show impaired retrieval of unpleasant emotional events (Buchanan, Tranel, & Adolphs, 2005, 2006). Buchanan et al. (2005) showed that patients with MTL damage limited to the hippocampus retrieved emotional AMs similar to healthy participants, in terms of both the number and affective quality of these AMs. In contrast, patients with damage to both the amygdala and the hippocampus retrieved fewer unpleasant AMs and rated their unpleasant memories as less intense, significant, and vivid compared to other participants. Buchanan et al. (2006) also examined whether right and left amygdala play a different role in the retrieval of emotional AMs, in patients with either left or right MTL damage. Results showed that patients with right-sided damage, but not with left-sided damage, retrieved less unpleasant AMs and rated them as less intense compared to healthy participants. Together with the Buchanan et al. (2005) study, these results suggest that the right amygdala – and its connection to PFC – may be a necessary component of the neural circuitry required for retrieval of unpleasant, highly intense AMs.

Neuroimaging studies also related the retrieval of emotional AMs to activation in the amygdala (for a review, see Cabeza & St Jacques, 2007). For instance, Daselaar et al. (2008) contrasted emotion- and reliving-modulated activation during AM retrieval and demonstrated that the first was greatest in the amygdala and anterior PFC, whereas the second was greatest in the visual cortex. Also in line with neuropsychological results is the finding that pleasant AM retrieval seems to activate the medial PFC, whereas unpleasant AMs seem to activate the right MTL (Markowitsch, Vandekerckhove, Lanfermann, & Russ, 2003). Emotional AMs have also been found to be related to greater activity in the hippocampus (Addis, Moscovitch, Crawley, & McAndrews, 2004) and bilateral amygdala-hippocampal interactions (Greenberg et al., 2005). Together, imaging findings suggest that the amygdala has a functional role in remembering unpleasant AMs.

Consistent with these findings, physiological research in the study of trauma and PTSD suggests that the three major brain regions involved in trauma-related memory disturbances are the amygdala, the medial prefrontal cortex, and the hippocampus (for a review, see Shin, Rauch, & Pitman, 2006). There is evidence that, whereas the amygdala is highly responsive to trauma-related memories, activation in the medial PFC, including the ACC and medial frontal gyrus, is largely decreased in PTSD. This pattern of amygdala hyperactivation and PFC deactivation may be associated to typical memory disturbances in PTSD with intrusions of highly emotional memories and the inability to recall other aspects of the trauma, possibly because of ineffective retrieval inhibition of involuntary memory intrusions.

Together, physiological findings suggest that the retrieval of unpleasant AMs is strongly related to activity in the amygdala and the PFC. Prefrontal brain activations thus may represent in part inhibitory processes, reflecting retrieval inhibition of unpleasant and traumatic AMs.

Future Lines of Research

We suggest that AM retrieval is regulated by inhibitory control. More precisely, inhibitory processes may affect irrelevant AMs to facilitate retrieval of relevant AMs. In this sense, retrieval inhibition would be an adaptive mechanism in AM retrieval to access relevant AM information within almost infinite possible ramifications of episodic, semantic, and emotional cues associated to various information along the search path. Retrieval of unpleasant AMs or traumatic events may also depend on inhibitory processes. Indeed, there is evidence from research in episodic memory that unpleasant material can be unintentionally and intentionally forgotten. The crucial question is whether this finding generalizes to unpleasant and trauma-related AMs.

To examine the role of retrieval inhibition in AM retrieval, two lines of research should be taken in future research. First, in behavioral experiments, inhibitory paradigms should be used to examine whether effects of emotional and neutral material found with simple item lists can be extended to AMs. This line of research is raring to go in healthy populations (Barnier, Hung, & Conway, 2004; Barnier et al., 2007; Joslyn & Oakes, 2005; Wessel & Hauer, 2006) as well as clinical populations (McNally, Clancy, Barrett, & Parker, 2004; McNally, Clancy, & Schacter, 2001; McNally, Metzger, Lasko, Clancy, & Pitman, 1998; McNally, Ristuccia, & Perlman, 2005). Second, in physiological experiments, inhibitory paradigms should be used to examine unintentional and intentional forgetting of emotional and neutral AMs instead of simple item material. No studies have yet been published addressing this second issue.

Regarding the first line of research and behavioral work in healthy populations, in RIF, Barnier, Hung, and Conway (2004) let participants generate specific emotional or nonemotional AMs in response to negative, positive, and neutral cue words. As in the standard RIF procedure, each cue word was associated to a number of other memories. After retrieval practice on some AMs, participants tried to recall all of their originally generated memories on a final recall test. A standard RIF effect was found for previously generated emotional and nonemotional AMs. Recently, Wessel and Hauer (2006) replicated the Barnier et al. (2004) finding for negative material, but did not observe RIF for positive material. In LM-DF, Barnier et al. (2007) adapted the standard LM-DF procedure to directed forgetting of unpleasant, pleasant, and emotionally neutral AMs. Participants generated a specific AM in response to a list of generic cues. After presentation of this list, they were instructed to either forget or continue remembering AMs associated to cues of this list. Next, a second list of cues was presented and again an AM had to be generated in response to each generic cue. Across various experiments, Barnier et al. found a standard directed forgetting effect for precue generated unpleasant, pleasant, and neutral AMs. Also in LM-DF, but within a diary paradigm outside the laboratory, Joslyn and Oakes (2005) investigated intentional forgetting of AMs. Participants were asked to keep a diary for two weeks. After the first week, they were instructed either to forget or continue remembering the first week's events. After a second week of keeping the diary, all participants returned to the laboratory and were asked to recall events of both weeks. Consistent to the controlled LM-DF experiment in the laboratory (Barnier et al., 2007), significant directed forgetting for AMs from the first week was found. Together, these findings provide first evidence that inhibitory processes may play a crucial role in AM retrieval.

In clinical populations, the ability to forget trauma-related and neutral words has been examined in LM-DF and IM-DF (McNally, Metzger, Lasko, Clancy, & Pitman, 1998; McNally, Clancy, & Schacter, 2001; McNally, Clancy, Barrett, & Parker, 2004; McNally, Ristuccia, & Perlman, 2005). Irrespective of method, clinical populations showed the same reliable forgetting of words as healthy controls, regardless of valence and relatedness of material to trauma. Thus, it seems that traumatized people do not differ in encoding or retrieval of trauma-related words. However, using simple words as substitutes for real AMs may underestimate the role of inhibitory processes in forgetting autobiographical trauma memories. Thus, further behavioral and physiological research in PTSD is needed to investigate inhibitory forgetting of unpleasant and traumatic AMs. In doing so, the TNT paradigm may be particularly promising. In contrast to other inhibitory paradigms, the forgetting in TNT has been found to be larger for unpleasant items compared to emotionally neutral material (Depue, Banich, & Curran, 2006). This finding suggests that retrieval of unpleasant information can be more easily suppressed than nonemotional information. Whether this effect holds for trauma-related material has still to be shown.

Conclusions

Inhibitory paradigms can be used to explore certain forms of unintentional and intentional forgetting in the laboratory. Doing so, evidence has arisen that inhibitory processes mediate the modulation in accessibility of irrelevant or to-be-forgotten information. Thereby, different inhibitory mechanisms have been suggested to reduce the accessibility of memory representations. The mechanisms differ in whether they affect the representation of irrelevant information itself or affect its retrieval routes, and whether they are initiated involuntarily or voluntarily.

Both unintentional and intentional forgetting, as examined in RIF, DF, or TNT impairment, are meant to arise from active inhibitory processes triggered by prefrontal brain regions. In particular, the ACC and the right LPFC are suggested to regulate brain activity in the service of selective retrieval and forgetting of irrelevant information. The ACC is meant to signal the need for inhibitory control, which is then exerted by the right LPFC. Thus, inhibitory processes down regulate memory-related activity in the hippocampus, the amygdala, and posterior regions. In addition, they may reduce the synchronicity of brain activity between relevant brain regions.

A review of physiological findings revealed a remarkable overlap of brain regions involved in AM retrieval with brain regions related to retrieval inhibition. Indeed, during AM search, mostly involved brain regions are the hippocampus, the amygdala, the ACC, the right LPFC, and medial PFC regions. Hippocampal and amygdala activity is suggested to be modulated by prefrontal activations which more or less guide memory search. Within this temporo-frontal network of AM retrieval, the amygdala becomes involved in the retrieval of unpleasant or traumatic AMs. With its strong interconnections to the hippocampus and PFC, it then plays a crucial role in voluntary and involuntary retrieval of emotional AMs.

We think that future examination of inhibitory forgetting of AMs will be promising with both behavioral and physiological experiments. Based on first evidence that both neutral and emotional AMs can be unintentionally and intentionally forgotten, future behavioral work should further specify the possible role of retrieval inhibition in AM retrieval, in both healthy and clinical populations. Future imaging studies will help to discover exactly what processes mediate selective remembering and intentional forgetting of autobiographical events, and to what extent these processes are functionally and neurally equivalent to inhibitory brain processes, as they are involved in selective retrieval and intentional forgetting of simple item lists.

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10

Seeing Where We're At

A Review of Visual Perspective and Memory Retrieval

Heather J. Rice

Introduction

When remembering an event, such as a trip to a local museum, it is common for individuals to report the experience of visual images from the event. Galton (1883) was one of the first to systematically examine these visual images, asking individuals to imagine "your breakfast-table as you sat down to it this morning – and consider carefully the picture that rises before your mind's eye" (p. 52). Individuals were asked to describe the color, illumination, and clarity of these images. Galton's findings revealed that visual imagery varied greatly across individuals, ranging from being "perfectly distinct" and "natural" to being able to remember, but not see, the scene.

More recently, it has been suggested that visual imagery is integral to the retrieval of autobiographical memories (i.e., memories for personally experienced past events; Greenberg & Rubin, 2003; Rubin & Greenberg, 1998). Several methodologies have shown visual imagery accompanies most autobiographical memories and these images are often very vivid (e.g., Brewer, 1988; Brewer & Pani, 1996; Galton, 1883; Kosslyn, Seger, Pani, & Hillger, 1990). Imagery is also related to other phenomenological properties; memories accompanied by more vivid visual imagery are rated as being recollected rather than known (Rubin, Burt, & Fifield, 2003; Rubin, Schrauf, & Greenberg, 2003) and are judged as actually having occurred rather than

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being imagined (Johnson, Foley, Suengas, & Raye, 1988; Johnson, Hashtroudi, & Lindsay, 1993). Perhaps the most convincing support for visual imagery's central role in autobiographical memory retrieval comes from individuals with damage to visual cortex who develop amnesia for long-term autobiographical memories (Rubin & Greenberg, 1998).

Soon after Galton's descriptive study of visual imagery, Freud (1899/1953) noted an interesting distinction in his patients' reports of childhood events. Specifically, patients reported seeing themselves in their memories, viewing the event from an external or third-person perspective, when recounting childhood events. For example, Freud presented the case study of a man, suffering from an unnamed phobia, who remembered visiting with his cousins as a child. When picturing the event, the man reported seeing himself alongside his cousins, viewing the event as an outside observer rather than from the viewpoint from which the event was originally experienced (p. 311). Similar reports were described by Henri and Henri (1896, as cited by Freud, 1953) when individuals were asked to describe their earliest childhood memories. Because events are not perceived from a third-person perspective (cf., Cooper, Yuille, & Kennedy, 2002; Nigro & Neisser, 1983), Freud posited that childhood memories accompanied by these external perspectives must be inaccurate reconstructions of the event. He further suggested that these memories are altered as a way to protect the individual from sexual or otherwise "objectionable" content. He called these memories "screen memories" and asserted that third-person perspectives were a phenomenological tag of repression.

Following Freud's description of screen memories, the topic of visual perspective in memory went unmentioned for nearly 100 years. Although a few philosophers noted their own experiences of perspective during the interim (Locke, 1971; Von Leyden, 1961; for reviews, see Brewer, 1986, 1996), it was debates over the accuracy of autobiographical memories that brought about the formal study of perspective (see Rubin, 1998). Third-person perspective memories were seen as confirmation of the malleability of memory since they are often experienced even though events are not encoded from a third-person perspective (see Nigro & Neisser (1983) for the argument that events can be encoded from a third-person perspective; see Spurr & Stopa (2003) for a manipulation of perspective during encoding via explicit instructions). Thus, seeing one's self in a memory was thought to be a possible hallmark of reconstruction.

The first study to empirically examine visual perspective during autobiographical memory retrieval characterized perspective as a cognitive strategy, rather than using a psychoanalytic standpoint (Nigro & Neisser, 1983). This focus on cognitive strategy has guided most of the subsequent research on visual perspective in autobiographical memory, and as such, will guide the current discussion.

Since Nigro and Neisser's (1983) first study, the literature examining visual perspective in autobiographical memory has grown substantially, particularly in the last 10 years. Studies range in focus from cognition to social psychology to clinical psychology to studies of personality. However, because these studies are so varied, there is often little connection made between them, making a review of the literature particularly beneficial at this point. For example, it is only recently that studies concerned with clinical populations, such as individuals with PTSD or social phobia, cite basic research investigating the role of emotion or self-awareness in visual perspective. Therefore, it is essential that these studies be reviewed and synthesized as a means of creating a more cohesive, distinct area of study concerned with visual perspective in autobiographical memory (for a review of visual perspective in relation to the self, see Sutin & Robins, 2008).

A review of the visual perspective literature is also beneficial given the growing number of studies showing that it plays an important role in autobiographical memory. For example, perspective can affect the way individuals experience emotion during retrieval (e.g., Berntsen & Rubin, 2006; Holmes, Coughtrey, & Connor, 2008; Robinson & Swanson, 1993; Terry & Horton, 2007–2008) and it can affect the types of details individuals report when remembering an event (McIsaac & Eich, 2002, 2004). Recent evidence has shown that the visual perspective individuals use to imagine future behavior also affects the likelihood of engaging in that behavior (Libby, Shaeffer, Eibach, & Slemmer, 2007). These findings suggest that perspective is a consequential aspect of the retrieval process. Perspective makes a difference rather than being just epiphenomenal.

Understanding the role of visual perspective in retrieval is also important to more applied issues. For example, the Cognitive Interview (Fisher & Geiselman, 1988), which law enforcement officials use to interview witnesses, asks individuals to recall events from several visual perspectives. As noted by McIsaac and Eich (2002), it is important to understand how visual perspective and autobiographical memory retrieval interact in order to effectively construct such interviews. Furthermore, individuals with a range of clinical disorders, such as PTSD, social phobia, and depression (e.g., Brewin, 1998; Coles, Turk, Heimberg, & Fresco, 2001; Kuyken & Howell, 2006; Wells & Papageorgiou, 1999) use perspective differently from normal controls, which will later be discussed in more detail (for more on perspective, PTSD, and depression, also see Williams & Moulds, chapter 15, this volume; for more on PTSD and memory more generally, see Krans, Woud, Näring, Becker, & Holmes, chapter 13, and Verwoerd & Wessel, chapter 14, this volume). Understanding how visual perspective affects memory retrieval might further our understanding of such mental disorders and aid in their treatment.

This review attempts to draw connections among the existing data that examine visual perspective during autobiographical memory retrieval.

Nigro and Neisser's (1983) seminal study has shaped many of the investigations that follow. For that reason, it will be discussed in detail. Subsequently, the relevant literature will be reviewed along lines of questioning delineated by this influential study, including the relationship between visual perspective and emotional components of the memory, degree of self-awareness, vividness of the memory, and the effect of reconstruction or mnemonic change. A discussion of future directions for research follows.

Point of View in Personal Memories – Nigro and Neisser's Seminal Study

In the first study of visual perspective, Nigro and Neisser (1983) contrasted and provided terms for two distinct categories of perspective. "Field perspective" referred to remembering an event through one's own eyes in "roughly the field of view that was available in the original situation" (p. 467). Conversely, "observer perspective" referred to visualizing a scene as an onlooker, or observer, witnessing the scene from an external vantage point. In addition, the individual may visualize himself or herself in these images. The current chapter will refer to these perspectives as first-person and third-person perspective, respectively.

Nigro and Neisser (1983) investigated four hypotheses motivated in part by Freud's characterization of screen memories. First, if third-person perspectives are a hallmark of reconstruction and mnemonic change, they should be older than first-person perspective memories. Second, memories that are more resistant to mnemonic change, such as emotional memories, should be remembered from a first-person perspective rather than a third-person perspective. The authors were not clear about why older memories would be considered more reconstructed (e.g., due to the effects of forgetting or the effects of repeated retrieval), nor did they explain why emotional memories are more resistant to mnemonic change than non-emotional memories.

The third hypothesis was based on Nigro and Neisser's proposal that situations in which a person is being observed or evaluated (i.e., highly self-aware) encourage detachment while the event is experienced. This detachment promotes the development of a third-person viewpoint during encoding, thus producing the same perspective at retrieval. This is contrary to Freud's (1899/1953) assertion that individuals do not experience events from a third-person perspective. Finally, Nigro and Neisser proposed that the type of information an individual tries to retrieve can affect the perspective one adopts; thus, by asking individuals to search for specific attributes of an event, they would be able to manipulate perspective.

To examine the first three hypotheses, participants were asked to recall everyday events that varied in emotional intensity and degrees of self-awareness (e.g., studying, watching the news, being in a group performance, being in an accident). Overall, individuals reported more memories accompanied by a first-person perspective than third-person perspective. This effect has been replicated many times (e.g., Frank & Gilovich, 1989; Robinson & Swanson, 1993) and suggests that first person is the default perspective used during retrieval. As predicted by their first hypothesis, memories accompanied by third-person perspectives were older than first-person perspectives. Supporting their second hypothesis, events that were high in emotional intensity, but low in self-awareness, were more likely to be remembered using a first-person perspective. In accordance with their third hypothesis, events that were high in self-awareness and emotion produced the greatest number of third-person perspectives. These events were "running from a threatening situation," "giving an individual presentation," and "being in a group performance." Although this did not provide direct support for the premise that events can be encoded from a third-person perspective, it did support the broader prediction that highly self-aware events would produce memories accompanied by third-person perspectives.

A separate experiment tested their final hypothesis, that perspective can be influenced by the purpose of retrieval. Participants were given the same cues used in previous experiments and instructed to either describe the "feelings they had experienced on the occasion," "the concrete, objective circumstances of the occasion," or asked simply to "describe the experience." Participants then reported the perspective they experienced during retrieval. Instructions to report the concrete, objective circumstances produced more third-person perspectives than did the neutral instructions or instructions to report about feelings. From these results the authors suggest that, unless otherwise instructed, the focus of retrieval tends to the emotional content of autobiographical events, which helps explain the general tendency to use a first-person perspective during retrieval.

To summarize, Nigro and Neisser found that emotion is related to perspective in that both retrieving emotional memories and focusing on the emotional aspects of an event produce more first-person perspective memories. They also suggested that self-awareness at encoding influences perspective at retrieval. Finally, they suggested a relationship between memory age and perspective, similar to Freud (1899/1953), such that third-person perspectives may be a product of mnemonic change or reconstructive processes. These findings have led to several related lines of inquiry, each of which will be reviewed in turn, in an attempt to draw conclusions from the existing literature regarding the role of visual perspective in autobiographical retrieval.

Emotional Intensity, Emotional Valence, and Visual Perspective

Nigro and Neisser (1983) suggested emotional memories produce more first-person perspective memories than neutral memories, and focusing on the retrieval of feelings experienced during an event produces more first-person perspectives than recalling concrete details. Further evidence for a relationship between visual perspective and the retrieval of feelings and emotions comes from a study in which participants recalled the details of controlled laboratory events from either a first-person or third-person perspective (McIsaac & Eich, 2002). Individuals instructed to use a first-person perspective at retrieval produced more emotional, physical, and psychological state information, whereas third-person perspectives produced more descriptions of concrete details, such as appearance and actions. This effect mirrors that of Nigro and Neisser, who found that focusing on the retrieval of feelings produced more first-person perspectives, whereas focusing on the retrieval of concrete details produced more third-person perspectives. Together, these studies suggest that the relationship between perspective and the information retrieved from memory is bi-directional. That is, using a particular perspective narrows the type of information retrieved, and narrowing the type of information one searches for affects the particular perspective used at retrieval.

Although emotional experience has long been described as comprised of two dimensions, valence and intensity (e.g., Duffy, 1934, 1941; Dunlap, 1932), it is unclear which of these properties produces the observed effects within the perspective literature. Strongman and Kemp (1991) cued memories with 12 emotional words that varied in both valence and intensity and found that, regardless of valence or intensity, individuals predominantly used first-person perspectives. In fact, of the 912 memories recalled in the entire study, 908 were recalled from a first-person perspective. Given that some of the cued events were likely high in both emotional intensity and self-awareness (e.g., shame), which Nigro and Neisser (1983) found were likely to produce third-person perspectives, it is unclear why so few memories were recalled using a third-person perspective. But certainly, these findings suggest that remembering emotional events produces first-person perspective memories.

A study comparing memories for positive, negative, and neutral events also found that emotional memories were more often remembered using first-person perspective than neutral memories, regardless of valence (D'Argembeau, Comblain, & Van der Linden, 2003). Robinson and Swanson (1993) found that first-person perspective memories were not rated as any more emotionally intense than third-person perspective. However, when individuals switched from a first-person to third-person perspective, this resulted in a drop in emotional intensity ratings. A study examining memories of events that involved self-evaluative emotions, positive (i.e., pride) and negative (i.e., shame) emotional memories produced equivalent ratings on a scale measuring perspective (D'Argembeau & Van der Linden, 2008).

Additional support comes from a study of emotional memories in which individuals recalled memories cued by 20 different emotional words that varied in valence and intensity (e.g., anxious, calm, disappointed, happy; Talarico, LaBar, & Rubin, 2004). Participants rated several properties of the event using the Autobiographical Memory Questionnaire (Rubin, Schrauf, & Greenberg, 2003). Regression analyses showed that emotional intensity accounted for significantly more variance in phenomenological ratings, including visual perspective, than valence. Moreover, intensity and first-person perspective ratings were positively related, whereas valence did not correlate with perspective ratings. Together, these studies suggest perspective is influenced by emotional intensity rather than valence.

More recent studies have shown that perspective can influence mood and the emotion felt during retrieval; remembering negative, non-traumatic events from a first-person perspective produced ratings of greater emotionality and feelings of nervousness than remembering from a third-person perspective (Terry & Horton, 2007–2008). Similarly, imagining positive events from a first-person perspective produced more positive changes in mood than did imagining from a third-person perspective (Holmes, Coughtrey, & Connor, 2008).

There is some evidence to suggest that valence, rather than intensity, has an influence on perspective. For example, when comparing individuals' most traumatic and most positive memories, traumatic memories were remembered using a third-person perspective more often than positive memories (Porter & Birt, 2001). However, these effects may have been due to intensity differences given that individuals with less severe traumas also reported less third-person perspective memories than those with more severe traumas. In contrast, Berntsen and Rubin (2006) cued memories using emotional cues that varied in valence and intensity. Remembering negative events produced higher third-person perspective ratings than positive memories. There was no difference in average intensity ratings across positive and negative valence, suggesting that intensity cannot account for the observed effect. In addition, when high and low intensity memories where compared, there was no difference in perspective ratings.

The effect of valence (i.e., negative memories produce more third-person perspective memories than positive memories) seems incompatible with the general emotional effect that Nigro and Neiser described (i.e., emotional memories are more often remembered using a first-person perspective). However, it is consistent with studies examining perspective use in clinical populations. For example, individuals with PTSD or PTSD-like symptoms often use third-person perspectives when recalling traumatic memories (Berntsen, Willert, & Rubin, 2003; McIsaac & Eich, 2004; Porter & Birt, 2001). Investigations of perspective in individuals with PTSD were motivated by reports of patients experiencing traumatic events from a perspective outside the body or dissociating from the event (Cardena & Spiegel, 1993; Freinkel, Koopman, & Spiegel, 1994). In fact, studies have shown that individuals with PTSD often experience out-of-body experiences during recall (Cooper, Yuille, & Kennedy, 2002; Reynolds & Brewin, 1999).[1]

These findings led to the prediction that PTSD patients would be more likely to remember traumatic events from third-person perspectives (Brewin, Christoulides, & Hutchinson, 1996; Foa, Steketee, & Rothbaum, 1989; van der Kolk & Fisler, 1995). Berntsen, Willert, and Rubin (2003) found that individuals with high scores on the Posttraumatic Stress Diagnostic Scale (PDS) (Foa, 1995) experienced more third-person perspectives when recalling traumatic memories than individuals with low PDS scores. McIsaac and Eich (2004) found that in their sample of PTSD patients, individuals more often used a first-person perspective when recalling traumatic memories. However, those individuals who did use a third-person perspective to recall traumatic memories rated them as less emotional and less anxiety provoking, and their recollections contained fewer affective details than individuals who used a first-person perspective. In a related study, Kenny and Bryant (2007) examined perspective use in trauma survivors. Participants were asked to recall a traumatic, positive, and neutral memory. Those individuals with a high level of avoidance, measured by the Impact of Event Scale (Horowitz, Wilner, & Alvarez, 1979), were more likely to use a third-person perspective when recalling their traumatic memory compared to individuals with a low level of avoidance. This effect was not observed for positive or neutral memories.

More recently, a large-scale study of university students with a range of scores on the PTSD Check List (PCL) (Weathers, Litz, Huska, & Keane, 1994) showed a correlation between PCL scores and perspective ratings (Rubin, Boals, & Berntsen, 2008); those with higher scores on the PCL tended to rate memories cued by 15 high imagery words (e.g., love, mother, sick) as being more third-person perspective. The same individuals also nominated their three most positive and negative memories. Comparing perspective ratings of these memories across individuals with high and low PCL scores revealed an interaction; high PCL scorers rated their negative memories as more third person than positive memories, whereas low PCL scorers did not show a difference.

Together, these findings have led to the suggestion that third-person perspective is used as a cognitive avoidance strategy to reduce the emotional intensity of traumatic memories (Berntsen, Willert, & Rubin, 2003; Kenny & Bryant, 2007; McIsaac & Eich, 2004; Rubin, Berntsen, & Bohni, 2008; Williams & Moulds, 2008). Depressed individuals may use a similar mechanism to avoid intrusive memories (Williams & Moulds, 2007). Moreover, chronic pain sufferers report less associated pain when remembering events from a third-person perspective compared to first-person (McNamara, Benson, McGenny, Brown, & Albert, 2005).

Support for the use of perspective as an avoidance strategy comes from an interesting effect observed by Robinson and Swanson (1993), which was briefly described earlier. Participants were asked to recall several events, rate their perspective, and then switch or maintain their perspective. Switching from first- to third-person perspective decreased participants' ratings of experienced affect, whereas switching from third- to first-person perspective did not produce a change. These findings were recently replicated using emotional cue words of varying emotional intensity and valence (Berntsen & Rubin, 2006), as well as with dysphoric individuals recalling intrusive memories (Williams & Moulds, 2008).

Robinson and Swanson (1993) proposed a model to account for this effect, in which they contrasted two types of affective information: an experiential code representing the feelings experienced during the event and a cognitive code representing the causes of experienced affect, such as goals and beliefs. They suggested that when both codes are available, memories will be accompanied by first-person perspectives, whereas when the experiential code has degraded or is no longer available, a third-person perspective is used.

Robinson and Swanson proposed that when switching from a third-person to first-person perspective, one attempts to reinstate the experiential code (associated with first-person perspective), but finding it unavailable will rely on the cognitive code (e.g., goals, beliefs) to reconstruct affective information. Consequently, affect intensity does not change, as the experiential code is no longer available. Conversely, switching from first-person to third-person perspective inhibits the experiential code, leaving the cognitive code to define the affective components of the event, resulting in the observed reduction of intensity. The model does not specify what occurs when the cognitive code is no longer available; however, one might assume this would lead to a first-person perspective, as the experiential code is still available. This model may also explain more recent findings; individuals with PTSD, depression, or chronic pain may inhibit the experiential code in an attempt to prevent the re-experiencing of emotions or physical sensations from the traumatic, intrusive, or painful event, thereby producing a third-person perspective.

A related hypothesis views perspective as an emotion regulation strategy (Kross, Ayduk, & Mischel, 2005). This hypothesis focuses on the type of information individuals attend to during recall, rather than the information available for recall, focusing on perspective as emotion regulation strategy. In a study examining memories of anger, individuals who took a third-person perspective *and* focused on the reasons for past emotions (i.e., the *why* of their emotion), rather than focusing on past feelings and sensations (i.e., the *what* of their emotion), reported lower emotional intensity ratings (cf., Wimalaweera & Moulds, 2008). This distinction is similar to that made by Robinson and Swanson, with the "why of the emotion" corresponding to the cognitive code and the "what of the emotion" corresponding to the experiential code. The key difference lies in the proposal that changes in intensity are due to attention to particular types of emotional information at retrieval, rather than the availability of particular codes.

One question that arises from these studies is, given that using a third-person perspective seems to prevent the re-experiencing of emotions from traumatic memories, why is it that individuals who use a third-person perspective continue to suffer from disorders such as PTSD? For example, McIsaac and Eich (2004) found that PTSD patients who used a third-person perspective rated their traumatic memories as less emotional and anxiety provoking compared to those who used a first-person perspective. Yet, these two groups did not differ in their PTSD symptom severity. It has been suggested that in order to fully process a traumatic event, and prevent the development of an intrusive memory, one must integrate both the experiential (the "what") and cognitive (the "why") codes; recalling an event from a third-person perspective prevents the processing of the experiential code, thereby producing intrusive memories (Foa & Kozak, 1986; McIsaac & Eich, 2004; Williams & Moulds, 2007). Although this helps explain why PTSD patients who use a third-person perspective do not show improved symptoms in comparison to those who use first-person perspective, it does not explain why individuals who use a first-person perspective, with presumptively fully integrated memories, do not show improved symptoms. Clearly, additional research is necessary in order to best integrate these findings into helpful techniques for therapy.

It is important to note that the majority of studies supporting the notion that third-person perspective serves as an avoidance mechanism investigate negative memories (McIsaac & Eich, 2004; Kenny & Bryant, 2007; Kross, Ayduk, & Mischel, 2005; Terry & Horton, 2007–2008; Williams & Moulds, 2008) and tend to focus on clinical populations. Given that it seems less likely one would want to avoid re-experiencing positive emotions, this focus on negative emotions is warranted. However, if a similar pattern is observed for positive memories, a more inclusive explanation of the relationship between perspective and emotion may be more appropriate.

There is some evidence to suggest that a similar effect would be observed if positive emotions were examined. When Robinson and Swanson (1993) first described this effect (i.e., a decrease in affective re-experiencing when switching from first-person to third-person perspective), participants were not limited to recalling particular types of memories. Thus, the observed effect may have been due to a drop in intensity for both positive and negative memories. Conversely, it is possible the effect was driven by negative memories. Berntsen and Rubin (2006) found the same decrease in intensity when individuals were cued with both positive and negative event cues. However, positive and negative memories were not examined separately, so there is again the possibility that negative memories drove the effect.

The only study to examine strictly positive events observed changes in mood after individuals imagined 100 positive events from either a first-person perspective or third-person perspective (Holmes, Coughtrey, & Connor, 2008). Imagining events from a first-person perspective produced a positive change in mood, whereas imagining them from a third-person perspective produced a negative change. These findings are interesting for several reasons. First, they support the notion that using a third-person perspective does not serve only as a protective factor, but can also have a deleterious effect. Second, it is the first study to show that perspective can influence mood, thus having a longer-term effect on individuals, beyond their phenomenological experience during recall. However, the study did not specifically examine memories, but rather the effects of imagining particular events. Participants also did not change from one perspective to another; rather, the investigators examined mood change prior to and after the use of a particular perspective.

To summarize, it is unclear whether valence, intensity, or both factors affect perspective use. Some studies suggest highly intense memories lead to first-person perspective, while other studies suggest recalling negative events, particularly traumatic events, often lead to third-person perspectives. Using first-person perspective during remembering produces the recall of more emotional details, while third-person memories produces recall of more concrete details. Finally, individuals with PTSD and PTSD-like symptoms are more likely to use third-person perspective when remembering traumatic memories, than those without PTSD-like symptoms. Using a third-person perspective to recall an event decreases the emotional intensity of the event. Individuals may use third-person perspective as a cognitive avoidance or emotion regulation strategy. Additional studies examining the relationship between emotional valence, intensity, and perspective simultaneously are necessary in order to clarify these findings, particularly since many of the extant studies are correlational. An understanding of these relationships will not only further our understanding of the role perspective plays in memory, but also have the potential to help in the development of treatments for disorders such as PTSD and depression.

