Toward a Science of Other Minds: Escaping the Argument by Analogy

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Since Darwin, the idea of psychological continuity between humans and other animals has dominated theory and research in investigating the minds of other species. Indeed, the field of comparative psychology was founded on two assumptions. First, it was assumed that introspection could provide humans with reliable knowledge about the causal connection between specific mental states and specific behaviors. Second, it was assumed that in those cases in which other species exhibited behaviors similar to our own, similar psychological causes were at work. In this paper. we show how this argument by analogy is flawed with respect to the case of second-order mental states. As a test case, we focus on the question of how other species conceive of visual attention, and in particular whether chimpanzees interpret seeing as a mentalistic event involving internal states of perception, attention, and belief. We conclude that chimpanzees do not reason about seeing in this manner, and indeed, there is considerable reason to suppose that they do not harbor representations of mental states in general. We propose a reinterpretation model in which the majority of the rich social behaviors that humans and other primates share in common emerged long before the human lineage evolved the psychological means of interpreting those behaviors in mentalistic terms. Although humans, chimpanzees, and most other species may be said to possess mental states, humans alone may have evolved a cognitive specialization for reasoning about such states.

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I.   INTRODUCTION

A central assumption of cognitive science is that mental states play a causal role in generating the behavior of most encephalized biological organisms. But the cognitions of humans, at least, include more than first-order emotions, desires, plans, beliefs, and such—we also reason about these states and processes. Premack and Woodruff (1978) coined the term "theory of mind" to refer to this capacity. "Such a system," they observed, "may properly be viewed as a theory because such [mental] states are not directly observable, and the system can be used to make predictions about the behavior of others" (p. 515). Indeed, core aspects of this system of second- (and higher-) order representations may be a more or less universal feature of human cognition (Povinelli & Godfrey, 1993; see Lillard, 1998, for a review). In this essay, we examine two questions about the seemingly universal aspects of theory of mind. First, what causal role do our second-order representations of mental states play in generating our behavior? Second, are we alone in possessing such a theory of mind?

Philosophers have formulated answers to both of these questions using various a priori arguments, but perhaps the most pervasive of these is the argument by analogy. This argument assumes that we can know which mental states produce which of our behaviors through introspection—or at least something very much like introspection (e.g., Russell, 1948). Thus, the argument asserts, we are justified in postulating specific mental states in other species by analogy to ourselves. That is, if we know that mental state x causes behavior y in ourselves, then we are on firm ground in inferring mental state x in another species to the extent that it exhibits behavior y (Hume, 1739–1740; Romanes, 1882, 1883).

In this essay, we critically examine some common assumptions about the role that second-order mental states play in generating the behavior of human and nonhuman primates. Some of these assumptions are explicit in the argument by analogy, whereas others simply appear to follow from it. We show that the argument by analogy fails to recognize the complexity of social behavior that can be generated by first-order intentional states—as evidenced by recent empirical research, which we discuss in some detail. We further show how the argument assumes that the high-level psychological representations that accompany specific human behaviors evolved in concert with those behaviors, and furthermore implicitly assumes that those behaviors are not possible in the absence of such representations. In making these assumptions, the argument overlooks the possibility that the complex social behaviors of nonhuman primates initially evolved under the control of low-level representational systems. And finally, as we shall see, it fails to grapple with the possibility that theory of mind did not initially evolve because it endowed our species with a suite of new behavioral units (units that were impossible to achieve without such a psychological system), but rather because it provided us with an extremely efficient means of reorganizing existing behavioral units.[1] Consequently, the argument by analogy has led many comparative psychologists to adopt an agenda of documenting (or if necessary, simulating) the similarities and downplaying the differences between humans and other primates. We argue against this approach, and advocate a new agenda for comparative psychology—one that comes to terms with the fact that similarity in behavior may not reflect similarity in psychology.

II. EVOLUTION OF THEORY OF MIND: A COGNITIVE SPECIALIZATION?

Perhaps no idea is more ingrained in the minds of comparative psychologists than that of psychological continuity among species. Darwin (1871/1982) set the stage with the *Descent of Man*, in which he reviewed enough anecdotal reports of animal behavior to convince himself that there was "no fundamental difference" (p. 446) in the psychological abilities of humans and other species. Darwin's emphasis on psychological continuity among species was exaggerated further by George John Romanes (1882, 1883), who saw fit to establish an entirely new field of comparative psychology on the argument by analogy: "Starting from what I know of the operations of my own individual mind, and the activities which in my own organism they prompt, I proceed by analogy to infer from the observable activities of other organisms what are the mental operations that underlie them" (p. 1–2). In time, comparative psychologists and neuroscientists alike came to see their central mission as an effort to document the similarities between humans and other primates (see Povinelli, 1993; Preuss, 1995). Although quantitative differences between species were embraced, little room arose for the investigation of qualitative differences (see Bitterman, 1960; Hodos & Campbell, 1969; Lockard, 1971; McPhail, 1987; Boakes, 1984; Burghardt & Gittleman, 1990; Povinelli & Eddy, 1996a, Chapter 1). Indeed, in the century that has elapsed since Romanes founded the field, comparative psychology has only rarely considered the possibility that humans possess cognitive specializations not shared by other living primate species. Indeed, there have only been one or two candidates for qualitative psychological differences among any species (for notable exceptions see Bitterman, 1975; Gallup, 1970, 1982; Rumbaugh & Pate, 1984).

In what follows, we examine the empirical evidence concerning the phylogenetic distribution of one particular psychological system—theory of mind. We concentrate on chimpanzees and other great apes, and critically evaluate claims that these species form representations of mental states. This selective review provides a context for us to present our solution to the questions described earlier; namely, the role that second-order mental states play in generating our behavior, and whether the behavioral similarities between humans and chimpanzees guarantee a comparable degree of psychological similarity.

## III. THEORY OF MIND: AN EXPERIMENTAL APPROACH

Some approaches to understanding the nature of mental states (including second-order mental states) in animals have relied on anecdotal reports of their spontaneous behavior (e.g., Darwin, 1871/1982; Romanes, 1882, 1883; de Waal, 1982, 1986, 1996; Whiten & Byrne, 1988). For reasons that shall become apparent, we have rejected this approach in the case of exploring other species' understanding of mental states, and instead have followed others in advocating a comparative experimental approach (Premack & Woodruff, 1978; Premack, 1988; Povinelli, 1991, 1993; Povinelli & Eddy, 1996a). Nine years ago we established a set of laboratories designed to systematically compare theory of mind and related psychological processes in chimpanzees and young children. Furthermore,

rather than adopting the common practice of rearing one or two chimpanzees in a home-like setting, and then relying on them for inferences about chimpanzee psychology, we selected a cohort of seven young chimpanzees that had been reared together with human caretakers from birth, and housed them together in a spacious indoor-outdoor complex with attached testing facilities. Even when the apes were young enough to be tested in less controlled settings (e.g., sitting on blankets face-to-face with experimenters), we did not do so. Instead, beginning when the apes were 2 to 3 years old, we established a standardized routine in which they were trained to leave their group one at a time and be tested through a Plexiglas partition—a predictable routine that has allowed us to conduct uninterrupted tests with them well into their adulthood. Thus, these animals have received extensive, daily interactions with humans from birth, but their primary attachments have been with their fellow apes. In short, they have been trained and socialized in such a way that they are eminently suitable for rigorous tests designed to determine whether or not chimpanzees reason about mental states.

IV.   SEEING AND ATTENTION: A CASE STUDY

Over the past nine years, our laboratory has examined both the similarities and differences between young children and chimpanzees' understanding of seeing, and other acts and gestures related to the mental state of attention. Here, we have not been interested in high-level aspects of selective attention such as the fact that a person typically only thinks about one thing at a time (e.g., Flavell, Green & Flavell, 1995a; Montgomery, Bach & Moran, 1998), but rather whether they grasp that other individuals have attentional experiences at all — experiences that (other things being equal) reflect their perceptual contact with specific aspects of the world. Of course, the exact timing of the development of young children's understanding of various mental states and processes is hotly contested. However, certainly by 4–6 years of age, children have constructed an understanding of key aspects of the mental world, as evidenced by experiments examining their understanding of mental state terminology, false belief, deception, sources of knowledge, visual perspective-taking, intention, desire, attention, appearance versus reality, emotion, pretend play, thinking and even consciousness —just to list a few of the areas currently under investigation (e.g., Astington & Gopnik, 1991; Baldwin, 1993; Bartsch & Wellman, 1995; Chandler, Fritz & Hala, 1989; Flavell, 1988; Flavell, Green & Flavell, 1993, 1995b; Gopnik & Meltzoff, 1996; Frye & Moore, 1991; Harris, 1989, 1991; Lillard, 1993; Meltzoff, 1995; Perner, 1991; Wellman, 1990; Wimmer & Perner, 1983). However, perhaps one of the most foundational aspects of young children's understanding of the mental world concerns their understanding of visual perception as a very simple attentional process; simply put, their understanding that other individuals "see" things.

