

Can Animals

Yes

Animals that pass the mirror test are self-aware and thus can infer the states of mind of another individual



by Gordon Gallup, Jr.

I used to tell students that no one ever heard, saw, tasted or touched a mind. There is no way for me to experience your experience, let alone that of a species other than my own. So although minds may exist, they fall outside the realm of science.

I have since changed my mind. A number of years ago I began to study whether primates could recognize themselves in a mirror. Most animals react to their images as if confronted by another animal. But chimpanzees, orangutans and, of course, humans learn that the reflections are representations of themselves—these creatures are objects of their own attention and are aware of their own existence. In the past three decades, I and other researchers have used the mirror test in various ways to explore self-awareness in animals. I conclude that not only are some animals aware of themselves but that such self-awareness enables these animals to infer the mental states of others. In other words, species that pass the mirror test are also able to sympathize, empathize and attribute intent and emotions in others—abilities that some might consider the exclusive domain of humans.

I began exploring self-awareness with mirrors in 1969, when I was at Tulane University. I presented a full-length mirror to preadolescent chimpanzees at the university's Delta Regional Primate Research Center. Initially, they reacted as if they were seeing other chimpanzees, but after a few days they grew accustomed to

the mirror and began to use it to make faces, look at the inside of their mouths, and groom and inspect other parts of their bodies that they had never seen before.

The Mirror Test

To determine whether they had learned to recognize their own reflections, I anesthetized each animal and applied red dye to an eyebrow ridge and to the top half of the opposite ear. Later, on awakening and seeing themselves in the mirror, the chimpanzees reached up and touched the red marks on their faces, following this in some instances with looking at and smelling their fingers. Chimpanzees that did not have the benefit of prior experience with mirrors acted as if confronted by another chimpanzee and failed to locate the marks on their faces. These findings of self-recognition have now been replicated with chimpanzees more than 20 times by scientists all over the world.

Many other animals, including a variety of primates, elephants, birds and even dolphins, have been tested for self-recognition. But only chimpanzees, orangutans and humans have consistently passed this test. (Marc D. Hauser of Harvard University reported that cotton-top tamarins pass the mirror test when their white tufts of hair are marked, but no one has been able to replicate these results.)

The failure to find self-recognition in other animals is not for want of trying. Susan D. Suarez of the Sage

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Empathize?



DONNA BIERSCHWALE USI, New Iberia Research Center

Maybe not

Even though chimpanzees pass the mirror test, they do not seem to conceive of others'—or even their own—mental states

by Daniel J. Povinelli

Let me begin with a point on which Gordon Gallup, Jr., and I agree: the reactions of chimpanzees when they see themselves in mirrors reveal that these animals possess a self-concept. Furthermore, we agree that this self-concept appears to be restricted to the great apes and humans. Beyond this point, however, our views diverge. Gallup speculates that the capacity for self-recognition may indicate that chimpanzees are aware of their own internal, psychological states and understand that other individuals possess such states as well. I have come to doubt this high-level interpretation of the chimpanzees' reactions to seeing themselves in mirrors. More generally, I question whether chimpanzees possess the deep psychological understanding of behavior that seems so characteristic of our species. In what follows, I describe why I have come to this conclusion, and I offer an explanation of how humans and chimpanzees can behave so similarly and yet understand this behavior in radically different ways.

Knowing That Others See

Consider the simple act of seeing. When we witness other people turning their eyes toward a particular object, we automatically interpret this behavior in terms of their underlying psychological states—what they are attending to, what they are thinking about, what they know or what they intend to do next. These inferences are often

solely based on fairly subtle movements of their eyes and heads.

Do chimpanzees understand seeing in this manner? Gallup thinks they do, and at first glance it seems hard to deny it. For example, chimpanzees exhibit a strong interest in the eyes of their fellow apes. Frans B. M. de Waal of the Yerkes Regional Primate Research Center at Emory University has reported that chimpanzees do not appear to trust the reassurance gestures of their former opponents unless such gestures are accompanied by a mutual gaze—that is, unless they stare directly into one another's eyes. Research from our own laboratory has established that chimpanzees follow the gaze of other apes—and of humans as well. If you stand face-to-face with a chimp, lock your gaze with hers and then suddenly look over her shoulder, the ape will reliably turn around, as if trying to determine what you are looking at.