Self-Awareness, Self-Concept, and Visual Perspective

Nigro and Neisser (1983) suggested self-awareness is related to perspective; memories for highly self-aware, emotional events produced more third-person perspectives than less self-aware and emotional events. Robinson and Swanson (1993) also showed that when individuals were asked to recall memories from four time periods in their life, those who scored high on a measure of public self-consciousness (Fenigstein, Scheier, & Buss, 1975) recalled more memories using a third-person perspective.

Additional support for this relationship between self-awareness and perspective comes from gender and cross-cultural studies. Huebner and Fredrickson (1999) hypothesized that females, who are more self-aware of their bodies as a result of the sexual objectification females experience (e.g., Fredrickson & Roberts, 1997), would use third-person perspective more often than males. When asked to think about which perspective they use when remembering events, females reported using third-person perspective more often than males. When asked to recall several specific situations, females reported more third-person perspectives for memories of attending a party, which women also rated as more negative, less positive, and having higher levels of associated shame and anxiety than men. Given the relationship between emotion and perspective discussed earlier, it is unclear whether the difference observed by Huebner and Fredrickson was due to the self-awareness of the events, or rather the negative emotions. It may be that females attempted to avoid thinking about the emotional components of the event, producing more third-person perspectives. Furthermore, gender differences are not commonly reported in studies of perspective and a recent study failed to find a correlation between gender and visual perspective use (Sutin & Robins, 2007). Thus, the emotional aspects of these memories may account for the difference in perspective, rather that self-awareness.

Yet, a cross-cultural study comparing Asian and Caucasian individuals provides further support that self-awareness is related to perspective (Cohen & Gunz, 2002). The authors hypothesized that because Eastern cultures emphasize the relation between self and others, whereas Westerners emphasize independence and individualism (e.g., Heine, Lehman, Markus, & Kitayama, 1999; Triandis, 1995), Asian individuals should attend more to the relationship between their behavior and others. Because of this, they predicted Asians would be more likely to use a third-person perspective as a means of "regulating one's actions to make sure one is behaving appropriately" (p. 55), particularly for events when they are the center of attention. Results supported this hypothesis: Asians rated memories in which they were the center of attention as more third-person than non-center-of-attention memories and more third-person than Caucasians regardless of the type of situation. Sutin and Robins (2007) also found that individuals of Asian descent were more likely to use third-person perspectives when recalling memories than Caucasians.

The relationship between self-awareness and perspective has also been investigated in clinical populations, most frequently in patients with social phobia. One impetus for investigating perspective use in this population is public self-consciousness – shown to affect perspective as discussed above (Robinson & Swanson, 1993) – which has been shown to be a strong predictor of social anxiety (Darvill, Johnson, & Danko, 1992). Furthermore, some models of social phobia make specific predictions regarding the use of third-person perspective, proposing social phobics evaluate their behavior in social situations based in part on third-person perspective imagery that they construct during encoding (Clark & Wells, 1995; Rapee & Heimberg, 1997). For example, social phobics report experiencing images in which they appear uncomfortable or anxious, such as one patient who described his image as being "like a camera zooming in on a horrible, red, panicky face, just the face and neck and the top part of the body. I look really put-on-the-spot and nervous" (Hackmann, Surway, & Clark, 1998, p. 9).

To examine differences in perspective at encoding, Spurr and Stopa (2003) had high and low socially anxious individuals give two presentations, one while focusing on using a first-person perspective and the other while focusing on using a third-person perspective. The high socially anxious group had more frequent negative thoughts and was more likely to believe these thoughts were accurate compared to the low socially anxious group, regardless of the perspective that was used during encoding of the event. Using an observer perspective during encoding led to more frequent negative thoughts than field perspective, regardless of group. Thus, when an individual experiences a third-person perspective during encoding, it helps validate the negative impression they have of their performance during the event (Clark & Wells, 1995; Spurr & Stopa, 2003).

Experiencing third-person perspectives at encoding then makes it more likely that third-person perspectives are experienced at retrieval. For example, individuals with social phobia and healthy controls were asked to recall a recent social and nonsocial situation during which they were anxious (Wells, Clark, & Ahmad, 1998). Those with social phobia used third-person perspective to a greater degree than controls when recalling the social situation, but showed no difference across groups for the nonsocial situation. A similar effect was observed by Coles, Turk, Heimberg, and Fresco (2001); individuals with social phobia used more third-person perspectives for more intense social memories, but normal controls did not. A study of controlled social events in the laboratory found social phobics rated these events as more third-person than controls both immediately and three weeks after the events (Coles, Turk, & Heimberg, 2002). Social phobics have also been shown to produce more third-person perspective memories for both positive and negative social memories compared to controls (D'Argembeau, Van der Linden, d'Acremont, & Mayers, 2006). Holding negative self-images in mind during social interactions increases social phobics' use of third-person perspective at retrieval compared to holding in mind a neutral self-image; observers blind to the condition also rated the performance more negatively for those holding a negative self-image compared to those holding a positive self-image in mind (Hirsch, Clark, Mathews, & Williams, 2003).

Wells and Papageorgiou (1999) suggest greater third-person perspective use during social situations should extend to all individuals with abnormal self-focused processing. Indeed, they found both individuals with social phobia and agoraphobia rated their social memories as more third-person compared to blood/injury phobics and controls. Agoraphobics also rated their neutral memories as more third-person than all other groups. Day, Holmes, and Hackmann (2004) found that agoraphobics experienced more images that alternated between first-person and third-person perspectives compared to controls. The authors suggest this was due to a change in focus between the self (i.e., third-person perspective) and the situation (i.e., first-person perspective). Spider-anxious individuals who rate high in social evaluative concerns use third-person perspectives more than those who rate low when asked to imagine spider-related imagery (Pratt, Cooper, & Hackmann, 2004). Individuals with body dysmorphic disorder also rate memories of being worried or anxious about their appearance as more third-person and being more negatively emotional than controls (Osman, Cooper, Hackmann, & Veale, 2004).

It has been proposed that third-person perspective imagery is critical to the development and maintenance of disorders such as social phobia and body dysmorphic disorder (Clark & Wells, 1995; Day, Holmes, & Hackmann, 2004; Osman, Cooper, Hackmann, & Veale, 2004; Rapee & Heimberg, 1997; Veale, 2004). According to a model proposed by Clark and Wells (1995), it is thought that individuals with social phobia become self-focused and monitor their behavior in social situations. In doing so, they construct a third-person perspective, which they base in part on feedback that they get from the situation. This tends to include internally generated information, such as thoughts, feelings, and physiological cues. Because this information is generally negative for those with social phobia, they create a negative impression of the situation. Furthermore, their attention to this negative information means that they often ignore external cues that might provide more positive assessments of the situation, such as a smile or eye contact. The individual then constructs a third-person perspective based on all of this information in order to assess how he or she looks to others. The experience of third-person perspectives at encoding then produces more third-person perspectives at retrieval.

Evidence suggests manipulations that affect visual perspective may ameliorate the anxiety experienced by those with social phobia (Wells & Papageorgiou, 2001). Instructing individuals with social phobia to attend to external information, rather than internally generated information such as heart rate, negative thoughts, and mental imagery, during controlled social situations, produced a reduction in social avoidance, self-consciousness, and negative belief. Furthermore, simply giving social phobics an instruction to focus on external environmental information decreased individuals' reliance on third-person perspective imagery, as well as reducing anxiety and belief in the catastrophic outcomes of social events (Wells & Papageorgiou, 1998).

Studies by Libby and colleagues (Libby & Eibach, 2002; Libby, Eibach, & Gilovich, 2005) have also examined the relation of the self and perspective, but in non-clinical populations. However, their research focuses on self-concept, rather than self-awareness. Based on evidence that experiencing a large-scale change in self-concept, such as a religious conversion, can lead individuals to feel as though their past self is a different person (e.g., Mathieson & Stam, 1995), Libby and Eibach (2002) proposed that a discrepancy between an individual's current and past self-concept would lead to a focus on the past self as a distinct individual within the remembered scene, thus constructing a third-person perspective. This hypothesis was borne out over a series of experiments, all of which found greater incidence of third-person memories for events conflicting with the individuals' current sense of self. For example, in one study participants nominated a personal attribute that had changed the most and least since high school, recalled five memories related to each attribute, and then indicated the accompanying perspective. As expected, memories for the changed attribute were more likely to be remembered using third-person perspective than the unchanged attribute. In another study, memories for religious events were more likely to be remembered using third-person perspective when individuals were induced to consider themselves anti-religious than when induced to consider themselves pro-religious.

The authors suggest that a third-person perspective results due to the mismatch between the past self and the current self. Individuals view the remembered response as incongruent with what their current response would be. They then attribute this discrepancy to their "old" disposition rather than the situation, because if presented with the same situation in the present, they would act differently. The way that individuals attribute behavior has been shown to affect visual focus (e.g., Storms, 1973; Watson, 1982). This explanation is supported by a study in which participants who recalled a laboratory conversation using third-person perspective were more likely to attribute their performance during the conversation to dispositional, rather than situational, aspects of the event (Frank & Gilovich, 1989). Libby, Eibach, and Gilovich (2005) have also shown that instructing individuals to use a third-person perspective at retrieval can increase one's perception of change from past to current self. However, the type of information one searches for moderates this effect. Searching for information related to change while using a third-person perspective produced greater judgments of self-change. In contrast, searching for information related to continuity between the current and past self while using a third-person perspective produced lesser judgments of self-change.

Interestingly, Libby, Shaeffer, Eibach, and Slemmer (2007) have shown that perspective can affect future behavior by influencing one's self-concept. In particular, individuals who imagined voting from a third-person perspective reported a greater pro-voting mindset than those who imagined voting from a first-person perspective. The authors ascribe this difference to individuals in the third-person condition making dispositional attributions about their imagined behavior. This change in self-concept also had long-term effects. Individuals in the third-person condition were more likely to vote in an election. Similarly, Vasquez and Buehler (2007) found that imagining the successful completion of a future task from a third-person perspective produced an increase in achievement motivation compared to using a first-person perspective (cf., Sutin & Robins, 2007). Together, these results suggest that perspective not only affects the way individuals think and feel about a past event at the current time, but can also affect how individuals behave.

The relationship between perspective and self-concept has also been used to explain findings within the clinical literature. Lemogne and colleagues (2006) asked depressed individuals and normal controls to recall positive and negative memories. Individuals who were depressed were more likely to use a third-person perspective when remembering positive memories compared to negative memories. They were also more likely than non-depressed individuals to recall positive memories from a third-person perspective. Bergouignan and colleagues (2008) found the same effect when comparing euthymic depressed individuals to normal controls. These differences were ascribed to a discrepancy between the current, depressed self and the remembered self in the positive memory. This discrepancy between the current and remembered self produced a greater reliance on third-person perspectives.

A recent review of the literature relating visual perspective and the self has tried to integrate the findings presented here into a model, while also incorporating some of the literature relating to emotion (Sutin & Robins, 2008). This model suggests that when retrieving a memory, a key component of the retrieval process is determining if a memory is relevant to the self. If a memory is self-relevant, it is then evaluated on two additional variables. First, is the memory a threat to the self-concept? If it is assessed as a threat to the self-concept, self-protective processes are engaged. If it is not a threat, self-enhancement processes are engaged. Secondly, a memory is assessed as to whether or not it is congruent with the self-concept. If it is congruent, feelings of authenticity are amplified, whereas if it is incongruent, there is a feeling of inauthenticity that the individual tries to reduce.

Using this model, the authors propose two competing theories to explain the extant literature. The first, called the Dispassionate Observer, describes third-person perspective as a way to decrease the emotion experienced and to distance the current self from the past self. In this case, if a memory makes a person feel bad or inauthentic, it is more likely to be remembered using a third-person perspective, whereas if it makes the person feel good or authentic, it is more likely to be remembered using a first-person perspective. The second, the Salient Self, describes third-person perspective as a way to increase the emotion experienced and to draw similarities between the current self and past self. It predicts that when a memory makes the person feel positive or authentic, individuals will use a third-person perspective to enhance the emotion experienced. If the memory is negative or inauthentic, individuals will use a first-person perspective.

There are a few problems with this model as it is described. Primarily, it does not account for some of the existing data. For example, it does not explain data suggesting that emotional memories, regardless of valence, produce more first-person perspectives (e.g., D'Argembeau, Comblain, & Van der Linden, 2003; Nigro & Neisser, 1983; Strongman & Kemp, 1991), nor does it explain the cultural differences found by Cohen and Gunz (2002). As described, it also does not account for some of the other differences observed across first- and third-person perspective memories, such as differences in vividness and other phenomenological variables. This model is an important step in trying to integrate literatures. However, there is still work to be done to describe the relationship between perspective, self-related processes, and emotion.

To conclude, self-awareness and self-concept seem to play a role in the use of visual perspective during recall. The existing research indicates self-aware events lead to more third-person than first-person perspective memories, particularly in individuals with abnormal self-focus, such as those with social phobia, agoraphobia, and body dysmorphic disorder. Memories of events that are less congruent with one's current self-concept are also more likely to produce third-person perspective.

Temporal Distance, Vividness, Constructive Processes, and Visual Perspective

In their original study of visual perspective, Nigro and Neisser (1983) reported two related findings; third-person perspective memories were older than first-person perspective memories and they were also less vivid. Similar findings have been reported in studies examining perspective; remote memories were more often categorized as third-person and rated as less vivid than recent memories (Piolino et al., 2006; Robinson & Swanson, 1993). In fact, the effect of temporal distance on perspective is the most reliable finding in the perspective literature (Frank & Gilovich, 1989; Nigro & Neisser, 1983; Piolino et al., 2006, 2007; Pronin & Ross, 2006; Robinson & Swanson, 1993; Sutin & Robins, 2007; Talarico & Rubin, 2003; cf., Brewer & Pani, 1996; Viard et al., 2007).

Nigro and Neisser, as well as others (Freud, 1899/1953; Robinson & Swanson, 1990), suggest that mnemonic change, or the effects of reconstructive processes, may explain this effect. The older a memory is, the more likely it has been subject to mnemonic change and reconstructive processes, which produces a third-person perspective. However, other properties of the memory, such as vividness, change as memories get older (e.g., Johnson, Foley, Suengas, & Raye, 1988; Nigro & Neisser, 1983; Robinson & Swanson, 1993; Talarico & Rubin, 2003), which makes it difficult to disentangle the effects reconstruction from other phenomenological changes that occur over time.

A study of patients with obsessive-compulsive disorder (OCD) has examined the hypothesis that mnemonic change produces third-person perspectives. Because OCD is characterized by obsessions, or recurrent and persistent thoughts, Terry and Barwick (1998/99) hypothesized that individuals with OCD would ruminate on specific events. This would, in turn, result in more opportunities for reconstruction and mnemonic change; thus, they predicted greater use of third-person perspectives in people with OCD than normal controls. Individuals with low-to-moderate scores on the Maudsely Obsessive-Compulsive Inventory (OCI) (Rachman & Hodgson, 1980) were less likely to remember events using third-person perspectives than were those with the highest and lowest OCI scores. This study may also provide an alternative explanation for the finding that intrusive memories tend to be retrieved from a third-person perspective in other clinical populations (e.g., Berntsen, Willert, & Rubin, 2003; Kenny & Bryant, 2007; McIsaac & Eich, 2004; Williams & Moulds, 2007, 2008). It is possible that the repeated retrieval of these intrusive memories produces the third-person perspective memories.

However, a study investigating the stability of flashbulb memories and everyday memories (Talarico & Rubin, 2003) suggests that the change from first-person perspective to third person is not due simply to the passage of time, nor the amount of mnemonic change, but may be related to other phenomenological changes, such as a decrease in vividness. On September 12, 2001, participants were asked to recall the episode in which they had learned about the September 11 attacks, as well as recall an everyday event from a few days prior. Participants then recalled the events again either 1 week, 6 weeks, or 32 weeks later. The standard relationship between perspective and time was observed for everyday memories; those tested 32 weeks later rated their everyday memories as more third person than they had during the first session, whereas those tested 1 week later rated their everyday memories as only slightly more third person than they had during the first session. Interestingly, flashbulb memories did not show a change in perspective ratings across the delay, even though these memories were rehearsed more often than the everyday memories. Furthermore, the retrieval of details from the everyday memories and flashbulb memories was equally inconsistent at the different delays, suggesting that both types of memories were subject to mnemonic change. This suggests that the passage of time, along with mnemonic change, does not produce the shift in perspective seen in many studies. Talarico and Rubin (2003) did observe the same pattern seen in perspective ratings for vividness ratings; flashbulb memories remained highly vivid, even after 32 weeks, and everyday memories became less vivid across the delays. This same pattern was observed for other phenomenological variables, such as belief in the occurrence of the event, degree of recollection, and degree of remembering the event rather than knowing the event occurred. Together, these findings suggest that the shift in perspective observed over time may be related to other phenomenological changes that occur over time.

There is some evidence to suggest that the key phenomenological variable may be the availability of visual information from an event. Rubin, Burt, and Fifield (2003) experimentally manipulated the degree of visual sensory information available at encoding, which resulted in interesting effects on perspective. Participants were shown several videotaped events, but presented with only audio information for half of the events. For events presented without video, participants were encouraged to imagine taking part in the events they heard unfold. Events presented without video were more often remembered using third-person perspective compared to events presented with both audio and video, and were also rated as less vivid. This suggests the availability of visual information from an event may influence the perspective used at retrieval; less visual information is more likely to produce third-person perspective. However, it is also possible constructive processes produced these results. Although the images associated with audio-only events were not necessarily *re*-constructed, since individuals never experienced the original visual input, images they did experience during retrieval were likely constructed from previous knowledge or experiences. Therefore, the need to construct one's own visual imagery in the absence of this visual input may produce more third-person perspectives.

Alternative explanations come from studies showing the same effect of temporal distance on perspective, but for future events rather than past. In particular, D'Argembeau and Van der Linden (2004) found the classical effect of temporal distance (i.e., older events more likely to be remembered using third-person perspective), but also found that imagining events further in the future was more likely to come from a third-person perspective than imagining events close in time. Pronin and Ross (2006) replicated this effect. Since imagined future events are not subject to mnemonic change, this suggests some other factor should explain the change in perspective. Construal level theory states that the way individuals represent events changes as the temporal distance of the event changes (Liberman & Trope, 2008; Trope & Liberman, 2003). When events are more recent, they are represented in terms of specific, concrete details, whereas more distant events are represented more abstractly. These are referred to as low-level and high-level construals, respectively. It may be that construal level affects perspective such that low-level construals produce first-person perspectives and high-level construals produce third-person perspectives.

Another potential explanation is that when remembering or imagining a more remote event, the remembered/imagined self differs more from the current self compared to a recent event (Wilson & Ross, 2003). As discussed earlier, third-person perspective has been associated with remembering events that are discrepant with one's current self-concept (Libby & Eibach, 2002).

Finally, a study of false memories suggests one more possible explanation. Heaps and Nash (2001) showed that after inducing false memories using an imagination inflation procedure (e.g., Garry, Manning, Loftus, & Sherman, 1996; Loftus, Coan, & Pickrell, 1996; Loftus & Pickrell, 1995), false childhood memories were more likely to be recalled using third-person perspective compared to true childhood memories. Gollnisch & Averill (1993) found similar effects when examining imagined emotional events; imagined events based heavily on previous episodes were remembered using a first-person perspective, whereas imagined events that were not based on specific episodes were remembered using a third-person perspective.

Heaps and Nash suggest several explanations for their findings, which parallel the findings of Nigro and Neisser (1983). First, individuals may focus on retrieving the concrete details of false memories because the emotional details are unavailable, which produces third-person perspectives. Second, false memories require more construction, thereby producing more third-person perspectives. Third, false memories may produce third-person perspectives because the associated imagery is less vivid. Support for this final hypothesis comes from studies showing that third-person perspectives are rated as less vivid (e.g., Nigro & Neisser, 1983; Robinson & Swanson, 1993) and that third-person perspectives result when individuals are deprived of visual information at encoding (Rubin, Burt, & Fifield, 2003). One theory explaining out-of-body experiences (OBEs) suggests that these disembodied viewpoints occur when one's representation of the environment becomes unstable (e.g., instances of extreme stress or fear; Blackmore, 1984). The lack of external information leads one to rely on one's long-term memory representation of the environment, which Blackmore suggests is an abstract, viewpoint-independent cognitive map. Thus, when sensory information is degraded, a third-person perspective is constructed. This same process may be used in memory (for similar argument, see Rubin, Berntsen, & Bohni, 2008). In fact, it has been suggested that some experiences of OBEs are actually third-person perspective memories of a traumatic event, rather than memories of the OBE experienced during the trauma itself (Rubin, Berntsen, & Bohni, 2008).

A fourth possibility, not suggested by Heaps and Nash, is that false memories rely more on the use of semantic knowledge about one's self and the world in order to construct a plausible false memory; this reliance on semantic memory may lead to more third-person memories. False memories were rated as more typical of individuals' general childhood behavior than were true memories (Heaps and Nash, 2001), suggesting participants may have drawn upon general autobiographical knowledge (Conway, 1996; Conway & Pleydell-Pearce, 2000) in order to construct a false memory. A similar notion was mentioned briefly by Robinson and Swanson (1990), who noted individuals often report "the image they experience [during third-person memories] is more like a template than an accurate depiction of themselves in the context of the remembered event," going on to suggest that these memories may be composed of more "generic images, each tied to a particular period or condition in their lives" when compared to first-person memories (p. 329). Similarly, studies have shown individuals know that memories accompanied by a third-person perspective occurred, rather than recollecting them, whereas first-person perspective memories are more recollected than known (Crawley & French, 2005; Piolino et al., 2006). Using subtly different cues, Libby (2003) demonstrated that focusing on the experience of a past event produces more first-person perspectives, whereas focusing on the objective knowledge that a past event occurred produces more third-person perspectives. Together, these findings suggest that the distinction between episodic and semantic memory may be related to perspective use.

From these studies, it is clear that there are several plausible explanations for the change in perspective that has been observed across temporal distance. These include the specificity of memory, the level of construal, the correspondence between the current self and imagined self, and the reliance on semantic versus episodic memory. In addition, there is evidence to suggest that visual information may influence perspective use. It is difficult to interpret the influence of distance, vividness, constructive process, and mnemonic change on perspective because these variables tend to co-vary; third-person perspective memories tend to be older, less vivid, and possibly more constructed. Evidence from flashbulb memory studies suggests that the change in perspective observed across time is not due simply to the passage of time, but may be related to other phenomenological changes that occur over time. Clearly, additional research is necessary to disentangle these possible alternatives.

Future Directions

The growing body of literature examining the role of perspective in autobiographical memory has revealed several interesting relationships between perspective, emotion, self-related processing, temporal distance, and vividness. Although these topics have been discussed in three distinct sections, it is important that we begin to integrate this literature. Sutin and Robins' (2008) theories of the Dispassionate Observer and Salient Self have helped begin this process. It is important that we begin to experimentally test this model, as well as theories that have already been put forth.

One factor that makes it difficult to disentangle the relationship between perspective and other variables is that many studies are correlational or quasi-experimental. Furthermore, many of the studies reviewed here did not focus on perspective, but rather included perspective as one of many measures collected. To use a hypothetical example, a study compares individuals with social phobia to those without the disorder and asks them to rate a social memory on several variables. They find that individuals with social phobia rate their social memories as more third person than controls. One might conclude that differences in self-awareness produced the effect. However, it is often the case that these groups differ along other variables. For example, those with social phobia may also rate their memories as more intensely emotional or less vivid, or that they believe their memory is accurate more than individuals without social phobia. These differences make it difficult to conclude that it is self-awareness that produces the variation in perspective, rather than other attributes of the memory. These issues make it critical that we begin to develop experimental designs focusing primarily on perspective.

Although these studies provide a better characterization of the role perspective plays in autobiographical memory, there are still many further questions for future research. For example, referencing the clinical literature, some have suggested that the distancing function third-person perspectives may provide is beneficial (Wilson & Ross, 2003). Others have suggested that it is deleterious to the recovery process (McIsaac & Eich, 2004; Williams & Moulds, 2007, 2008). Understanding which of these is true, or under what circumstances using a third-person perspective might have a beneficial versus deleterious effect, has important practical implications for therapy.

Also of practical importance is the relative accuracy of first- and third-person perspectives (for a similar suggestion, see Sutin & Robins, 2008).

This is especially pertinent given that one retrieval cue used in the Cognitive Interview is varying perspectives, as discussed in the introduction to this chapter. Although McIsaac and Eich (2002, 2004) did find substantial differences in the types of details individuals retrieved, they found no difference in accuracy between the two perspectives after a delay of a few minutes. In contrast, a study using a week's delay did find that first-person perspectives produced more accurate recall compared to third-person perspectives (Kim, Ciovica, Cho, & St. Clair, 1999). This suggests that perspective may affect both the content and accuracy of memories.

Another area that has not been explored is how these different perspectives are constructed and represented. Manipulating perspectives has been examined within the spatial memory literature (for a review, see Zacks & Michelon, 2005), but generally these studies require that an individual rotate their first-person perspective to different locations within a mental image. It is not clear how this transformation occurs for third-person perspectives. More broadly, it has been suggested that similar processes may be involved in remembering, navigation, theory of mind (i.e., perspective-taking), and imagining future events (e.g., Buckner & Carroll, 2007). If true, one might expect to see correlations between visual perspective during retrieval and measures of spatial manipulation. There is some evidence to suggest a relationship between visual perspective and spatial manipulation; Lorenz and Neisser (1985) found a positive relationship between spatial manipulation measures and the tendency to use first-person perspective. Participants who were more able to deliberately manipulate the spatial configuration of visual images were also more likely to view memories through their own eyes. The authors suggested that people with greater spatial ability have richer, more detailed memories than others, which prevents memories from shifting from a first-person to third-person perspective.

Research investigating the use of visual perspective in memory retrieval is steadily growing after a long period of neglect. In the past ten years it has continued to incorporate increasingly diverse topics. However, there are still many questions remaining to be explored. The current review is a means of taking stock of questions that have already been examined and to introduce questions that have not yet been answered, in hopes of furthering our understanding of the role of visual perspective in memory retrieval.

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Notes

1. It is unclear whether third-person perspectives in memory and out-of-body experiences (OBEs) are related. Neurological evidence suggests that similar brain regions in the temporoparietal junction may underlie the occurrence of OBEs (Blanke, Landis, Spinelli, & Seeck, 2004; Blanke et al., 2005; Blanke, Ortigue, Landis, & Seeck, 2002) and the ability to transform one's perspective (Zacks, Gilliam, & Ojemann, 2003; Zacks, Vettel, & Michelon, 2003). A unique attribute of OBEs is the sensation of being physically located outside the body, which is thought to be caused by a breakdown in individuals' spatial representations across reference frames (Blackmore, 1984; Blanke et al., 2004) and does not occur when recalling memories from different perspectives. However, some have suggested that many OBEs can be explained as a memory phenomenon; remembering a trauma from a third-person perspective provides the feeling that the event was experienced from an external location (Rubin, Berntsen, & Bohni, 2008).

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11

The Emergence of Recollection

How We Learn to Recall Ourselves in the Past

Robyn Fivush and Patricia J. Bauer

Introduction

> The stream of thought flows on; but most of its segments fall into the bottomless abyss of oblivion. Of some, no memory survives the instant of their passage. Of others, it is confined to a few moments, hours or days. Others, again, leave vestiges which are indestructible, and by means of which they may be recalled as long as life endures. (James, 1890, p. xx)

Much of our early life falls into the "bottomless abyss of oblivion," unable to be recalled as an explicit memory. As adults recollecting back to our early years, most of us have no memory at all of our early beginnings, and a gradual sense of the "awakening of consciousness as a series of spaced flashes, with the intervals between them gradually diminishing until bright blocks of perception are formed, affording memory a slippery hold" (Nabokov, 1951/1989, pp. 20–21). In the psychological literature, Freud (1905/1953) first described this phenomenon, which he called *infantile amnesia*, as the veil behind which we cannot see. For most adults in Western cultures, the earliest memory is dated at about age 3 to 3½ years (reviewed in Bauer, 2007a; Nelson & Fivush, 2004; Pillemer & White, 1989), although, as eloquently described by Nabokov, memories of early childhood tend to be sparse, gradually increasing in density across the preschool years (Pillemer & White, 1989) and only

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becoming a subjectively experienced sense of continuous memory in late childhood or adolescence (Habermas & Bluck, 2000; McAdams, 2001).

In this chapter, we explore the early development of the ability to consciously recollect personal experiences. Whereas recall implies the ability to call to mind a past event, recollection further requires the ability to reflect on the past *as past* (Nelson, 1993; Tulving, 2002), to be aware that the current self is recalling a past self, or what Tulving has called *autonoetic* memory. Thus, recollection is a complex skill with a long developmental history. It emerges from developments in multiple other domains, including neurological, cognitive, and socio-emotional, as well as basic memory abilities. Moreover, these developments are modulated within social-cultural contexts that facilitate the expression of some forms of memory and recollection over others (for similar arguments, see Nelson & Fivush, 2004). From this theoretical framework, which draws from sociocultural theory (Gauvain, 2001; Vygotsky, 1978), dynamic systems approaches (Thelen & Smith, 1997), and developmental cognitive neuroscience (e.g., Bauer, 2007a), recollection is not an all-or-none ability, but rather emerges gradually throughout infancy and childhood, as component skills develop and converge (Bauer, 2007b; Nelson & Fivush, 2004). In this chapter, we focus on the early emergence of the ability to recollect during the first few years of life. We first discuss the neural substrate that permits recollection, and describe how these neural processes develop. We then turn to a discussion of how this nascent ability is shaped within social contexts across the preschool years; in particular we explore developments in language, self, and perspective-taking that allow children to begin to take a subjective perspective on their recollective experiences.

The Neural Substrate of Recollection

For adults, the neural substrate that permits recollection of past events has been relatively well worked out. Famous cases such as HM (Corkin, 2002; Scoville & Milner, 1957) provided early indications that medial-temporal lobe structures were essential for formation of new episodic memories that later could be recollected. The suggestion has been supported and the findings extended through neuroimaging studies. The combination of methods has made clear that the ability to encode, store, and later retrieve personally relevant memories with a sense of reliving depends on a multicomponent network involving temporal (hippocampus, and entorhinal, parahippocampal, and perirhinal cortices) and cortical (including prefrontal and other association areas) structures (e.g., Eichenbaum & Cohen, 2001; Markowitsch, 2000; Zola & Squire, 2000).

Neural events in the life of a memory

The first step in the life of a memory is *encoding*. The process begins as the elements that constitute an event register across multiple cortical areas. That is, as we experience an event, neurons in primary somatosensory cortex respond to inputs from the skin (registering information about light touch) and muscles and joints (registering information about the position and movement of our extremities). In parallel, neurons in primary visual cortex respond to the form, color, and motion of objects in the event; and neurons in primary auditory cortex respond to various attributes of the sounds of the event. Inputs from these primary sensory areas are sent (or projected) to sensory association areas that are dedicated to a single modality (somatic sensation, vision, or audition), where they are integrated into whole percepts of what the object or event feels like, looks like, and sounds like, respectively. These unimodal sensory association areas in turn project to polymodal (also termed multimodal) posterior-parietal, anterior-prefrontal, and limbic-temporal association areas where inputs from the different sense modalities are integrated and maintained over brief delays (on the order of seconds: e.g., Petrides, 1995).