For humans, seeing is a quintessentially mentalistic act. A number of years ago, John Flavell and his colleagues identified at least two developmental transitions (or levels) in how children understand seeing (see Masangkay et al., 1974; Flavell, Flavell, Green & Wilcox, 1980; Flavell, Shipstead & Croft, 1978; Lempers, Flavell & Flavell, 1977; Flavell, Everett, Croft & Flavell, 1981). Their work suggested that by 2 years of age or so,
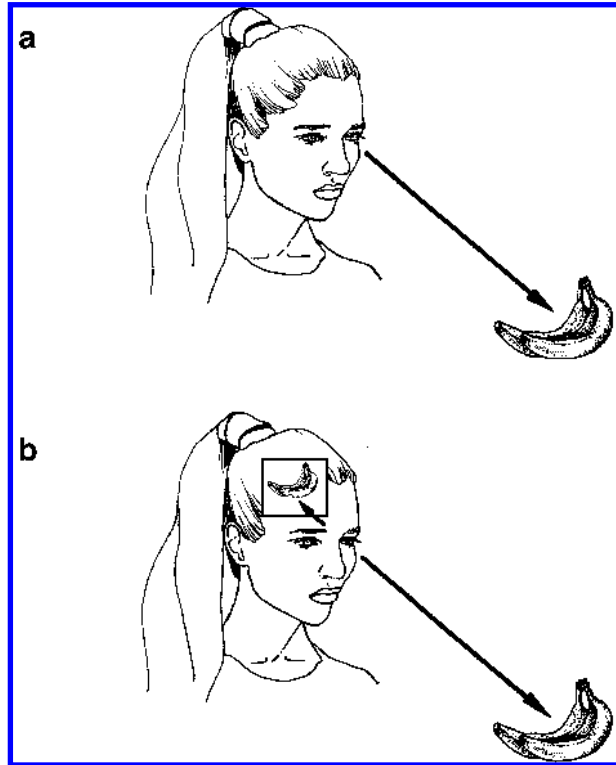
Figure 1.   (a) By 2 to 3 years of age, human children come to understand seeing as a the projection of attention; (b) By 4 to 5 years of age, children develop an understanding that seeing results in a particular mental representation of the external world.

children appear to realize that visual perception connects people to objects or events in the external world. In this sense, they can be said to have to possess at least a very simple notion of visual attention. At this first level, they appreciate whether someone can or cannot see something, and can produce the state of affairs that will allow someone to see (or not see) something. By 4 years of age, however, children also come to understand seeing on another, deeper level. In particular, they begin to grasp that the act of seeing is associated with a particular internal vantage point on the world. Figure 1 offers a metaphorical depiction of these two levels of understanding visual perception. Other research has confirmed and extended these findings by demonstrating that 4- to 5 year-olds, but not younger children, appear to understand that visual perception causes internal knowledge states in both the self and others (Wimmer, Hogrefe & Perner, 1988; Gopnik & Graf, 1988; Perner & Ogden, 1988; Povinelli & deBlois, 1992; Ruffman & Olson, 1989; O'Neill & Gopnik, 1991; O'Neill, Astington & Flavell, 1992).[2]

Having previously obtained largely unconvincing results in studies examining chimpanzees' understanding of the connection between seeing and knowing (see Section V), we turned our attention to what (in humans at least) appears to be a less sophisticated (or

at least an earlier-emerging) understanding of the attentional aspect of seeing. We realized that although chimpanzees might or might not construct an understanding of the role that seeing plays in creating knowledge, they may well appreciate seeing as a projection of attention. Indeed, from our casual observations of their everyday behavior, we felt confident that they must. As we shall see, however, this confidence was just another inferential error encouraged by the deceptively persuasive force of the argument by analogy.

Gaze-following

First, let us consider some of the striking similarities in how chimpanzees and humans process information about the eyes and gaze-direction of others. Beginning at approximately 6 to 12 months of age, human infants begin to respond to the gaze direction of others (Scaife & Bruner, 1975; Butterworth & Cochran, 1980; Butterworth & Jarrett, 1991; Corkum & Moore, 1995; Moore & Corkum, 1998). At this age, if infants observe their mother turn and look off in a particular direction, they will turn and look in the same direction. However, at this age infants do not appear to understand that the adult is looking at something in particular. Rather, once they begin to look in the same general direction as the adult, they fixate on whatever object appears first in their scan path (Butterworth & Cochran, 1980; Butterworth & Jarrett, 1991). Furthermore, they do not look behind themselves to follow the gaze of others into invisible space. By approximately 12 to 18 months of age, infants elaborate their gaze-following abilities so that they will now scan past distractor targets to the true locus of the adult's gaze, follow gaze in the space behind them, and even follow gaze in response to eye movements alone (Butterworth & Cochran, 1980; Butterworth & Jarrett, 1991; Moore & Corkum, 1998). Although this cluster of abilities has been interpreted in different ways, the development of gaze-following has played a prominent role in several theories concerning infants' development of an understanding of other minds (e.g., Corkum & Moore, 1995; Baron-Cohen, 1994; Hobson, 1993).

Early on, it occurred to us that if the emergence of gaze-following in human infants is causally related to the construction of (or, indeed, reflects the presence of) an explicit understanding of the concept of attention, it would be wise to ask about its presence in other species. Thus, in a series of studies, we experimentally investigated the gaze-following abilities of chimpanzees (see Povinelli & Eddy, 1996a, Experiment 12; Povinelli & Eddy, 1996b, 1997; Povinelli, Bierschwale & Čech, 1999). Our results provided the first experimental evidence that not only do chimpanzees follow gaze, they do so with the sophistication exhibited by 18-month-old human infants (see Figure 2). Thus, chimpanzees will (a) follow the gaze of others in response to movement of the head and eyes (or even just the eyes), (b) they will follow gaze to particular quadrants of space outside of their own immediate visual field (e.g., behind them), and (c) they will follow gaze even if they do not witness the movement of the other individual's head. Furthermore, chimpanzees even take into account how the projected path of someone's gaze interacts with opaque barriers—that is, they do not make the mistake of following your gaze right through an opaque barrier (see Figure 3; Povinelli & Eddy, 1996b, Experiment 2).

Figure 2.   (a–c) Young chimpanzees share with human infants major aspects of a gaze-following system that allows them to coordinate their visual gaze with that of others.

We have proposed that gaze-following evolved through the combined effect of several selective forces which emerged in the context of group-living (Povinelli & Eddy, 1994, 1996a, 1996b). For example, the benefits of the early detection of predators, or predicting the likely moves of group members (e.g., Chance, 1967; van Schaik, van Noordwijk, Warsono & Sutrino, 1983), could easily have established a selective gradient that favored individuals who responded to changes in the visual/facial orientation of conspecifics by orienting their own visual systems along a projected vector from the face of those conspecifics. Later refinements of the mechanism may have included selective attention to those visual orientations that were unusual, sudden, or occurred in volatile contexts (for example, orientations that occurred in unison with certain emotional displays). In any event, because derived mammals such as primates posses the orienting reflex
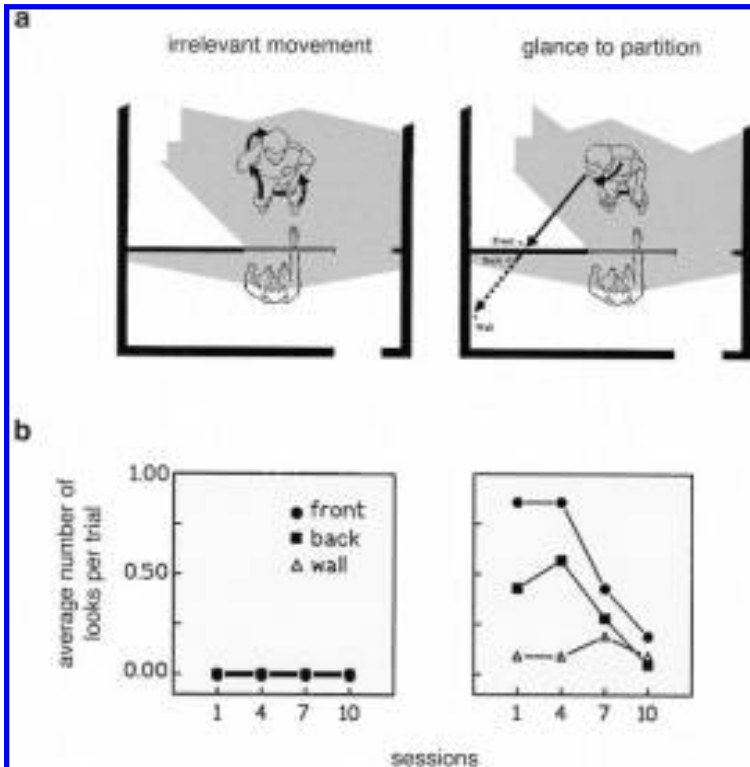
Figure 3.   (a) Laboratory setup for an experiment designed to determine if chimpanzees take into account opaque barriers that obstruct an experimenter's line-of-sight. In the test condition (glance to partition), chimpanzees may either look around to the front (the experimenter's side) of the partition, to the back of the partition, or to the rear wall would the experimenter's gaze would strike if the partition were not present; (b) Results indicate that in the test condition the subjects initially prefer to look to the front of the partition, until they habituate. See Povinelli and Eddy; 1996b for full details and other experimental control conditions.