In short, the spontaneous behavior of chimpanzees seems to make a fairly persuasive case that they can reason about the visual perspectives of others. Does this behavior, then, provide confirmation of Gallup's model? Maybe, but maybe not. The problem is that there are other equally plausible interpretations that do not assume that chimpanzees are reasoning about one another's visual experiences. The case of gaze following illustrates the problem quite well. A chimpanzee who follows your gaze leads you to assume that the animal is trying to figure out what you are looking at. But what excludes

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Colleges and I gave a pair of rhesus monkeys, reared together in the same cage, continuous exposure to themselves in a full-length mirror for 17 years (more than 5,000 hours of mirror exposure a year). Despite this extended opportunity to learn about the mirror, neither monkey ever showed any evidence of self-recognition. On the other hand, when I would walk into the room where they were kept and they saw my reflection in the mirror, they would immediately turn to confront me directly. So it was not that they were incapable of learning to interpret mirrored information about other objects correctly.

Experiments have also failed to uncover compelling evidence of self-recognition in gorillas. After pondering those results, Suarez and I decided to give gorillas the benefit of the doubt, reasoning that maybe gorillas do not care about the superimposed marks. We tested this hypothesis at the Yerkes Regional Primate Research Center at Emory University by applying marks to gorillas' wrists as well as to their faces. We discovered that on recovery from anesthesia all the gorillas touched and inspected the marks on their wrists. But despite extensive prior experience with mirrors, none of the gorillas were able to locate comparable marks on their faces that could be seen only in the mirror.

Gorillas naturally avoid making eye contact with one another, so a possible reason for their mirror-test failure is that they avoid eye contact with their reflection and hence never

We ought to be able to identify animals that can or cannot recognize themselves in mirrors and their empathetic tendencies.

learn to recognize themselves. Daniel J. Shillito and Benjamin B. Beck of the National Zoological Park in Washington, D.C., and I recently tested this hypothesis, relying on a technique developed by James R. Anderson of the University of Stirling in England. It calls for a pair of mirrors placed together at an angle that renders it impossible to make eye contact with the reflection. But none of the gorillas showed evidence of self-recognition, not even one that had more than four years of exposure to mirrors.

In other tests of learning, problem solving and cognitive functioning, differences in performance among species are typically a matter of degree, not kind. What is to be made of such decisive differences in self-recognition? Maybe the reason most species cannot process mirrored information about themselves stems from an inability to conceive of themselves. Correctly inferring the identity of the reflection presupposes an identity on the part of the organism making that inference.

That conclusion seems reasonable, considering the way members of *Homo sapiens* interpret mirror images. Humans do not begin to show compelling evidence of mirror-guided self-recognition until they reach 18 to 24 months of age—about the same time at which the prefrontal cortex begins to mature in



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SELF-RECOGNITION is evident when chimpanzees touch the red dot painted on their faces. Once familiar with the mirrors, they will inspect themselves and make faces.

structure and function. Younger infants react to themselves in mirrors as though they were seeing other children, just as most species do. At about the time that children learn to recognize themselves, they begin to show other evidence of self-conception, such as using personal pronouns, smiling after mastering a task and engaging in self-conscious play.

Before about two years of age, no one has experiences that can be consciously recalled in later life. Consistent with my interpretation, this period of “infant amnesia” stops at about the same time that children begin to show self-recognition. As would be expected, the onset of an autobiographical memory only begins with the emergence of self-conception.

That may terminate prematurely at the other end of the life span if dementia sets in. Disturbances in self-awareness and impaired structure and function of the prefrontal cortex often accompany this condition. Thus, for some, human development may be bounded at both ends by periods of unconsciousness.

Knowing Mental States

Some practical advantages are derived from being able to conceive of the self. I argue that self-awareness, consciousness and mind are an expression of the same underlying process, so that organisms aware of themselves are in a unique position to use their experience as a means of modeling the experience of others. When you see someone in a situation similar to one you have encountered, you automatically assume his or her experience will be similar to yours. Although it is probably true that no two people experience the same event in exactly the same way, as members of the same species we share the same sensory and neurological mechanisms. So there is bound to be considerable overlap between your experience and mine.

Moreover, given a knowledge of how external events influence my mental states (and vice versa), I have a means of modeling the mental states of others.

To see my point, imagine you have a dog that returns home one day in obvious distress: it has porcupine quills in its nose. You could either have a veterinarian remove the quills, or you could attempt to extract them yourself using a pair of pliers. If you were to opt for the latter, it would be an excruciating ordeal for you. Not that you would experience any pain in the process, but as you pulled the quills from the dog's nose and witnessed its reaction, it would prove virtually impossible not to empathize with the dog. That is, you would use your prior experience with pain to model your dog's ostensible experience.

But how do you think another unrelated dog witnessing this transaction would respond? Pet owners may be surprised to learn—and any veterinarian can tell you—that dogs are empathetically oblivious to pain and suffering in other, unrelated dogs. I suspect that dogs experience pain in much the same way that we do, but because they cannot conceive of themselves, dogs cannot use their experience with pain to model painful experiences in other creatures. (They might, of course, react to the yelping.)

affect oncoming drivers on a dark country road, for instance.