For longer maintenance, the inputs that constitute an event or experience must be stabilized or *consolidated*, a task attributed to medial-temporal structures, in concert with cortical areas (McGaugh, 2000). Specifically, information from association areas converges on perirhinal and parahippocampal structures from which it is projected to the entorhinal cortex and in turn to the hippocampus. Within the hippocampus, conjunctions and relations among the elements of experience are linked into a single event. Association areas share the burden of consolidation, by relating new memories to episodes already in storage: information processed in the hippocampus is projected back through the temporal cortices which in turn project to the association areas that gave rise to their inputs. Eventually, traces are stabilized such that the hippocampus is no longer required to maintain them; consolidated traces are *stored* in neocortex.[1]

Finally, the *raison d'etre* for encoding, consolidation, and storage of mnemonic traces is to permit later *retrieval*. Behavioral and neuroimaging data implicate prefrontal cortex in retrieval (e.g., Cabeza, McIntosh, Tulving, Nyberg, & Grady, 1997; Cabeza et al., 2004; Maguire, 2001; Markowitsch, 1995; Nyberg, 1998). For example, damage to prefrontal cortex disrupts retrieval of facts and episodes. Deficits are especially apparent (a) in free recall (vs. recognition), (b) for temporal information (vs. items), (c) for specific event features, and (d) for source. Imaging studies have revealed high levels of activation in prefrontal cortex during retrieval of episodic memories from long-term stores (reviewed in Gilboa, 2004). Activations in medial prefrontal cortex are observed during retrieval of internally generated information, such as the thoughts and feelings that put the *auto* in *auto*biographical memories (e.g., Cabeza et al., 2004). Imaging studies also have implicated additional brain regions that were not suspected to have a role in autobiographical memory, based on behavior alone. For example, lateral posterior parietal and precuneus are implicated in retrieval of autobiographical memories. These regions show increased activation when individuals report retrieving more details, and especially when individuals recognize presented items more accurately, and judge their recognition to be based more on recollection than familiarity (reviewed in Gilboa, 2004).

In addition to the temporal-cortical episodic network, when individuals encode and retrieve emotional events, amygdalar activations are observed (Cahill, 2003; for reviews, see LaBar & Cabeza, 2006). Interestingly, women and men show different effects. During encoding, women and men show increased activation in left amygdala and right amygdala, respectively (e.g., Cahill Uncapher, Kilpatrick, Alkire, & Turner, 2004; Canli, Desmond, Zhao, & Gabrieli, 2002). During retrieval, males have more activation in the left parahippocampal gyrus; females have more activation in the right insula and right dorsolateral prefrontal cortex (Piefke, Weiss, Markowitsch, & Fink, 2005). This brief review makes clear that multiple brain regions are involved in the creation, maintenance, and retrieval of memories, and thus are implicated in recollection.

Development of the neural bases of autobiographical memory

Although we have a great deal more to learn about the events involved and the timing of development of the structures and connections of the temporal-cortical network that supports recall, critical pieces of information are in place. In terms of brain development in general, there are changes in both gray and white matter throughout childhood and well into adolescence (e.g., Caviness, Kennedy, Richelme, Rademacher, & Filipek, 1996; Giedd et al., 1999; Gogtay et al., 2004; Sowell et al., 2004). By 5 years of age the child's brain is roughly 90 percent of adult volume (Kennedy, Makris, Herbert, Takahashi, & Caviness, 2002), with an additional 5 percent increase by age 11 (Caviness et al.). Reflecting changes in vasculature, glia, neurons, and neuronal processes, gray matter increases until puberty. However, noting the substantial slowdown in brain growth beyond the first decade, Caviness et al. identified the period of 7 to 11 years as the "final critical phase of brain growth." Beyond puberty, as a result of pruning and other regressive events (i.e., loss of neurons and axonal branches), the thickness of the cortical mantle declines (e.g., Giedd et al.; Gogtay et al.; Sowell, Delis, Stiles, & Jernigan 2001; Van Petten, 2004). In contrast to curvilinear change in gray matter volume, white matter volume increases linearly with age (Giedd et al.). Increases in white matter are associated with greater connectivity between brain regions and with myelination processes that continue into young adulthood (e.g., Johnson, 1997; Klingberg, Vaidya, Gabrielli, Soseley, & Hedehus, 1999; Schneider, Il'yasov, Hennig, & Martin, 2004). Overall, the brains of girls are 93 percent the volume of boys'. For most structures, scaling of differences in size is uniform. Exceptions are the hippocampus, which is disproportionally larger in girls, and the amygdala, which is smaller in girls (Caviness et al.; Kennedy et al.). Throughout childhood and early adolescence, white matter volume is smaller in girls than boys (Giedd et al.).

In terms of the temporal-cortical episodic memory network, there are changes in the temporal as well as the cortical components. In primates, much of the hippocampus matures early, with adult levels of synapses and glucose use by 6 months of age (Seress, 2001). However, the dentate gyrus (which links the temporal cortices and the CA3 cell fields of the hippocampus), frontal cortex, and temporal-cortical connections develop later. In dentate gyrus the rise to peak numbers of synapses occurs at 8 to 20 months of age and the adult number of synapses is reached at 4 to 5 years (Eckenhoff & Rakic, 1991). Hippocampal volume increases gradually throughout childhood and into adolescence (e.g., Gogtay et al., 2004; Pfluger et al., 1999; Utsunomiya, Takano, Okazaki, & Mistudome, 1999). As well, myelination in the hippocampal region continues throughout adolescence (Arnold & Trojanowski, 1996; Benes, Turtle, Khan, & Farol, 1994; Schneider et al., 2004).

In prefrontal cortex, the rise to peak numbers of synapses occurs at 8 to 24 months of age. Pruning to adult levels does not begin until late childhood and adult levels are not reached until late adolescence or early adulthood (Huttenlocher, 1979; Huttenlocher & Dabholkar, 1997). There are well-documented reciprocal connections between the hippocampus and frontal lobes. However, the development of these connections has not been fully elucidated (Barbas, 2000; Fuster, 2002). There also are age-related changes in the lateral temporal and parietal cortices. Cortical gray matter changes occur earlier in the frontal and occipital poles, relative to the rest of the cortex, which matures in a parietal-to-frontal direction. The superior temporal cortex is last to mature (though the temporal poles mature early; Gogtay et al., 2004). The late development of this portion of cortex is potentially significant for memory as it is one of the polymodal association areas that plays a role in integration of information across sense modalities. Finally, little is known about development of regions implicated in emotional memory, such as the amygdala.

A logical expectation is that the protracted course of development of the structures and interconnections in the temporal-cortical network has implications for episodic and autobiographical memory, and for recollection. Late development of prefrontal cortex can be expected to impact all phases of the life of a memory trace from its initial encoding through consolidation to retrieval. Late development of the dentate gyrus is significant because in the adult, it is the major route by which information makes its way into the cell fields of the hippocampus. Although data are limited, it seems that this projection is necessary for adult hippocampal function (Nadel & Willner, 1989). If the "route in" to the structure implicated in encoding and consolidation is less developed, we may expect less efficacy and efficiency in these early stages of processing of new information. The consequences of less effective and efficient early-stage processing are profound: if encoding processes are compromised, there is less information to be consolidated. If consolidation is compromised and/or the information available for consolidation is degraded, then less information will be stored. If less information is stored, there will be less information to retrieve. The result is an expectation that with development, infants and children will be able to encode, store, and retrieve richer, more detailed memory representations that will lend to their retrieval a sense of reliving and recollection.

The Social Context of Recollection

Whereas neural developments set the stage for the basic abilities to encode, consolidate, and retrieve personally experienced events, the social interactions in which infants and preschoolers engage modulate how these memories will be expressed, understood, and maintained. In this section, we first review basic developments in behavioral memory that occur across infancy, and then describe how emerging developments in language and self-understanding begin to coalesce through socially guided reminiscing interactions to culminate in the phenomenon of recollection.

Infancy

In traditional theories of cognitive development, no place was the "bottomless abyss of oblivion" into which the stream of thought flows deeper than in infancy. Until the 1980s, infants were thought to live in a "here and now" world, without a past and without a future (Piaget, 2000). The perspective held sway in part for methodological reasons. The most common means of testing memory for past events involve comprehension of verbal instructions and/or verbal report. These requirements could not be met by infants who by definition lack the capacity for speech (*infantia*, Latin for "inability to speak"). The obstacle was overcome with development of elicited and deferred imitation as a nonverbal analogue to verbal report. In elicited and deferred imitation, props are used to produce an action or multi-step sequence that participants imitate immediately (elicited imitation), after a delay (deferred imitation), or both. Use of this paradigm has revealed that by 6 months of age, infants remember individual actions for 24 hours (Barr, Dowden, & Hayne, 1996), and by 9 months, retention extends to 1 month. As many as 50 percent of 9-month-olds show evidence of recall of actions in the correct temporal order over the same delay (e.g., Carver & Bauer, 1999). By 20 months of age, infants recall multi-step sequences in order after delays of as many as 12 months (Bauer, Wenner, Dropik, & Wewerka, 2000). Research using imitation-based tasks has found that children not only recall the past, but their memories are well organized: causal, temporal, and goal-based organization is readily apparent (e.g., Bauer, 1992; Bauer & Travis, 1993). As it is for older children, recall is influenced by the structure of events (e.g., Barr & Hayne, 1999; Bauer, Hertsgaard, Dropik, & Daly, 1998; Wenner & Bauer, 1999) and verbal reminders (Bauer, Hertsgaard, & Wewerka, 1995; see also Hayne, Barr, & Herbert, 2003).

These findings clearly indicate that infants are able to recall the past. Yet, there are pronounced changes in recall throughout infancy that have implications for the development of recollection. For example, with age, infants recall more detailed and differentiating information. One type of differentiating information is *when* an event occurred. At virtually every delay, older infants have been found to retain more information about the temporal order of actions of multi-step sequences relative to younger infants (e.g., Barr, Dowden, & Hayne, 1996; Bauer, Wenner, Dropik, & Wewerka, 2000; Herbert & Hayne, 2000). By 20 months, infants exhibit temporally ordered recall after as long as 12 months (Bauer et al.). Thus, by the second year of life, infants reliably recall one type of episodic information, namely, temporal order (e.g., Bauer et al.; Bauer, Wiebe, Waters, & Bangston, 2001).

Infants also remember specific and distinctive information about events. This is an important achievement because it is the details that differentiate one event from another and confer upon memories their status as *episodic* (i.e., memories of unique events, located in specific place and time). The ability to remember distinctive information is apparent at least by 16 months of age. It is apparent when infants remember the identity of the specific props or objects used to enact an event sequence (e.g., Lechuga, Marcos-Ruiz, & Bauer, 2001). For example, in Bauer and Dow (1994), 16- and 20-month-olds were exposed to novel sequences and later tested for recognition of the props used to produce them. In the recognition test, the props were paired with objects that were perceptually different from the target props, but which nevertheless could be used to produce the event (e.g., children were shown a rattle with rectangular nesting cups and a rubber ball; distracter props were two round barrel halves and a small block). Both age groups reliably selected the original props, thereby indicating memory for the specific features of the events. The 20-month-olds performed more systematically, relative to the 16-month-olds (Ms = 81% and 68% correct selections, respectively).

Thus, by the end of the first year of life, infants recall unique details about specific experiences and can organize these experiences temporally. However, the extent to which these memories are recollective is unclear. If a full recollective experience involves autonoetic knowing, or awareness that one is a self remembering back to a previous self, then these early memory developments may not yet reach the definition of recollection. It may be only when memory is integrated with other developing systems, including language and self-understanding, that true recollection emerges.

The preschool years

One of the most obvious markers of the transition from infancy to the preschool years is the development of language, and with it, the development of verbal recall. Most children begin to use a word or two sometime around their first birthday, and language quickly develops through the second year of life, both in terms of increasing vocabulary and increasing conversational skills (Nelson & Ross, 1980). Interestingly, children begin to participate in shared reminiscing about their past experiences almost as soon as they begin to talk, at about 16 to 18 months of age. However, at this young age, children do not use their language to tell "what happened" in an event already past. Instead, they participate in memory conversations by answering questions posed by adult partners. Essentially, the adult partner tells what happened and asks the child to affirm or deny the events (Eisenberg, 1985; Hudson, 1990). As such, the adult is providing the content as well as the structure of the conversation. For example, the adult might say, "We had ice-cream, didn't we?" and the child would participate by responding, "Yes!"

By about 24 months of age, children begin to contribute to memory conversations by providing mnemonic content. At this age, when parents ask their children, "What did we have?" they can expect an answer: "Ice-cream!" Children do not, however, go on to elaborate their responses. If parents want to know the flavor of the ice-cream, for example, they must ask that specific question. Thus, the structure of the conversation is provided by the adult, and the burden for keeping the conversation going is borne by the adult.

By age 3 years, most children are more actively engaged in sharing their past with others. Although at this age most memory conversations still are initiated by parents, children do bring up past events as potential topics of conversations (Nelson & Fivush, 2000). Some children are able to tell complete, albeit brief, stories about past events (e.g., Fivush, Gray, & Fromhoff, 1987). More commonly, they participate by providing content-filled responses to inquiries from their parents, as well as some elaborations. An excerpt from a conversation between a 3-year-old child and her parent illustrates these characteristics well (from Bauer, 2007a):

PARENT: Do you remember when, um, when we went in our car and we saw some donkeys out our car window? Who was in the car with us?

CHILD: I don't know.
PARENT: Was Sandy in the car?
CHILD: *(nods head in agreement)*
PARENT: Who else was in the car?
CHILD: Dada.
PARENT: Was it snowing outside that day or was it hot?
CHILD: Cold.
PARENT: It was cold?
CHILD: And the reindeers, and dada reindeer not there.
PARENT: A reindeer? Remember those donkeys that came up to our car window? They . . .
CHILD: Yeah. It runned closer to you.
PARENT: But we didn't open our window, did we?
CHILD: No, we don't.

Between the ages of 3 and 5, children become more competent participants in shared reminiscing, and by the end of the preschool years, most children are able to provide a reasonably coherent independent narrative of a personally experienced event to a listener. This developmental progression raises two critical questions: first, what is the role of language in the development of recall and recollection, and second, what is the role of social interaction with more competent adults during the preschool years in facilitating the development of these abilities?

Language, narrative, and memory Clearly, memory is not linguistically based. Current theories of autobiographical memory agree that memory is a highly dynamic system in which information is represented at multiple levels, including sensory experience, emotional experience, semantic information, and conceptual knowledge (Conway & Pleydall-Pearce, 2000; Rubin, 2006). In essence, upon retrieval, memory traces are reconstituted "in the moment," by pulling together the distributed strands of experience stored in neocortex. Evidence of this dynamic process comes from neuroimaging studies that "eavesdrop" on the brain as memories are retrieved and elaborated. Retrieval-related neural activations are observed in medial-temporal (hippocampus) and right frontal structures (ventrolateral, dorsolateral, and medial regions), as well as in the retrosplenial area of the posterior cingulate cortex. As memories are elaborated, activations are observed in visual cortex, parietal cortex (precuneus), auditory cortex, and left prefrontal cortex (Daselaar et al., 2008). Levels of activation in these regions of the brain are greater for memories that individuals indicate are more detailed and vivid, and in which they have a greater sense of personal involvement and reliving. When emotionally salient memories are retrieved, activations also are observed in amygdala (for a review, see

Rubin, 2006). The process takes time: an average of 12.25 seconds (Daselaar et al.).

Although memory traces are not stored as "stories" read off as they are retrieved, language is critical in organizing and expressing autobiographical memory. More specifically, language allows for recounting the past, both to oneself and to others, in narrative form. Narratives are culturally canonical linguistic structures that provide an organizational tool for understanding and representing personal experience (Bruner, 1990; Ricouer, 1991). Although events are experienced in time, and as already described, by the end of the first year of life infants are able to recall events in correct temporal order, narratives move beyond recounting a simple chronology. Narratives include information about how and why events occurred as they did; this information can be explanatory, evaluative, and/or interpretive (Fivush & Haden, 2005; Labov, 1982; Peterson & McCabe, 1992), and, as such, narratives create a sense of the past replete with emotion, motivation, and intention, essentially creating a human drama.

Moreover, it is only through language and narrative that we can fully share the past with others. Whereas objects and places from the past can be referenced outside of language, it is only through language that we can share our feelings, evaluations, and interpretations of past events. And ultimately, it is through this kind of shared reminiscing, in which our narrative understanding is confirmed, negated, contested, and negotiated with others, that our individual narrative understanding evolves over time, and that we come to understand our experience as *ours*, as remembered from a particular subjective perspective (Fivush, 2001; Fivush & Nelson, 2006). Given that children's ability to verbally recall and narrate the past develops in conversational interactions with adults, the role that adults play in facilitating these developments becomes crucial.

The role of adult-guided reminiscing Over the past three decades, it has become established that parents, and in particular mothers, show individual differences in the way in which they reminisce with their preschool children (for a review, see Fivush, Haden, & Reese, 2006). Parents differ along a dimension of elaboration (Fivush & Fromhoff, 1988; Hudson, 1990; Reese, Haden, & Fivush, 1993; for a review, see Fivush, Haden, & Reese, 2006), such that some parents reminisce about the past in more elaborated ways, providing more detailed information, asking more open-ended questions and inviting and reinforcing their children's participation in the reminiscing conversation to a greater extent through the use of more evaluations and confirmations. In contrast, parents who are less elaborative reminisce about the past in more spare ways, providing little detail, asking few questions and providing little evaluation and feedback. To illustrate, here is a highly elaborative mother reminiscing with her 3-year-old child about a visit to the aquarium (from Reese et al.):

MOTHER: Remember when we first came in the aquarium? And we looked down and there were a whole bunch of birdies . . . in the water? Remember the name of the birdies?
CHILD: Ducks!
MOTHER: Nooo! They weren't ducks. They had on little suits. *(pause)* Penguins. Remember what did the penguins do?
CHILD: I don't know.
MOTHER: You don't remember?
CHILD: No.
MOTHER: Remember them jumping off the rocks and swimming in the water?
CHILD: Yeah.
MOTHER: Real fast. You were watching them jump in the water, hmm?
CHILD: Yeah.

Here we see that although the child has difficulty recalling accurate information, the mother continues to provide additional details, weaving a coherent story of what occurred. Contrast this with the following example of a less elaborative mother, also reminiscing with her 3-year-old child, about a visit to the zoo:

MOTHER: What kind of animals did you see, do you remember?
CHILD: Lollipops
MOTHER: Lollipops aren't animals, are they? Who, what kind of animals did you see?
CHILD: Giraffe.
MOTHER: You saw giraffes? And what else?
CHILD: RRROAR!
MOTHER: What's roar?
CHILD: Lion.
MOTHER: What else did you see?
CHILD: ROAR!
MOTHER: What else did you see?

In this example, when the child has difficulty recalling, this mother does not provide additional cues and details of the event, but simply repeats her questions, asking the child to list information rather than following in and elaborating on provided information to create a story.

Perhaps not surprisingly, parental reminiscing style influences child outcome both concurrently and over time, such that children of parents with a more elaborative style engage in reminiscing conversations more fully, and by the end of the preschool years are able to independently provide more detailed and coherent narratives of their personal past than are children of parents with a less elaborative style (Bauer & Burch, 2004; Farrant & Reese, 2000; Fivush, 1991; Flannagan, Baker-Ward, & Graham, 1995; Haden, 1998; Harley & Reese, 1999; Hudson, 1990; Peterson, Jesso, & McCabe, 1999; Peterson & McCabe, 1992; Reese, Haden, & Fivush, 1993; Welch-Ross, 1997). These relations are observed for the typical events of everyday life, as well as for emotionally salient and traumatic events, such as recollection of a devastating tornado (Bauer, Burch, Van Abbema, & Ackil, 2007) and trips to the emergency room (Sales, Fivush, & Peterson, 2003).

Importantly, parental reminiscing style is context-specific. That is, parents who are more elaborative in reminiscing contexts are not necessarily more talkative overall, nor are they more elaborative in other conversational contexts such as book reading, free play, or caregiving routines (Haden & Fivush, 1996; Hoff-Ginsburg, 1991). Moreover, parental reminiscing style uniquely predicts children's narrative recall even when children's language skills and temperament are controlled (Farrant & Reese, 1996; Reese, 2002a, 2002b). Finally, more experimental studies in which mothers are instructed to be more elaborative demonstrate that maternal elaborative reminiscing directly predicts children's narrative recall (Peterson, Jesso, & McCabe, 1999). Relevant studies with fathers have not been conducted. Thus it is clear that children are learning how to narrate their personal experiences through participating in parent-guided reminiscing about the past.

Durability and density of early memories There is strong reason to believe that the adult guide that one has in reminiscing has far-reaching influences, throughout childhood and into adulthood. Although most of the research on the effects of parental reminiscing style has focused on the preschool years, long-term longitudinal studies reveal that children of mothers using a more elaborative style produce longer and more detailed memories throughout the school years (again, relevant studies with fathers have yet to be conducted). For example, mothers who were more elaborative when their children were $3^1/_2$ years of age had children who made more contributions to the conversations when they were 8 years of age (Fivush, unpublished data). The relation extends beyond collaborative to independent narratives. That is, children whose mothers were more elaborative when they were 3 years of age produced more detailed and more complete independent narratives at the age of 9 years (Bauer, 2007b).

Although the relations between maternal style and later collaborative and independent narratives are correlational (not causal), the patterns suggest that exposure to an elaborative conversational style early in the preschool years has lasting effects that work to increase the amount that older children remember about early life experiences. Indeed, the effects may help to explain the phenomenon of childhood amnesia (the relative paucity among adults of events from the first 3 to 4 years of life). Jack, MacDonald, Reese, and Hayne (2007) provide evidence that as adolescents, individuals whose mothers were more elaborative with them during the preschool years, have earlier first memories than children of less elaborative mothers. We have replicated this relation in an independent sample (Larkina, Merrill, Fivush, & Bauer, 2009). Children and their mothers engaged in joint reminiscing when the children were 40 months of age. When the same children were 14 years of age, we used an online survey to collect their earliest memories. The adolescents whose mothers were highly elaborative in conversation in the preschool years provided earlier memories ($M = 2.70$ years) than children whose mothers were less elaborative ($M = 3.33$ years). These studies indicate that maternal reminiscing style could be one of the critical factors that influences the "boundary" of childhood amnesia.

Although much remains to be explored about the long-term consequences of early parental reminiscing style, the few studies that have begun to examine this question converge on findings that parental elaboration early in the preschool years is related to both earlier age of first memory as children grow older, as well as to children's own more detailed and coherent personal narratives. But as we have argued, recollection involves more than simply bringing a past event to mind; it involves the conscious awareness that one is recalling an event from one's own past; that is, it requires a sense of self as an experiencer across time (James, 1890; Tulving, 2002). It is to this development that we now turn.

Memories of the self It is generally accepted that autobiographical memory and self are intertwined (Conway & Pleydall-Pearce, 2000; McAdams, 2001), in that autobiographical experiences partly define the developing self-concept and the current self-concept colors memory of the past. But recollection further implies that the current self is recalling a past self that experienced an event in a particular way. This is actually quite a complex cognitive accomplishment. To manage it, children must be aware that they exist through time as a continuous being, that their memories are cognitive representations of events experienced by the self in the past, and that these representations may or may not be accurate and/or consistent over time. As time passes, one may reinterpret and re-evaluate past events in new ways and now have a different perspective on the past than one did previously, or that others may have about that same event. Thus, the ability to recollect must rely, at least in part, on developments in understanding of self and other, and mind.

The early development of self-awareness Even infants have a rudimentary awareness of self in the moment (for an overview, see Rochat, 2009), but this early awareness does not coordinate a sense of self through time. The earliest indication of an enduring self-concept is related to self-referenced behavior during the mark task, in which a dab of color is surreptitiously placed on the child's nose or forehead. Children who then see themselves in the mirror and touch their own body where marked, as opposed to touching the image in the mirror, are said to have a concept of self (Lewis & Brooks-Gunn, 1979). This behavior appears developmentally anywhere between 16 and 22 months of age.

Interestingly, however, mark-directed behavior is still quite limited at this early age. Povinelli and his colleagues (Povinelli, 2001; Povinelli, Landau, & Perilloux, 1996) extended the mark task by videotaping children during a play interaction, during which a sticky note is surreptitiously placed on their head. Three-, 4-, and 5-year-old children are brought into an adjoining room immediately after the play session and shown a video of what just transpired. Four- and 5-year-olds, upon seeing themselves on the video taken just moments earlier, immediately reach up to remove the sticky note; 3-year-olds do not seem to coordinate the current state of the self with the immediately prior state of the self. Although many of them comment on the sticky note, pointing at the video screen, they do not reach up to remove it from their heads. Perhaps most interesting, 4-year-olds will reach up to remove the sticky note even if they see the video for the first time days later, suggesting that they are not quite coordinating concepts of self over time; they see themselves on video with a sticky note and assume it is still on their head. Five-year-olds perform as adults would be expected to. That is, they coordinate the pictures of themselves on a timeline and know whether or not the sticky note is still on their head: immediately after the play session, they reach up to remove the sticky note, but days later they do not. Thus the notion of a self extended in time, in which different views of the self can be coordinated across different time points in ways that allow children to understand when they are the same and when they are different, develops late in the preschool years.

Understanding of mental states is even more complicated (Astington, 1993; Wellman, 1990, 2002). Here children must learn that they themselves have mental states, such as thoughts, beliefs, desires, and emotions, that direct their behavior, and that others also have mental states that may be the same or different as one's own (e.g., *I like chocolate ice-cream but you prefer vanilla*; *I like going on roller coasters, but you are scared of them*). Even more complicated for recollection, children must learn that their own mental states can change over time (e.g., *I used to be sad when Mommy left me at daycare, now I am happy because I get to play with my friends*; *I used to be scared of dogs, but now I like dogs*), as well as that other people's mental states can change over time, and different people can remember the same event in different ways (e.g., *I remember seeing the giraffe at the zoo, but you do not*; *I remember Mommy was happy seeing Santa, but I was scared*). In essence, children must develop what has been labeled a "theory of mind" which allows them to coordinate their own mental states with those of others both in the present and in the past (for related arguments, see Fivush & Nelson, 2006).

The neural substrate for self One possible partial explanation for the protracted development of a sense of self extended in time, with thoughts, feelings, and reflections that are one's own, is that realization of these concepts seemingly depends on activity in a brain region that is late to develop. Neuroimaging work has revealed medial prefrontal cortex to be involved in a number of tasks that require self-referential processing. For example, when adults are asked to decide whether a scene evokes a pleasant or unpleasant reaction in them, activation in medial prefrontal cortex is observed. In contrast, deciding whether a scene is indoor versus outdoor evokes significantly less activity in this region (Lane, Fink, Chau, & Dolan, 1997). Activations in medial prefrontal cortex also are observed when individuals retrieve personal or autobiographical memories (Cabeza et al., 2004; Daselaar et al., 2008). Indeed, it may be that this neural region is "interested" any time one is required to reference internally generated information, such as one's thoughts or feelings (e.g., Simons, Gilbert, Owen, Fletcher, & Burgess, 2005). As described earlier, prefrontal cortex is famously late to develop. For example, it is not until late adolescence or early adulthood that adult levels of synapses (Huttenlocher, 1979; Huttenlocher & Dabholkar, 1997) and neurotransmitters such as acetylcholine (discussed in Benes, 2001) are reached.

Maternal reminiscing about mental states The requisite neural substrate provides the threshold for self-understanding, but social interaction is critical in how this self-understanding unfolds. That is, parents who are highly elaborative not only talk about past events in more detailed ways, they also include more narrative interpretation and evaluation, including information about what Bruner (1990) has called "the landscape of consciousness." By narrating events dense with thoughts, emotions, beliefs, and desires of self and others, parents who are more elaborative help their young children create narratives with psychological depth.

In general, parents who talk more about internal states have children who develop a larger vocabulary about internal states earlier in development, and show higher levels of understanding of mind (Carpendale & Lewis, 2004; Symons, 2004). Reminiscing about past internal states requires an even deeper understanding of mind, in that children must be able to coordinate states of mind of both self and other across extended periods of time. Moreover, it is exactly this form of awareness – that one may have different perspectives on an event either oneself over time, or from other people – that seems to be key for recollection. The awareness that it is the self recalling an event is illustrated in the following example of a mother reminiscing with her

4-year-old daughter about a friend who had spent the night (from Fivush, Brotman, Buckner, & Goodman, 2000):

MOTHER: I remember when you were sad. You were sad when Melinda had to leave on Saturday, weren't you?
CHILD: Uh huh.
MOTHER: You were very sad. And what happened? Why did you feel sad?
CHILD: Because Melinda, Melinda say, was having *(Unintelligible word)*.
MOTHER: Yes.
CHILD: And then she stood up on my bed and it was my bedroom. She's not allowed to sleep there.
MOTHER: Is that why you were sad?
CHILD: Yeah. Now it makes me happy. I also, it makes me sad. But Melinda just left.
MOTHER: Uh huh.
CHILD: And then I cried.
MOTHER: And you cried because ...
CHILD: Melinda left.
MOTHER: Because Melinda left? And did that make you sad?
CHILD: And then I cried *(makes "aaahhhh" sounds)* like that. I cried and cried and cried and cried.
MOTHER: I know. I know. I thought you were sad because Melinda left. I didn't know you were also sad because Melinda slept in your bed.

In this example, we see that the mother and child are engaged in discussing both what the child felt and why. The conversation is an aid to the child's understanding of her own evaluation of the experience, both when it occurred and in the present, as well as a negotiation about what the mother thought the child was feeling, thus providing the child with a sense that mental states are internal, subjective, and must be shared for others to understand what one is feeling and why. By integrating discussions of internal states into reminiscing, parents who are more elaborative may be helping their children understand that remembering involves a subjective perspective; that one remembers from a particular point of view which may be the same or different over time and across individuals.

In general, parents who use more internal state language, and especially emotional language, when reminiscing with their preschool children have children who use more of this kind of language in these concurrent conversations (for an overview, see Fivush & Haden, 2005). More importantly, there is limited but growing evidence that earlier parental reminiscing about internal states is related to children's developing use of this kind of language in their own autobiographical narratives. For example, Rudek and Haden (2005) demonstrated that mothers who use more language reflecting mental states, words such as *know*, *understand*, *believe*, during reminiscing when their children are 3-years-old, have children who at age 5 use more of this kind of language in their independent autobiographical narratives. Regression analyses suggest that mothers influence children's concurrent use of this kind of language, which, in turn, predicts children's later use of mental state terms in autobiographical reminiscing. Bauer et al. (2005) also found that mothers' use of internal state language when reminiscing with their 7–11-year-old children about a highly stressful tornado 4 months after the storm, was related to children's use of mental state words in an interview 11 months later. Finally, Kuebli, Butler, and Fivush (1995) found that maternal use of emotion language when reminiscing with their 3-year-old children was related to children's use of emotion language 2 years later. Although only a handful of correlational studies have addressed this issue, it seems that mothers who focus more on the internal "landscape of consciousness" that provides a subjective perspective on personal experience have children who come to tell autobiographical stores richer in subjective perspective themselves.

The Development of Recollection

Evidence from both neurological developments and memory behavior as it evolves in social interaction converge on the idea that recollection is a complex process with a long developmental history. Whereas many of the requisite neural structures for recall are developed by the end of the first year, and infants are already able to recall distinctive information about specific events in an organized temporal order, developments in neural structures, language, and self-understanding continue and are modulated through parentally guided reminiscing in ways that create individual differences in children's trajectory. Parents, and especially mothers, who help their children create more elaborated personal narratives saturated with internal state language have children who come to tell autobiographical narratives that are more coherent, more detailed, and more subjective. Thus it seems that, whereas neurological developments set the stage for recollective experiences, it is through social interactions that allow for integration of memory, language, and understanding of self and other, that recollection emerges.

If it is the case that recollection is an activity that emerges in particular kinds of social interactions, then it would follow that recollection, although universal among humans, may take different forms in different social and/or cultural contexts. Although beyond the scope of this chapter, it is the case that recollective experience is culturally variable (for a full theoretical discussion, see Wang, 2001), and may also vary by gender (for an overview, see Fivush & Buckner, 2003).

Moreover, recollection continues to develop across the lifespan. In this chapter, we examined the early emergence of recollective ability, but theory and research further suggest that recollection may take on new forms and functions at key developmental transitions. One such transition is adolescence, as individuals develop the social and cognitive skills that allow for a more overarching and integrative ability to connect the past, present, and future, as well as more sophisticated perspective taking skills, that allow for the construction of an extended life narrative (Habermas & Bluck, 2000; McAdams, 2001). Other transitions include mid-life, as individuals take on the task of understanding their lives from a broader societal perspective (McAdams, 2001), and old age, as individuals look back over their lives to create a sense of integrity (Webster, 2001).