(Pavlov, 1927; Sokolov, 1963), the evolution of this simple head-turning response could ensure "joint visual attention" in the sense that both animals wind up attending to the same object or event) without either animal ever representing the attentional state of the other. These considerations led us to propose that gaze-following might be an ancient behavioral mechanism that evolved as part of a commensal relation among social primates. Results by Emery et al. (1997) and Tomasello, Call, and Hare (1998) have begun to confirm these predictions by demonstrating at least a general capacity for gaze-following in several species of Old World monkeys.

Certainly, this is a plausible, parsimonious model for the evolution of gaze-following. But what does parsimony matter? After all, humans also represent attention in such circumstances, and so perhaps chimpanzees do as well. From another perspective, if 18-month-old human infants interpret that other individuals can see (and in this simple sense, 'attend') to objects or events (e.g., Baldwin, 1993), might not chimpanzees also?

Mutual Gaze

We might be tempted to look for a possible answer to this question in the context of the spontaneous communication of chimpanzees and other primates. After all, the eyes of conspecifics serve not only as beacons that warn of the direction of impending danger, but in primates, at least, they also serve to mediate complex social interactions. In many species of anthropoid monkeys, for example, direct eye contact is part of a relatively stereotyped threat display (Redican, 1975; Perret et al., 1990). Thus, direct eye contact is avoided, even in the context of friendly social interactions (e.g., de Waal, 1989). In contrast, mutual gaze plays a more flexible role in humans and other great apes. Here, mutual gaze is an important factor in both agonistic and affiliative social interactions (Köhler, 1925; Goodall, 1986; de Waal, 1989; Bard, 1990; Gómez, 1990; Schaller, 1963). Furthermore, in chimpanzees, at least, establishing mutual gaze seems to be especially important during 'reconciliatory' social interactions that immediately follow conflicts (de Waal, 1989). In more experimental settings, Gómez (1990, 1991) has reported the apparent use of mutual gaze by a young gorilla as a means to enlist the assistance of human caretakers, and Povinelli and Eddy (1996c, Experiment 1) provided an experimental demonstration that chimpanzees are drawn to interact more with individuals making direct eye contact with them than others who are not.

Some researchers interpret the mutual gaze that occurs among great apes during complex social interactions as prima facie evidence of an understanding of the attentional aspect of seeing (e.g., Gómez, 1996). Indeed, some developmental psychologists have maintained that mutual gaze is a crucial feature of intentional communication (e.g., Bates, Camaoini & Volterra, 1975). In general, there seems to be widespread acceptance of the largely intuitive notion that because mutual gaze in adult humans is often attended by second-order intentional states, comparable behavior in human infants (or other species) is attended by similar representations.

But is mutual gaze in apes really attended by the same psychological representations as in adult humans? Based largely on work with an infant gorilla, Gómez (1990, 1991, 1996) has argued that it may be. He interprets the gorilla's deployment of mutual gaze during attempts to enlist a human's assistance as evidence of "a strategy to control the visual attention of the human addressee"—a strategy said to be "comparable to that of human infants at the beginning of preverbal communication" (Gómez, 1996, p. 138). Similarly, spontaneous acts involving tugging on the caregivers clothing before establishing mutual gaze and making requests are described by Gómez as "ostensive," which he defines as "a way to express and assess communicative intent" (p. 131). Does this mean that the ape simply understands the behavioral configurations that lead to successful social interactions, or does it also mean that the animal represents the caregiver as possessing (unobserved) internal attentional states? Although his views are somewhat unclear, Gómez (1996) seems to favor the latter interpretation: "To engage in ostension one has to be capable to some degree of mindreading, including the attribution of mindreading abilities to the receiver. Thus, if great apes are capable of some form of ostension, this

would mean that they are reaching into one of the most complex aspects of human communication" (p. 145).

Gaze-following and Shared Attention: A Dissociation

We, too, have been impressed by the striking commonality in mutual gaze and gaze-following between humans and great apes—commonalities that we assume reflect the operation of at least a subset of homologous psychological operations. However, our apes have forced us to remain skeptical about the extent of the identity of those psychological operations. For example, as we have seen, there are at least two very different interpretations of the psychological structures associated with the act of gaze-following. A 'high-level' model (for lack of a better term) assumes that an organism that follows gaze does so because it represents the other's state of attention ("What is he looking at?," "What does she see?"), and hence glances in a particular direction to answer the question posed by this representational structure. On the other hand, a 'low-level' model (again, for lack of a better term) proposes that gaze-following is a fairly automatic response, triggered by an interaction between certain endogenous and exogenous factors unrelated to a representation of attentional states. Adult humans have the ability to interpret the gaze direction of others in explicitly attentional terms (although, as we shall see, the causal role played by such representations is unclear), and a number of researchers have argued that by at least 18 to 24 months of age, human infants, too, have this same ability (Baldwin, 1991, 1993; Corkum & Moore, 1995; Baron-Cohen, 1994). But is the gaze-following response necessarily associated with such representations, and if not, can we isolate the cases in which it is from the cases in which it is not?

We have attempted to answer this question in a variety of ways. In one series of studies, we compared chimpanzees and 3-year-old children for their understanding of the referential aspect of gaze-direction (e.g., Povinelli, Bierschwale & Čech, 1999). In a preliminary training phase, we taught our chimpanzees to use the human pointing gesture to choose between one of two opaque containers. As the ape entered the test unit, the experimenter simply pointed to one of these containers (while keeping his or her gaze directed to a point midway between the two). Once the apes learned to respond correctly to the pointing gesture (which, interestingly, was far from immediate; see also Pointing, below), we exposed them to probe trials on which, instead of pointing, the experimenter either gazed directly at the correct container by turning his or her head (at-target) or glanced above (but not at) the correct container (above-target) (see Figure 4a).

We reasoned that organisms who understand the referential aspect of gaze (that is, who represent the attentional aspect of gaze) ought to appreciate the distinction between the at-target and above-target trials. For example, we predicted that 3-year-old children would interpret the at-target gesture as indicating that the surprise was hidden in the container at which the experimenter was gazing, but would interpret the above-target gesture as indicating that the experimenter was looking at something other than the containers, and hence conclude that his or her gaze was irrelevant to the location of the reward. If correct, they should display a preference for one container over the other on the at-target trials (the
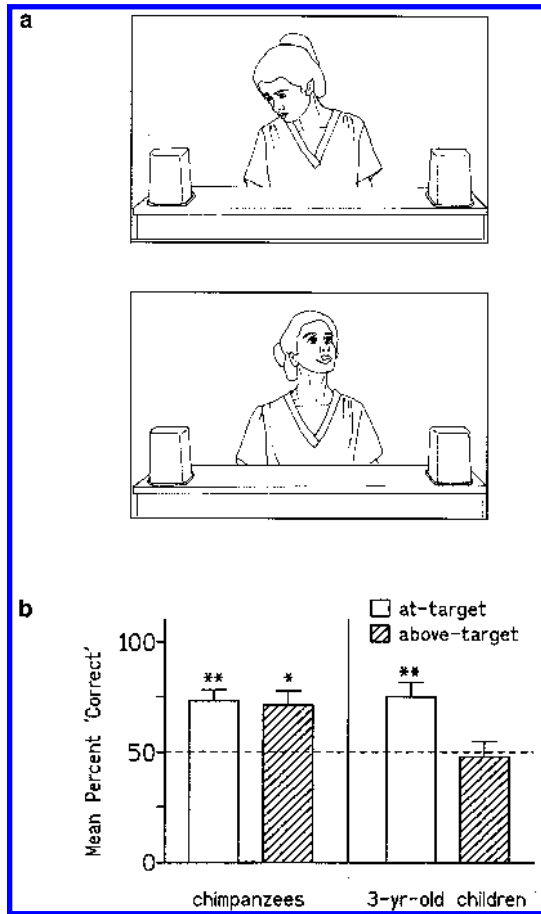
Figure 4.   (a) Two conditions used to determine if chimpanzees and 3-year-old children appreciate the referential aspect of gaze. (b) Results (±SEM) show that 3-year-olds interpret the conditions appropriately (choosing selectively in the at-target condition, but randomly in the above-target condition), whereas chimpanzees use a more general orientation cue.