So back to my main point: I maintain that knowledge of mental states in others presupposes knowledge of mental states in oneself and, therefore, that knowledge of self paves the way for an inferential knowledge of others. Most humans routinely make inferences and attributions about what other people may or may not know, want or plan to do. By the same token, species that fail to recognize themselves in mirrors should fail to use introspectively based social strategies such as sympathy, empathy, attribution, intentional deception, grudging, gratitude, pretense, role playing or sorrow.

Evidence for Empathy

We ought to be able to identify animals that can or cannot recognize themselves in mirrors and their empathetic tendencies in some fairly definitive ways. If you were to cover the eyes of an animal at some point, how would it later respond to a cagemate wearing a blindfold? An animal that is self-aware ought to be in a position to use its prior experience with blindfolds to take into account its cagemate's inability to see. If you were to teach an animal to vocalize for a food reward every time you entered the room and then blocked its hearing with earplugs or headphones, how would it respond the next day if you entered the room wearing headphones? If self-aware, it should vocalize more loudly to compensate for your impaired ability to hear.

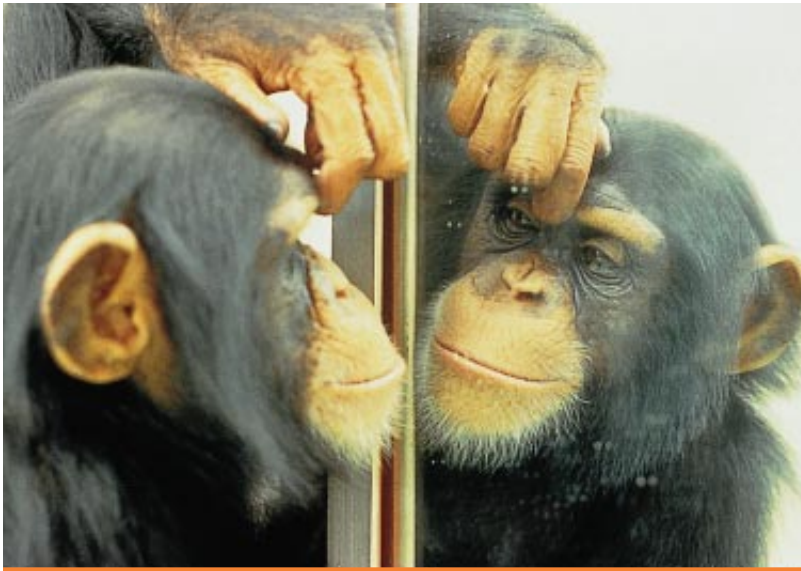
In these kinds of tests, monkeys that fail to show evidence of self-recognition (as distinct from chimpanzees and orangutans, which are great apes) seem completely incapable of taking into account what other monkeys may or may not know. Dorothy L. Cheney and Robert M. Seyfarth of the University of Pennsylvania have found that vervet monkeys give alarm calls on seeing a predator even if other monkeys have already seen it, too. Likewise, they found that Japanese monkey mothers do not distinguish between offspring that know or do not know about food or danger when it comes to alerting their babies to the presence of one or the other.

Monkeys that cannot recognize themselves in mirrors approximate what psychologists call radical behaviorists. Their



Another way to illustrate this incapacity involves people who have a condition called blindsight experience. These patients have sustained extensive damage to the visual cortex and often act as if they were blind, even though their primary visual system remains intact. Lawrence Weiskrantz of the University of Oxford and his colleagues discovered that such patients can show a surprising ability to “guess” the identity of objects and their location. In other words, vision in such patients has been reduced to an unconscious sensation. Blindsight patients can still respond to visual information, but they are not aware of it. As a consequence, they have been rendered mindless when it comes to vision. I would predict that individuals born with blindsight can grow up using guessing strategies and hence act visually normal. Their condition would become apparent only if they were placed in a situation that required them to make inferences about the visual experiences in other people—understanding how high-beam headlights





have been too young; the onset of self-recognition in chimpanzees does not occur until adolescence. Still another possibility is that we humans categorize our experiences (for example, by sight, hearing or smell). Lacking language, chimpanzees may not distinguish between visual, auditory and tactile experiences. Therefore, inferences they make about attention may be more global.