We began this chapter with a quote from William James. With the convergence of multiple developmental threads across the preschool years, we move from the abyss of oblivion to the self-reflective ability to state, as in Lerner and Loewe's (1958) famous song lyrics, "Ah, yes, I remember it well."

Note

1. Whether memories ever are wholly independent of the hippocampus is debated. Not debated, however, is that damage to medial-temporal structures impairs acquisition of new information (Zola & Squire, 2000); the impairment is most pronounced for episodic features of events (e.g., Vargha-Khadem et al., 1997). Also clear is that with time, memories become less vulnerable, suggesting they have stabilized.

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12

You Get What You Need

The Psychosocial Functions of Remembering

Susan Bluck, Nicole Alea, and Burcu Demiray

Introduction

Throughout the history of psychology, theoreticians have from time to time sought to remind researchers and scholars that individuals live in the world (Bronfenbrenner, 1977; Gibson, 2003). That is, when studying or modeling human perception, emotion, thought, or behavior we would do well to attend to the role of the environment in understanding how such processes occur within the individual (Stokols, Clitheroe, & Zmuidzinas, 2000). The study of memory can also benefit from examining individuals in context (Zacks, Hasher, & Li, 2000). Eloquent reminders to examine memory in the context of everyday life have occurred at regular intervals (Bartlett, 1932; Baddeley, 1988; Neisser, 1978). The focus of this chapter is to explore how taking a functional perspective can help researchers better understand how and when autobiographical memories are retrieved. A central tenet of the functional approach is that memories are retrieved at particular times in particular person-environment contexts because individuals need them to serve self, social, and directive functions (Bluck & Alea, 2002).

We first review the Self-Memory System (SMS) model (Conway & Pleydell-Pearce, 2000; Conway, Singer, & Tagini, 2004), a prominent theory of autobiographical memory organization and retrieval. The model is reviewed in relation to its role in voluntary and involuntary retrieval. In the

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second part of the chapter, a tentative conceptual model is presented to highlight the benefits that might accrue from placing the SMS model, which has largely been described in terms of intrapersonal processes, more squarely in the environment. Finally, existing research on how autobiographical memory serves self, social, and directive functions in everyday settings is reviewed.

Review of Retrieval in the Self-Memory System

Autobiographical memories are not stored for retrieval in the brain as static, holistic representations (i.e., traces) but are reconstructed from abstract representations of past experiences (Mace, 2007). Retrieval of a given memory is a product of the SMS (Conway & Pleydell-Pearce, 2000; Conway, Singer & Tagini, 2004) and retrieval in any given instance is thought to occur in accordance with the current goals of the self. The SMS is a complex, dynamic coordinator of the relation between self and autobiographical memory. It consists of three major components: episodic memory, the long-term self, and the working self, as shown in Figure 12.1 (Conway, Singer & Tagini, 2004). These components are briefly reviewed here with a particular focus on their role in retrieval.

Episodic memory contains the event-specific sensory, perceptual, cognitive, and affective details that invoke a feeling of remembering or even

FIGURE NOT AVAILABLE

Figure 12.1 Generation of autobiographical memories (Conway, Singer, & Tagini, 2004).

reliving on retrieval (event-specific knowledge; Conway, 2005; Conway & Pleydell-Pearce, 2000). Most episodic information remains available for retrieval for short periods of time (i.e., minutes, hours, days) and then decays. Some episodes, however, are retained for longer periods and integrated into the autobiographical knowledge base where it can be later retrieved.

The *long-term self* consists of the *autobiographical knowledge base* and the *conceptual self*. The autobiographical knowledge base includes remembered personal knowledge that is hierarchically organized into the *life story schema* (Bluck & Habermas, 2000) which is the global story of one's whole life, *lifetime periods* which might be considered the chapters of the life story (McAdams, 2001; e.g., "when I lived in the United States," or more emotionally meaningful periods such as "when my father was dying"), and *general events* that represent single personal memories, generic personal memories (i.e., of repeated episodes), and autobiographical facts (Brewer, 1986). Connection of the periods and events of one's life into a life story sometimes occurs through *autobiographical reasoning* (i.e., temporal, causal, and thematic linking; Habermas & Bluck, 2000). Retrieval of a specific autobiographical memory requires a stable pattern of activation over the various levels within the knowledge base. Note that this hierarchical organization is closely aligned with Neisser's (1986) ecological view of the nested structure of autobiographical memory, and has been empirically demonstrated (e.g., Burt, Kemp, & Conway, 2003) using both diary and photography methodologies. In short, the autobiographical knowledge base constitutes an organized and connected body of information about one's past that can be accessed during retrieval. The *conceptual self* contains a different type of information: abstract information about the self that is known, not remembered. For example, it includes socially constructed schemata such as personal scripts and possible selves, as well as one's attitudes, beliefs, and values (i.e., an elaboration of self-schema; Brewer, 1986). The autobiographical knowledge base feeds the conceptual self with new personal information that is abstracted and crystallized in the conceptual self. Conversely, the conceptual self contributes to the organization of autobiographical knowledge in this bidirectional relationship that produces the long-term self.

In contrast to the long-term self, the *working self* includes immediate control processes that coordinate and modulate current cognition, affect, and behavior (Conway & Pleydell-Pearce, 2000). The working self is seen as a process (Conway, Singer & Tagini, 2004) of categorizing and evaluating incoming stimuli. The working self is responsible for generating mental models of the psychological present: through the working self, existing goals in the current moment are made salient and evaluated, and priorities are established for goal processing.

The working self collaborates with episodic memory and the long-term self

Autobiographical memories are generated as a result of the interaction between the three components of the SMS (Conway, Singer, & Tagini, 2004). The reciprocal relation between the long-term self and episodic memory is mediated by the working self through current self-goals. These goals determine which episodic memories are needed for goal attainment and should currently be retrieved and in what form. As such, autobiographical memories are generated and retrieved in ways that serve the prioritized goals of the working self, though when retrieval is in process all components of the SMS are interactively involved. That is, retrieval from autobiographical memories constitutes a collaborative pattern of activation guided by the working self but involving episodic memory and the long-term self.

Types of retrieval and the SMS

The SMS model describes how both generative and direct retrieval occur (Conway & Pleydell-Pearce, 2000). Note that generative retrieval is related to intentional voluntary recall whereas when direct retrieval occurs the individual may have the sense that the memory just "popped to mind." That is, direct retrieval is responsible for what have been termed *involuntary memories* (Berntsen, 1996; Mace, 2007). Generative retrieval requires control processes such as cue elaboration to activate pathways throughout the autobiographical knowledge base, as well as the setting of verification criteria for when the retrieval model has accessed the relevant material. When verification occurs, a memory is constructed. In direct retrieval, a cue that activates event-specific knowledge (in most cases) in the autobiographical knowledge base is mapped through spreading activation to a general event and lifetime period and is then assessed for its correspondence with working self-goals (for concerns with this view, see Berntsen, 2007). If there is correspondence with self-goals, the individual experiences spontaneous involuntary recall. Such recall occurs several times per day (Berntsen, 1996).

Retrieval In Situ:

You Get What You Need

The above is only a brief summary of the detailed explication of the SMS by Conway and colleagues (Conway & Pleydell-Pearce, 2000; Conway, Singer, & Tagini, 2004). Their model has advanced our theoretical understanding of autobiographical memory and clearly elaborates central components and important processes of remembering. One aspect of the model that may not have been well elaborated, as yet, is the role of the environment in retrieval (i.e., the environment is only alluded to in the notion of cues). The environment is important in why we remember what we do, when we do. The environment is also often a part of what we retrieve when we construct an autobiographical memory (i.e., *where* is a canonical feature of most memories; e.g., Brown & Kulik, 1977; Wagenaar, 1986). In this section, we consider the role of the environment from a functional perspective in the hopes that these rather speculative considerations might over time help to refine the SMS model. These considerations have implications for understanding the retrieval of both voluntary and involuntary memories.

The functional approach

Various researchers have described the benefits of a functional approach to memory (e.g., Baddeley, 1988; Bruce, 1989; Neisser, 1978; Pillemer, 1992): the primary concern is not with how well humans remember their personal past (though performance and accuracy do play a role), but with *why* humans remember mundane and significant life events often over long periods of time. Much of the memory research literature to date has focused on performance and accuracy. Examining function provides a different and potentially complimentary view of the remembering individual: Organisms are not simply information processors (emphasis on memory capacity and veridicality) but are processing information as it flows by them in their ecological context (emphasis on memory utility in serving adaptive purposes). One of the major tenets of the functional approach is that organisms, including people, are dynamic systems whose behavior occurs at least partially in response to their current environment in order to allow adaptation.

In the following, four aspects of the SMS model are discussed with extensions or reinterpretations based on placing the SMS in an environmental context (see Figure 12.2). As per Baddeley (1988), these comments are an attempt to move theory forward through grounding it in ecological phenomena. This is not meant to be an exhaustive overhaul of the model, but simply to provide insights into how future iterations of the model might benefit by giving the person-environment interaction a larger guiding role in the retrieval of autobiographical memories.

Tension between Correspondence and Coherence? In terms of the distinction between *adaptive correspondence* (i.e., sensory-perceptual records of goal activity which are experience-near) and *self-coherence* (i.e., long-term stores of conceptually rich, remembered information) (Conway, Singer, & Tagini, 2004), the functional approach is in line with Conway

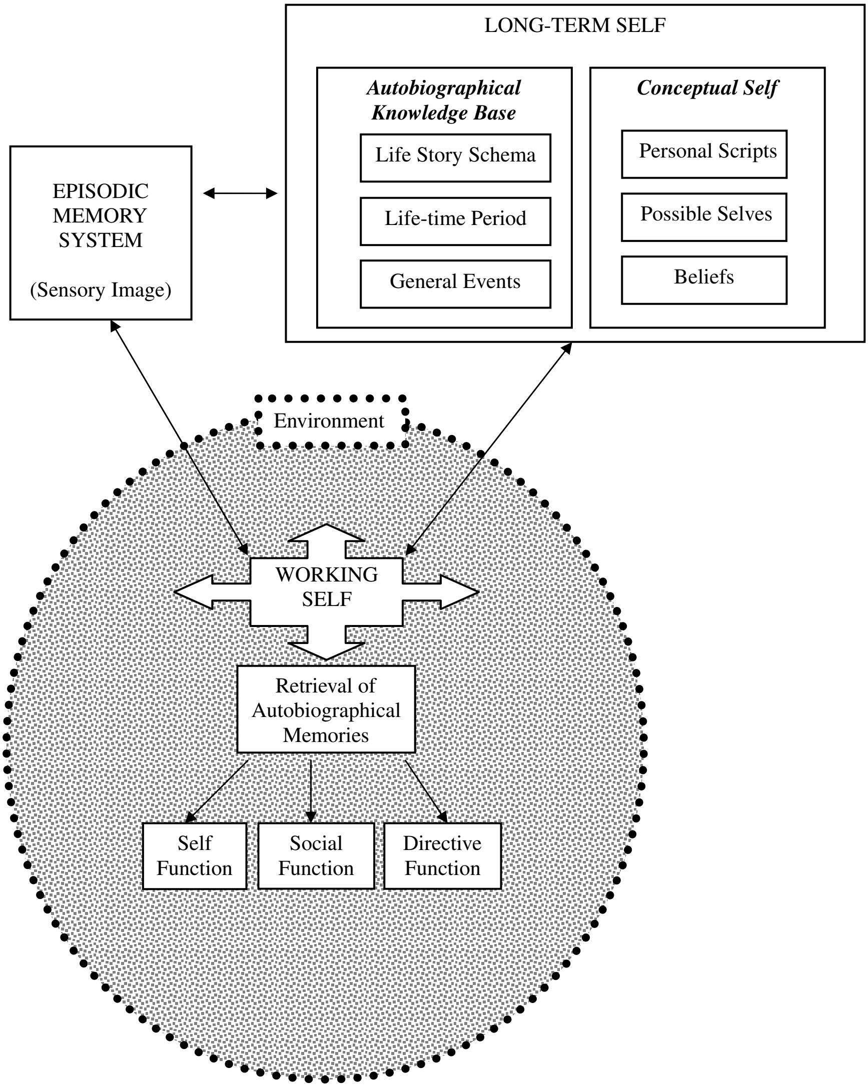

Figure 12.2 A functional model of autobiographical memory retrieval.

et al.'s (2004) suggestion that memory must show correspondence with actual experiences in one's environment. More specifically, from a functional perspective the way that memory is organized is a reflection of the experienced human environment. That is, memory is organized to reasonably correspond to the nested structure of reality (Neisser, 1986).

Autobiographical memory must also have coherence, however, in the sense that it cannot simply be a mostly-correct record of a series of scattered individual experiences of the self in the environment, but must provide a coherent and meaningful record of the self over long periods of time (e.g., one such coherent organization may be the *life story schema*; Bluck & Habermas, 2000). The point of departure from Conway and colleagues is that from a functional perspective there is not a tension between correspondence of memory with the outer environment and the development of a coherent sense of self over time. Instead, the self over time exists at all moments in the environment or, if considered at the micro-level, in a series of ever-changing environments. Thus, the correspondence of autobiographical memory (i.e., the record of one's lived experiences in the environment) and the coherence of the self (i.e., the psychological representation of the one doing the living) are integrated. Adaptive correspondence is necessary for, not in tension with, self-coherence. The human organism must ground its awareness of the past and current self in the lived environment to ensure its ability to adaptively negotiate current and future situations. Although this may seem only a subtle change of perspective, it has implications. For example, from the perspective of tension between correspondence and coherence one might suggest that individuals show "inaccuracies" in memory that represent "biases" that are used to promote an "illusory" positive view of self. From the functional perspective, this would be seen as an organism perceiving their environment and storing and retrieving information in the manner that is most adaptive.

Organism–Environment Interaction To be clear, Conway and colleagues (Conway & Pleydell-Pearce, 2000; Conway, Singer, & Tagini, 2004) certainly acknowledge that individuals process information in their environment. They have done yeoman's work in elaborating the intra-individual processes that relate self to autobiographical memory. Reference to the environment or situational context in their models thus far, however, has been limited to implicit reference through the use of constructs such as cues and task demands.

Given the SMS model presented in Figure 12.1 (from Conway, Singer, & Tagini, 2004), which aspects of this system might be most in contact with, and thereby responsive to, the person's situational context (i.e., the environment)? As shown in our tentative new model in Figure 12.2, it is the working self that most directly interfaces with the environment (i.e., in SMS terms, is processing cues and task demands). Of course, one could argue that the entire SMS is embodied and that each human body exists in a larger context. For conceptual purposes, however, the figure diagrams the environment encircling only the working self and the functions served in person-environment interactions.

The basic question that arises in taking a functional perspective is whether all retrieval is driven by working self-goals (as per the SMS model) or whether some memories are largely retrieved because they are adaptive in the given environmental situation but are not actually linked (or strongly linked) to the larger hierarchy of self-goals. That is, we suggest that the environment may be an equal player with the hierarchy of self-goals in driving retrieval. Enduring goals of the self are certainly likely to influence retrieval in various ways. It may be, however, that in individual situations the momentary, transient retrieval of specific memories is largely driven by proximal environmental demands.

Thus, a person, Chloe, is in her environment (i.e., in this case, working on a paper at her desk) and something happens in her environment. For example, another person, Irene, walks in and is crying. Irene and Chloe have been good friends for many years. A moment ago Chloe's retrieval of autobiographical memories was largely dependent on goals of the self (e.g., at multiple levels she was being conscientious; creating a good storyline for her article; typing the letter C). As nothing about her environment was particularly impinging on her consciousness, her goals were largely self-directed. This new happening in her environment, however, is captured by the working self as part of its role in monitoring the psychological present. Notice how the constructs "cue" or "task demand" could be used to describe this situation but don't fully capture the situation of a calm, concentrated Chloe being assailed by a weeping Irene. Thus, without Irene entering the scene the entire chain of mental events that follows (including retrieval) is highly unlikely to occur. Given that this new event has occurred in the environment, we suggest that the working self does not simply access the hierarchy of self-goals to decide if dealing with this situation is relevant to existing self-goals or not. Instead, Chloe has to respond to this situation in one manner or another, regardless of whether it fits with her current self-goals. The environment places demands on the individual. The working self must certainly access some long-term self-goals (e.g., Chloe knows that she is a kind and sensitive person) and some autobiographical knowledge (e.g., she remembers having known Irene over many years).

The working self also, however, must ask whether this is a situation in which retrieval of existing autobiographical knowledge might be adaptive, that is, serve a psychosocial function. This situation could be handled with or without retrieval of past information. It might, for example, be handled simply through listening and proffering a handkerchief. Alternatively, it might be adaptive to access relevant personal memories that could be helpful for, in this case, social bonding. This might be done through generative retrieval (i.e., Chloe actually tries to remember having been in some similar situation herself) or may occur through direct retrieval (i.e., Chloe sees Irene and suddenly remembers a situation in which she herself was also very upset). If the situation appears to be one in which remembering might be a boon for dealing with environmental events, then the autobiographical knowledge base is activated through the episodic memory system. The search, either voluntary or involuntary, is now on to retrieve an autobiographical memory that Chloe will ponder and/or share in order to feel and show empathy (a facet of the social bonding function) to Irene. Retrieval, or construction, of the memory takes place as described in the SMS model with the addition that the exact memory that is retrieved, the emphasis on particular aspects of the retrieved event (e.g., emotional aspects over setting features), and the boundaries of the memory (i.e., where the "story" begins and ends in the current retrieval session) are guided not only by self-goals but by environmental (in this case social-interactionist) demands. That is, retrieval is also guided by the demand to produce a memory that attempts to, in this case, serve the function of creating a great social bond between Chloe and Irene through empathy.

Self-Goals in Relation to Functions of Remembering The functional perspective suggests that there are broad classes of functions served by autobiographical remembering (self-continuity, social bonding, and directive functions; Bluck & Alea, 2002; Cohen, 2008; Pillemer, 1992). How does the construct of functions of autobiographical remembering fit with or differ from the construct of self-goals in the SMS? Though the exact overlap between them will not be fully elaborated here, we suggest that functions are a more fundamental, less differentiated construct than self-goals and may be based in human evolutionary history (Neisser, 1988). That is, we would argue that all humans need to maintain self-continuity in order to navigate their daily lives (Bluck & Alea, 2008). A sense that one is the same person across a continuous biographical timeline is a basic necessity for engaging in a whole range of other behaviors. Theorists have also suggested that the most primary function of autobiographical remembering is social bonding (Neisser, 1988; Nelson, 2003). In order to survive and thrive, humans must form ties with kin and non-kin, and remember other individuals in order to build groups and communities. Directing one's present and future behavior is the third broad function of autobiographical remembering. Humans use memory to build models of the world (Lockhart, 1989) that can be used to make choices and set plans for future behavior. They also sometimes draw on specific episodes to guide them in like circumstances (Pillemer, 1998). Thus, the functions of autobiographical memory refer to some of the fundamental requirements of the human organism.

The current goals of the working self may sometimes reflect these larger functions, but are not in themselves as fundamental. As in the Chloe and Irene example, the individual may retrieve a memory to serve the fundamental function of maintaining social bonds with others. At the level of goals represented in the long-term self, she may be carrying out the goal of being a "good friend" because she is a kind person, and at the level of the goals of the working self that manifests as redirecting her attention from the paper she is writing to fully listen and attend to Irene.

While the functions of autobiographical memory may be more fundamental to the organism, the utility of self-goals is also clear: they are not fundamental but instead are flexibly and responsively created and changed to fit the idiosyncratic life trajectory of the individual person. That is, current self-goals, as per Conway, Singer, and Tagini's (2004) model, draw on scripts, possible selves, beliefs, and attitudes of the long-term self. As such they are molded by cultural expectations and differences such that individuals of different ages, gender, and cultural background develop an idiosyncratic and unique sense of self and self-goals. In sum, functions represent necessary adaptations of all members of the human species, and self-goals represent unique, individual manifestations of individual organisms.

Involuntary Remembering The SMS model outlines how retrieval of both voluntary (generative retrieval) and involuntary (direct retrieval) memory occurs. Both types of retrieval involve processing information from the environment or sometimes from one's own thoughts (e.g., chaining; see Mace, 2009). Voluntary memory is a highly useful tool for humans as it allows us to volitionally find information about the past just when we need it. It appears, however, that at least by its broadest definition, involuntary memory is likely to be a more common phenomenon. That is, most episodes retrieved in a given day are likely to be cued by our outer or inner environment directly, not sought after through an intentional explicit search (see Franklin & Baars, Chapter 6, this volume; Mace, Chapter 3, this volume; Richardson-Klevahn, Chapter 7, this volume). Berntsen's (2007) recent model of retrieval of involuntary memories insightfully combines motivational and environmental features. She argues that individuals process information in their immediate situation (i.e., large role for environmental cues) in the context of their current life situation (i.e., certain current cues are more salient because they are relevant to longer-term concerns given the individual's larger life context).

Given that involuntary memories may be more common than voluntary recall in daily life, researchers are now referring to different categories of involuntary memories (Mace, 2007). For example, one such type is the classic involuntary memory of Proust's current taste of a madeleine transporting him back in memory, back into a very specific environment (i.e., his Aunt Leonie's room) in which he had tasted madeleines before. He recalls how, "the old grey house, where her room was rose up like the *scenery of a theater* . . . and with the house, the town" (Proust, 1928/1998, pp. 66–67). The passage describes a simple environmental stimulus at a sensory level (i.e., a taste) cueing a distant memory of the self in another environment. Thus, a person's environment at the time of an event can be such an essential feature of the memory that even a small match with one's current environment allows full retrieval of the environment in which the original event occurred. Thus the environment is important both as a source of current input that may necessitate retrieval, and as a central feature of already experienced events. For example, note that involuntary memories are most often cued by environmental events (Bertnsen, 2007) and many involuntary memories involve a peripheral feature of a current event or environment acting as a cue for a memory in which that feature is not peripheral but quite central (Berntsen, 2007). This suggests that while memory is organized according to thematic content of what occurred (Conway & Pleydell-Pearce, 2000) and events may be clustered temporally (Brown, 2005), the remembered environment, or "the home of the self" at the time of the event, can also be an important feature.

Evidently, more recent research has shown that this Proustian category of involuntary memory is not particularly common (Berntsen, 2007; for a discussion, see Ball & Mace, 2007). For example, about 40 percent of involuntary memory cues are abstract, but involve being cued by words exchanged in social conversations. These language-based cues are likely related to multiple functions depending on their content. Still, about 30 percent of involuntary memories are cued by sensory information in the current environment (Ball & Mace, 2007). Although classic Proustian memories are not the most common type of memory, they may still reveal something important about retrieval. What they may demonstrate is that the occurrence of a particular feature in the environment (i.e., in this case, a taste) can access the autobiographical knowledge base with little reference to specific working self-goals. We speculate here that this type of involuntary "precious fragment" (Linton, 1986) might, however, serve a larger self-continuity function. This type of involuntary memory has been shown likely to occur when the individual is in a diffuse attentional state (Berntsen, 1998). Could these memories simply be pulling the organism back to conscious consideration that they existed in the past, and that they exist now? That is, the function of such Proustian memories is to serve as a basic reminder that the individual is located in space across time. This notion is at least consistent with findings that involuntary memories tend to be more frequently of specific episodes than voluntary memories (Berntsen & Hall, 2004) and that they are likely to be of temporally remote scenes with high levels of contextual detail that involve a strong sense of traveling back in time and are accompanied by positive emotion that is not so much connected to the recalled event but to the experience of recalling it (Berntsen, 2007).

This discussion has centered, so far, on the role of the environment on retrieval of an infrequent type of involuntary memory. Involuntary memories are not usually of the Proustian type and are infrequently cued by sensory triggers (Mace, 2007). They are more commonly episodes that are cued by other memories one has (i.e., through clustering, Brown, 2005; or chaining; Mace, 2009). Note, however, that involuntary memories may also arise in relation to memories that others in our environment are sharing with us (e.g., mutual reminiscence, co-construction of remembered events; Ball & Mace, 2007; Pasupathi, 2001) or by situations that arise in our environment and need attention. Through responding to the environment, and to the memories of others in the environment, individuals are able to build representations of others and of the world (Lockhart, 1989). But, crucially, one's own biographical identity is also located in the context of relations to others and to the world. Thus, self-continuity (self over time) is maintained but by connecting our own memories of being in the world and interacting with others, there is also a continual location of self in the ever-changing environment.

In sum, retrieval of involuntary (as well as voluntary) memories occurs in response to person-environment interactions. Environmental features of the immediate situation act as cues for retrieval of memories that are relevant and adaptive to the individual (Berntsen, 2007). While the environment provides a context for retrieval, location or environment is often also a central feature of the recalled event. Both voluntary and involuntary remembering may thereby serve psychosocial functions such as helping individuals to maintain a sense of self-continuity over time, or to perceive themselves in situ.

A Review of Empirical Research Using a Functional Perspective

We have argued above that adopting a functional approach to understanding memory retrieval, whether voluntary or involuntary, necessitates placing the working self in context. Memories are generally retrieved when they are useful, at the moment when they are needed, and with the scope that is needed, to meet psychosocial functional demands placed on the individual by their environment. This section demonstrates the utility of the functional approach in generating novel and interesting research questions through a review of empirical research that has adopted the functional approach. Autobiographical memories have been theorized to serve three major functions: self, social, and directive (Bluck & Alea, 2002; Cohen, 1998; Pillemer, 1992; see also Webster, 2003, for reminiscence functions), and the review below provides insight into how memories, when recalled in their ecological context, serve each of these.

The self function

The self function involves retrieving autobiographical memories to maintain a sense of being the same person over time (i.e., self-continuity; Barclay, 1996; Bluck & Alea, 2008) or to update the self while maintaining continuity (Conway, 1996). Retrieval of memories provides one with knowledge of the self in the past, and how past self-knowledge relates to the present and the projected future self (Bluck, Alea, Habermas, & Rubin, 2005; Conway, Singer, & Tagini, 2004; Neisser, 1988). Retrieving autobiographical memories to maintain a sense of self-continuity may be particularly important when individuals face a threat or challenge to self-continuity because of external changes such as facing a negative event, or moving to a new country or city (Bluck & Alea, 2008; Robinson, 1986). Internal changes such as feelings of anger or sadness can also trigger retrieval of autobiographical memories as an emotion regulation strategy to improve feelings about the self (Cohen, 1998; Pasupathi, 2003). That is, from a functional perspective, both external and internal environmental cues can trigger direct or involuntary retrieval of autobiographical memories that are recalled to serve the function of self-continuity as needed in the current environment.

Research on the self function of autobiographical memory has focused on asking individuals the extent to which they use autobiographical memories to meet self-continuity needs and whether retrieval facilitates the process of achieving a clear sense of identity. For example, in one study, when asked explicitly about the extent to which they retrieve and think about autobiographical memories to serve a self function, young adults self-reported using autobiographical memories to meet self demands quite regularly (i.e., from *occasionally* to *often* on a Likert scale; Bluck, Alea, Habermas, & Rubin, 2005). In follow-up work, Bluck and Alea (2008) provided additional evidence that memories are retrieved for self-continuity reasons when most needed. That is, individuals with low self-concept clarity or a self-concept that was poorly defined and not internally consistent were more likely to retrieve autobiographical memories to serve the self-continuity function. This was particularly true of the younger adults in their sample, who are faced with the developmental task, imposed by cultural demands, of forging a sense of adult identity (e.g., Habermas & Bluck, 2000).

Autobiographical memory retrieval also serves a self-enhancement function, in that individuals strategically recall past selves in a manner that is enhancing for the current self (e.g., Kanten & Teigen, 2008; Wilson &

Ross, 2000, 2001, 2003). In one study, for example, Wilson and Ross (2003) had undergraduates evaluate their current self and a self from the beginning of the term (i.e., a fixed time ago), which was couched as being either psychologically close or psychologically distant. Individuals in the psychologically close condition recalled their past self as similar to their current self (i.e., self-continuity). Those in the distant condition retrieved their past selves as inferior to their current self (i.e., self-enhancement). This research suggests that people not only use memory to maintain continuity but attempt to view recent selves as positive and continuous with their current self, while downgrading more distant past self memories as needed so as to feel more positive about themselves in the present (i.e., upward comparison). This enhancement adjustment in reflecting on the past occurs in other contexts as well, such as judging marital satisfaction (e.g., Karney & Frye, 2002). Thus, the past is recruited to meet current environmental demands (i.e., maintaining a strong sense of self or positive marital relationship). In terms of the discussion of correspondence and coherence above, this research provides an example of how both processes serve to shape memories such that they are functional for the individual.

The social function

The social function of autobiographical memory involves retrieving memories when needed in an effort to develop, maintain, and enhance social bonds with other individuals in the environment (Alea & Bluck, 2003; Nelson, 1993; Neisser, 1988; Pillemer, 1998). Research on the social function of autobiographical memory has taken several directions, focusing on functions served by retrieving memories to use in conversations, to develop intimacy with others, and to empathize with others. Autobiographical memories provide material for conversations with others (e.g., Cohen, 1998; Norrick, 2000; Pillemer, 1992) and are retrieved so that memories can best serve the social needs posed by the social interaction (Hyman & Faries, 1992; Pasupathi, Lucas, & Coombs, 2002). Hyman and Faries (1992), for example, asked individuals to report on previous autobiographical memories that had been shared with others. They found that common reasons for sharing these memories were simply to provide material for conversation (i.e., to create social ease), to update others about what was going on in one's life (i.e., to get to know the other better), and to teach and inform others who might benefit from one's experiences (i.e., to pass on useful information). Pasupathi and colleagues (2002) investigated spontaneous references to the past in long-term married couples' conversations about pleasant and conflict issues. Memories were retrieved for different reasons depending on the conversational context. When discussing pleasant topics, couples focused mostly on retrieving past experiences simply to enjoy reminiscing and to collaboratively re-evaluate the shared event (i.e., rehearsing positive social bonds). Discussing conflict topics led to different reasons for retrieval of autobiographical memories. This focused more on the fundamentals of the relationship, included using memories to explain oneself and to evaluate the other person (i.e., testing and attempting to repair or loosen social bonds). Thus, the conversational context influences the functions of autobiographical memory retrieval in social interactions (Alea & Bluck, 2003; Pasupathi, 2001).

Research on the social functions of autobiographical memory has focused on retrieving memories in an effort to initiate social bonds in new environments where others are unknown, by providing autobiographical information about oneself to others (Bluck, Alea, Habermas, & Rubin, 2005; Cohen, 1998; Nelson, 1993; Pillemer, 1998). Alternatively, when already in the context of an ongoing relationship, engaging in private or collaborative memory retrieval can be used to serve the function of enhancing the level of intimacy in the relationship (Alea & Bluck, 2007; Alea, Sanders, & Vick, 2008; Bazzini, Stack, Martincin, & Davis, 2007; Vick & Alea, 2008). Bluck and colleagues (2005) found that young adults self-report retrieving and sharing autobiographical memories in order to nurture existing social relationships, such as developing and strengthening friendships, more often than to serve other functions of autobiographical remembering. In a series of studies, Alea and Vick (Alea, Sanders, & Vick, 2008; Vick & Alea, 2008) examined whether retrieving and writing about various types of relationship memories (i.e., when one first met their current spouse, a positive event, a negative event) was related to marital satisfaction in the context of an ongoing relationship. They found that the relation of memories to marital satisfaction depended on whether the memory was positive or negative. Retrieval of negative memories was related to less marital satisfaction. Thus, even private memory retrieval without social sharing can influence social bonds. This has been further established in experimental work (Alea & Bluck, 2007) which compared whether retrieving autobiographical relationship events about one's spouse, compared to fictional relationship events (i.e., a control condition), differentially affected current feelings of relationship intimacy with one's spouse. Intimacy was enhanced only when autobiographical events were retrieved, and this was particularly true for women (for gender differences in the intimacy function of reminiscence, see Webster, 1995). Recent work with couples has also found that retrieving autobiographical memories about instances where the couple laughed together, as opposed to individual laughter-related events, was related to enhanced marital satisfaction (Bazzini et al., 2007). Thus, both private memory retrieval and joint reminiscing about the good times shared with one's partner can serve the function of enhancing feelings of intimacy in relationships.