cup to which the experimenter was gazing), but display no preference for either container on the above-target trials. Indeed, this is exactly what the children did (see Figure 4b). In direct contrast, however, the chimpanzees failed to distinguish between these two cases— they simply chose the container on the same side of the apparatus to which the experimenter's head was turned (Figure 4b). It was as if they approached the frontal aspect/facial orientation of the experimenter, and then chose the container to which they were closest. Did they simply fail to notice the distracted gaze of the experimenter on the above-target trials? No, because the subjects were 4.5 times more likely to look above and behind themselves on the above-target trials than the at-target trials, and 82% of their first glances behind themselves on the at-target trials were to the same side to which the experimenter had glanced (see Povinelli et al., 1999, Experiment 1). Thus, despite their interest in the

gaze-direction of the experimenter, the chimpanzees did not appear to imbue it with referential significance — even after having set the stage by training them to respond to pointing. Other studies of this phenomenon (e.g., Povinelli, Parks & Novak, 1992, Control Trials; Anderson, Salleberry, & Barbier, 1995) have not utilized the crucial above-target condition, and thus fail to effectively distinguish between the high- and low-level models.
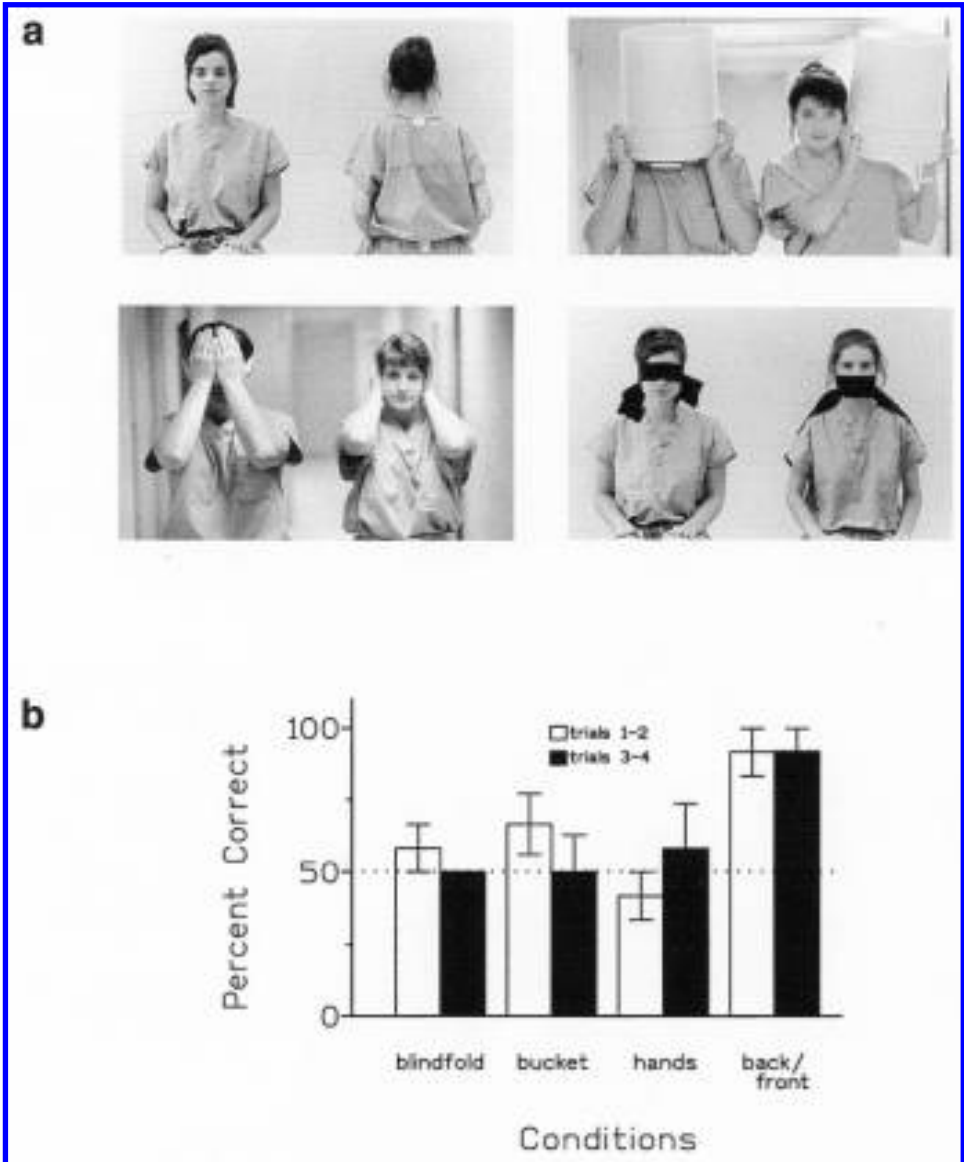
Understanding Seeing

If chimpanzees' interest in the eyes, and their ability to process and exploit the gaze direction of others, is evidence that they understand visual attention as an internal mental state, then chimpanzees understand that others *see*. In short, if the high-level model is correct, they ought to realize that fellow chimpanzees, people, or even other animals have internal visual experiences. Indeed, our natural inclination to analogize finds much in their spontaneous behavior to support this view. For example, we frequently witness our animals reach out toward us, palm up, using their species-typical begging gesture. Sometimes, we fail to notice these gestures, and so the animals exaggerate them by reaching out even further. The animals may even slam their palms against the wall or cage mesh, causing us to turn and look. Witnessing our response, the chimpanzees gesture again, now bobbing their heads in excitement as we finally approach them. On the surface, such events would seem to be enough to convince even the skeptics that chimpanzees have some notion of seeing, or at the very least, of attention.

But do they really? Over the past six years we have undertaken a major effort to determine whether chimpanzees know that others have visual or other kinds of attentional experiences in the kinds of natural scenarios just described (Povinelli & Eddy, 1996a, 1996b; Povinelli, 1996; Reaux, Theall & Povinelli, 1999; Theall & Povinelli, 1999). In the process of doing so, we have attempted to isolate some of the factors that control when chimpanzees will deploy this visually-based gesture.