Also, most studies have focused on whether chimpanzees can take various informational states of mind into account (that is, whether they can figure out what another individual knows). But the data on humans show that children attribute feelings and motivation before they have the ability to attribute informational states of mind. Beginning at about the time or shortly after (but never before) they learn to recognize

interactions with other monkeys seem to be based entirely on an analysis driven by the external features of the other monkey and not on what it might be thinking or what it might want to do. Chimpanzees, on the other hand, ought to represent primitive, albeit imperfect, cognitive psychologists—they should be able to respond empathetically and modify their behavior accordingly.

Initial experiments by Daniel J. Povinelli and Sarah T. Boysen of Ohio State University showed that chimpanzees appear to distinguish between what humans may or may not know. When two humans pointed toward different cups, the chimpanzees learned to pick the cup implicated by the human who had witnessed which cup had been baited with food. Although chimpanzees seemed to recognize ignorance on the part of human informants, rhesus monkeys did not.

Further evidence for cognitive empathy in chimpanzees comes from a mutual problem-solving experiment in which humans and chimpanzees had to perform different tasks. For instance, a chimpanzee had to pull a handle to bring food cups within reach but could not see which cup had been baited, whereas the human who could not reach the cups had to point to the baited cup. The chimpanzees were able to switch roles with the humans with no decrement in performance. Rhesus monkeys, however, failed to show any evidence of transfer when the roles were reversed.

Arguing against self-awareness and empathy of chimpanzees, Povinelli cites experiments that failed to find evidence in chimpanzees for an ability to take into account what another creature sees. He concludes that chimpanzees cannot even conceive of their own mental states, let alone those of others.

There are some explanations for the negative results, however. Povinelli's experiments relied on chimpanzees that might



themselves in mirrors, children start to make primitive inferences about emotional states of mind in others; the more sophisticated ability to infer informational states of mind does not happen until a year or two later. Autistic children, in contrast, have difficulty taking into account what other people may know, want or feel. As expected, self-recognition in autistic children is often delayed or even absent.

Because chimpanzees and orangutans pass the



mirror test, Povinelli hypothesizes that they possess a motor self-concept rather than a psychological one. That is, they do not really recognize themselves but simply learn an equivalence between their behavior and what they see in the mirror.

But matters of appearance have little to do with movement. So why should chimps and orangutans seem so intent on using mirrors to look at and inspect parts of their bodies they have never seen before? Why should they bother to respond to strange but motorically inconsequential red marks on their own faces? Suzanne Calhoun and Robert Thompson of Hunter College describe the reaction of a chimpanzee that, on being reintroduced to a mirror a year after learning to recognize herself, became very agitated when she opened her mouth and saw several missing teeth. It is hard to see how this reaction could be understood purely in motor terms.

Self-Awareness and the Brain

Other, more speculative clues about self-awareness lie in the physical makeup of the brain: certain areas seem to be responsible for it. Donald T. Stuss of the Rotman Research Institute in Toronto and I have been collaborating on a long-term project that focuses on human patients who have damage to the frontal cortex, the part of the brain responsible for some of the most complex activities of the mind. Preliminary data show that such patients seem unable to model mental states in others.

Self-awareness may correlate with activity in the right prefrontal cortex. Julian P. Keenan and Alvaro Pascual-Leone of Harvard Medical School, along with my colleagues N. Bruce McCutcheon and Glenn S. Sanders and me, tested how fast humans can recognize faces. When responding with the left hand (controlled by the right hemisphere), subjects identified their own faces faster than the faces of friends or co-workers. In addition, subjects viewing their own faces displayed significant changes in electrical potentials in the right prefrontal cortex. Moreover, when we altered the electrical activity in this brain area with magnetic fields, subjects changed their response rates to their own faces but not to the other faces.

Given this evidence of functional lateralization of self-awareness in humans, it is interesting to note that compared with other great apes, gorilla brains are the least anatomically lateralized. The absence of a highly specialized right hemisphere might explain the gorilla's weak and inconsistent performance in the mirror tests. Povinelli claims that the gorilla's failure here is a "crucial test" of his theory of the motor self-concept. In particular, he speculates that it arose as an adaptation to life in the trees: unlike chimpanzees and orangutans, gorillas spend most of their time on the ground. But at night, gorillas still return to the trees to sleep, even though they are at a greater risk of falling because they are so large. In fact, humans are the ones that have much more completely emancipated themselves from the branches. Therefore,



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humans and not gorillas ought to fail to recognize themselves in mirrors.

Povinelli's data notwithstanding, I think most people working in this area would agree that the jury is still out on whether great apes can attribute mental states to others. Much of the research in this topic is consistent with the conclusion reached by Nicholas Humphrey of the University of Cambridge

Many species may have clever brains but blank minds.

that many species may have clever brains but blank minds: clever brains in the sense of learning, memory and problem solving, but blank minds in the sense of being unable to use their experience to take into account the experience of others. As evidenced by the behavior of people who sleepwalk and those who suffer from blindsight, you do not have to know what you are doing in order to do it in an appropriate way. Humans and possibly a few species of great apes appear to have entered a unique cognitive domain that sets us apart from other creatures.