A more recent line of research focuses on a different facet of social bonding. When the situation demands, retrieval of autobiographical memories can be used to elicit empathy and reassurance from others (Ainsworth, Bluck, & Baron, 2009; Bender, Lachmann, Pohl, & Chasiotis, 2008; Pohl, Bender, & Lachmann, 2005; Cohen, 1998; Robinson & Swanson, 1990). Pohl and colleagues (2005) had all participants retrieve specific autobiographical memories (e.g., first time riding a bike alone) and rate the extent to which they adequately and vividly recalled the event (e.g., the color of the bicycle). They found that as autobiographical memory performance increased, empathic concerns and willingness to take another's perspective also increased. Experimental studies are providing additional information about the relation between retrieval of autobiographical memories and empathy. In one study, participants were presented with empathy-inducing pictures or neutral pictures and autobiographical memory retrieval and empathy were measured. Those individuals who viewed empathy-inducing pictures had better autobiographical retrieval and showed greater empathic concern (Bender et al., 2008). In a different line of empathy research (Ainsworth et al., 2009) perspective-taking (i.e., one facet of empathy) was more likely to occur in response to an individual experiencing pain when participants were in a condition where they shared their own autobiographical memory of having been in pain. In the control condition, repeating the individuals' pain experience back to them did not affect empathy level. Thus, there is a growing body of research demonstrating that memories are retrieved in response to particular social situations in the environment such as for material in conversations, to sustain intimate bonds, and to show empathy to others.

The directive function

The directive function of autobiographical memory involves retrieving past experiences to guide present and future thoughts and behavior (Baddeley, 1988; Bluck, Alea, Habermas, & Rubin, 2005; Pillemer, 1998). Problems in one's current environment can sometimes be solved by retrieving autobiographical memories: if faced with a problem, individuals bring to mind memories of situations involving a similar problem and use the memory to work through the challenge (Bluck & Alea, 2002; Cohen, 1998; Pasupathi, Lucas, & Coombs, 2002). Comparatively little research has clearly examined the directive function of autobiographical memory. This is somewhat surprising since it is self-reported as being the most common reason why autobiographical memories are retrieved (Bluck et al., 2005). One reason for this lack of research may be that the directive function subsumes self and social functions so that the latter are more specific and amenable to study (Bluck et al., 2005). Pillemer (1998) has been a leader in the examination of the directive function of memory with his book, *Momentous Events, Vivid Memories*. He argues that the retrieval of specific personal event memories, as opposed to more abstract memory representations such as scripts (Abelson, 1981) or general memories (Nelson, 1993), provides important and often overlooked guidance for people as they face new situations in their lives. That is, he suggests that specific episodes can be powerful drivers of behavior in facing challenges posed by one's current environment, and that specific memories are often retrieved involuntarily when needed in response to current concerns (Pillemer, 1998, 2003). The book provides numerous examples of the power of retrieving memories of specific "momentous events" (e.g., witnessing the September 11 terrorist attacks in the USA) as a means for directing behavior (e.g., choosing not to fly or enter public places immediately following the attacks). Supporting these claims, in recent experimental work (Beaman, Pushkar, Etezadi, Bye, & Conway, 2007), researchers have found that the specificity of autobiographical memories (retrieved in response to cue words) predicted current social problem-solving ability in both younger and older adults.

The directive function of autobiographical remembering, then, basically suggests that memories of past experience are retrieved in a given current context in order to direct behavior and thought (Pillemer, 1992). This can occur through specific memories being related to, or representative of, the learning of a life lesson. Such lessons are utilized as a touchstone to decide what action to take, or more generally as a background for behavior; lessons can encapsulate important insights into one's self or life (McLean & Thorne, 2003). Some research in this area involves having individuals recall self-defining memories that are used as directives (Singer & Moffitt, 1991), and thus involves examining memory serving both self and directive functions through self-defining memories (e.g., Blagov & Singer, 2004; McCabe, Capron, & Peterson, 1991; McLean, 2005; Pratt, Norris, Arnold, & Filyer, 1999). Wood and Conway (2006), for example, found high levels of meaning-making in self-defining memories, particularly women's memories. That is, these women were attempting to develop higher-order lessons that could be derived from their experience for use in future situations. Making meaning out of past autobiographical events has also been seen as an effort to explain one's current self during late adolescence when individuals need guidance in the task of integrating their past to forge an adult identity (McLean, 2005). While adolescents may be using past memory to achieve developmental tasks, the tendency to see life lessons as attached to specific remembered experiences appears to increase in adulthood (McCabe et al., 1991; Pratt et al., 1999). Bluck and Glück (2004) report that after sharing a memory of a time in which they had acted wisely, most people also were able to produce a life lesson related to that memory that they report using in their current life. The likelihood of having a life lesson attached to one's memory was higher in adults than in adolescents. Thus, the directive function of autobiographical memory may become more prevalent as one grows older and the number and diversity of autobiographical episodes to draw upon increases. Use of the directive function may also be dependent on autobiographical reasoning skills that only fully mature in adulthood (Habermas & Bluck, 2000). In another study assessing lessons related to specific autobiographical memories, researchers found that individuals who work in a hospice environment were more likely to use death-related memories to serve psychosocial functions generally, but also were likely to relate specific autobiographical memories to the learning of life lessons about, for example, dealing with death in future and resetting life priorities for their current life (Bluck, Dirk, Mackay, & Hux, 2008; Mackay, Ainsworth, & Bluck, 2007).

Research from a functional perspective:

Summary

Individuals retrieve autobiographical memories to serve self, social, and directive functions that are useful in responding to their varied and changing social and physical environment. Much of the research to date has involved the voluntary retrieval of autobiographical memories (i.e., memories are retrieved in response to a researcher's request; cf., Pasupathi, Lucas, & Coombs, 2002). Thus, future research might also focus on the functions of involuntary retrieval of autobiographical memories. This is an important area for future research since retrieval in everyday contexts is likely to be largely involuntary in response to environmental context and cues. The review above also highlights the fact that individual characteristics may affect how one interacts with the environment and thereby the use of memory to serve different functions. For example, age and gender appear to have an impact on the goals of the working self and hence on the functions of the memories that are likely to be well remembered and retrieved by men and women across the lifespan. Other characteristics related to the working self, such as personality (e.g., Alea & Bluck, 2003; Cappeliez & O'Rourke, 2002) and cultural identity (e.g., Alea & Ali, in press; Wang & Conway, 2004; Wang, 2006), are also likely to impact how the individual views and processes information from their environment and thereby the ways in which memory can serve them in their daily life. While there is certainly room for further research, the body of research thus far is convincing evidence that adopting a functional approach provides an interesting window on autobiographical memory retrieval.

Conclusion

The focus of this chapter has been to examine autobiographical remembering from a functional perspective. This perspective emphasizes the role not only of intrapersonal processes, but of person-environment interactions in retrieval. The chapter reviews the self-memory system (SMS) model (Conway & Pleydell-Pearce, 2000; Conway, Singer, & Tagini, 2004) and provides four potential areas in which the SMS model might speculatively be improved upon by allowing a larger role for person-environment interactions in retrieval. Retrieval is thus viewed as an adaptive process by which "you get what you need" from memory in order to respond to the environment. Whether voluntary or involuntary, it is argued that memories are retrieved at particular times in particular contexts in order to serve self, social, and directive functions.

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Part IV

Theories of Abnormal Remembering

13

Exploring Involuntary Recall in Posttraumatic Stress Disorder from an Information Processing Perspective

Intrusive Images of Trauma

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Introduction

The ability to recall our past is a very valuable and characteristically human quality. Remembering earlier experiences gives us a sense of who we are, where we are coming from and where we are going (Barclay, 1996). It provides us with a personal identity and sense of self, and it is through memory that we learn and develop ourselves. In memory's most romantic form, we take a trip down memory lane and think back to that summer's night with our love and we fully enjoy the remembrance. Unfortunately, such a trip can also confront us with memories of negative experiences. For instance, the partner might have rejected and left us. Usually, although painful, we can endure these negative memories. Sometimes, however, we have experiences so horrific or frightening that we would rather avoid remembering them at all costs. Ironically, memories of extremely negative or traumatic events seem to

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be far less under our control than the more pleasant or neutral ones and are termed "intrusive memories."

> I was in my car that was parked in my street when a man puts a knife to my neck. He comes out of nowhere. I think I'm going to die and am afraid that he might hurt my daughter if he realizes I live there. I try to be calm. The mugger says "give me all your money" and he is aggressive. I think I'm going to die. He checks my pockets and rummages through my purse. I should be aggressive and scare him, like start the car, but I don't. He runs off and I look back to my house and see my daughter crying and banging at the door. Maybe she saw me and she could be traumatized. She's too young.

The example above is a reconstruction of a trauma memory that came to be intrusive for the mugging victim. We reconstructed the story based on actual reports from this victim collected by Holmes, Grey, and Young (2005, p. 9). The image of the mugger's knife on the neck and the daughter crying and banging on the door frequently haunt the victim, leading to high distress during this involuntary recall. In a follow-up study by Grey and Holmes (2008) more illustrations of intrusive images can be found. For example, one participant developed PTSD after a road traffic accident and reported intrusive memories of the moment when a scaffold on the pavement smashed the windscreen of the car. At that time, the participant thought that he or she would be decapitated and the intrusive image of the scaffold is accompanied by intense anxiety (Grey & Holmes, 2008).

PTSD is classified as an anxiety disorder in the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV-TR, American Psychiatric Association, 2000). This psychological disorder can develop after a traumatic event, which is defined in the DSM-IV-TR as a situation in which "the person experienced, witnessed, or was confronted with an event or events that involved actual or threatened death or serious injury, or a threat to the physical integrity of self and other" and "the person's response involved intense fear, helplessness, or horror." Examples of traumatic events are experiencing or being a witness of military combat, violent personal assault, and natural or manmade disasters (APA, 2000). The features that define PTSD are: *re-experiencing* the traumatic event such as intrusive images, thoughts, and nightmares; *avoidance* of reminders of the traumatic event such as avoiding conversations about the trauma or avoiding the scene where the trauma occurred; *emotional numbing*, featured by a lack of interest for significant activities and feeling alienated from others; and symptoms of *hyperarousal* such as sleeping problems, irritability, and exaggerated startle (APA, 2000). Posttraumatic stress symptoms such as the ones described are common after a traumatic event. Therefore, only in a case where they persist for more than one month is the diagnosis of PTSD considered.

PTSD is featured by several striking memory phenomena. For example, although a traumatic memory is usually very detailed, PTSD patients may have trouble with effortful and deliberate recall of their experience, or so-called trauma-related amnesia. Furthermore, traumatic memories can be activated by triggers that seem to have "generalized" from the initial encoded information (Conway & Holmes, 2005). What is striking about re-experiencing in PTSD especially is that it tends to disrupt ongoing activities and create attentional problems, often impairing important life aspects. The present chapter focuses on re-experiencing in the form of intrusive images of the index trauma. Intrusive images can be described as uncontrollable and unbidden mental pictures that pop into consciousness. An intrusive image is often a memory representation[1] of the traumatic event, rich in sensory detail, which is illustrated by the mugging example presented above. Because intrusive images develop in almost all PTSD patients (Speckens, Ehlers, Hackmann, Ruths, & Clark, 2007), it is a highly salient and important topic in clinical practice. A major goal of therapy is often to reduce the frequency of involuntary recall as well as the impact that this re-experiencing of the traumatic event has on the patient. Symptoms of re-experiencing are intriguing because they are somehow different from our "normal" memories, those we can access and control more or less at will. The unbiddenness and uncontrollability that characterize intrusive images indicate that during the processing of traumatic information something "unusual" happens. As a result, intrusive images can lead to the subjective experience that the event is actually happening right now, rather than that the experience is something from the past. PTSD sufferers can relive the traumatic event and experience the negative emotions that were present in the original experience in a full-blown flashback. Markedly, there is a sense of "current threat" in PTSD (Ehlers & Clark, 2000), even though the traumatic event, and thus the actual danger, is in the past. This could be said to be the differentiating feature of PTSD in relation to other anxiety disorders, where intrusions are usually related to a present or future threat. The here-and-now feature of traumatic intrusive memories indicates that during the processing of traumatic information, a temporal structure is relatively lacking, leading to a memory representation that is not so much encoded in a conceptual context and integrated in autobiographical memory, but is more or less isolated (Ehlers & Clark, 2000; Brewin, Dalgleish, & Joseph, 1996).

In sum, intrusive images are an intriguing topic of research because of their clinical importance, as well as for the theoretical enigmas that they confront us with in light of memory research. What follows is a discussion and review of the theory, empirical findings, and current state of research on the topic of intrusive images in PTSD from an information processing perspective.

PTSD Theories

Currently, information processing theories of PTSD are very influential in inspiring research on involuntary recall in trauma. However, other theoretical explanations have been put forward in the past. For example, in a pioneering series of laboratory studies, Horowitz (1969) applied a combination of psychoanalytic and psychobiological theory based on ideas by Freud and Breuer to explain the occurrence of intrusive images from stressful film material in healthy participants. Horowitz suggested that normally the individual is in an emotional homeostasis where psychological processes are functioning in an integrated fashion. However, the overwhelming experience of a traumatic event can interfere with the psychological processes and disrupt homeostasis. As a consequence, a "repetition compulsion" occurs, in which the individual attempts to repress the traumatic memory but is unsuccessful because of weakened psychological defenses, which results in intrusive images. At other times, the trauma memory is successfully repressed to protect the individual from being overwhelmed with emotions, which results in amnesia. Successful repression is alternated with compulsive repetition in the form of intrusive memories in order to resolve the conflict induced by the traumatic event and reinstate homeostasis. In a later paper, Horowitz (1975) introduced the concept of "cognitive processing," a feature of current information processing theories of PTSD. Although his theory may seem outdated to us, Horowitz's experimental paradigm is not, as we shall see later on in this chapter. Brewin and Holmes (2003) note that Horowitz was a pioneer in modern-day experimental research of analogue traumatic intrusive images. In their review the authors evaluated the most influential theories of PTSD from past to present. They conclude that current information processing models of PTSD have the advantage that they allow for the generation of specific hypotheses as well as providing a theoretical explanation for the whole of PTSD symptoms by building on earlier theoretical accounts.

Current information processing models of PTSD are largely based on theories of autobiographical memory that describe "normal" memory processes. For example, Conway and Pleydell-Pearce (2000) propose a model of autobiographical memory in which information is stored in different levels of specificity. Very detailed memory representations that mainly consist of perceptual information are part of the Event Specific Knowledge (ESK) that forms episodic memories. Information in the ESK is usually abstracted into General Events that can include one or more events with a common theme. At the top of this hierarchy are Lifetime Periods that describe more general knowledge about a certain life-time period. Specific patterns of activation across these levels define an autobiographical memory. Goals of the self direct the formation of knowledge structures and hence regulate the organization and retrieval of autobiographical memories. Theories of PTSD aim to specify what processes in memory formation depart from "normal" processing in order to explain PTSD symptoms.

Cognitive model of PTSD

One information processing theory that is very influential for experimental research on intrusive images is the cognitive model of PTSD by Ehlers and Clark (2000). This model acknowledges that posttraumatic stress symptoms are a normal phenomenon in the direct aftermath of a traumatic event. A main difference between "normal" and pathological reactions according to this model is the experience of "current threat" in PTSD, which, as mentioned earlier, also delineates an important difference between PTSD and other anxiety disorders. Whereas the latter are mainly focused on a possible future threat (e.g., being humiliated by others when visiting a birthday party in social phobia), PTSD is concerned with a threat that is actually in the past (i.e., the traumatic event). According to the cognitive model of PTSD, current threat is caused by extremely negative appraisals of the traumatic event and its consequences, as well as by characteristics of the memory representation itself. Although the main focus of the model is on the persisting power of the negative appraisals, the quality of the trauma memory plays a crucial part as well. Ehlers and Clark (2000) suggest that conceptual processing leads to "normal" autobiographical memory representations that can be retrieved deliberately. In contrast, more data-driven processing (i.e., perceptual processing) leads to memory representations that relatively lack a conceptual context and are therefore easily activated by internal or external cues. Data-driven processing leads to an enhanced perceptual priming effect for traumatic material. This perceptual priming effect entails that traumatic information in memory is especially sensitive for perceptually similar cues that automatically trigger the trauma memory representation. Ehlers and Clark (2000) offer extensive suggestions of treatment interventions based on their model. One of their suggestions is to reduce current threat by learning to discriminate between the past (the time of the traumatic event) and the present by looking at differences between objectively neutral cues that signaled danger then and now. This way, the traumatic event is thought to become more integrated in autobiographical memory and unhelpful appraisals that maintain symptomatology are corrected.

Dual representation theory

Another influential information processing model of PTSD is the dual representation theory (DRT; Brewin, 1989; Brewin, Dalgleish, & Joseph, 1996; Brewin, 2001). DRT states that information from a traumatic event is represented in memory in at least two different codes or locations. This idea is based on the distinction between conscious processing, which is a slow and serial process wherein reflective meaning is conveyed to the information that is encoded, and a more automatic processing of sensory information. The latter operates in a parallel fashion, thereby having more or less unlimited processing capacity. Memory representations that stem from automatic processing contain mostly sensory information from the event, as well as the meaning of the event that was automatically assigned to the event at the time (e.g., this is a life-threatening situation). Memory representations stemming from more conscious processing involve perceptual features and are integrated in a conceptual context bound by the temporal and causal structure of the event. These representations can be retrieved deliberately from autobiographical memory, and are apt to change due to conscious reprocessing that entails assigning attributions and meaning. Therefore, these memory representations are called Verbally Accessible Memories (VAMs). During a traumatic event, the conscious processing of information is interfered through hormonal changes that are associated with extreme stress reactions. In contrast, the more automatic processing is not that much affected by extreme stress, and may even be enhanced, which could serve an evolutionary function of allowing quick responses. The memory representations that stem from automatic perceptual processing have not been subjected to conscious elaboration and assignment of meaning, so they cannot be retrieved deliberately. However, because they contain detailed sensory information, these memory representations are automatically activated by cues that bare similar sensory qualities (visual, olfactory, bodily sensations, emotions, etc.) with the information that is encoded. Therefore, in DRT (Brewin, 1989; Brewin et al., 1996; Brewin, 2001), the latter memory representations have been termed Situationally Accessible Memories (SAMs). In effect, the SAMs constitute the involuntarily recalled experiences, or intrusive images, after a traumatic event. Depending on several factors (e.g., duration and severity of trauma, tolerance for involuntary recall experiences, amount and quality of social support, avoidance behavior), emotional processing can be successful and stress symptoms decrease. In other cases, emotional processing becomes chronic or is inhibited (Brewin, 1989; Brewin et al., 1996; Brewin, 2001).

It is noted here that DRT (Brewin, 1989; Brewin et al., 1996; Brewin, 2001) and the cognitive model of PTSD (Ehlers & Clark, 2000) differ in some respects. Whereas DRT provides a detailed account of peri-traumatic processing, the focus of the cognitive model of PTSD lies in the concept of "current threat" and negative appraisals in relation to the traumatic event and its consequences. DRT (Brewin, 1989; Brewin et al., 1996; Brewin, 2001) describes different outcomes of peri-traumatic information processing and discusses possible neurological correlates, whereas the cognitive model of

PTSD (Ehlers & Clark, 2000) focuses more on clinical implications for the treatment of PTSD. However, there is a convergence in that both models are based on theories that describe "normal" memory processes (e.g., Conway & Pleydell-Pearce, 2000). Furthermore, the concepts of VAMs and SAMs in DRT are closely related to the idea of data-driven processing and conceptual processing in the cognitive model of PTSD, respectively. What is most important for the purpose of the current chapter, as argued by Holmes & Bourne (2008), is the idea that intrusive images stem from a sensory form of processing with a relative lack of conceptual processing.

An empirical view on information processing theories of PTSD

In a recent review of research on experimental investigations of intrusion development, Holmes and Bourne (2008) proposed an empirical model based on information processing theories of PTSD (i.e., Brewin et al., 1996; Brewin, 1989, 2001; Ehlers & Clark, 2000). This model is explicitly formulated to aid the generation of specific and testable hypotheses in the study of information processing during the traumatic event ("peri-traumatic" processing) and intrusion development. The model does this by simplifying and explicating the overlap between DRT (Brewin et al., 1996; Brewin, 1989, 2001) and the cognitive model of PTSD (Ehlers & Clark, 2000).

Holmes and Bourne (2008) propose that memory representations become intrusive when the balance between perceptual and conceptual information processing during trauma encoding is shifted towards the first. Importantly, both types of information processing are present during encoding, and it is the relative balance that accounts for the subsequent intrusive experiences. Thus, during a traumatic event, information processing is in a highly perceptual form, relatively lacking conceptual processing, leading to involuntary recall in the form of intrusive images. According to this assumption, manipulating either form of information processing can either increase or decrease the frequency of intrusive images. An increase in intrusive images occurs by either enhancing perceptual processing or by interfering with conceptual processing. A decrease in intrusive images occurs by either interfering with perceptual processing or by enhancing conceptual processing. With regard to perceptual processing, it is noted that information of all sensory modalities (smell, vision, hearing, touch, and taste) is important. However, since traumatic intrusions are mainly visual in nature (e.g., Speckens, Ehlers, Hackmann, Ruths, & Clark, 2007), the empirical model by Holmes and Bourne (2008) as well as laboratory studies of intrusion development have mainly focused on visual perceptual processing. Conceptual processing has been used interchangeably with the term verbal processing, because it is thought that creating a meaningful context and time coding for any event is done by using the symbolic function of verbalization.

In sum, theoretical models of PTSD like the cognitive model of PTSD (Ehlers & Clark, 2000) and the DRT (Brewin et al., 1996; Brewin, 1989, 2001) are useful for a more complex understanding of PTSD symptoms that go beyond involuntary recall in the form of intrusive images. With regard to empirical research, a simple model as proposed by Holmes and Bourne (2008) is useful for formulating clear and testable hypotheses on circumstances under which memory representations become intrusive.

Empirical Investigations of Intrusive Trauma Memories

Trauma film paradigm

One obvious challenge in studying the underlying cognitive mechanisms of PTSD is that if studies use patients suffering from posttraumatic stress symptoms, the traumatic event has already happened. That is, it is difficult to study "encoding" processes, or even the early aftermath retrospectively. Furthermore, there are clear ethical reasons why a traumatic event cannot be simulated. Therefore, experimental studies have used analogue traumatic situations, like the trauma film paradigm to study peri-traumatic information processing.

In the trauma film paradigm (Holmes & Bourne, 2008), participants view a "trauma film" as an analogue traumatic event under controlled circumstances. A trauma film usually depicts events that can be defined as traumatic according to the DSM-IV-TR (APA, 2000): involving actual or threatened death, serious injury, or a threat to the physical integrity of the self or others (Criterion A; APA, 2000). For example, the film used by Steil (1996) shows real-life footage of the aftermath of road traffic accidents (RTAs) in which victims are severely injured or dead. In typical studies using the trauma film paradigm, healthy participants (e.g., non-clinical participants, often university students) view a trauma film. Before film viewing, measures of individual differences like personality traits can be collected. Before and after film viewing, measures of state variables, like emotional state, are administered to study the impact of the film. Participants are then instructed to report any intrusive images from the trauma film in a diary for a period of time, often one week, and then return for follow-up. In the follow-up session the diary entries can be discussed and measures like memory questionnaires relating to the film can be collected (Holmes & Bourne, 2008). To manipulate information processing during the film, participants can, for example, be instructed to view the film from a certain perspective, or they perform a concurrent task while viewing the film that taps into perceptual and/or conceptual information processing resources.

Regardless of the clear differences between a trauma film and real trauma, there are clues indicating that the underlying mechanisms of intrusion development are similar in both situations. Support for this notion was reviewed by Holmes (2004), suggesting that forms of involuntary recall can be placed on a continuum. On one side of the continuum there is the involuntary recall as it is experienced in PTSD, like full-blown "flashbacks." On the other side of the continuum one can place involuntary recall from viewing a trauma film. The studies reviewed by Holmes (2004) suggest that the main features of intrusive experiences, i.e., mainly visual images of details or scenes of the trauma that can be either static or moving as in a film, are shared by the different forms of traumatic experiences on the continuum. For example, it was found that London school children experienced symptoms similar to those found in PTSD after viewing 9/11 events on television (Holmes, Creswell, & O'Connor, 2007).

Early uses of the trauma film paradigm

Before contemporary information processing theories of PTSD, and even before the acknowledgment of PTSD in the DSM-III in 1980, the trauma film paradigm was used to explore classic physiological stress reactions under controlled circumstances. In several experiments, Lazarus and colleagues (e.g., Lazarus & Alfert, 1964; Lazarus & Opton, 1964) studied the effect of threat from a stressful film on skin conductance and heart rate. To illustrate, in one study (Folkins, Lawson, Opton, & Lazarus, 1968), participants received three sessions of one of three types of training (relaxation, simulated desensitization, or cognitive rehearsal training) or they received no training in the control condition. After the third session, participants viewed a stressful film showing work-related accidents and applied their trained skills. The results showed differential effects for the different training conditions on skin conductance and heart rate measures.

The first studies to use the trauma film paradigm to explore more psychological constructs like involuntary recall were done by Horowitz (1969). In these studies, it was shown for the first time that intrusive images occur in healthy participants after viewing a stressful film. Where Lazarus and colleagues used terms like "short-circuiting of threat" (Lazarus & Alfert, 1964; Lazarus, Opton, Nomikos, & Rankin, 1965) that are reminiscent of an early information processing view, Horowitz introduced the term "cognitive processing" in 1975 to describe how intrusive images after viewing a stressful film occurred. In one study, Horowitz (1969) showed participants a neutral and a stressful film and had them report their subjective experiences during a distraction task after the film. The participants' reports showed significantly more intrusive experiences from the stressful film than from the neutral film in the 24 hours following film viewing. What is important to highlight here is that it was the first study showing intrusive experiences from a stressful film under controlled circumstances.

Recent findings exploring peri-traumatic processing

Studies that were inspired by recent information processing theories like the DRT (Brewin et al., 1996; Brewin, 1989, 2001) and the cognitive model of PTSD (Ehlers & Clark, 2000) have made use of the trauma film paradigm to test predictions that can be formulated in terms of the empirically oriented model proposed by Holmes and Bourne (2008). What follows is a review of key studies that used the trauma film paradigm to study the development of intrusive images, starting with studies exploring peri-traumatic processing.

Based on the distinction between data-driven processing and conceptual processing as formulated in the Ehlers and Clark (2000) cognitive model of PTSD, Halligan, Clark, and Ehlers (2002) manipulated information processing style during viewing of a trauma film. Participants viewed the film with the instruction to focus on the perceptual information and to be absorbed by this (data-driven processing condition), or with the instruction to concentrate on the order and causes for the events that were unfolding (conceptual processing condition). Intrusive experiences were measured with a symptom questionnaire one week later. The results showed no differences between the two conditions with regard to intrusion frequency. The authors argued that individual preferences for processing style might have overruled the experimental instructions. In other words, some people may naturally engage in more data-driven or conceptual processing than others. In the second experiment, Halligan et al. (2002, Experiment 2) created natural groups based on a cognitive processing style questionnaire (Ehlers, 1998) to distinguish between natural data-driven and conceptual processing style preferences. Both groups viewed the trauma film and, in line with the cognitive model of PTSD (Ehlers & Clark, 2000), participants with a more data-driven processing style reported more intrusive experiences compared to participants with a more conceptual processing style. The findings suggest that a preferred cognitive processing style is not easily manipulated by merely giving explicit instructions.

Brewin and Saunders (2001) initially set out to test the idea that peri-traumatic dissociation is related to intrusion development. Dissociation is a broad term that is used to describe experiences that indicate that cognitive processes normally functioning in an integrated way can become disrupted through high stress levels. This disruption can result in a change in consciousness and perception (Holmes et al., 2005). Examples are feeling like being in a dream or being a character in a film, rather than having first person experiences (derealization), or feeling disconnected from one's own body like a robot (depersonalization). Brewin and Saunders' (2001) experiment involved two conditions. In one condition, participants viewed a trauma film without an extra task. In the experimental condition, participants viewed the film while performing a concurrent task, namely tapping a complex key pattern. Participants recorded their intrusive images from the film in an intrusion diary for two weeks following film viewing. It was hypothesized that the concurrent task would divide attention and thus create a situation analogous to dissociation, leading to more intrusive images. Contrary to predictions, the participants in the concurrent task condition reported fewer intrusive images than participants in the no-task control condition. From the perspective of information processing theories of PTSD, Holmes, Brewin, and Hennessy (2004) proposed that the concurrent tapping task actually places a demand on visuospatial processing resources that are required for the processing of visual (and spatial) information. A visuospatial task in this respect is defined as a task that requires resources of working memory for the processing of visual and spatial information. By this, the perceptual processing of the film material was reduced by a competing demand from the tapping task, leading to a decrease in intrusive images.

This hypothesis led to a series of experiments further exploring a dual processing account of PTSD. In the first experiment, Holmes, Brewin, and Hennessy (2004) showed participants a trauma film under one of three conditions: no extra task, with the visuospatial tapping task as in Brewin and Saunders (2001), or after a dot-staring task to induce dissociation. Although the participants in the dot-staring condition reported a higher increase in state dissociation from pre- to post-film compared to the other two conditions, the number of intrusive images was not significantly different from participants in the no-task control condition. Participants in the visuospatial tapping condition, however, reported fewer intrusive images after one week compared to both participants in the no-task control condition and the dot-staring condition. This finding replicates the effect by Brewin and Saunders (2001), in line with predictions formulated by Holmes et al. (2004). The modulation of intrusion frequency was not accounted for by distraction since the attention rating for the film was significantly lower in the dot-staring and visuospatial tapping condition, but only the latter showed a reduced frequency of intrusive images.

In the second experiment, Holmes, Brewin, and Hennessy (2004) varied the amount of cognitive load of the visuospatial task by having participants tap a single key, an overpracticed visuospatial pattern, or a complex visuospatial pattern, while viewing the trauma film. In the overpractised pattern condition, participants performed the pattern tapping from Brewin and Saunders (2001) until they were able to perform the task effortlessly. This task was added to investigate the effect of the visuospatial component of tapping while reducing its cognitive load. In the complex pattern condition, participants performed the same tapping task but without practice. In line with predictions, the number of intrusive images from the trauma film reported after one week was lowest in the complex visuospatial tapping condition, followed by the overpracticed tapping condition. The single key tapping was not significantly different from no task. The finding that visuospatial tapping during the encoding of a trauma film reduces intrusive images has recently been replicated by Krans, Näring, Holmes, and Becker (2010).

Further evidence for the role of perceptual processing in intrusion development stems from a study by Stuart, Holmes, and Brewin (2006). Instead of performing the visuospatial tapping task, participants performed an alternative visuospatial task – modeling cubes and pyramids alternately from clay. A similar task is used in clinical practice to help PTSD patients remain in the here-and-now during imaginal exposure, when the trauma memory is vividly brought back to mind. The rationale was that modeling clay is a visuospatial task and should thus reduce intrusive images. Participants performed the clay task during one part of the trauma film. During the other part of the task they did not perform any concurrent task. By specifying the scene of the intrusive images in an intrusion diary, the intrusive images could be related to a specific film part. In line with predictions, participants reported fewer intrusive images from the film part during which they were modeling clay than during which they had not performed an extra task.