For these studies, we initially trained our subjects to enter their testing unit and 'request' a food item from familiar experimenters (see Figure 5a–c). On each trial, a single experimenter was present, either on the left or right (randomly determined). If the chimpanzees gestured through the hole directly in front of the person, they were handed a highly desirable food reward. Of course, this scenario simply capitalized on what our apes naturally do every day. However, after they learned to be selective about which hole to beg through, we confronted them with probe trials (inserted into a matrix of the easy training trials) in which *two* familiar experimenters were present. Initial control trials ensured that when the choice between two experimenters did not involve reasoning about seeing (e.g., one person holding out food, the other holding out an undesirable block of wood), the apes easily chose correctly. However, when it came to the crucial distinctions depicted in Figure 6a, in most cases the chimpanzees gestured as often to the experimenter who could see them as to the one who could not (see Figure 6b). There was, however, a single important exception. On the back/front trials the chimpanzees were correct from Trial 1 forward. Here, without any differential feedback, the apes were drawn to gesture to the correct experimenter (the one facing forward).
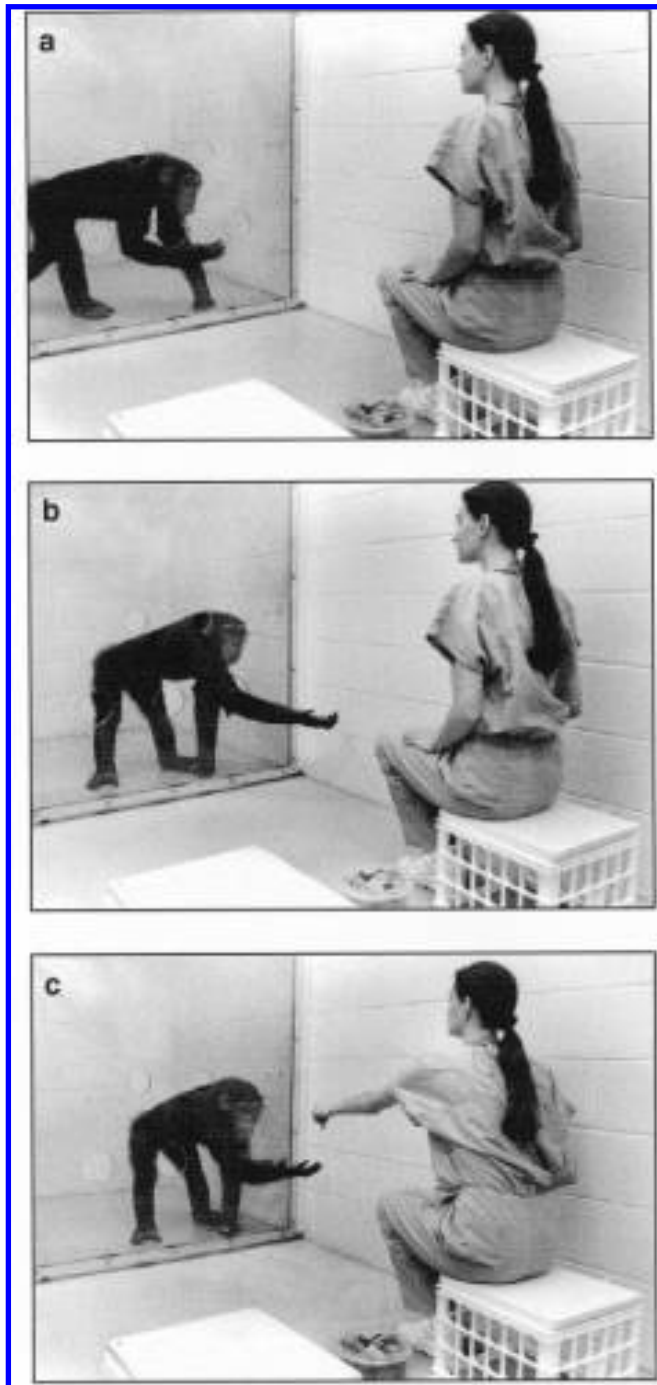
Figure 5.   (a) Chimpanzee enters indoor test unit after door is opened, (b) uses species-typical begging gesture to 'request' food from a familiar experimenter, who (c) hands the ape a piece of food. Subjects learn to gesture through either left or right hole, depending on where the experimenter is sitting.

Figure 6. (a) Conditions used to explore chimpanzees' understanding of seeing: back/front, buckets, hands-over-the-eyes, and blindfolds; (b) Results (±SEM) of initial experiment by condition indicate that subjects gesture equally to the experimenters who can and cannot see them, except in back/front condition (dotted line indicates performance expected by chance).

These results puzzled us. Why would the apes perform almost perfectly on the back/front condition, but randomly on the three other conditions? First, it seemed plausible that the back/front condition was simply the most natural and obvious instance of the seeing-versus-not-seeing conditions that we had constructed. Although we had modeled
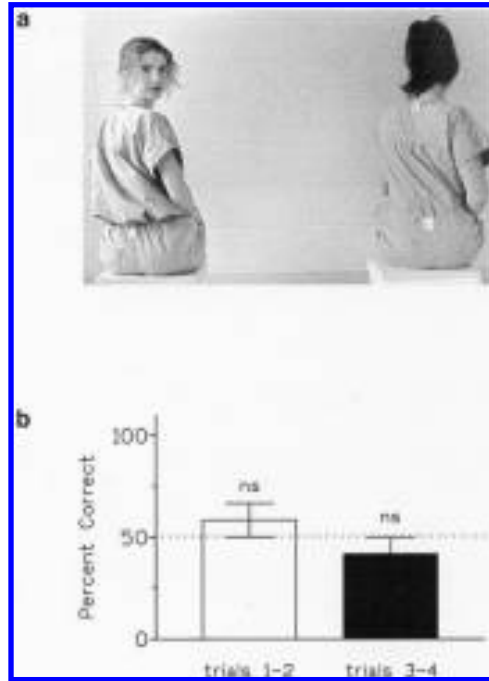
Figure 7.   (a) Stimulus configuration of looking-over-the-shoulder condition and (b) results (±SEM) of trials 1–4 (dotted line indicates performance expected by chance).

all of the other conditions (buckets, blindfold, hands-over eyes) after things we had seen the chimpanzees doing during their spontaneous play behavior (for a description, see Povinelli & Prince, 1998), it was still possible that these conditions were more subtle than back/front —hence explaining the apes' different reaction to that condition. However, another explanation was possible as well, one consistent with the low-level model. Perhaps the chimpanzees were simply doing what they had learned to do, either in their everyday interactions with each other and with us, or indeed during their training for this study—'Gesture to someone facing forward.'[3] To distinguish between these possibilities, we devised a new condition—as naturalistic as front/back—which involved one experimenter looking over his or her shoulder and another who was not (see Figure 7a). This condition effectively teased apart the two competing accounts. If our apes were genuinely interpreting the attentional aspect of the back/front trials because this situation was more obvious to them, they should also perform well on this new, looking-over-the-shoulder condition. After all, the posture is one that they encounter every day. On the other hand, if the apes were merely following a 'Gesture to someone facing forward' rule, we should expect them to perform randomly, which, as it turns out, is exactly what they did (Figure 7b). In contrast, they continued to perform excellently on the back/front trials.

We found the initial results of these rather simple tests difficult to believe. Thus, we decided to pursue this line of experimentation more thoroughly. First, we constructed
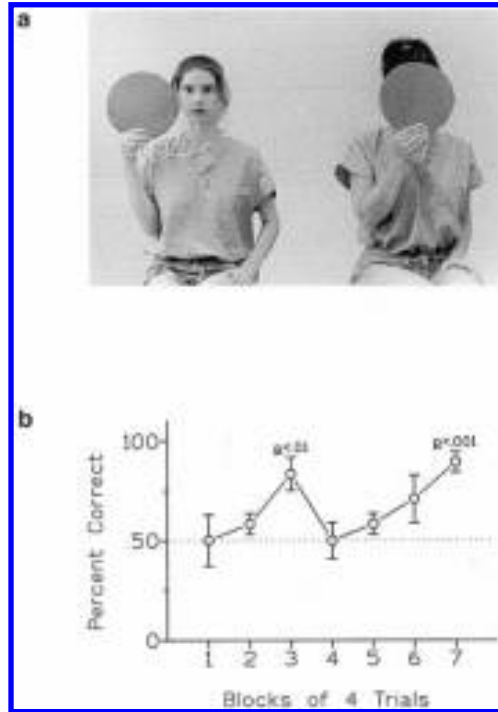
Figure 8. (a) Stimulus configuration for screens conditions and (b) results (±SEM) of trials 1—4 (dotted line indicates performance expected by chance).

some simple opaque screens, and prior to testing the apes, we used these screens to play "peek-a-boo" games with our apes. We even gave them the screens so that they could play with them themselves. Nevertheless, when we tested the apes using the new screens condition (see Figure 8a), in their initial trials they were just as likely to gesture to the experimenter who could not see them as to the one who could (see Figure 8b).

Although we cannot summarize all of our seeing/not seeing experiments here, we would be remiss not to note that after considerable experience, many of our apes began to learn to gesture to the person who could (in truth) see them. For example, after 10 to 16 trials of the screens condition, our apes were performing at levels exceeding chance (see Figure 8b). Further studies indicated that the apes were able to generalize this performance to the looking-over-the-shoulder condition (Povinelli & Eddy, 1996a, Experiment 9). Of course, it is important to keep in mind that the apes were reinforced only when they gestured to the experimenter who could see them. But did their above-chance performance reflect a conditional discrimination based solely on the observable features of the experimenters, or did the apes also understand this discrimination at a more abstract, mentalistic level?