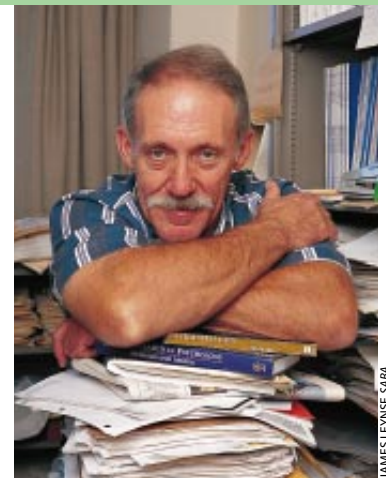
This model of consciousness and mind based on self-awareness has brought me full circle. When I devised the initial test of self-recognition almost 30 years ago, it is apparent that I was using my experience and imagination about how I would respond to strange facial marks to anticipate how chimpanzees might respond to such marks if they could recognize themselves in mirrors. Moreover, if this model or some modified version of it eventually proves correct, it would mean that the ability to conceive of oneself in the first place is what makes consciousness and thinking possible. The famous quote from Descartes would have to be rewritten as "I am, therefore I think." 5A

About the Author

GORDON GALLUP, JR.'s research interests run the gamut: he has hypnotized chickens to examine how their immobility serves as a defense against predation, worked on open-field behavior in rats, looked at depression and reproductive failure in people, theorized about the demise of the dinosaurs and monitored risk-taking behaviors in menstruating women. Each project—odd though it might sound—adds to our understanding of the evolutionary forces that underlie behavior, both animal and human.

Gallup devised the mirror test while he was a graduate student at Washington State University. The idea came to him one day while he was shaving in front of the mirror.

After serving on the faculty at Tulane University, Gallup accepted a position as a professor and chair of psychology at the State University of New York at Albany. He lives on an old dairy farm, where he grows his own food—potatoes, tomatoes, beans and corn—and maintains a small herd of beef cattle. In the fall, Gallup bales hay and chops wood before heading off to teach class and grade exams. And he enjoys it. "I just love being outside and doing physical work," he says. "It helps me keep one foot firmly planted in reality."



JAMES LEVYNE SABA

POVINELLI *Maybe Not*

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the possibility that evolution has simply produced “mind-blind” mechanisms that lead social primates to look where other animals look, without entertaining any ideas about their visual perspective?

To disentangle these issues, we need to study the behavior of these animals in more revealing experimental situations. One method occurred to us after watching our chimpanzees in their everyday play. They frequently covered their heads with blankets, toy buckets or even their palms and then frolicked around their compound until they bumped into something—or someone. Occasionally they would stop and lift the obstruction from their eyes—to peek, as it were—before continuing their blind strolls. On more than one occasion I made the mistake of imitating these behaviors while playing with the animals, a maneuver that left me vulnerable to a well-timed play attack!

Does this behavior mean that chimpanzees have a concept of seeing? For example, when they play with someone else who



GAZE FOLLOWING is a common behavior among chimpanzees. When the experimenter looks over the chimpanzee's shoulder (left), the ape looks in the same direction (right).

covers his or her head, do they know that this person cannot see them, or do they simply learn that this person is unable to respond effectively?

To answer these questions, we examined one of our chimpanzees' most common communicative gestures: begging. First, we allowed them to beg for food from an experimenter who was sitting just out of their reach. When they did so, they were handed an apple or banana. Next, we confronted them with two familiar experimenters, one offering a piece of food and the other holding out an undesirable block of wood. As we expected, the chimps had no trouble: after glancing at the two experimenters, they immediately gestured to the one offering the food.

This set the stage for our real objective, which was to provide the apes with a choice between a person who could see them and a person who could not. If the high-level model of chimpanzee understanding were correct, the chimps would gesture only to the person who could see them. We achieved the “seeing/not-seeing” contrast by having the two experimenters adopt different postures. In one test, one experimenter wore a blindfold over her eyes while the other wore a blindfold over her mouth. In the other tests, one of the experimenters wore a bucket over her head, placed her hands over her eyes or sat

with her back turned to the chimpanzee. All these postures were modeled after the behaviors we had observed during the chimpanzees' spontaneous play.

The results of this initial experiment were astonishing. In three of the four tests—the ones involving blindfolds, buckets and hands over the eyes—the apes entered the lab and paused but then were just as likely to gesture to the person who could not see them as to the person who could. In several cases, the apes gestured to the person who could not see them and then, when nothing happened, gestured again, as if puzzled by the fact that the experimenter did not respond.