As well as the role of perceptual processing, the role of verbal conceptual processing has also been studied. The third experiment in the Holmes, Brewin, and Hennessy (2004) study was designed to investigate verbal conceptual processing in relation to intrusion development. Participants viewed a trauma film under one of three conditions: without an extra task, while counting backwards out loud in 3's, or while verbalizing the unfolding scenes out loud (verbal enhancement). It was hypothesized that counting backwards in 3's would interfere with the verbal conceptual processing of the film by placing a demand on resources needed for verbal conceptual processing. This interference should result in an increase in intrusions. Verbalizing the scenes was hypothesized to aid the verbal conceptual processing of the film, leading to a decrease in intrusions. After one week, participants in the counting backwards condition reported more intrusive images from the film compared to both the no-task control condition and the verbal enhancement condition. This finding supports the idea that interfering with verbal conceptual processing of stressful information increases intrusion frequency. In the study by Holmes et al. (2004, Experiment 3), the prediction that the verbal enhancement task would decrease intrusive images was not supported. The authors note that, on closer inspection, participants in the verbal enhancement condition seemed to verbalize mainly physical aspects of the film, so the lack of a decrease could be due to low task compliance in that conceptual processing was not adequately enhanced. The effect of the verbal interference task was replicated and extended in two experiments by Bourne, Frasquilho, Roth, and Holmes (in press), with the instruction of counting backwards in 7's instead of 3's.

Although the effects of manipulating perceptual processing are rather consistent, studies of verbal conceptual processing manipulations have come up with mixed findings. Krans, Näring, and Becker (2009) attempted to replicate the effect of verbal interference and to extend Experiment 3 from Holmes, Brewin, and Hennessy (2004) by improving the verbal enhancement instruction. The no-task control condition and the counting backwards in 3's task were the same as in Holmes et al. (2004, Experiment 3). In the improved verbal enhancement condition, participants were instructed to verbalize their own feelings and thoughts in relation to the unfolding events in the trauma film. To enhance compliance, the tasks were practiced with the participants until they were able to perform the task without errors during one minute. Surprisingly, participants in the verbal interference condition (counting backwards in 3's) reported fewer intrusive images from the film after one week than participants in the verbal enhancement condition (Krans et al., 2009). This finding is in the opposite direction of what would be expected from information processing models of PTSD. The verbal enhancement task did not change the frequency of intrusive images compared to the no-task control condition. As in Holmes et al. (2004, Experiment 3), participants in the verbal enhancement condition paused longer during the film compared to the verbal interference task of counting backwards in 3's. This finding may indicate that participants have difficulty processing traumatic information in a conceptual way during encoding. With regard to finding a decrease in the verbal interference condition in contrast to Holmes et al. (2004, Experiment 3), the findings are not clear cut.

In a study by Nixon, Nehmy, and Seymour (2007), participants viewed scenes from the film *Irreversible*, showing graphic scenes of physical and sexual violence. Participants viewed the film in one of three conditions: while either having a cognitive load (having to remember a 9-digit number), while hyperventilating, or without a concurrent task. The cognitive load task was used to prevent verbal conceptual processing of the film. For the purpose of the current chapter we only report the results on the cognitive load task and the no-task control condition. Intrusive images were measured immediately post-film with a free thinking task, in which participants indicated an intrusive experience by lifting their finger. Intrusive experiences after one week were measured with a questionnaire (Impact of Event Scale; Weiss & Marmer, 1997). In line with predictions, the participants in the cognitive load task reported more frequent intrusive images immediately post-film compared to the no-task control group. However, after one week, there was no significant difference between the cognitive load group and the no-task control group. In an earlier study (Butler, Wells, & Dewick, 1995) it was also found that significant differences in intrusion frequency were present after three days but not after one week.

Pearson and Sawyer (submitted, Experiment 1) tested the effect of a visuospatial task and a cognitive load task. Instead of a trauma film, participants viewed negatively and positively valenced pictures. During picture viewing, participants performed a visuospatial tapping task, a random number generation (RNG) task, or no concurrent task. RNG requires participants to say aloud numbers from 1 to 10 in a random fashion. This induces a cognitive load since the production of non-random series needs to be monitored continuously. Surprisingly, the results showed that participants in both the visuospatial tapping condition and the RNG condition showed a decrease in intrusive images for both negatively and positively valenced pictures after one week compared to the no-task control condition. The finding that the visuospatial tapping task reduced intrusive images is in line with the information processing models of PTSD (Brewin et al., 1996; Brewin, 1989, 2001; Ehlers & Clark, 2000). However, the finding that the RNG condition also reduced intrusive images was surprising. In a further examination, Pearson and Sawyer (submitted, Experiment 2) modulated the cognitive load of both the visuospatial task and the RNG task. The results showed the same pattern in that the increasing cognitive load of the visuospatial task significantly decreased intrusion frequency, consistent with the findings of Holmes, Brewin, and Hennessy (2004, Experiment 2). However, the pattern was also replicated for the RNG tasks. Interestingly, from these results it appears that intrusive images from positively valenced pictures can be modulated and induced in the same fashion as intrusive images from negative information.

Table 13.1 reviews the studies just described. The main argument from information processing models of PTSD (Brewin et al., 1996; Brewin, 1989, 2001; Ehlers & Clark, 2000; Holmes & Bourne, 2008) is that the imbalance between perceptual and conceptual information processing predicts intrusion development. Although the findings from studies manipulating perceptual processing are rather robust, attempts to manipulate intrusion frequency through the manipulation of conceptual processing have not been equally successful. In part, methodological differences between studies are likely to account for these mixed findings. However, it cannot be overlooked that the role of verbal conceptual processing, as well as its exact functioning, is not as straightforward as initially believed. One issue is that the nature of verbal conceptual processing and what constitutes a verbal conceptual processing task or not remains to be better delineated.

Recent findings exploring posttraumatic processing

The large majority of research on information processing models has focused on peri-traumatic processing. To date, only a few studies have looked at posttraumatic processes, although this is important for several reasons. First, there is a theoretical importance. Is the distinction between perceptual and conceptual processing as relevant posttraumatically as it is thought to be peri-traumatically? Can consolidation of information in memory still be manipulated? Second, it is important because if posttraumatic processing can be manipulated for the good of the patient this has implications for possible treatment or prevention interventions. The latter reason is especially important, since studies on the effectiveness of intervention immediately post-trauma are rather mixed, with some studies showing an improvement (Sijbrandij et al., 2007) in PTSD symptoms, but some showing a disturbing worsening of stress symptoms (e.g., Bisson, Jenkins, Alexander, & Bannister, 1997; Mayou, Ehlers, & Hobbs, 2000). Importantly, in clinical guidelines of the treatment of PTSD (National Institute for Health and Clinical Excellence, 2003), interventions immediately post-trauma are not recommended for aforementioned reasons. Research on information processing post-trauma could be helpful in shedding light on these discrepancies and possibly aid in the development of effective intervention.

The few studies that have used the trauma film paradigm to look at post-film effects differ in the extent to which they directly assess an information processing account as outlined in this chapter. However, they are important to review in line of this reasoning to provide a complete picture.

As noted, information processing models of PTSD like the DRT (Brewin et al., 1996; Brewin, 1989, 2001) and the cognitive model of PTSD (Ehlers & Clark, 2000) come down to the idea that intrusive images develop because of a shift in balance between perceptual and conceptual processing in favor of the first (Holmes & Bourne, 2008). The event-specific knowledge of the traumatic event is not further integrated in the autobiographical knowledge base (Conway & Pleydell-Pearce, 2000), and are therefore prone to automatic activation through internal or external cues that are similar in sensory qualities. This is in contrast to the deliberate way in which memories can be recalled from autobiographical memory. The implication is that if the trauma memory becomes more integrated, intrusive images should decrease. As a test of this hypothesis by Krans, Näring, Holmes, and Becker (2009) had participants view a trauma film. Afterwards, participants received a verbal recognition memory test for one part of the film, but not for the other part, in line with the experimental within-subjects design used in Stuart, Holmes, and Brewin (2006). Participants then recorded their intrusive images from the film for one week, with a specific description of the image so that it could be assigned to film parts. In line with predictions, participants reported more intrusive images from the film part for which they had not received the memory test, compared to the part for which they had. The memory test contained statements about the film for which participants had to decide whether the statement was true or false. A possible explanation is that the memory test may have advanced the conceptual integration of the film information. In support of this idea, participants performed better on a cued-recall memory test about the film for the film part for which they received the memory test a week earlier, compared to the film part for which they had not

Table 13.1 Review of recent findings from the trauma film paradigm

Study	*Experiment*	*Conditions*	*Measure (at 1 week unless otherwise indicated)*	*Significant order of intrusion frequency (highest to lowest)*
Halligan, Clark, & Ehlers (2002)	1	Data-driven instruction Conceptual processing instruction	Symptom questionnaire	No significant difference
	2	Data-driven natural group Conceptual processing natural group	Symptom questionnaire	Data-driven Conceptual processing
Brewin & Saunders (2001)		No task Visuospatial tapping	Intrusion diary 2 weeks	No task Visuospatial tapping
Holmes, Brewin, & Hennessy (2004)	1	No task Visuospatial tapping Dot-staring	Intrusion diary	Not task and dot-staring Visuospatial tapping
	2	No task Single key tapping Overpracticed tapping Complex pattern tapping	Intrusion diary	No task and single key Overpractised tapping Complex pattern tapping
	3	No task Counting backwards in 3's Verbalizing film scenes	Intrusion diary	Counting backwards in 3's No task and verbalizing scenes
Stuart, Holmes, & Brewin (2006)		No task Modeling clay	Intrusion diary	No task Modeling clay

Bourne, Frasquilho, Roth, & Holmes (in press)	1	No task Counting backwards in 3's Visuospatial tapping	Intrusion diary	Counting backwards in 3's No task Visuospatial tapping
	2	No task Counting backwards in 7's	Intrusion diary	Counting backwards in 7's No task
Krans, Näring, & Becker (2009)		No task Counting backwards in 3's Verbal enhancement	Intrusion diary	Verbal enhancement Counting backwards in 3's
Nixon, Nehmy, & Seymour (2007)		No task Cognitive load (hyperventilation)	Post-film Free thought Questionnaire (IES)	Post-film Free thought: Cognitive load No task Questionnaire (IES): No task and cognitive load
Pearson & Sawyer (submitted)	1	No task Visuospatial tapping Random number generation	Intrusion diary	No task Visuospatial tapping and RNG
	2	No task Single key tapping Complex pattern tapping Articulatory suppression Random number generation	Intrusion diary	No task Single key tapping and articulatory suppression Complex pattern tapping and RNG

received a memory test. These results suggest that going over the trauma film information can effectively reduce intrusion development, possibly by integrating the trauma information. With regard to post-film perceptual processing, one recent study by Holmes, James, Coode-Bate, and Deeprose (2009) showed that performing a visuospatial task after a trauma film also successfully reduces intrusive images from the film.

Butler, Wells, and Dewick (1995) explored the effect of worry and imagery on intrusive images from a trauma film after film viewing. Participants were instructed to either worry about the film in verbal form (worry group), imagine the film in mental pictures (imagery group), or take some time to settle down (control group) after the film. Participants reported any intrusive images from the film in a diary during one week after film viewing. There were no significant differences between the three groups in intrusion frequency after a 7-day period, but the authors noted that most intrusive images were reported in the first three days in the diary. After three days, participants in the worry group reported significantly more intrusive images from the film compared to both the imagery group and the control group. Although the study by Butler et al. (1995) does not explicitly test an information processing account of PTSD, their results do have implications on the level of post-trauma processing. The hypotheses were based on the idea that verbal worrying is a way to reduce anxiety in the short term, while this strategy may be a harmful form of avoidance in the long run. Although worrying and verbal processing are both in verbal activities, worry is more preoccupied with questions about what could have happened and possible (negative) implications. Worry, then, is importantly distinct from conceptual processing because worry may not reflect contextualizing a stressful event in a helpful way. Additionally, the effects of possible different forms of verbal processing may interact with the time point at which it occurs (peri-traumatically or post-traumatically).

The final study that is discussed here is unique in that it is one of the first studies to use the trauma film paradigm to explore a possible application for clinical practice. Following Ehlers and Clark (2000), cognitions about a traumatic event and its consequences are important in the maintenance of intrusive images. A frequently used measure of posttraumatic cognitions is the PTCI (Post Traumatic Cognitions Inventory; Foa, Ehlers, Clark, Tolin, & Orsillo, 1999). Based on this questionnaire, Mackintosh, Woud, Postma, Dalgleish, and Holmes (submitted) created a trauma specific Cognitive Bias Modification (CBM) training (Mathews & Mackintosh, 2000) used for the indirect training of participants for a positive or negative interpretation of analogue posttraumatic stress symptoms. Participants were presented with incomplete, ambiguous scenarios based on items of the PTCI Self-scale. The scenarios contained typical post-trauma cognitions, e. g., with how well a person thinks he/she can cope with the trauma or whether he/she believed to have acted adequately during the traumatic event. Participants were instructed to complete these scenarios in either a positive or negative way. It was hypothesized that this training manipulates post-trauma processing, and would induce an interpretation bias towards analogue trauma symptoms compatible to the valence of the participants' training condition. After the training (Experiment 1), participants viewed a trauma film and then recorded their intrusive images of the film in a one-week diary. The results showed that although there were no differences in the frequency of intrusive images, the distress that accompanied the intrusive images was significantly lower in the positive training condition compared to the negative training. In a second experiment, the same trauma CBM procedure was applied after film viewing. This time, participants in the positive condition reported a lower intrusion frequency, though not intrusion distress, compared to the negative condition. However, when intrusive thoughts and images were included that could not be traced back directly to the film, like in Experiment 1, differences in distress emerged in the same pattern as in Experiment 1. Overall, these findings indicate that the trauma film paradigm could prove to be useful for testing clinical applications. Further, the study illustrates that negative cognitions about one's reactions to a traumatic event could relate to both a higher frequency of intrusive images as well as higher distress associated with the intrusive thoughts and images. Again, this is a possible nuance that distinguishes between peri-traumatic and posttraumatic processes, in the way that distress related to intrusive images is more likely to have effect on appraisals and vice versa during and after the aftermath of trauma. These results are obviously in line with the role of appraisals in the onset and maintenance of PTSD, as described in the cognitive model of PTSD by Ehlers and Clark (2000).

Conclusions and Discussion

The goal of this chapter was to provide and review an information processing perspective on involuntary recall after psychological trauma. Historically, the acknowledgment of PTSD as a psychiatric disorder has not been straightforward, partly due to political and social factors. However, even before this, PTSD related theory and experimental research has been innovative, especially when we consider that this chapter has only addressed the very specific topic of intrusive image-based trauma memories.

As we have seen, an influential current perspective on involuntary recall in PTSD comes from an information processing tradition. We discussed two important information processing theories, namely the dual representation theory by Brewin and colleagues (1996, 1989, 2001) and the cognitive model of PTSD by Ehlers and Clark (2000). Although they differ on several aspects, both theories converge on the idea that a shift in balance between perceptual and conceptual processing lies at the heart of involuntary recall in PTSD. With this in mind, Holmes and Bourne (2008) developed a pragmatic model of PTSD to guide the design and interpretation of experimental studies of intrusive images. In light of the successful results on visuospatial processing and mixed findings with regard to verbal-conceptual processing, the model may need revision.

In relation to providing support for the information processing view of involuntary recall in PTSD, the trauma film paradigm has proven to be a useful tool to study causal influences of underlying mechanisms that are not accessible by studying actual PTSD patients. Important factors in the development and maintenance of PTSD can be distinguished in pre-trauma factors, like individual differences in trait anxiety, dissociation and cognitive abilities, peri-traumatic factors and posttraumatic factors (for more on the role of pre-trauma individual differences in intrusion development, see Verwoerd and Wessel, chapter 14, this volume).

With regard to peri-traumatic information processing, research findings continue to provide support for the idea that intrusive images rely on an image-based memory system that stems from a shift towards perceptual processing with a relative lack of conceptual processing. Studies showing that specific interference of peri-traumatic perceptual processing (e.g., Halligan, Clark, & Ehlers, 2002; Brewin & Saunders, 2001; Holmes, Brewin, & Hennessy, 2004, Experiments 1 and 2; Stuart, Holmes, & Brewin, 2006; Pearson & Sawyer, submitted) reduce the frequency of subsequent intrusive images from a trauma film provide extensive support for this. The possible mechanism through which this works is that a concurrent visuospatial task reduces the vividness and emotionality of mental imagery, as shown by Baddeley and Andrade (2000) and Kemps and Tiggemann (2007).

Findings related to peri-traumatic conceptual processing have yielded more mixed results, with some studies showing that interfering with conceptual processing reduces intrusive images (e.g., Holmes, Brewin, & Hennessy, 2004, Experiment 3; Nixon, Nehmy, & Seymour, 2007; Bourne, Frasquilho, Roth, & Holmes, in press) and some studies showing the opposite effect (e.g., Pearson, Sawyer, & Holmes, 2008; Krans, Näring, Holmes, & Becker, 2009). To solve this incongruence, methodological aspects from these studies need to be addressed. At the moment, studies have started to explore the effect of presence versus absence of a verbal conceptual context preceding the presentation of visual trauma material to investigate whether a context is a prerequisite for conceptual interference to reduce intrusive images. On a more theoretical level, conceptual processing of a traumatic event may not be as straightforward as the verbalization of ongoing events. For example, Conway and Pleydell-Pearce (2000) have argued that personal goals at the time of trauma are strongly related to the way a trauma memory can be integrated into an autobiographical knowledge base. From this perspective, helpful conceptual processing of a traumatic event entails more than understanding the causal and temporal sequence of the event. Interfering with or enhancing verbal processing during a trauma film, then, may not be tapping directly into the process of contextualizing trauma information within autobiographical memory. Clearly, more research on the exact form and role of conceptual processing in analogue and actual traumatic involuntary recall is needed.

One exciting field of research that has started to emerge is the study of posttraumatic processing. So far, findings are encouraging in that a memory test immediately after viewing a trauma film showed a reduction in subsequent intrusive images (Krans, Näring, Holmes, & Becker, 2009), as well as a visuospatial task after film viewing does (Holmes, James, Coode-Bate, & Deeprose 2009). Because the aftermath of trauma defines the moment when PTSD symptoms are presented, studies like the CBM training by Mackintosh, Woud, Postma, Dalgleish, and Holmes (submitted) are promising for possible application in clinical practice.

We started this chapter by emphasizing the importance of autobiographical memory, how it gives us a personal identity and a life story to tell. It is not difficult to see how memory-related problems in trauma, such as intrusive re-experiencing, can have a profound impact on the life of an individual. In the context of an identity-shaping autobiographical memory, being the victim of a traumatic event can also establish drastic changes in the individual's experience of personal identity. In PTSD patients, the feeling of having changed for the worse after the traumatic event is certainly not uncommon (Ehlers, Maercker, & Boos, 2000), in light of the often gruesome events that they have experienced. On the other hand, identity changes after a traumatic event need not always be negative. Some theories have argued that a traumatic event can even spark a positive self-growth and changes for the better (e.g., Affleck & Tennen, 1996). Maybe it is not so surprising that survivors of severe physical injuries can claim that they appreciate and enjoy life more since their accident, as we see when we watch television shows like *ER*. In light of this chapter, we should be aware that the effects trauma and its symptoms reach much further than only the occurrence of intrusive images.

Specific features of autobiographical memories serve several functions that help us live our lives (Bluck, 2003). For example, in the case of memory sharing, research has shown that the more detailed and emotional a memory is, the more social support the person that shares the memory receives from a listener (Alea & Bluck, 2003). Perhaps a productive function of intrusive images from a traumatic event can be found in this sense. After all, intrusive images are defined by high levels of detail and emotion. Taking into account that effective cognitive behavioral treatment of PTSD relies on the trauma survivor sharing a detailed account of the trauma memory, the specific features of traumatic intrusive memories may allow for a starting point towards recovery.

Finally, we end this chapter by stating that the importance of continued research on involuntary recall phenomena cannot be stressed enough, as involuntary recall in trauma is most impairing and stressful in the everyday activities of a trauma survivor. This chapter reviewed current theory and experimental research findings in the area of PTSD, but many more psychiatric disorders are related to involuntary recall (for reviews, see Hackmann & Holmes, 2004; Holmes, Arntz, & Smucker, 2007; Clark, 2005). For example, the cognitive-behavioral model of OCD proposed by Clark and O'Connor (2005) states that several reasoning errors lead to a state of doubt, that lead to the obsessional feature of intrusive experiences in PTSD. Morrison (2005) proposes that an external source allocation of the origin of intrusive experiences is typical in psychosis (for more on intrusive memories in depression, see Williams and Moulds, chapter 15, this volume). Intrusive phenomena across disorders should be considered and this could provide an interesting discussion on intrusive experiences. There is a rising consensus on the idea that intrusive phenomena in different disorders may have more features in common than features that distinguish between them. Future research findings from more general theories of memory can help to support the specific clinical theories that provide the necessary understanding needed for good clinical practice and theoretical development.

Note

1. This is in contrast to intrusive images where the content depicts a worry or fear about something that could (have) happen(ed) but has not necessarily happened (e.g., the image of people laughing when preparing for a presentation, as in social phobia). However, research indicates that many intrusive images, at least in psychological disorders, are related to some earlier experience (Brewin, 1998).

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14

Unwanted Traumatic Intrusions

The Role of Pre-trauma Individual Differences in Executive Control

Johan Verwoerd and Ineke Wessel

Introduction

Memory may present itself in ways that evoke amazement and wonder. The sight of a long-forgotten toy or accidentally stumbling upon a photograph of one's first love may bring back happy memories within a fraction of a second. These lost moments suddenly return with great perceptual clarity and feeling of reliving. Not surprisingly, because of its intrinsic beauty to the rememberer, this type of involuntary memory is also known as aesthetic memory (Berntsen, 2007).

In contrast, the involuntary remembering of a traumatic event reflects a radically different experience. According to the fourth edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV), a traumatic event involves the "actual or threatened death or serious injury, or a threat to the physical integrity of self or others" with a subjective response of "intense fear, helplessness or horror" (APA, 1994, pp. 427–428). These horrific experiences will often give rise to recurrent memories that are extremely stressful for the rememberer. Especially for people who develop a posttraumatic stress disorder (PTSD) after trauma, the repeated occurrence of intrusive memories is felt as a heavy burden, which may deregulate everyday functioning (e.g., work, family) for many years. The symptoms of PTSD comprise: (1) recurrent intrusive distressing recollections of the traumatic event; (2) avoidance of trauma-related stimuli and/or a general numbing of emotional responsiveness; and (3) increased levels of arousal (APA, 1994).

The Act of Remembering: Toward an Understanding of How We Recall the Past.

Epidemiological studies suggest that traumatic events are relatively common. Lifetime prevalence rates range from 51.2 percent (Kessler, Sonnega, Bromet, & Hughes, 1995) to as much as 89.6 percent (Breslau et al., 1998). In spite of this high prevalence of traumatic stressors, relatively few people exposed to trauma will subsequently develop PTSD. For example, of the 89.6 percent of a representative adult sample from metropolitan Detroit reporting exposure to DSM IV traumatic stressors, only 13 percent of the women and 6.2 percent of the men developed PTSD (Breslau et al., 1998). This discrepancy indicates that most trauma survivors are able to overcome the psychological consequences of trauma exposure (McNally, Bryant, & Ehlers, 2003). Why, then, do some people develop PTSD?

Involuntary re-experiencing is a hallmark symptom of the posttraumatic response. Apparently, many people are able to gradually gain control over posttraumatic symptoms in the weeks after a traumatic experience (see Rothbaum, Foa, Riggs, & Murdock, 1992), including these involuntary stressful memories. This raises the possibility that features of the information processing system that are implicated in the regulation of conscious thought may also be involved in the down-regulation of intrusive stressful memory. These features are also known as executive control functions. In this chapter, we explore the idea that executive functioning is involved in the persistence of intrusive memories. The neuropsychological literature contains a number of studies on memory aberrations and executive functioning in PTSD. We start by looking at this literature.

Neuropsychological Findings

A large body of work compared PTSD patients with trauma-exposed and normal healthy controls on a wide range of neuropsychological measures employing emotionally neutral stimulus material. These measures often reflect a variety of memory tests, including initial learning/encoding, short-delay recall (SDR), long-delay recall (LDR), retention (LDR minus SDR), cued recall, and recognition. A recent meta-analysis showed that PTSD-related cognitive impairments mainly occur in the verbal domain, and that visuospatial abilities are relatively intact (Brewin, Kleiner, Vasterling, & Field, 2007; see also Johnsen & Asbjørnsen, 2008). The meta-analysis further showed that, by and large, this verbal deficit was reflected by problems with the immediate recall of target information. According to Brewin et al. (2007), impairments in immediate, but not delayed, memory imply dysfunction of attention and/or strategic processing, impacting the initial registration of information. This idea of PTSD-related impairment in strategic processing is supported by the finding that Persian Gulf War veterans with PTSD demonstrated significant deficits on tasks involving sustained attention, mental manipulation, initial acquisition of information, and retroactive interference (Vasterling, Brailey, Constants, & Sutker, 1998). These task-specific impairments may reflect problems with higher level coordination/strategic abilities. In the neuropsychological literature, these higher level abilities are also known as executive functions, and are linked to the frontal areas of the brain. Interestingly, higher level coordination functions play an important role in neurobiological models that describe PTSD as an anxiety disorder associated with changes in neural circuitry involving frontal and limbic systems (e.g., Southwick, Rasmusson, Barron, & Arnstein, 2005; see also Francati, Vermetten, & Bremner, 2007; Hariri, Bookheimer, & Mazziotta, 2000). The basic idea behind these models is that fearful stimuli elicit activity in the amygdala, and that this activity is modulated by control mechanisms located in the prefrontal areas. It is thought that a deficit in the prefrontal regulation of amygdala activity may be responsible for persistent PTSD symptoms such as intrusive re-experiencing and hyperarousal (cf. Southwick et al., 2005). Taken together, it may be hypothesized that executive control is an important mechanism underlying individual differences in response to trauma.

Some evidence to sustain this idea comes from studies that specifically investigated the role of executive control in PTSD (e.g., Leskin & White, 2007; Gilbertson et al., 2006; Vasterling et al., 2006; Koso & Hansen, 2006). For example, in a study of combat veterans, Gilbertson et al. (2006) used the number of perseveration errors on the Winconsin Card Sorting Test (WCST; Heaton & Pendleton, 1981) as an index of executive control. Compared to combat veterans without PTSD, veterans with PTSD showed an impaired ability to resist making these perseveration errors. Importantly, no group differences were found on the number of nonperseverative errors, suggesting that the effect was not merely attributable to a general pattern of increased errors in the PTSD group. Furthermore, in a study of Bosnian war veterans, Koso and Hansen (2006) used several indices of executive control, such as a sentence completion task requiring suppression of naturally occurring sentence endings and the Trail Making Test (TMT; Lezak, 1995). The TMT is a timed paper and pencil test which is thought to index sustained attention, set shifting, and visual scanning. The participants with PTSD showed more impairment on these executive indices than age and IQ matched non-PTSD participants. Finally, Leskin & White (2007) compared undergraduates with PTSD with a high trauma exposure and low trauma exposure group without PTSD on three different indices of executive control. The results showed that PTSD participants were specifically impaired on an index of the ability to resist conflicting contextual responses. In contrast with the findings of Koso and Hansen (2006), PTSD participants did not show impairments on the TMT. In interpreting their findings, Leskin and White (2007) suggested that neurocognitive deficits related to PTSD might be subtle and not always detectable using relatively insensitive traditional paper-and-pencil testing such as the TMT. In line with this, several other studies using the TMT as an index of executive control failed to find PTSD-related impairments on this measure (Barret, Green, Morris, Giles, & Croft, 1996; Crowell, Kieffer, Siders, & Vanderploeg, 2002; Gurvits et al., 1993; Vasterling et al., 2006; Zalewski, Thompson, & Gottesman, 1994; for more details on the suitability of measures of executive control, see Leskin & White, 2007). Taken together, in spite of issues pertaining to measurement sensitivity, these results provide preliminary evidence for the involvement of executive control in the commonly observed cognitive impairments in patients with PTSD.

Executive Control as a Premorbid Vulnerability Factor

The next question that arises is whether cognitive impairments in PTSD are a consequence of the toxic effects of the exposure to a traumatic event, or may predate the trauma experience and PTSD onset. In the latter case, the cognitive impairments would represent a vulnerability factor that might explain individual differences in trauma response resulting in either natural recovery or in persistent symptomatology and eventually, PTSD (see Vasterling & Brailey, 2005).

The idea that premorbid individual differences in cognitive ability may set people at risk for developing PTSD after trauma was investigated in several studies. These studies used different approaches. For example, Macklin et al. (1998) used archival military records to obtain measures of pre-trauma functioning. The results showed that lower pre-combat intelligence increased the risk of PTSD after combat exposure (see also Pitman, Orr, Lowenhagen, & Macklin, 1991; Koenen, Moffitt, Poulton, Martin, & Caspi, 2007; Breslau, Lucia, & Alvarado, 2006). A different approach was taken by Gilbertson et al. (2006). These authors selected combat veterans with and without PTSD, and compared their performance with that of their identical twins who were unexposed and had no PTSD. This approach allows for separating the toxic effects of combat exposure and PTSD from familial vulnerability factors that increase or decrease the risk of psychopathology. The results revealed evidence for familial vulnerability on indices of verbal ability, executive control (i.e., perseveration errors), and IQ. Specifically, unexposed brothers of PTSD combat veterans scored significantly lower on these indices than the unexposed brothers of combat veterans without PTSD. The authors suggested that neuropsychological functioning acted as a source of risk/resilience when combat veterans were later faced with traumatic events (Gilbertson et al., 2006; for a related study, see Kremen et al., 2007). The third approach consists of longitudinal studies that actually assess neurocognitive functioning both pre- and post-trauma. In the only published study that we are aware of (Parslow & Jorm, 2007), 1,599 young adults who reported one or more traumatic experiences related to a major natural disaster (a widespread fire) were selected from a larger longitudinal epidemiological study. The key finding of this study is that fire-related re-experiencing was inversely related to performance on indices of word recall (immediate and delayed),[1] digit span (backwards), coding speed, and verbal intelligence measured some three years before the trauma.

In sum, decreased performance on neuropsychological tasks seems to index a pre-morbid vulnerability factor for the development of PTSD. As for the precise nature of this vulnerability factor, the results of several studies suggest that executive control may be a suitable candidate. However, there are two disadvantages to the approach taken in these studies. To begin with, the neuropsychological literature broadly defines executive control in terms of functioning of the frontal areas of the brain. Accordingly, a variety of tasks requiring planning and organization is used to index executive control. This broad definition complicates developing hypotheses on the specific executive functions that might be involved in PTSD development. A second disadvantage is that the majority of studies investigating the neuropsychology of PTSD employed diagnostic groups. That is, traumatized participants were assigned to a PTSD group upon meeting diagnostic criteria for the diagnosis, irrespective of their precise symptom profile. As noted, PTSD consists of several symptom clusters, of which re-experiencing constitutes a hallmark feature. As this involves the unbidden occurrence of stressful memories in awareness, it may be informative to more directly investigate the link between this specific symptom and the mechanisms that are thought to be responsible for the regulation of the contents of conscious thought. The basic cognitive psychology literature contains a wealth of knowledge on attention and (working) memory processes that might aid specifying the construct of executive control, its sub-functions, and its link with intrusive thoughts and memories. It is to this literature that we turn next.

Executive Control in the Experimental Memory Literature

Working memory capacity

Recent conceptualizations of working memory appear to share two assumptions. First, working memory is described as a set of temporary active long-term memory (LTM) representations under supervision of an executive or attentional controller, thought to facilitate goal-directed behavior.[2] For this purpose, executive control would sustain the active maintenance of goal-relevant information and exclude goal-irrelevant information from conscious thought (Kane, Conway, Hambrick, & Engle, 2007; see also Friedman &

Miyake, 2004; Miyake et al., 2000). A further assumption of these working memory theories is that people show innate or early acquired individual differences in executive/attentional control (Friedman et al., 2008; Engle, 2002). Important in this respect is the construct of working memory capacity (WMC). WMC has been defined as the ability to actively maintain or recover access to goal-relevant information in a wide range of contexts that also trigger irrelevant and interfering responses, such as memories and behaviors (e.g., Kane et al. 2004, Unsworth & Engle, 2007, Kane et al., 2007). Note that the use of the term "capacity" in the WMC model differs fundamentally from the view of primary memory as a passive store with a limited number of items or chunks (7 ± 2; Miller, 1956, cited in Kane et al., 2007). WMC as an ability depends on the amount of executive resources available for goal-directed behavior (e.g., Engle & Oranski, 1999). Thus, WMC is just as important in the retention of a single representation of a goal as it is in determining how many representations can be maintained. WMC does not refer to memory, but to how executive attention is used to maintain or suppress information (Engle, 2002; Kane, Bleckley, Conway, & Engle, 2001).