Rather than letting our preconceptions settle the issue, we decided to continue to attempt to determine what, precisely, our apes had been learning. To do so, we readministered the original set of conditions, plus two new ones (distracted/attending and eyes
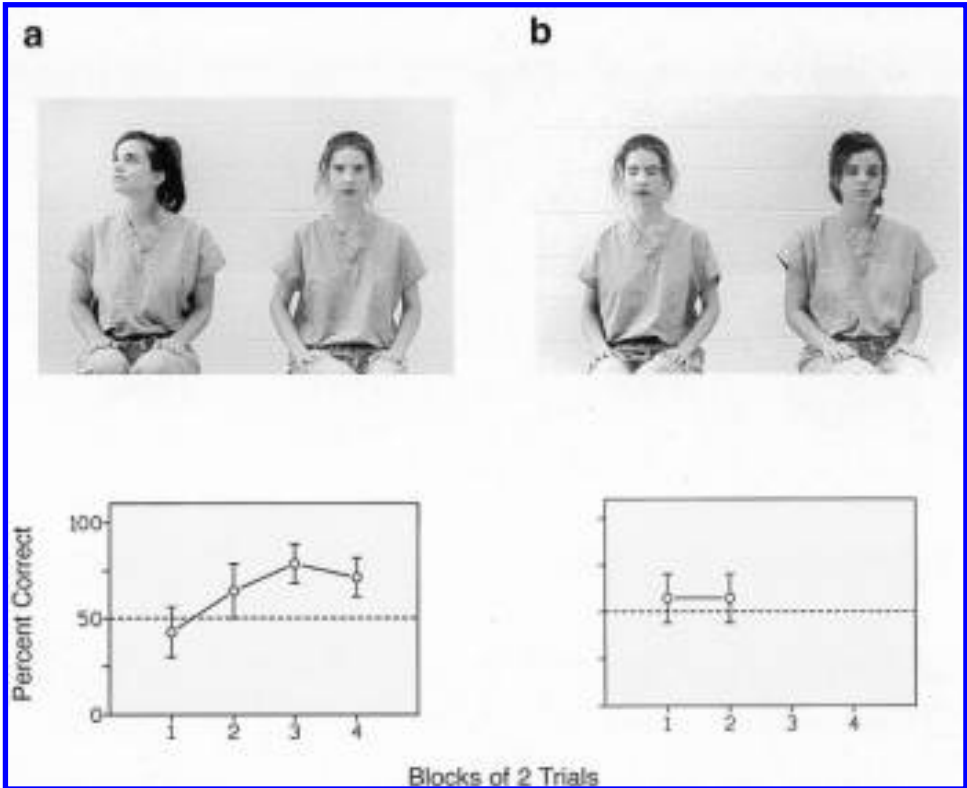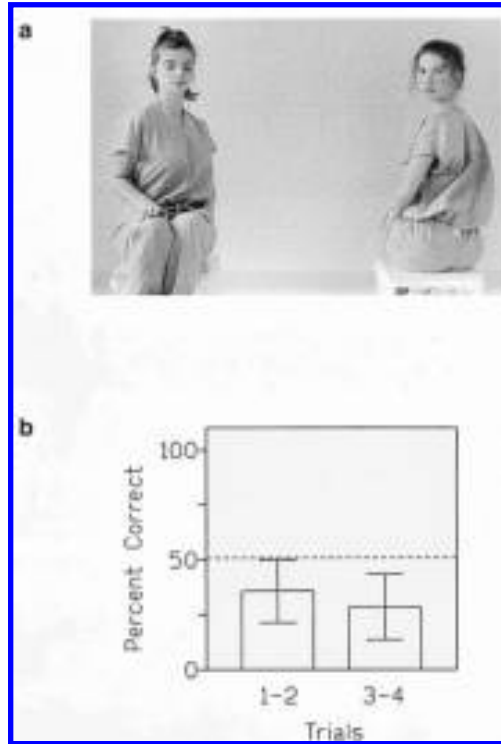
Figure 9. Stimulus configurations and results (±SEM) of (a) attending-versus-distracted and (b) eyes open/closed conditions.

open/closed; see Figure 9a–b). On the one hand, the high-level model predicted excellent performance on all conditions. On the other hand, the low-level model (the face rule) predicted excellent performance on all conditions *except* blindfolds, distracted/attending, and eyes open/closed. The reason for this latter prediction was that if the apes had simply learned a rule about the face, this rule could be satisfied on the buckets, hands-over eyes, screens, and looking-over-the-shoulder trials (where in each case one person's face was completely visible and the other person's face was completely obscured). In contrast, on blindfolds, distracted, and eyes open/closed trials, approximately the same amount of both faces was visible. Thus, if the subjects were relying on the face rule their performance should be impaired on just these three conditions. In a series of sobering studies, these are exactly the results we obtained (see Povinelli & Eddy, 1996a, Experiments 12–14). Additional tests continued to confirm the hypothesis that far from relying on representations of the attentional states of the experimenters, our apes were gradually forming a series of rules which they applied in the following linear order of importance: frontal aspect > face > eyes. To put it bluntly, it was more important to the ape that your general frontal aspect (or face) was visible, than whether your eyes were open (see Povinelli &

Eddy, 1996a, Experiments 12–14). (It is important not to mistakenly interpret these results as meaning that apes are uninterested in the eyes or eye movement. For example, as we indicated above, we have repeatedly shown that these same animals will follow the gaze of an experimenter, even in response to eye movements alone. However, if the low-level account of their interest in the eyes is correct, then such sensitivity would be orthogonal to the question posed by our seeing/not seeing tests.)

Perhaps the most striking findings of this project were obtained in a series of longitudinal follow-ups that were conducted approximately one and two years after this initial study (Povinelli, 1996; Reaux, Theall & Povinelli, 1999). In an effort to explore whether our animals' performance on these tests would change as they passed from juveniles, to adolescents, to young adults, we returned to these procedures when the animals were 7, and then again when they were 8 to 9 years of age. Two major findings emerged. First, despite the fact that the subjects were performing at levels exceeding chance on many of the conditions by the end of the initial tests (see especially, Povinelli & Eddy, 1996a, Experiment 13), they displayed very little of this understanding a year later when they were retested at 7 years of age (Povinelli, 1996). Indeed, even at 8 to 9 years of age, the subjects did not initially perform at levels exceeding chance on the majority of the conditions—even the ones they had learned very well by the end of the initial sets of tests (i.e., those involving the face rule). These findings were all the more striking because the absence of strong retention occurred despite the fact that throughout this 2.5-year period these apes were immersed in numerous studies (using different procedures) in which the central questions focused on what they understood about attention and other mental states. In some sense, it was as if the additional training actually interfered with their understanding of how to solve these seeing/not seeing tests—an understanding that appears to have been very shallow indeed. For a detailed discussion of the implications of these longitudinal results, see Povinelli (1999).

The second major finding to emerge from the longitudinal project was that even at 8 to 9 years of age, after we retrained them to above-chance performance on several of the original conditions, crucial transfer tests suggested that their performance was still not based on an understanding of seeing. In the most dramatic case, consider the 'mixed' condition depicted in Figure 10a. Note that the condition is composed of the *incorrect* option from the eyes open/closed condition, and the *correct* option from the looking-over-the-shoulder condition. We administered this mixed condition to our apes after several of them had relearned the conditions upon which they are based (eyes open/closed and looking over shoulder). If their successful performance on these latter conditions were based on an understanding of seeing, they should have had no trouble with the new, mixed condition. On the other hand, if the subjects were simply relying on the hierarchical rule structure described earlier (frontal aspect > face > eyes), then despite their ability to solve the eyes open/closed and looking-over-the-shoulder problems separately, when mixed in the manner depicted in Figure 10a they ought to prefer the *incorrect* option. In one of the most jarringly correct predictions of the low-level model, this is exactly what our apes did (see Figure 10b). Indeed, an examination of the data for individual subjects revealed that

Figure 10.   (a) Stimulus configuration created from mixing the correct options from looking over-the-shoulder (see Figure 7a), and incorrect option from eyes open/closed (see Figure 9b), along with (b) results (±SEM) of trials 1—4 (dotted line indicates performance expected by chance).

the better their performance on the eyes open/closed and looking-over-the-shoulder conditions the more strongly they preferred the incorrect option in the mixed condition!

Pointing

It did not escape our notice that the ability of chimpanzees to use their gestures to 'choose' among people or objects might suggest, by itself, that they understand something about the mental life of others. For example, the act of gesturing to one experimenter over another might indicate that the animals understood that other organisms have internal states that can be directed. (For a similar point of view for the emergence of pointing in infancy, see Camaioni, 1992; Baron-Cohen, 1994). Indeed, leaning heavily upon the argument by analogy, a number of researchers have claimed that chimpanzees do, in fact, 'point' in precisely this manner (see Leavens, Hopkins, & Bard, 1996; Krause & Fouts, 1997; Miles, 1990).