We were not prepared for such findings. Surely our apes understood that only one of the experimenters could see them. Indeed, the apes did perform excellently in one of the tests, where one experimenter sat with her back turned to the chimpanzees. But why only this one? At first we assumed that the back/front test was simply the most obvious or natural contrast between seeing and not seeing. In this test the apes might have been demonstrating their genuine understanding of seeing—an understanding that was obscured by the arguably less natural postures in the other tests.

Another idea, however, began to nag at us. Perhaps the apes' excellent performance on the back/front test had nothing to do with their reasoning about who could or could not see them. Maybe they were just doing what we had taught them to do in the first part of the study—gesture to the front of someone who was facing them. Or perhaps the act of gesturing to the front of a social partner is simply a hardwired social inclination among chimpanzees, unconnected to a psychological concept of seeing or attention.

As a first attempt to distinguish among these possibilities, we conducted another test in which both experimenters sat with their backs to the chimpanzees, but one looked over her shoulder at them. This posture was quite familiar to the apes—in their daily interactions, they frequently looked over their shoulders at one another. The high-level model of chimpanzee understanding predicted that the animals would gesture only to the experimenter who could see them. The low-level model predicted that the apes would choose at random because they could not see the front of either experimenter. Their performance turned out to be random—they were just as likely to gesture to either experimenter.

I should point out that what I am describing are the apes' initial reactions to these situations. As you might guess, with enough experience of not being handed a banana after gesturing to someone whose face was not visible, our chimpanzees quickly learned to choose the other option. But what exactly did the apes learn? Did they finally realize what we were asking them—“Oh, I get it! It's about seeing!”—or had they simply learned another rule that could work every time: “Gesture to the person whose face is visible.”



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We examined this question in an extended series of studies, the results of which were consistent with the low-level model. For example, after the chimpanzees learned not to gesture to an experimenter whose head was obscured by a cardboard disk, we retested the animals using

the original conditions (buckets, blindfolds, hands over the eyes and looking over the shoulder). We realized that if the apes had genuinely understood the idea of seeing, they ought to gesture only to the experimenters who could see them in all the other tests as well. But if the chimpanzees had simply



CHIMPANZEE UNDERSTANDING of the concept of seeing was tested in a series of experiments. Confronted with pairs of “seeing” and “not-seeing” experimenters (above), the chimps were equally likely to gesture to either one. The apes performed better in the back/front test (right), but their performance was random in the looking-over-the-shoulder test (below).



learned to gesture to a person whose face was visible, they would still choose randomly in the blindfold test, because the faces of the experimenters were equally visible (one had the blindfold over her eyes; the other had it over her mouth). Just as the low-level model predicted, the chimpanzees were more likely to gesture to the experimenter who could see them in all the tests except one—the blindfold test.

These findings contrast sharply with the development of these abilities in human infants. John H. Flavell and his colleagues at Stanford University have shown that children as young as two or three years seem to understand the concept of seeing. And indeed, when we tested young children using our seeing/not-seeing method, we found that even two-and-a-half-year-old children performed at levels suggesting that they understood that only one of the experimenters could see them.

Growing Up Ape

Let me address one important criticism of our work raised by Gallup concerning the age of our animals. The initial tests were conducted in 1993 and 1994, when the chimpanzees were

five to six years old. Although several of our apes were displaying all the traditional evidence of recognizing themselves in mirrors, some of them were still on the cusp of developing this ability. Could it be that older chimpanzees might fare better in the seeing/not-seeing tests?

One year after the initial research—and after our apes had been engaged in many other studies—we assessed their reactions to several of the original seeing/not-seeing tests. Much to our surprise, the chimpanzees initially responded at random, even to the test where one of the experimenters hid her head behind a cardboard disk—a test the apes had learned extremely well a year earlier. Our chimpanzees’ performance improved only gradually, after considerable trial and error. Furthermore, after another year had passed and our apes had become young adults, additional tests revealed that they were still relying on rules about the frontal posture, faces and eye movements of the experimenters—not about who could see them. Thus, despite the fact that many of our chimpanzees had displayed evidence of self-recognition for more than four years, we had no evidence that they genuinely understood one of the most basic empathic aspects of human intelligence: the understanding that others *see*.