WMC is usually measured with complex span tasks (e.g., Operation Span; Conway et al., 2005). These tasks present participants with the traditional memory span demand to immediately recall brief lists of unrelated items. Additionally and critically, these tasks also consist of a secondary processing component for purposes of preventing rehearsal, challenging the maintenance of to-be-recalled items. For example, the operation span task (OSPAN; see Conway et al., 2005) requires subjects to read aloud and verify arithmetic equations in combination with the instruction to memorize unrelated words following the equations (e.g., IS $6 + 5 = 11$? Yes/No *Ball*). Empirical work shows that performance on complex span tasks is associated with performance on a wide range of indices of higher-order cognitive processes, such as standard measures of intelligence (Kane et al., 2004), active goal maintenance during Stroop performance ("name the color, ignore the word"; Kane & Engle, 2003), and flexible target responding in an attentional orienting task (Unsworth, Schrock, & Engle, 2004).

All in all, the WMC model provides some interesting clues to suspect that a relatively poor performance on complex span tasks may be linked to intrusive memory phenomena. After all, good complex span performance would require the ability to ignore or dismiss irrelevant information. Intrusive memories are by definition unwanted and irrelevant to the task at hand. Thus, the ability to ignore goal-irrelevant information should also pertain to intrusive memory in daily life. Indeed, findings from a number of analogue studies are in line with this idea. To begin with, Klein & Boals (2001) showed that OSPAN performance was negatively associated with the self-reported frequency of intrusive memories related to a stressful life event. Furthermore, Brewin and Beaton (2002) explored whether OSPAN performance predicted the frequency of experimentally induced intrusions in a standard thought suppression paradigm (see Wegner, Schneider, Carter, & White, 1987). Participants were told not to think of a white bear and to press a button if they noticed any white bear thoughts occurring despite their suppression attempts. The results showed that OSPAN performance and the frequency of button presses were inversely related. Thus, participants relatively high in WMC were better at keeping unwanted white bear thoughts from conscious awareness. Additionally, a follow up study showed similar findings for personally relevant obsessive thoughts in a group of undergraduates (Brewin & Smart, 2005).

Although these results sustain the idea that relatively poor WMC is linked to intrusive thoughts and memories, there are also a number of studies that failed to find evidence for this idea. For example, in an attempt to replicate Brewin and colleagues' findings using a more ecologically valid target for thought suppression than a white bear, Wessel and colleagues (Wessel, Huntjens, and Verwoerd, 2010) instructed their participants to suppress memories of a stressful film. The results indicated that pre-film OSPAN performance was *positively* related to intrusions Likewise, in two studies (Nixon, Nehmy, & Seymour, 2007; Wessel, Overwijk, Verwoerd, & de Vrieze, 2008, Study 1), OSPAN performance was assessed prior to watching a stressful film. Participants recorded spontaneously occurring intrusive memories of that film during several days after watching. Both studies failed to find a relationship between OSPAN performance and the frequency of film-related intrusions (for a more detailed overview on the use of trauma films in analogue settings, see Krans, Woud, Näring, Becker, & Holmes, Chapter 13, this volume).

All in all, empirical evidence for the idea that WMC is involved in intrusive cognition is mixed. Of course, on the one hand, this might indicate that executive control would not qualify as a stable predictor of persistent intrusions. On the other hand, however, complex span measures may provide a suboptimal way of measuring the specific construct of interest. A closer look at measures such as the operation span reveals that good performance may require many diverse higher level abilities, such as the updating of working memory contents after each set of equations/words, switching between solving arithmetic equations and remembering words, and maintaining target material in an active state until retrieval. Thus, although performance on WMC tasks such as the OSPAN may depend on general executive resources, these indices are possibly less sensitive for the detection of subtle deficits in executive functioning that would be linked to intrusive re-experiencing after trauma. Put differently, perhaps there are specific components of executive functioning that are important for ignoring or dismissing intrusions that are not captured by general measures of WMC.

Executive control as a multi-component construct

A separate literature (e.g., Friedman & Miyake, 2004) used latent variable analyses to address the question of whether executive functioning should be regarded as a multi-component rather than a unitary construct. The general idea behind these studies is that executive control can be defined as a group of semi-independent abilities, each responsible for a different aspect of behavior. For example, Miyake et al. (2000) provide empirical evidence for the idea that executive functioning may be subdivided into three correlated but separate abilities: *shifting* between task sets, *updating* of working memory contents, and *inhibition* of prepotent response tendencies.

A further division of the inhibition component of executive functioning may be of particular importance for present purposes. This involves the distinction between inhibition at the response level and inhibition at the cognitive level. Friedman and Miyake (2004) found that performance on tasks requiring the stopping or preventing of prepotent responses (e.g., the Stroop, stop-signal and antisaccade tasks; see also Miyake et al., 2000) represented a different latent variable (*response inhibition*) than measures of resistance to proactive interference (*resistance to PI*; indexed by list-learning paradigms). Response inhibition may be involved in preventing the natural but socially inappropriate tendency to say something embarrassing about a colleague's new purple dress. As an example of resistance to PI, consider the first weeks after purchasing a new mobile phone. During this time, it would be difficult to access the new number in long-term memory because the extensively used old number would persistently intrude into conscious awareness. Flexible access to the memory representation of the new number would require a well developed ability to resist unwanted interference from the old number. Interestingly, this executive ability of resistance to PI seems to be related to individual differences on complex measures of WMC (e.g., Kane & Engle, 2000; Rosen & Engle, 1997, 1998). This may indicate that part of the variance of well-known indices of WMC may be attributed to the *specific* ability to resist or inhibit interference from working memory. Consistent with this, Friedman and Miyake (2004) found that resistance to PI, but not response inhibition, showed a relationship with everyday self-reported intrusive thoughts. As trauma-related intrusive memories may be seen as a profound example of experiencing unwanted interference in real life, a deficit in the general ability to resist PI in working memory may set people at risk for persistent intrusive re-experiencing and PTSD.

Interference Control and Intrusive Memories

In a series of analogue studies, we investigated the idea that the executive ability of resistance to PI is related to intrusive memories. In a first study

(Verwoerd, Wessel, & de Jong, 2009), nonselected undergraduates completed indices of the executive abilities of resistance to PI and response inhibition. The proactive interference task consisted of studying two lists of paired associates (i.e., AB – AC). The lists were construed such that for each pair, the cue (A) was strongly related to the target (B) in the first list, but weakly related to the target (C) in the second list (e.g., Sheep-Wool [list1]; Sheep-Grass [list 2]). The idea was that List 2 learning would require effort to override a strong tendency to respond with the List 1 target and that a relatively weak executive control would be reflected by more difficulty with List 2 learning. As an index of response inhibition, the color-name Stroop task was administered. In addition, participants reported how often they had experienced intrusive memories of a highly stressful event from their personal past in the week before the test session. The results showed a unique relationship between intrusive memories and the ability to resist PI (controlled for potential confounders such as gender, depression, and age of the reported events). Such a relationship was absent for the executive ability of response inhibition. Although this is consistent with the idea that the specific executive subcomponent of interference control plays a role in the persistence of intrusive memories, it remains undecided whether such a deficit was already present prior to the stressful event. Therefore, we conducted two further prospective studies using a trauma film as an analogue stressor (see Holmes & Bourne, 2008).

To begin with, Wessel, Overwijk, Verwoerd, and de Vrieze (2008, Study 2) used a similar resistance to PI task, but administered it prior to the presentation of a stressful film fragment. One day after the presentation of the stressful film, participants returned to the lab and were asked to rate the frequency of intrusive thoughts about the film over the last 24 hours. The results showed a negative relationship between pre-film resistance to PI and intrusive thoughts about the film. This indicates that people with a relatively inefficient ability to resist PI in working memory were more inclined to report a high frequency of film-related intrusive thoughts. Interestingly, this relationship remained when potential confounders such as film-related distress, positive and negative affect, and gender were controlled. Furthermore, Verwoerd, Wessel, de Jong, Nieuwenhuis, and Huntjens (submitted) aimed at replicating and extending these findings to a different index of the ability to resist PI. They used a modified version of the California Verbal Learning Test (CVLT; Delis, Kramer, Kaplan, & Ober, 1987), which requires participants to study two lists of words that consist of different semantic categories. Some categories appear in both lists (shared categories, e.g., *animals* in List 1 and List 2), whereas other categories are present in one, but not the other list (unshared categories, e.g., *vegetables* in List 1 and *musical instruments* in List 2). The decrease in recall performance of shared category words in the first and second lists was used as an index of the ability to resist PI. In addition, as a measure of intrusions, participants were asked to record film-related intrusive memories in a take-home diary during 7 days after the first session. The results showed that decreased performance on the CVLT was related to a relatively high frequency of diary intrusions in the week following the presentation of the stressful film. Again, this relationship remained intact after controlling for prior trauma exposure, gender, neuroticism, and depression. This conceptual replication of the earlier findings with paired associates learning (Verwoerd, Wessel, & de Jong, 2009; Wessel et al., 2008, Study 2) implies that it is unlikely that the relationship between resistance to PI and intrusive memories depends on task-specific parameters. All in all, it appears that a relatively inefficient executive ability to resist PI in working memory might be a unique predictor of persistent intrusive memories after a stressful event.

How, then, might an executive ability such as resistance to PI contribute to either natural recovery or the development of psychopathology after trauma? Consider someone who was injured in a major traffic accident involving actual death and injury of several people. In the aftermath of this event, this person may frequently experience stressful intrusive memories in the form of visual images of specific moments during the accident. For example, the person may suddenly experience a mental image of being stuck in the car with no possibility of getting out, realizing that he would probably die. In order to pick up everyday life again (e.g., preparing for an upcoming exam, resuming work as a financial controller), it would be increasingly helpful to ignore these stressful intrusions. Resistance to PI would enhance goal-directed behavior and focusing on tasks at hand. To the extent that that is successful, it would also allow for achieving gradual control over intrusions. By contrast, when someone has a poorly developed ability to resist PI, intrusive memories may go astray, resulting in the development of PTSD. Nevertheless, questions remain how *exactly* resistance to PI works in order to ignore these stressful intrusive memories. In other words: what are the mechanisms underlying this relationship?

Executive Control May Help Disengagement of Attention from Stressful Trauma Reminders

In the clinical psychological literature, studies investigating intrusive memories of trauma almost exclusively rely on subjective indices such as questionnaires, structured interviews, and diaries. Of course, the results of such studies are informative with respect to several aspects of intrusive memories, such as their frequency, modality (e.g., visual, tactile, auditory), and the phenomenological experience that accompanies them (e.g., vividness and nowness; for an overview, see Ehlers, Hackmann, & Michael, 2004).

However, a relatively unexplored aspect of intrusive re-experiencing concerns the conditions determining its actual occurrence.

In general, clinical theories of PTSD (e.g., Ehlers & Clark, 2000) assume that intrusive re-experiencing reflects a direct retrieval process. That is, in contrast to an effortful strategic search for the specifics of an event (i.e., intentional retrieval), direct retrieval is automatic and cue-driven. It arises when a retrieval cue maps directly onto the content of a specific representation in long-term memory. Thus, in the context of PTSD, reminders that match the specific circumstances of a traumatic event (e.g., the color of a car, the smell of a rapist's breath) would trigger involuntary reliving (Ehlers & Clark, 2000). However, several accounts of PTSD (see Dalgleish, 2004) suggest that traumatic intrusions are not only triggered by cues that are unambiguously related to the traumatic event. Seemingly unimportant cues in the environment may also obtain intrusion-triggering power. Ehlers and colleagues (Ehlers, Michael, Chen, Payne, & Shan, 2006; Ehlers & Clark, 2000) argued that perceptual priming might be responsible for this. Enhanced perceptual priming can be conceptualized as increased activation of fragments of the representation of the traumatic experience in long-term memory. More specifically, the enhanced perceptual priming hypothesis (e.g., Ehlers et al., 2006; Michael & Ehlers, 2007) states that a primary focus on sensory (i.e., predominantly visual) details during encoding of the traumatic event would give rise to preferential processing of those environmental stimuli that bear a strong perceptual resemblance to the original traumatic situation. In our example of the traffic accident survivor, a flash of sunlight reflected by his bedroom window may trigger the visual image of the rapidly approaching headlights he saw just before being hit by a car (cf. Ehlers, Hackmann, & Michael, 2004). In this example, the sunlight works as a perceptual reminder of the earlier trauma. Preferential processing of trauma reminders would then increase the probability of direct retrieval, i.e., a direct match between perceptual trauma reminders and parts of the sensory-perceptual representation of the traumatic event. Such a direct match would, in turn, trigger the entire trauma memory, resulting in full-blown re-experiencing, including emotional responses (e.g., fear).

We argued above that a well-developed executive ability (i.e., resistance to PI) existing prior to trauma exposure may support gaining gradual control over intrusions. Perhaps this ability specifically reduces the processing bias for perceptual trauma reminders in the external environment (Ehlers & Clark, 2000) by interrupting the retrieval process. This, in turn, would loosen the association between a cue and traumatic memory, allowing for the formation of alternative associations of that cue with more neutral memory representations (see Brewin, Dalgleish, & Joseph, 1996; Brewin & Beaton, 2002). Alternatively, inefficient executive control may be responsible for a failure to cut short the retrieval process. This might manifest itself as a prolonged attentional engagement with perceptual reminders in the post-trauma environment.

A first step in exploring this idea would be to establish that, indeed, an inability to disengage attention from reminders is associated with a relatively high frequency of intrusive memories. For this purpose, we (Verwoerd, Wessel, de Jong, & Nieuwenhuis, 2009) conducted a study using a stressful film as analogue trauma. Participants were asked to detect neutral targets (rotated buildings) in a single target Rapid Serial Visual Presentation task (RSVP; e.g., Most, Chun, & Widders, 2005). Shortly before target appearance, a distracter image was presented. The distracters were visual images extracted from the stressful film (i.e., persons and objects that figured in that film) or were neutral control pictures of persons and animals.

Film-related interference was defined as a relatively high number of errors in target detection after film distracters in comparison with neutral distracters. The results showed that the degree of film-related interference on the RSVP predicted subsequent intrusions recorded in a one-week diary. This indicates that a difficulty to disengage attention from perceptual trauma reminders might serve as cognitive mechanism underlying persistent intrusive memories after trauma. To further explore whether this relationship would indeed reflect genuine differences in the (in)ability to disengage attention, several other variables were included in the analyses. First, self-report indices of film-related distress and neuroticism were included to control for any effects of increased levels of anxiety (state and trait) on the processing of film-related distracters on the RSVP (see Barnard, Ramponi, & Battye, 2005). Results showed that the relationship between film-related interference on the RSVP and the frequency of diary intrusions remained significant after controlling for these distress-related variables. This indicates that a relative inability to detect targets after film reminders did not simply result from individual differences in anxiety. Secondly and more importantly, self-reported attentional control (assessed prior to presentation of the stressful film), was significantly associated with RSVP target detection. Of course, this self-report measure of attentional control provides merely a global index of executive ability, and it remains to be seen whether this result is replicated when a behavioral measure of resistance to PI is employed. Nevertheless, this finding is in line with the idea that individual differences in executive control were involved in preventing elaborate processing of film-related distracter stimuli. As such, these findings provide preliminary evidence for the idea that inefficient pre-trauma executive control may manifest itself in an inability to disengage attention from perceptual trauma reminders in the post-trauma environment. An interesting avenue for future research would be to formally test whether an association between pre-trauma resistance to PI and persistent intrusive memories will be (partly) mediated by an individual's ability to disengage attention from perceptual trauma reminders. This would significantly increase understanding of the underlying mechanisms explaining how inefficient executive control might exactly lead to the uncontrolled occurrence of intrusive memories after trauma. Knowledge about underlying mechanisms might be particularly valuable for developing specific interventions for people at risk for developing persistent intrusive memories

Further Theoretical Considerations

We started this chapter by noting that apparently many people who are exposed to a traumatic stressor are able to overcome the emotional turmoil that may arise in the aftermath of such an event. We proposed that (part of) their resilience may be due to efficient executive functioning. That is, by focusing more and more on daily tasks as time progresses and thus preventing unwanted stressful memories from occupying working memory resources, people may gradually gain control over traumatic intrusions. Alternatively, relatively inefficient executive functioning may constitute a pre-trauma vulnerability factor that is responsible for the maintenance of intrusive memories, and ultimately, may contribute to the development of PTSD. Recently, Levy and Anderson (2008) advanced a similar proposal. This proposal is based on the memory inhibition theory that Anderson and colleagues have been developing for the past 15 years (see Anderson, 2005; Anderson, Bjork, & Bjork, 1994; Anderson & Green, 2001; Anderson & Spellman, 1995; Levy & Anderson, 2002, Levy and Anderson, 2008). How does the present idea relate to this inhibition account?

Anderson and colleagues propose that exerting executive control is instrumental in the suppression of unwanted memories. In 2001, Anderson and Green introduced the Think/No-Think (TNT) paradigm. In this task, participants first extensively learn a list of cue-target combinations of neutral words (e.g., *braid – doll*, *tattoo – uncle*). During a later think/no-think phase, only the cue word of those pairs is presented. Participants receive two types of instructions. The first is that on particular trials, they should respond to the cue (e.g., *braid*) as quickly as possible by saying the target word out loud (e.g., *doll*). On other trials, however, participants not only have to withhold overt responding upon cue presentation (e.g., *tattoo*), but they are also instructed to keep the target (e.g., *uncle*) out of conscious awareness altogether (suppression). The crucial question is what happens to the targets during a later cued recall task. The typical finding is that under respond instructions, target recall increases linearly with the number of times a particular cue was presented (i.e., 0, 1, 8, or 16 times). By contrast, cued recall of suppressed targets shows a linear decrease as a function of the number of times the conscious thought of these targets was to be avoided. Anderson and colleagues (Anderson & Green, 2001; Levy & Anderson, 2002) interpret this latter result in terms of inhibition. According to their view, exerting executive control in order to avoid conscious awareness of an item reduces the activation level of that item in long-term memory, rendering it less available for recall.

This latter notion of reduced activation of long-term memory representations is especially appealing in light of trying to account for a gradual subsiding of traumatic intrusions over time. Strong emotions give rise to strongly activated long-term memory representations. For example, there is good evidence that stress hormones (such as (nor)epinephrine) act on the amygdala, which results in better memory for negatively emotional than neutral stimuli (for overviews, see Cahill & McGaugh, 1998; van Stegeren, 2008). Because of high levels of activation, the traumatic memory would be triggered easily (see also Dalgleish, 2004). Thus, if exerting inhibitory executive control indeed reduces activation levels, the probability that these unwanted traumatic memories intrude into consciousness would also be reduced. From the outset, our research program on executive control and intrusive memories was inspired by this particular implication of Anderson's inhibition theory (e.g., Overwijk, Wessel, & de Jong, 2009; Wessel, Overwijk, Verwoerd, & de Vrieze, 2008; for more on inhibition in the context of retrieving information from autobiographical memory, see Pastötter & Bäuml, Chapter 9, this volume).

Although the assumption that executive control reduces the availability of an unwanted memory is fascinating, it also invites problems. Note that it is difficult to measure the activation level of a memory representation directly. In order to conclude that, indeed, decreased activation of the underlying LTM representations is responsible for relatively poor memory performance, alternative explanations must be ruled out. For example, because a task such as the TNT heavily depends on learning cue-target pairs, observing impaired recall using the same cues as in the study phase would leave room for an interpretation in terms of weakened cue-target associations. In that case, it would be more appropriate to speak of decreased accessibility rather than decreased availability. Anderson and colleagues (Anderson & Green, 2001; Anderson et al., 2004; see also Anderson & Spellman, 1995) came up with an ingenious way of circumventing this problem. They reasoned that if memory representations have a relatively low activation level, using a test consisting of cues that are related to the targets but not to the original learning context should also result in impaired performance. Indeed, this independent probe method rendered impaired recall for previously suppressed items (Anderson & Green, 2001; Anderson et al., 2004).[3] However, to the best of our knowledge, these are the only two studies that reported significant suppression effects on the independent probe test and they both came from Anderson's group. There are at least two other publications reporting a failure to find independent probe effects (Bulevich, Roediger, Balota, & Butler, 2006; Wessel, Wetzels, Jelicic, & Merckelbach, 2005). In addition, there are a number of published studies that focused on same probe testing, but in which independent probe recall performance was not assessed (probably due to restrictions set by the experimental design, e.g., Depue, Banich, & Curran, 2006; Depue, Curran, & Banich, 2007; Hertel & Gerstle, 2003; Hertel & Calcaterra, 2005; Joormann, Hertel, Borzovich, & Gotlib, 2005). Thus, all in all, it seems that the empirical evidence for the independent probe effect is scarce at best. An additional problem for the study of traumatic memory is that it is not obvious how to implement independent probe testing in case of complex autobiographical memories (for a detailed discussion of this problem, see Barnier, Hung, & Conway, 2004). Given these complications and the scarcity of empirical evidence in the case of simple (word) stimuli, we wonder about the additional value of an account in terms of decreased activation for understanding executive control perhaps leading to a decrease in the occurrence of intrusive traumatic memories.

Taken together, although our idea concurs with Levy and Anderson's (2008) suggestion that deficient premorbid executive control may constitute a risk factor for the development of PTSD, our views differ when it comes to the precise mechanism. Inhibition theory focuses on the putative consequences of exerting inhibitory control for the memory representation itself. In contrast, we propose that executive control facilitates the loosening of associations between the trauma memory and perceptual trauma reminders.

Conclusion and Future Directions

Executive control and more specifically resistance to PI may help trauma-exposed people to gradually gain control over traumatic intrusions in the aftermath of a traumatic event. More specifically, executive control may be instrumental in reducing a perceptual processing bias, in that it may facilitate disengaging attention from trauma reminders. This might help loosen the association between cue and trauma memory, which in turn would leave room for the formation of alternative associations, for example between the (former) trauma reminder and more neutral concepts in long-term memory. Alternatively, people with a relatively inefficient executive control might fail to abort the associative and reflexive retrieval process that arises upon encountering perceptual cues that resemble environmental details encoded during the traumatic event.

All in all, we propose that deficient executive control constitutes a vulnerability factor that is expressed as an inability to disengage attention from perceptual trauma reminders in the post-trauma environment. As such, it may be responsible for the maintenance of intrusive memories that naturally arise in the aftermath of trauma and, ultimately, contribute to the development of PTSD. As this suggestion is based mainly on analogue studies, an interesting avenue for future research would be to test whether a premorbid deficit in executive control predicts intrusive memories after real-life traumatic events. For example, prospective studies of soldiers tested before and after deployment to a war zone might establish whether poor resistance to PI is a vulnerability factor for persistent intrusive memories. This may add knowledge to earlier prospective investigations (e.g., Parslow & Jorm, 2007; Gilbertson et al., 2006) which explored PTSD-related deficits in larger test batteries without focusing on the role of specific executive abilities. To keep measurement as sensitive as possible, future work may combine several individual indices of resistance to PI in order to construct a latent variable (cf. Friedman & Miyake, 2004) as a predictor of persistent intrusions after trauma exposure. In addition, to further test the idea that a specific inability to disengage attention from perceptual trauma reminders might underlie persistent intrusive re-experiencing after trauma, investigators may adapt the RSVP paradigm for use in naturalistic studies. For example, photographic material from a trauma scene (a major traffic accident, a natural disaster) might be selected and presented shortly after trauma exposure. It would be interesting to see whether decreased RSVP target detection after visual reminders of that particular traumatic event (e.g., photographs of wrecked cars, medical service personnel/ambulances) would predict intrusive memories and PTSD at a later point in time. All in all, if such future work shows that, indeed, poor pre-trauma executive control is responsible for an inability to disengage attention from perceptual trauma reminders and thus the maintenance of intrusive memories after real-life trauma, this may inform the development of interventions that specifically target those people who are most vulnerable for the development of PTSD.

Notes

1. In this study, delayed recall does not imply retention over a longer period, as initial recall was not taken into account.
2. A collection of theoretical models has given different headers to this latter component and its functions, such as central executive (Baddeley, 1996), supervisory attentional system (SAS; Atkinson and Shiffrin, 1968), attentional control (Unsworth and Engle, 2007), and executive control (Friedman et al., 2008; Levy and Anderson, 2008). In this chapter, we use the term executive control.
3. It should be noted that Bulevitch et al. also failed to find suppression effects using same probe testing. Wessel, Wetzels, Jelicic, and Merckelbach (2005) were able to find same probe suppression effects. In addition, at least three additional experiments in our lab (e.g., Overwijk, Wessel, Huntjens, & Zandstra, unpublished data; Wessel, Huntjens, & Verwoerd, 2010) consistently show null-results for independent probe testing. For same probe testing, suppression effects were replicated in these experiments.

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15

The Content, Nature, and Persistence of Intrusive Memories in Depression

Alishia D. Williams and Michelle L. Moulds

Recent research has demonstrated that intrusive memories of negative autobiographical events represent an overlapping cognitive feature of depression and posttraumatic stress disorder (PTSD; APA, 1994). Clearly, the *content* of intrusive memories in depression and PTSD is necessarily distinctive – in PTSD, the triggering event (and thus the content of the intrusions) must be traumatic (i.e., life threatening). Nonetheless, the intrusiveness of the memories in both conditions speaks to the possibility that common cognitive processes underpin their persistence in both disorders. This overlap challenges traditional notions of the dichotomy/categorical division between mood and anxiety disorder symptomatology, and is in accordance with a transdiagnostic approach that underscores the utility of investigating shared clinical features across different disorders (Harvey, Watkins, Mansell, & Shafran, 2004). Understanding the role of intrusive memories will have significant potential implications for both theoretical models of depression and for the development of clinical interventions that specifically target intrusive memories in depressive disorders (Brewin, 1998).

The current chapter will review the body of research that delineates the cognitive processes that underpin the manifestation, experience, and persistence of intrusive memories in depression. This chapter will first review the relevant literature on intrusive memories in the context of PTSD. Cognitive

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models of intrusion maintenance in PTSD will be presented to provide a theoretical grounding for discussion of intrusive memories in depression. The chapter will then detail the research that demonstrates the existence of intrusive memories in depression and discuss the implications of the parallels observed between the intrusion profiles across these two disorders.

Intrusive Memories in PTSD

Spontaneously occurring memories are a core diagnostic feature of PTSD (see Krans, Woud, Näring, Becker, & Holmes, Chapter 13, and Verwoerd & Wessel, Chapter 14, this volume). Intrusive memories in this context are defined by the involuntary reliving of a past traumatic event, and may be experienced in either typical autobiographical form or in "flashback" form. They can include visual representations and other sensory modalities such as auditory, olfactory, and kinetic re-experiencing (Bryant & Harvey, 1998; Ehlers & Steil, 1995; Ehlers et al., 2002). In the context of PTSD, intrusive memories are conceptualized as indices of unsuccessful emotional processing of the trauma. Emotional processing was first described by Rachman (1980) as "a process whereby emotional disturbances are absorbed, and decline to the extent that other experiences and behavior can proceed without disruption" (p. 51). Therefore, unsuccessful emotional processing in the context of PTSD is indicated by the persistence of images, thoughts, memories, or kinetic sensations of the traumatic event. Emotional processing is impeded by the employment of avoidant coping mechanisms and inhibitory processes that prevent the experience of negative affect and emotional distress (Rachman, 1980). Consistent with this conceptualization, cognitive and behavioral avoidance of trauma memories contributes to the maintenance of PTSD symptoms and predicts the course of the disorder (Brewin & Holmes, 2003).

Several variables have been implicated in the maintenance of intrusive memories in PTSD. These include experiential characteristics of the memories, the attributions assigned to them, and the use of cognitive coping strategies to manage them.

Characteristics of intrusive memories in PTSD

There is evidence that key characteristics of intrusive memories play an important role in contributing to the maintenance of PTSD. Ehlers, Hackmann, and Michael (2004), Ehlers et al. (2002), and Hackmann, Ehlers, Speckens, and Clark (2004) conducted detailed analyses of the content and qualities of intrusive memories of trauma survivors. Participants were questioned about a range of features of the memories; e.g., whether intrusions consisted of sensory experiences (visual, sound, smell) and bodily sensations, the presence of any triggers of the intrusive memory, and whether the intrusion content corresponded with the "worst" moment of the trauma. These studies demonstrated that the content of intrusive memories typically consist of stimuli that were present prior to the moments of the trauma with the largest emotional impact, rather than the worst (i.e., most traumatic) aspect of the trauma per se (Ehlers et al., 2002), prompting the conclusion that intrusive memories function as a "warning signal." In addition, this line of work highlighted that intrusions in PTSD are experienced in multiple sensory modalities. Intrusions predominantly consist of brief visual snapshots (Ehlers & Steil, 1995; Hackmann et al., 2004; van der Kolk & Fisler, 1995), but Hackmann et al. (2004) found that kinetic or bodily sensations (e.g., sensations of pain, autonomic arousal) also commonly accompanied intrusions. Intrusions also had auditory and olfactory components, although the latter were the least commonly reported (Hackmann et al., 2004).

Michael, Ehlers, Halligan, & Clark (2005) investigated whether key characteristics of intrusive memories are linked to the persistence of PTSD symptoms. In their sample of assault survivors, the *presence* and *frequency* of intrusive memories predicted 17 percent of the variance in PTSD severity at 6 months post-assault. Notably, the addition of intrusive memory features (i.e., distress associated with the intrusions, "here and now" quality of the intrusions, lack of context of the intrusions) to the regression explained an additional 43 percent of the variance. The lack of context cues may partially explain why individuals re-experience the memory as an event that is occurring in the present rather than in the past, because the memory is not linked to clearly defined temporal information (Ehlers & Clark, 2000). Michael et al. (2005) noted that it may be the quality of perceived "nowness" that differentiates intrusive trauma memories from normal autobiographical memories. Interestingly, nowness was identified by Speckens, Ehlers, Hackmann, and Clark (2006) as a predictor of poor treatment response to imaginal exposure for PTSD. As previously mentioned, inadequate integration of the trauma memory with other autobiographical information has been theorized to explain the persistent quality of intrusive memories, as integration is believed to lead to their reduction and eventual cessation (Ehlers & Clark, 2000).

Additionally, the sense of reliving has been linked to "hotspots" or portions of the trauma memory that evoke a high degree of distress (Ehlers & Clark, 2000; Grey, Holmes, & Brewin, 2001). Holmes, Grey, and Young (2005) suggested that hotspots represent moments of the trauma that have been processed in a sensory-perceptual mode, and found that these hotspots often matched reports of intrusion content. These authors proposed that the high level of arousal associated with these moments impedes processing and increases the likelihood of intrusions occurring when relevant cues are present. Taken together, these findings highlight the importance of key characteristics of intrusive memories in contributing to their persistence, and in turn, to the maintenance of PTSD.

Interpretations and appraisals of intrusive memories in PTSD

Appraisals of the significance of intrusions have also been implicated in the persistence of PTSD symptomatology. Ehlers and Steil (1995) proposed that negative interpretations assigned to intrusive memories, rather than their presence or frequency per se, results in the persistence of PTSD. Indeed, Steil and Ehlers (2000) found that idiosyncratic, dysfunctional meanings (e.g., "I am going crazy") assigned to intrusive symptoms significantly predicted PTSD severity, over and above intrusion frequency. The role of negative interpretations in predicting PTSD maintenance has been consistently demonstrated in additional retrospective and prospective studies (Dunmore, Clark, & Ehlers, 2001; Halligan, Michael, Clark, & Ehlers, 2003; Mayou, Ehlers, & Bryant, 2002).

Furthermore, negative appraisals and beliefs about intrusions may remain if individuals engage in safety behaviors. Safety behaviors include both cognitive and behavioral strategies that are employed to reduce symptoms (in this case, intrusions), but that paradoxically maintain or even increase them by preventing disconfirmation of the maladaptive cognitions that drive the symptomatology (Salkovskis, 1989, 1991). For example, in PTSD, the belief "I'll go crazy if I think about the accident" will likely promote the safety behavior of suppression of trauma memories. However, suppression prevents learning that one in fact can think about the memory and although feel distressed, not "go crazy." In this way, suppression contributes to PTSD persistence by both preventing disconfirmation of this faulty belief and increasing the frequency of intrusive memories (Ehlers & Clark, 2000).