The question of whether apes 'point' is a subtle one, and is far too complex to be examined fully here. But, we must at least note that captive apes may well discover how we react to their behavior, without ever themselves reasoning about attention as an internal
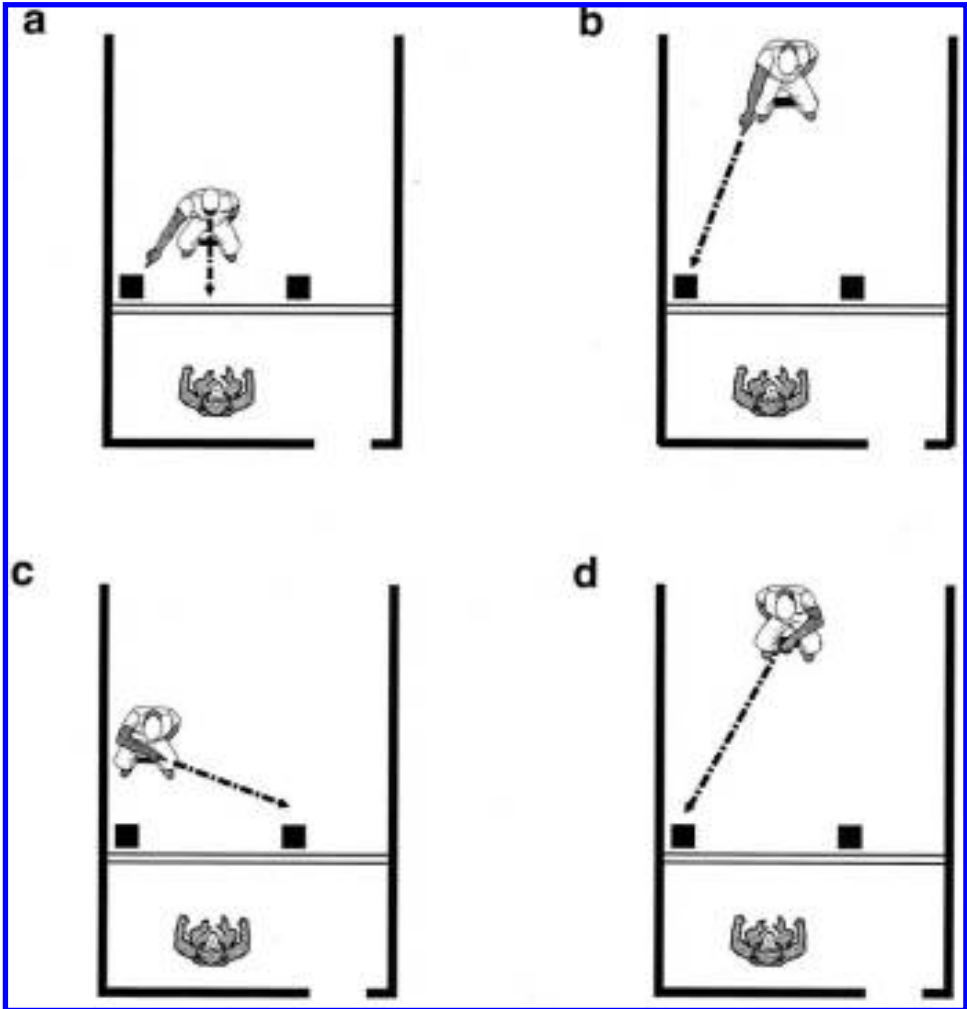
Figure 11.   Conditions used to explore adolescent chimpanzees' understanding the referential aspect of pointing: (a) standard pointing training trials with experimenter's hand 5 cm from correct location, (b) probe trials with experimenter's 120 cm from correct box and 150 cm to the incorrect box, (c) probe trials with pointing hand referencing correct box, but closer to the incorrect box, (d) probe trials with pointing hand equidistant from both boxes.

state. Indeed, the same possibility exists with respect to the emergence of pointing in human infants (e.g., Kaye, 1982; Leung & Rheinghold, 1981; Desrochers, Moriesette & Ricard, 1995). We experimentally explored what chimpanzees understand about pointing by teaching our seven apes (across dozens of trials) to pick a box to which their caregiver pointed (Povinelli et al., 1997; Figure 11a). They gradually learned that if they opened the box to which the experimenter pointed, they would discover a food reward inside. No such reward lay inside the other box. (That they did not initially select the box to which we pointed was revealing in its own right, especially given the extensive experience our apes

have had with this gesture in their spontaneous interactions with their human caretakers from birth. For additional evidence that chimpanzees do not grasp the referential significance of the pointing gesture, see Tomasello, Call, & Gluckman, 1997.)

Nonetheless, having trained our apes to exploit our pointing gesture in this manner, we outlined several alternative ways in which they might be interpreting it. One set of possibilities was that the apes understood the idea of reference all along, but either needed some experience in order to apply it in this context (after all, chimpanzees do not naturally 'point'), or perhaps were just distracted by procedural aspects of the test. However, an alternative set of possibilities was that the apes learned either a distance-based rule such as, 'Open the box closest to the caregiver's hand' or a local-cue rule such as 'Open the box+finger/hand configuration.' Broadly speaking, these two frameworks imply something very different about the nature of our apes' understanding of the pointing gesture. Whereas the referential model implied that they understood at least the proto-declarative aspects of the gesture (i.e., that the experimenter was 'commenting' on the location gesturally), the distance or local-cue models implied that the apes were simply exploiting the gestures as physical cues to locate the box that contained the reward.

We pitted these general models against each other by confronting our apes, as well as 2- to 3-year-old children, with numerous configurations of an experimenter pointing to one of two boxes. In the first study, we simply moved the experimenter's hand from 5 cm from the correct box and 75 cm from the incorrect box to 120 cm from the correct box and 150 cm from the incorrect box (see Figure 11b). If the local-cue model were correct, the subjects' performances ought to fall apart. On the other hand, both the referential understanding and cue-distance model predicted continued success. The chimpanzees' reactions were striking. First, on the standard trials where the experimenter's hand was 5 cm from the correct box the apes had no difficulties whatsoever selecting the correct location. In contrast, when the experimenter's hand was 120 cm away from the correct box, 5 of the 7 animals chose at random between the two boxes—despite the fact that they looked directly at the experimenter before making a choice on 100% of these trials. In other words, in complete support of the predictions of the local-cue model, simply moving the experimenter's hand further away from the box crippled most of the apes' ability to locate the food. However, two of the apes continued to perform well. But did they do so because they were choosing the box closest to the experimenter's hand (the cue-distance model), or because they understood the gesture as a declarative act communicating the location of the food (the referential comprehension model)?

In order to tentatively choose between the cue-distance and referential understanding models, we constructed a number of new configurations for the apes and 26-month-old children. Two of the most relevant cases are depicted in Figure 11c–d. In one case, the experimenter's pointing gesture was clearly directed at one of the boxes, but the tip of the index finger was positioned equidistant between the two boxes (Figure 11c). In the other case, the finger/hand of the experimenter was actually closer to the *incorrect* box, even though it clearly referenced the correct box (Figure 11d). The results provided unambiguous support for the cue-distance model. Despite the fact that they glanced at the experimenter before responding on over 94% of the trials, the apes (including the two that

had performed well in the first study) consistently chose the box closest to the experimenter's hand, regardless of what box was being referenced. Furthermore, when the pointing gesture was equidistant from the two boxes, but nonetheless clearly referenced one box but not the other, these two apes chose randomly. In contrast, 26-month-old children performed excellently even in the most difficult conditions (see Povinelli et al., 1997). Previous studies (including some of our own) that have suggested that nonhuman primates may understand the referential aspect of pointing have not implemented the controls that could rule out local-cue or cue-distance accounts (e.g., Menzel, 1974; Povinelli, Nelson & Boysen, 1992; Call & Tomasello, 1994).

Given these results, what should we make of claims that chimpanzees (or other great apes) 'point'? It is critical to distinguish between the production of pointing (or pointing-like) gestures, and the comprehension of those gestures. Even in human infants, the level of social understanding that accompanies the production of pointing is notoriously difficult to resolve. In the case of chimpanzees, there is no evidence that their species exhibits pointing gestures (either proto-declaratively or proto-imperatively) in the wild, nor, indeed, do they gesture in such ways to each other in captivity. Rather, their gesturing appears to be highly specific to interactions with humans. It is easy to imagine how apes might come to conventionalize a gesture that looks similar to pointing as the result of their interactions with humans (for other examples, see Tomasello, Gust, & Frost, 1989). Indeed, given that chimpanzees possess several natural gestures that involve arm extensions (e.g., goal-directed reaching, food begging, ally recruitment), and given that humans automatically interpret such gestures mentalistically, it is hard to imagine the circumstances under which captive chimpanzees would *not* develop a gesture that structurally resembles pointing—regardless of how they understand it.