The Meaning of Self-Recognition

If we knew nothing more about chimpanzees, we might simply conclude that they understand visual perception in a very different manner than we do. Other studies in our laboratory, however, have suggested that chimpanzees may not understand any behavior in a psychological manner. For example, careful tests revealed that our apes do not comprehend pointing gestures as referential actions, nor do they understand the difference between accidental and intentional behavior. Furthermore, recent tests conducted with Daniela K. O’Neill of the University of Waterloo suggest that our original interpretations of our earlier studies on cooperation—which Gallup cites in support of his theory—may have been incorrect. Although



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our chimpanzees easily learn to cooperate with one another, our new results cast doubt on whether they truly appreciate the differing subjective mind-sets of their partners.

If chimpanzees do not genuinely reason about mental states in others, what can we say about their understanding of self? Exactly what is revealed by their antics in front of mirrors? And do such reactions to mirror images really indicate

the onset of autobiographical memory—in both apes and humans—as Gallup suggests?

As a first attempt to answer these questions, we shifted our attention to humans—specifically, two-, three- and four-year-old children. In a series of studies, we individually videotaped the children as they played an unusual game with an experimenter.

Self-recognition in chimpanzees and human toddlers is based on a recognition of the self's behavior, not the self's psychological states.

During the game, the experimenter praised the child and used this opportunity to place a large, brightly colored sticker secretly on top of the child's head. Three minutes later the children were shown either a live video image of themselves or the recording we had made several minutes earlier, which clearly depicted the experimenter placing the sticker on the child's head.

These tests revealed that the younger children—the two- and three-year-olds—responded very differently depending on whether they observed the live or delayed images. When confronted with a live image, the vast majority of the two- and three-year-olds reached up and removed the sticker from their heads. When confronted with three-minute-old images, however, only about one third of the younger children reached up for the sticker. Did the others simply not notice the sticker in the delayed video? Hardly. After experimenters drew their attention to the sticker in the video and asked them, "What is that?" the majority of the children responded, "It's a sticker." But this acknowledgment did not cause them to reach up and remove the sticker.

In one sense, of course, the children clearly "recognized themselves" in the delayed video. When they were asked, "Who is that?" even the youngest children confidently replied, "Me!" or stated their proper names. This reaction, however, did not seem to go beyond a recognition of facial and bodily features. When asked, "Where is that sticker?" the children frequently referred to the "other" child: "It's on her [or his] head." It was as if the children were trying to say, "Yes, that looks like me, but that's not *me*—she's not doing what I'm doing right now." One three-year-old girl summarized this psychological conflict quite succinctly: "It's Jennifer," she stated, only to hurriedly add, "but why is she wearing my shirt?"

So when do children come to think of themselves as having a past and a future? Our studies have revealed that by about four years of age, a significant majority of the children began to pass our delayed self-recognition test. Unlike their younger counterparts, most four- and five-year-olds confidently reached up to remove the sticker after they observed the delayed video images of themselves. They no longer referred to "him" or "her" or their proper names when talking about their images. This finding fits nicely with the view of Katherine Nelson of the City University of New York and others, who believe that genuine autobiographical memory appears to emerge in children between 3.5 and 4.5 years old—not at the two-year mark that Gallup favors. Of course, any parent knows that two-year-olds can recall past events, but this is very different from understanding that those memories constitute a genuine "past"—a history of the self leading up to the here and now.

Although it is still too early to rule out Gallup's model alto-

gether, our research suggests that self-recognition in chimpanzees and human toddlers is based on a recognition of the self's behavior, not the self's psychological states. When chimpanzees and orangutans see themselves in a mirror, they form an equivalence relation between the actions they see in the mirror and their own behavior. Every time they move, the mirror image moves with them.

They conclude that everything that is true for the mirror image is also true for their own bodies, and vice versa. Thus, these apes can

pass the mirror test by correlating colored marks on the mirror image with marks on their own bodies. But the ape does not conclude, "That's me!" Rather the animal concludes, "That's the same as me!"

Thus, although Gallup and I agree that passing the mirror test reveals the presence of a kind of self-concept, we differ on the nature and scope of that concept. Gallup believes that chimpanzees possess a psychological understanding of themselves. In contrast, I believe these apes possess an explicit mental representation of the position and movement of their own bodies—what could be called a kinesthetic self-concept.



SELF-RECOGNITION TEST for chimpanzees (left) was modified for human children with the help of video images (below). The experimenter secretly placed a sticker on each child's head. Young children reached for the sticker (right) only when the video image was live.



Ironically, this may be close to what Gallup himself had in mind when he originally published his discovery nearly 30 years ago. He noted that self-recognition appears to require the ability to project "kinesthetic feedback onto the reflected visual image so as to coordinate the appropriate visually guided movements via the mirror."