Cognitive avoidance of intrusive memories in PTSD

Cognitive conceptualizations of PTSD (e.g., Ehlers & Clark, 2000; Ehlers & Steil, 1995; Foa, Steketee, & Rothbaum, 1989) posit that successful emotional processing of the trauma is prevented when the individual employs avoidant cognitive strategies. Cognitive avoidance includes intentional attempts at thought/memory suppression, efforts to dissociate or detach oneself from the affective qualities of the trauma experience, and engaging in rumination (Ehlers & Clark, 2000). Various forms of cognitive avoidance, and the evidence of the supporting role of each in the management of intrusive memories in PTSD, are now reviewed.

Thought suppression refers to intentional, conscious attempts to remove a thought from attention. Wegner (1994) proposed a theory of mental control that includes an effortful operating system that searches for information that is compatible with an individual's preferred mental state, and an automatic monitoring system that seeks out evidence of failures in the operating system. This Ironic Process Theory (Wegner, 1994) suggests that when intrusions are unsuccessfully suppressed by the use of inappropriate distractors, this failure activates a circular process of monitoring of target intrusions and searching for further distractors (Wegner, 1994, 1997; Wegner & Wenzlaff, 1996). It is important to note that the operating process is capacity-limited and therefore its functioning is adversely affected by interfering cognitive tasks, whereas the monitoring process is able to function despite the introduction of a cognitive load (Rassin, Merckelbach, & Muris, 2000). There is evidence that the asymmetry in functioning between the two processes can lead to increased suppression failures as well as to a heightened ability to detect these failures when under cognitive load (Wegner & Erber, 1992). Thus, efforts to suppress material can result in a "rebound effect" in that unwanted mental representations become highlighted and more prevalent.

Empirical studies support the role of thought suppression in PTSD symptom maintenance (Aaron, Zagul, & Emery, 1999; Amir et al., 1997; Ehlers, Mayou, & Bryant, 1998) and in memory reoccurrence (Shipherd & Beck, 1999). Suppression of trauma memories has also been hypothesized to contribute to re-experiencing symptoms by preventing information from being processed conceptually. Research suggests that the use of suppression and other avoidant strategies to control trauma memories is associated with posttraumatic anxiety because it affects engagement with and resolution of aversive memories (Guthrie & Bryant, 2000).

Rumination refers to negative recyclic thinking about the trauma and its consequences, how the trauma could have been prevented, and evaluations of one's actions during the trauma. Rumination involves thinking *about* the causes and consequences of the trauma, rather than directly reliving the emotions associated with the event (Ehlers & Clark, 2000). Although rumination may appear antithetical to the concept of avoidance in that it involves directing attention to and extensively thinking about the trauma, it is proposed that this type of analytical thought limits the activation of the fear network that is necessary for the resolution of PTSD (Foa, Steketee, & Rothbaum, 1989). Thus, rumination discourages emotional reliving of the event and thereby serves an avoidant function. Rumination is proposed to interfere with the consolidation of the trauma memory (Ehlers & Clark, 2000), and to contribute to the persistence of intrusions. There is also evidence that rumination in PTSD triggers intrusive memories (Michael, Halligan, Clark, & Ehlers, 2007).

A memory feature that may be linked to cognitive avoidance is the vantage perspective from which a memory is recalled. Memories recalled in the first person are experienced from the individual's original or "field" perspective, whereas memories recalled in the third person are experienced from an "observer" perspective. Field perspective memories contain more information on affective, physical, and physiological states, while observer memories contain more descriptive and less affect-laden information (Nigro & Neisser, 1983). (For more on vantage perspective, see Rice, Chapter 10, this volume.)

McIsaac and Eich (2004) proposed that recalling trauma memories from a third-person, observer perspective may serve as a cognitive avoidance mechanism similar to suppression techniques. In effect, an observer perspective may function as a means of removing oneself from reliving the specific event by becoming a "detached spectator" In accord with this suggestion, both research and clinical observations indicate that this is common in victims of disasters and assaults (Cardena & Spiegel, 1993; Foa & Rothbaum, 1998, as cited in McIsaac & Eich, 2004). In addition, McIsaac and Eich (2004) proposed that the adoption of a third-person vantage point when recalling trauma memories may hinder the emotional processing of the traumatic event. On the basis that emotional processing requires integration of both cognitive and affective information (Foa & Kozak, 1986), recalling a memory from a detached observer perspective could prevent the integration of the affective components of the memory by limiting emotional activation in favor of a focus on the concrete and objective details of the original experience (McIsaac & Eich, 2004). Since emotional activation and subsequent integration of this information is critical in reducing the frequency of intrusive memories, observer perspective recall may therefore interfere with exposure-based therapies (McIsaac & Eich, 2004) and thus contribute to the maintenance of intrusions.

Summary of Intrusive Memories in PTSD

Investigations of the content, form, characteristics, and management of intrusive memories have culminated in the emergence of a clearer understanding of these memories in PTSD. In addition, such research has demonstrated the importance of these variables in maintaining and predicting the course of the disorder, as well as their potential to interfere with treatment regimes. This body of research has not only advanced understanding of intrusive trauma memories, but has served as a useful database for guiding hypotheses regarding intrusive memories in depression.

Intrusive Memories in Depression

A number of studies have provided evidence that intrusive memories are not unique to PTSD, but are also reported in depression (Brewin, Hunter, Carroll, & Tata, 1996; Carlier, Voerman, & Gersons, 2000; Kuyken & Brewin, 1994, 1995, 1999) by approximately 86 percent of clinical patients

(Kuyken & Brewin, 1994). Kuyken and Brewin (1994) first investigated intrusive memories in depression. They found that females who experienced childhood abuse reported levels of intrusions that were comparable to those reported by PTSD patients (as indexed by the Impact of Event Scale, IES; Horowitz, Wilner, & Alvarez, 1979). Further, levels of intrusions and avoidance on the IES positively correlated with severity of reported abuse as well as depression severity (Kuyken & Brewin, 1994). Brewin et al. (1996) extended these initial findings by investigating intrusive memories in a sample of both female and male depressed patients. The authors investigated a broader range of experiences and events (i.e., not solely confined to a history of abuse). The intrusive memories reported by their sample were classified into four main categories: illness/death, relationship/family problems, abuse/assault, and work/financial problems. Common emotional responses that corresponded with memories included guilt, sadness, helplessness, anger, shame, and anxiety. Consistent with Kuyken and Brewin (1994), the results indicated that depression severity was positively correlated with the frequency of intrusive memories. Additionally, there was a relationship between the duration of the current depressive episode and the total number of memories reported (Brewin et al., 1996), such that participants who reported more memories experienced episodes of longer duration. There is also evidence of a relationship between intrusive memories and the maladaptive cognitive features that characterize depression. For example, depressed individuals with more intrusive memories of abuse reported lower self-esteem, a more negative attribution style, and greater avoidance (Kuyken & Brewin, 1999).

Extending this line of work beyond cross-sectional studies, Brewin, Reynolds, and Tata (1999) found that in a sample of clinically depressed patients, avoidance of intrusive memories was predictive of depression symptoms at 6-month follow-up, after controlling for baseline levels of depression. Additionally, Brewin, Watson, McCarthy, Hyman, and Dayson (1998) demonstrated an association between intrusive memories and depression in a longitudinal study of matched samples of depressed cancer patients. They found that the presence and avoidance of intrusive memories at baseline predicted anxiety levels at 6-month follow-up. Taken together, these longitudinal findings indicate that intrusive memories play an important role in the course of depression, and, importantly, demonstrate that intrusive memories are more than an epiphenomenon of depression.

Evidence of Shared Features of Intrusive Memories in PTSD and Depression

While the studies reported above demonstrate that the presence of intrusive memories is common to both depression and PTSD, more recent work has begun to systematically explore the degree to which the features of such memories, and the way in which such memories are managed, overlap in the two disorders.

Content and characteristics of intrusive memories in depression

In an investigation of the similarities of intrusive memories in PTSD and depression, Reynolds and Brewin (1998) found that both groups employed similar coping strategies in response to intrusions. Additionally, Reynolds and Brewin (1999) found significant qualitative overlap in the memories reported by patients across these disorders. With the exception that PTSD patients reported more "out-of-body" dissociative responses, both clinical groups reported comparable ratings of intrusion vividness and associated distress, and both noted that memories were accompanied by kinetic sensations. These findings prompted Reynolds and Brewin (1999) to conclude that "the presence of intrusive memories does not distinguish PTSD from major depression as clearly as might be inferred from diagnostic checklists" (p. 212).

Birrer, Michael, and Munsch (2007) recently compared intrusive images in patients with PTSD and depressed patients with and without trauma and found few differences between these groups. Although depressed patients without trauma were less likely to report their intrusion in a visual sensory modality and were less likely to report an accompanying sense of "nowness" compared to PTSD patients, intrusions were experienced similarly across the diagnostic groups in terms of other sensory modalities, intrusion duration, and frequency. In line with previous research (e.g., Brewin, Dalgleish, & Joseph, 1996; Ehlers & Clark, 2000), a range of identifiable triggers was also noted. The most commonly reported trigger across all three diagnostic categories was rumination, which highlights the need to assess for internal as well as external triggers in both depressed and PTSD patients (Birrer et al., 2007). Finally, intrusive images relating to critical life events (childbirth, divorce, etc.) reported by depressed samples were rated as equally distressing as intrusions about traumatic events reported by PTSD patients, supporting the abovementioned findings of Reynolds and Brewin (1999).

In another recent study, Patel et al. (2007) documented the co-occurrence of intrusive images with intrusive memories. Intrusive images defined here referred to an isolated component of the memory or to imagined events that could have happened. The authors found that images were experienced as snapshots of the memory that formed the intrusion and generally held significant meaning to the individual. Patel et al. (2007) noted the potential parallel of these images to hotspots in PTSD that typically represent the moments of the trauma that have the greatest emotional impact (cf. Holmes, Grey, & Young, 2005).

Looking specifically at intrusive memories, Williams and Moulds (2007a) used descriptive and correlational methodologies to outline the content and features of these intrusions in a dysphoric sample, and investigated whether intrusion characteristics linked to intrusive memories in PTSD were also characteristic of intrusive memories in depression. Basic analyses of the content and defining characteristics of negative intrusive memories revealed findings consistent with Brewin et al. (1996) regarding the themes of the memories. The majority of respondents reported intrusions of interpersonal events, but personal failures such as poor academic and work performance, death and illness of others, and injuries or abuse to oneself were also common. The findings were also consistent with those obtained in PTSD samples (Ehlers et al., 2002) regarding the sensory experiences most commonly associated with intrusive memories. Respondents indicated that memories were predominantly of a visual/feeling/auditory modality, although some participants also endorsed kinetic and olfactory memories.

The most interesting finding to emerge was the relationship between levels of depression, intrusion-related distress, and the sense of nowness or reliving of the original event. Michael, Ehlers, Halligan, and Clark (2005) identified the capacity of the sense of nowness to predict concurrent and longitudinal PTSD severity, irrespective of frequency of intrusions, re-experiencing symptoms, and baseline diagnostic status. Williams and Moulds (2007a) found that the sense of nowness emerged as a significant predictor of both levels of distress and levels of depression, indicating that this intrusive memory feature is not unique to trauma memories. This finding is of great interest in the context of theoretical accounts of intrusion maintenance in PTSD that implicate the lack of integration of the intruding memory with other autobiographical memories (Ehlers, Hackmann, & Michael, 2004; Ehlers & Clark, 2000). Normal autobiographical memories are argued to be organized by thematic representations and temporal representations that are personally relevant (Conway & Pleydell-Pearce, 1997, as cited in Ehlers & Clark, 2000). Ehlers and Clark (2000) suggest that in PTSD the trauma memory is not sufficiently elaborated or integrated into one's autobiographical memory knowledge base. Thus, the trauma memory lacks grounding to the temporal information that typically organizes autobiographical memories, resulting in the experience of a sense of current threat and nowness when trauma memories come to mind. Interestingly, this intrusion characteristic has been identified by Speckens, Ehlers, Hackmann, and Clark (2006) as a predictor of poor treatment response to imaginal exposure for PTSD. It is highly likely that nowness may also prove to be a key variable to consider in the application of emotional processing treatment procedures to depression proposed by Brewin and colleagues (e.g., Brewin, Hunter, Carroll, & Tata, 1996; Brewin, Reynolds, & Tata, 1999; Kuyken & Brewin, 1994), discussed later in this chapter.

Appraisals of the meaning of intrusive memories in depression

The role of appraisals of intrusive memories in the maintenance of depression has received preliminary research attention (Starr & Moulds, 2006; Williams & Moulds, 2008a). In a nonclinical sample, dysfunctional meanings of intrusive memories and intrusion-related distress predicted depression levels (Starr & Moulds, 2006). These associations remained significant when intrusion frequency and severity of the event (i.e., of the event that formed the content of the intrusive memory) were partialled out, providing initial empirical evidence for a role of dysfunctional meanings of intrusive memories in the maintenance of depression. Further, these findings suggested that the use of avoidant cognitive strategies, such as suppression, may be contingent upon the subjective meaning of the intrusive memory, rather than the mere presence of these memories. Williams and Moulds (2008a) similarly found that assigning negative appraisals to one's intrusive memory was positively associated with levels of distress, dysphoria, and the employment of cognitive avoidance mechanisms. These results parallel the findings demonstrated in the PTSD literature, as assigning negative appraisals to one's intrusion was similarly the best predictor of PTSD severity (Steil & Ehlers, 2000). Additionally, we found that beliefs about the need to control intrusions were significantly correlated with negative appraisals of intrusions and current dysphoric status (Williams & Moulds, 2008a). This finding suggests that a theoretical conceptualization of the management of intrusive memories in depression should consider the importance of beliefs about controlling memories, in addition to the negative appraisals of memories.

These studies assume that maladaptive appraisals are secondary to the occurrence of an intrusive memory. That is, the experience of an intrusive memory prompts the appraisal "having this memory over and over means that there is something wrong with me." However, such appraisals likely reflect the presence of underlying negative beliefs that are activated by the occurrence of an intrusion (Moulds et al., 2008). These authors also speculate that such beliefs may not be exclusive to intrusive autobiographical memories, but may instead reflect beliefs about the experience of *any* negative emotion or experience. Such beliefs may exist prior to the occurrence of negative life events/stressors, and render an individual vulnerable to interpret intrusive memories of such events negatively. Longitudinal investigations are needed to address the question of whether pre-existing beliefs about intrusive memories/negative emotions increase an individual's vulnerability to appraise and respond to intrusions in a manner that is maladaptive, and thus prompt avoidance responses and in turn, depression.

A related issue pertains to the influence of current mood on an individual's tendency to assign negative appraisals to intrusive memories. It may be that negative appraisals of intrusive memories are made regardless of an individual's mood state, (i.e., whether depressed or not). In the event of the experience of future intrusive memories, such appraisals could serve as a vulnerability factor for escalation into a depressive episode (Moulds et al., 2008). An alternative possibility is that maladaptive appraisals of intrusions are less likely to be activated when one is no longer in an active depressive episode; that is, negative interpretations may merely be a function of the depressogenic, negative interpretation style that characterizes depression. A relevant theoretical framework to consider here is Teasdale's (1988) differential activation hypothesis (DAH), which proposes that the degree of activation of negative content (e.g., dysfunctional attitudes) and cognitive processes (e.g., rumination) during a dysphoric state determine the likelihood of depression recurrence. This model holds that negative cognitive processes become associated with low mood during early episodes of depression so that future experiences of low mood reactivate these processes and result in escalation into a depressive episode; thus, depression recurrence (Lau, Segal, & Williams, 2004). With this theoretical model in mind, future prospective investigations are required to index intrusive memories, corresponding appraisals, and associated management strategies at different stages of depression (i.e., during and between depressive episodes). Furthermore, cross-sectional comparisons of currently depressed, recovered depressed, and never-depressed participants are required to clarify whether intrusive memories and associated parameters represent another cognitive process that is predictive of depression relapse in the context of the DAH (Moulds et al., 2008).

Further support for the notion that shared cognitive processes may underpin intrusion maintenance in PTSD and depression comes from recent research into the use of safety behaviors. Moulds, Kandris, Williams, and Lang (2008) investigated a range of safety behaviors in response to intrusive memories in a sample of high dysphoric participants. This study supported previous research (Starr & Moulds, 2006) in that the dysfunctional beliefs commonly reported by PTSD patients were also endorsed by dysphoric individuals. Additionally, participants reported that they engaged in a range of cognitive and behavioral safety behaviors, consistent with the adoption of safety behaviors in response to intrusions in PTSD (Ehlers & Clark, 2000). Cognitive distraction, such as focusing on the words of a song to avoid thinking about the memory, was the most commonly reported strategy, but behavioral distraction (e.g., exercise) and the use of alcohol or drugs were also reported.

Cognitive avoidance of intrusive memories in depression

Thought suppression is a commonly employed strategy used by depressed individuals in an effort to avoid the pervasive negative intrusions that typify depressive thinking (Wenzlaff, 1993). Wegner proposed that the Ironic Process Theory (as described earlier in relation to PTSD) could also account for the increase in intrusions subsequent to suppression efforts in depressed individuals. Some of the core features of depression, notably the ease with which negative thoughts come to mind and depletions in cognitive capacity, may influence the operation of the ironic process and thus make depressed individuals less successful at suppression (Beevers, Wenzlaff, Hayes, & Scott, 1999; Conway, Howell, & Giannopoulos, 1991; Wenzlaff, Wegner, & Roper, 1988). As a result, depressed individuals may be left highly susceptible to rebound effects. In fact, Wenzlaff et al. (1988) reported that depressed participants used more negative distracters in a suppression task compared to non-depressed participants and that it was the selection of these distracters that accounted for the rebound in thought occurrence. Additionally, Dalgleish and Yiend (2006) demonstrated that dysphoric participants who were instructed to suppress a negative autobiographical memory reported more intrusions during suppression than did non-dysphoric participants. In addition, the dysphoric participants later experienced facilitated access to other negative memories in response to a cued-memory task.

Williams and Moulds (2007b) examined how repeated suppression efforts may help to maintain intrusive memories in a sample of high and low dysphoric participants. High dysphoric participants reported intrusive memories of a longer duration, and rated their memories as more distressing, than did low dysphoric participants, although these differences were not statistically significant. This trend suggested that the effects of suppression may be particularly maladaptive for depressed individuals and accords with the research demonstrating that depletions in cognitive capacity associated with depression may generally make individuals less successful at suppression (Beevers, Wenzlaff, Hayes, & Scott, 1999; Conway, Howell, & Giannopoulos, 1991; Wenzlaff, Wegner, & Roper, 1988). Additionally, it was found that participants' ratings of distress while experiencing their intrusive memory were higher when instructed to suppress, suggesting that suppression may also lead to a heightened distress response, which may in turn fuel further suppression efforts, resulting in the maintenance of intrusive memories.

In the context of depression, rumination has been defined as repetitive but passive thinking about possible precipitating factors, current symptoms, and the consequences of these depressive symptoms (Nolen-Hoeksema, 1991). Rumination is a core cognitive process in depression, implicated in the onset of depression (Nolen-Hoeksema, Morrow, & Fredrickson, 1993) and the maintenance of negative mood in dysphoric individuals (for a review, see Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). Although rumination appears to involve the processing of symptom-relevant information, and therefore may appear antithetical to the concept of avoidance, ruminating in response to intrusive memories may impede successful *emotional processing* of the memory. Emotional processing involves the integration of emotionally relevant trauma-related information into conceptual memory. Successful processing is integral to the cessation of intrusive memories (Ehlers & Steil, 1995; Foa & Kozak, 1986).

Despite substantial evidence of the detrimental effects of ruminative self-focus, paradoxically (as noted and reviewed by Watkins, 2004), there are clear suggestions that under some circumstances, self-focus can actually promote well-being and confer benefits, including improvements in negative affect (Hunt, 1998; Lepore, 1997). The work of Watkins and colleagues (Watkins, 2004; Watkins & Teasdale, 2001, 2004) has addressed these seemingly contradictory effects and has suggested that it is not ruminative self-focus per se that is problematic; rather, it is the mode of processing (abstract/analytical or concrete/experiential) adopted *during* self-focus that determines whether self-focus has a positive or a negative outcome (Watkins & Moulds, 2005). Abstract/analytical processing is characterized by *why?* questions (e.g., "Why do I feel this way?"), while concrete/experiential processing involves a focus on moment-to-moment experience (e.g., "How do I feel?"). These modes of processing have also been applied to the processing of negative events. Watkins (2004) investigated the differential impact of concrete/experiential and abstract/analytical processing on recovery from a laboratory-based negative event (i.e., a forced failure task). Participants were instructed to write about their failure experience in one of these two conditions. The findings demonstrated that participants in the abstract/analytical group reported more intrusions about the failure experience than those who wrote in a concrete/experiential mode. On the basis that intrusions indicate unsatisfactory emotional processing (Rachman, 1980), the results support the proposal that abstract/analytical self-focus (i.e., rumination) prevents successful processing of emotional events.

Indeed, Williams and Moulds (2010) confirmed the role of ruminative processes in managing intrusive memories, and raised the possibility that rumination following negative events may limit emotional processing, and thus be involved in the development of intrusive memories in depression. Intrusive memories are of autobiographical events; therefore, by definition, they are self-relevant. However, such memories may not necessarily be self-*referential*; that is, they may not be directly linked to one's sense of self and one's personal character (Borton, Markowitz, & Dieterich, 2005). It is possible that the effects of rumination about an intrusive memory are more toxic if the content of the memory is also self-referential (Williams & Moulds, 2007d). To examine this possibility, Williams and Moulds (in press) experimentally assessed the differential effects of analytical ruminative processing and distraction on the experience of self-referent naturally occurring intrusive memories. The results demonstrated that subsequent to the analytical induction, participants rated their intrusive memory as more negative, more distressing, and more evocative of a negative emotional response compared to participants who were exposed to the distraction induction. Inducing analytical rumination also resulted in participants reporting worse (i.e., more sad) mood relative to those in the distraction condition.

Together, these findings suggest that depressed individuals may get caught up in a ruminative cycle that, due to the documented effects of analytical self-focus, may exacerbate the emotional response elicited by the intrusions and perpetuate biased attentional focus on these intrusions. This process may be similar to that suggested by Williams, et al. (1997) in relation to normal autobiographical memory. Focusing on negative information can lead to a process of mental elaboration of the original material in a manner that creates additional pathways of retrieval leading back to the original activating event. Recent research (Donaldson, Lam, & Mathews, 2007) has documented an attentional bias for negative information in depressed individuals who have high levels of trait rumination. It may be that ruminating about negative life events in an analytical manner not only disrupts successful emotional processing, and therefore leads to intrusive memories of such events, but that the operation of an attentional bias makes the process of disengaging from rumination more difficult in depressed individuals (Donaldson et al., 2007), thus contributing to intrusion maintenance. Similarly, reductions in cognitive capacity or executive resources associated with depression have been suggested to lead to difficulties in disengaging from ruminative processing when attempting to retrieve specific autobiographical memories, thus contributing to overgeneral memory retrieval (Williams et al., 2007). Recent research has documented the occurrence of an observer perspective in deliberately retrieved memories in depression. Kuyken and Howell (2006) found that observer perspective memories were more common in depressed adolescents than in never-depressed controls, and suggested that the incongruence between an adolescent's current and ideal self-perception may prompt retrieval from this perspective as it would facilitate objective evaluation. Similarly, Lemogne et al. (2006) reported that depressed individuals experienced fewer field perspective memories for positive events and suggested the role of current negative affect in mediating this retrieval pattern. Given that depressed adolescents also rehearsed their negative memories more often than never-depressed controls (Kuyken & Howell, 2006), one possibility is that rehearsal served as a mechanism that increased the likelihood of retrieving memories from an observer vantage perspective.

Furthermore, there is evidence that the vantage perspective from which intrusive memories are recalled plays a role in depression. The tendency to recall intrusive memories from an observer perspective is correlated with measures of cognitive avoidance such as rumination and emotional disengagement in high dysphoric, but not low dysphoric, participants, suggesting the compounding effect of depression (Williams & Moulds, 2007c). In a recent experimental investigation, recall vantage perspective was manipulated in order to assess the different functional roles of an observer versus field perspective (Williams & Moulds, 2008b). Participants who naturally recalled their memories from a field perspective who received an experimental instruction to shift from a field to an observer perspective reported decreased experiential ratings following this shift. Specifically, observer memories were associated with reduced distress and vividness, and a reduced sense of reliving the event, compared to the recall of these memories from a field perspective. The converse shift in perspective (i.e., instructing participants who naturally recalled their memories from an observer perspective to instead recall them from a field perspective) did not lead to a corresponding increase in experiential ratings. Nonetheless, this shift resulted in reduced ratings of observation and detachment. These results align with recent conceptualizations of the underlying processes proposed to be responsible for mode of recall. Robinson and Swanson (1993) posited that memory reconstruction depends on the availability of specific information. These authors suggested that a cognitive code specifies beliefs and goals linked to an event, and that an experiential code provides affective information in the form of emotional arousal experienced at the time of the event. Recall vantage perspective may therefore be dictated by the type of affective information available or accessible; the presence of the cognitive code resulting in an observer perspective and the presence of both the cognitive and experiential code resulting in a field perspective (Robinson & Swanson, 1993). This model may account for the asymmetry in participants' accounts of their memories when instructed to shift recall perspective. The observed reduction in affect ratings obtained in other studies (Berntsen & Rubin, 2006; Robinson & Swanson, 1993) may be due to the accessibility of the cognitive code and the inhibition of the experiential code when instructed to shift from a field to an observer perspective. Conversely, when participants were instructed to shift from an observer to a field perspective, the experiential code should drive memory reconstruction. If this code is inaccessible, either due to active inhibition or degradation, then the cognitive code is exclusively accessed and a corresponding increase in affect ratings would not occur. This account is consistent with the notion of active cognitive avoidance. Intrusive memories may be preferentially reconstructed from an observer perspective due to attempts to inhibit the experiential code, and thus to inhibit the emotional components experienced at the time of the event.

This conceptualization implies that strategic retrieval from an observer perspective would arise in response to negative or unpleasant memories only. Evidence from the trauma literature suggests that recall vantage perspective may be uniquely related to avoidance in negative memories. Kenny and Bryant (2007) reported that traumatized participants who were highly avoidant were significantly more likely to recall their traumatic memory from an observer vantage perspective than participants who rated low in avoidance. By comparison, the relationship between avoidance and observer recall was not evident in participants' recall of positive or neutral memories, suggesting that the adoption of an observer vantage perspective was not due to a stable retrieval style, but rather was specific to the retrieval of distressing trauma memories. Future investigations of intrusive memories in depression should include positive memories in order to confirm the specificity of these results. Given that depression is associated with deficits in processing positive information (MacLeod, Tata, Kentish, & Jacobsen, 1997), and that the avoidance of intrusive memories is associated with deficits in the intentional retrieval of specific autobiographical memories (Brewin, Watson, McCarthy, Hyman, & Dayson, 1998), it may be that depressed individuals have additional difficulty accessing pleasant experiential features of positive memories if retrieval occurs from an observer perspective. Future research that investigates this possibility could be informed by current studies on positive mental imagery deficits in depression (Holmes, Lang, Moulds, & Steele, 2008).

An additional possibility is that an interplay exists between rumination and recall vantage perspective such that engaging in analytical rumination subsequent to a negative event prevents the encoding of the holistic emotional features of the event, resulting in later retrieval in the form of an observer perspective memory. In contrast, if one reflects on an event in an experiential manner, by re-living the moment-to-moment experience of the event, the associated emotional information may be better consolidated, resulting in a rich and detailed memory. This in turn may prompt subsequent recall of the event from a field perspective. Alternatively, retrieval from an observer vantage perspective may prompt maladaptive self-reflection in the form of analytical rumination. At this stage, such accounts are speculative. Future studies with dysphoric and depressed samples that explore the relationship between vantage perspective and rumination are needed to confirm the precise interaction between rumination about adverse events and recall of the events from an observer perspective.

Moving Towards a Model of Intrusive Memories in Depression

Despite the body of research reviewed here, the depression literature is currently lacking a conceptual framework to account for intrusive memories. A useful model that may inform our understanding of the nature of intrusion maintenance in depression is Ehlers and Steil's (1995) cognitive model from the PTSD literature (outlined earlier in this chapter). The findings that have

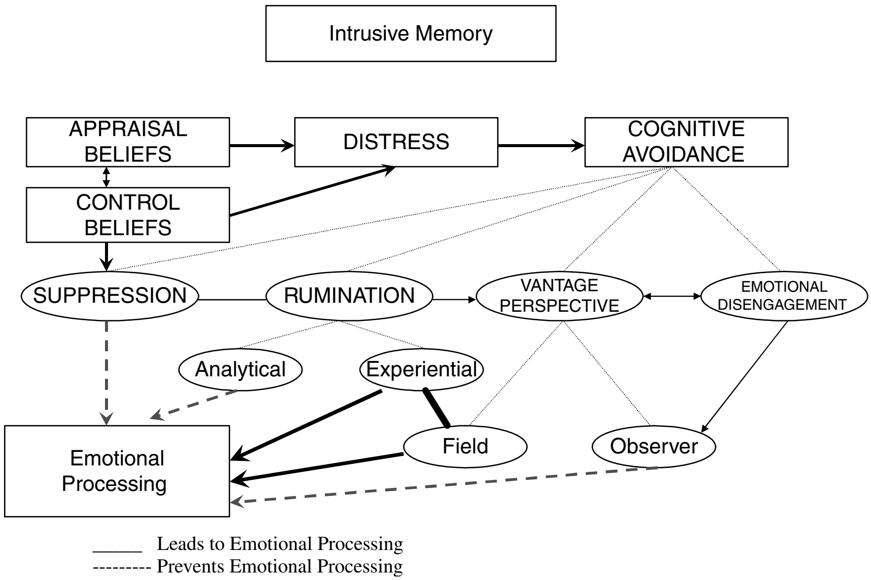

Figure 15.1 A model of intrusive memories in depression.

been reviewed generally demonstrate the applicability of this model within the context of depression. Furthermore, the collective findings have prompted us to propose an elaborated, albeit tentative, model of intrusive memory maintenance (depicted in Figure 15.1). Within this framework, we propose that maladaptive appraisals may interact with beliefs about the importance of exerting control over one's intrusions and lead to distress, which in turn can prompt the employment of various cognitive avoidance mechanisms. Control beliefs may also lead directly to efforts to suppress which, as an avoidant response, may disrupt successful emotional processing. Similarly, engaging in analytical rumination may prevent emotional processing and may additionally prompt the later retrieval of a negative event from an observer vantage perspective, which further impedes the processing of affective information, and therefore emotional processing. Efforts to emotionally disengage from an experience during retrieval may similarly lead to recall from an observer vantage perspective. The model also proposes that successful emotional processing can occur despite initial engagement in avoidant processes. Although subsumed under the process of rumination, experiential self-focus involves concrete focusing on moment-to-moment experiences and may therefore facilitate successful emotional processing. Experiential self-focus may also prompt retrieval of memories from a field perspective, and similarly promote emotional processing by facilitating integration of the affective elements of the memory.

It must be noted that although findings from the current body of research support many of the proposals put forth by this model, at this stage it is a tentative account of the occurrence and maintenance of intrusive memories in depression. Nonetheless, this proposed framework provides an initial theoretical basis from which to generate additional hypotheses regarding the nature and management of intrusive memories in depression, and offers a basis to guide the experimental test of the following proposed clinical implications.

Summary

The findings reviewed in this chapter demonstrate critical overlaps in the experiential features linked to intrusive memories in depression and PTSD. As such, they underscore the value of taking a transdiagnostic approach (Harvey, Watkins, Mansell, & Shafran, 2004) in order to further our understanding of the cognitive processes that underpin the manifestation, experience, and persistence of intrusive memories in depression.

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