But why do humans, chimpanzees and orangutans possess this kinesthetic self-concept, whereas other nonhuman primates—such as monkeys—do not? One clue may be the large difference in body size between the great apes and other primates. Consider orangutans, which may represent the closest living approximation to the common ancestor of the great apes and humans. Several years ago, John G. H. Cant of the University of Puerto Rico and I spent months in the Sumatran

rain forest observing the orangutan's chaotic blend of slow, carefully planned movements and sudden, breathtaking acrobatics. We concluded that the problems encountered by these 40- to 80-kilogram (90- to 180-pound) animals in bridging the gaps between trees were qualitatively different from the problems faced by the much smaller monkeys and lesser apes. We hypothesized that as the ancestors of the great apes evolved, quadrupling in body size over 10 to 20 million years, they may have needed to evolve a high-level self-representational system dedicated to planning their movements in their arboreal environment. Ultimately, this unprecedented increase in body size for a tree-dwelling mammal may have left a psychological imprint on the great apes: an explicit kinesthetic self-concept. It was this self-concept that Gallup tapped millions of years later in his tests of chimpanzee self-recognition.

A crucial test for our theory is the gorilla, the largest non-



human primate. Although gorillas share the same common ancestor as humans, chimpanzees and orangutans, they have readapted to spending most of their lives on the ground. The surprising absence of self-recognition in this species may reflect the fact that gorillas no longer needed to execute the complex movements that were necessary to transport their enormous body weight across the gaps between trees. Their evolution appears to have focused on aspects that were more relevant to their new terrestrial way of life, including a more rapid physical growth rate than is found in chimpanzees and orangutans. This process may have interfered with the development of a kinesthetic self-concept. Humans, in contrast, slowed down their growth rate, allowing more years for cognitive development.

If self-recognition depends on a kinesthetic rather than a psychological self-concept, it would help explain some puzzling facts. Several studies have found no connection between the ability of 18- to 24-month-old infants to pass the mirror test and their ability to understand that a mirror reflects any object placed in front of it. Our theory explains this result by postulating that the infants do not see their mirror images as representations of themselves. Rather they see their images as a special class of entities that share their behavior and appearance.

Our theory also explains why toddlers often fail the self-recognition test if there is even a minimal disruption of the visual feedback—for example, a two-second delay in the video images of themselves. Although the children continue to recognize their facial and bodily features, the two-second disjunction between their actions and the movements of their images leads them to conclude that the images are not equivalent to themselves. Finally, our theory explains why both toddlers and

chimpanzees, after recognizing themselves in the mirror, may nonetheless persist in looking behind the mirror, as if searching for the “other” child or ape.

Understanding Minds: A Human Specialization

At this point we are still left with a troubling question: How can humans and chimpanzees share such sophisticated social behaviors but understand them so differently? Why do humans interpret these behaviors in terms of psychological states, but apes do not?

My answer may become more obvious if we imagine our planet 60 million years ago, long before any of the modern primates had evolved. Alison Jolly of Princeton University has speculated that as the solitary lifestyle of the small, early primates gave way to existence in large groups, these animals were forced to cope with increasingly complex social interactions. As a result, Jolly argues, the primates became stunningly adept at reasoning about one another's actions, slowly evolving the rich array of social behaviors now observed among the modern primates: gaze following, deception, appeasement and so on.

But, in my view, none of these behaviors required the early primates to reason about one another's mental states. Our research suggests that only one primate lineage—the human one—evolved the unique cognitive specialization that enables us to represent explicitly our own psychological states and those of others. But in evolving this specialization, we did not discard our array of basic primate behaviors. Our new awareness of the mental dimension of behavior was woven into our existing neural circuitry, forever altering our understanding of our own behavior and the behavior of those around us. Other species, including chimpanzees, may simply be incapable of reasoning about mental states—no matter how much we insist on believing that they do.

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About the Author

DANIEL J. POVINELLI first became interested in chimpanzee behavior in 1979, when he was 15 years old. While doing research for a high school debate, Povinelli came across an article by Gordon Gallup, Jr., in *American Scientist* describing his mirror tests on chimpanzees. “The elegance and ingenuity of Gallup's tests really struck me,” he says. “I thought that here might be a species profoundly similar to our own.” Inspired, Povinelli studied primate behavior as an undergraduate at the University of Massachusetts at Amherst and earned his Ph.D. in biological anthropology from Yale University in 1991. He then joined the University of Southwestern Louisiana's New Iberia Research Center, a 150-acre facility that is home to more than 300 chimpanzees. Now an associate professor, Povinelli directs the center's division of behavioral biology, which studies cognitive development in both chimpanzees and young children. Over the years Povinelli has become a friend and colleague of Gallup's, but his view of the chimpanzee's mental abilities has diverged from that of his mentor. “It took a lot of patience on the part of the chimpanzees,” he says, “but they've finally taught me that they're not hairy human children.”



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