V.   INTENTION, KNOWLEDGE, AND BELIEF

Of course, when it comes to understanding others in terms of mental states, humans reason about far more than just attention. What about chimpanzees' understanding of other internal mental states? Given that an appreciation of the simple aspects of attention appear to be among the earliest-emerging aspects of the 'human' theory of mind, there is at least some reason to think that if chimpanzees do not develop this kind of understanding, it is unlikely that they develop an understanding of intention, knowledge, and belief. Indeed, an objective assessment of early studies examining chimpanzees' (and other species') understanding of knowledge and ignorance (e.g., Povinelli, Nelson & Boysen, 1990; Povinelli, Parks & Novak, 1991; Povinelli, Rulf & Bierschwale, 1994; Premack, 1988) have indicated that they are better explained in terms of their reasoning about observable contingencies than in terms of an understanding of a hidden variables such as knowledge or belief (see Povinelli, 1994; Povinelli & Eddy, 1996a; Sober, 1998). Indeed, in a recent (and particularly well-controlled) investigation, Call and Tomasello (1999) tested chimpanzees and orangutans for their understanding of false belief. This investigation offered compelling evidence that despite their ability to understand the procedural aspects of the task, these animals were not able to represent others as possessing mistaken beliefs—the

so-called acid test for a theory of mind (e.g., Bennett, 1978; Dennett, 1978; Harman, 1978; Wimmer & Perner, 1983). Other work in our laboratory has failed to reveal evidence that chimpanzees reason about intentions as internal states. For example, when the intensity of accidental and intentional actions are carefully matched, chimpanzees do not appear to distinguish between accidental and deliberate events (e.g., Povinelli, Perilloux, Reaux & Bierschwale, 1998). Similarly, Tomasello, Call, & Gluckman (1997) recently reported that unlike 2.5- and 3-year-old human children, chimpanzees and orangutans failed to grasp the communicative intent of novel signs that were designed to inform them of the location of hidden treats. Finally, we have shown that when expert chimpanzees (who have previously learned how to act with other expert peers to solve a cooperative problem) are paired with ignorant partners, they do not respond by demonstrating the needed actions, or even by directing their ignorant partners' behavior to the relevant features of the task —perhaps because they do not conceive of knowledge and ignorance to begin with (Povinelli & O'Neill, 2000).

In general, then, experimental work has consistently suggested that chimpanzees and other great apes do not reason about internal mental states. Despite their ability to learn to solve nearly every problem we have posed to them, low-level models that envision chimpanzees as intelligent empirical generalists have consistently generated more accurate predictions about their behavior than have high-level models that envision them as making inferences about unobservable mental states.

VI. THE REINTERPRETATION HYPOTHESIS

At this point, our general reader may be puzzled. How is it, they will wonder, that chimpanzees—especially chimpanzees!—can exhibit the remarkably sophisticated social behaviors so eloquently described by Jane Goodall (1971, 1986), Frans de Waal (1982, 1989, 1996) and others, without possessing at least an inkling of others as psychological agents? After all, the social world of primates is one in which dominance status, recent positive or negative interactions, and complicated and shifting alliances all play major roles in determining what should be done next. To wit, how could it be that nonhuman primates deceive and manipulate each other (e.g., de Waal, 1986; Byrne & Whiten, 1985; Whiten & Byrne, 1988) if they do not represent each others' beliefs? Furthermore, how could chimpanzees share with us so many of these social behaviors, down to the finest level of detail, and yet interpret them so differently? If we were to reply that these animals just learn, through trial and error, that certain behaviors lead to certain consequences, the general reader would remain deeply unsatisfied. First, such an explanation seems to involve a double-standard: The exact same behaviors are to be explained in different ways depending solely on whether they are performed by humans or by other primates. Second, such a simplistic account seems to fly in the face of the reality of our close common ancestry—is there not some biological doctrine that could be invoked to bolster the probability that when two species are closely related, similar behavior must be attended by similar psychological causes?

Alas, both extremes may be wrong. If we are to make progress toward understanding how humans and chimpanzees can resemble each other so closely in behavior, and yet differ so dramatically in psychological functioning, we need to abandon the visual rhetoric of *National Geographic* documentaries and re-examine reasons why we may have been led astray in the first place. In short, we need to re-examine the argument by analogy (for a more formal treatment, see Povinelli & Giambrone, 1999). One of the central premises of the argument is that introspection (or something like introspection) can accurately reveal which of our behaviors are caused by which of our mental states (e.g., Russell, 1948). In the case of gaze-following, for example, the argument assumes that we know that our representation of the other person's mental state of attention plays at least a necessary role in causing us to turn and follow his or her gaze. Now, although we would not dispute that in some cases this is true, we would vigorously dispute the claim that such representations *always* play this kind of "but for" role in the generation of the gaze-following response. Indeed, in this particular case, we would even question whether such representations *usually* play this kind of causal role. More generally, of course, we question the suitability of introspection to isolate the exact nature of that role. Indeed, the human proclivity for rapidly generating after-the-fact (sometimes impossible) explanations for our behavior highlights this problem.

To illustrate our point more generally, let us briefly consider other systems in which higher-order representations (akin to second-order intentional states) covary with, but frequently play no *direct* causal role in the production of a given behavior (for a detailed treatment of this example, see Povinelli & Giambrone, 1999). For example, a speedometer can be usefully thought of as a device which represents, but does not directly cause, the motion of system comprised of an automobile and its driver (hereafter we simply refer to this as 'the automotive system'). Several aspects of this system are instructive. First, note that prior to the installation of the speedometer, the automotive system possessed a wide range of behavioral propensities (accelerating-decelerating, starting- stopping, traveling along an infinite series of paths, et cetera). Furthermore, the installation of the speedometer did not eliminate or fundamentally alter this initial set of behavioral propensities, nor at first glance did it suddenly endow the system with a suite of new propensities. To illustrate this latter point, we would not immediately see a change in the behavioral propensities of the system if at some later timepoint we removed the speedometer—after all, the relevant propensities were established by design constraints of the system that were in place long before speedometers were invented.

But if speedometers did not endow the automotive system with a vast array of fundamentally new basic behaviors (behaviors that were impossible without this representational device), why were they added in the first place? Our answer is simple. Although speedometers did not immediately allow for (or directly cause) the appearance of new behavioral propensities per se, they most certainly did have subtle (but ultimately dramatic) indirect effects on the timing, efficiency, organization, and interactions of the already-existing set of propensities of the system. As just one example, prior to the addition of speedometers, it was certainly possible (at least in principle) to drive a specified distance in a specified period of time. Speedometers, however, made such

actions easy to achieve, and perhaps even practically feasible for the first time. Furthermore, the introduction of an explicit representation of 'speed' into the system may have had cascading consequences on the arena of action in which the automotive system was operating. On this view, endowing the automotive system with a device to represent its own speed can be said to have indirectly led to the invention of new social institutions such as speed limits, as well as entire bureaucratic structures dedicated to enforcing them. To summarize, this example clearly illustrates how the addition of higher-order representations can have profound effects on a behavioral system through indirect effects on existing behavioral propensities. Such representations might, but need not, endow the system with a plethora of new basic behavioral propensities in order to be extremely advantageous.[4]

Likewise, our reinterpretation hypothesis proposes that the majority of the most tantalizing social behaviors shared by humans and other primates (deception, grudging, reconciliation) evolved and were in full operation long before humans invented the means for representing the causes of these behaviors in terms of second-order intentional states. In this sense, our reinterpretation hypothesis may be the evolutionary analog of Annette Karmiloff-Smith's (1992) concept of 'representational redescription,' which she posits as a major driving force in human cognitive development. Her proposal envisions a process in development whereby information implicitly *in* the mind is progressively recoded at increasingly explicit levels both within and across domains in ways that make this information increasingly available *to* the mind. One interpretation of our hypothesis is that humans have uniquely evolved the psychological mechanisms that allow for the most abstract levels of representational redescription (Karmiloff-Smith, 1992). But then what causal role is left for second-order intentional states? In our view, the highest level psychological descriptions of behaviors do not necessarily directly prompt the behavior they attend. To be sure, in some cases they may do so, but in many other cases they may serve to regulate behavior at a higher level of hierarchical description. In many cases, however, they may merely be convenient (and useful) ad hoc descriptions of our behaviors—behaviors that both can and do occur without such descriptions.

Perhaps one troubling question remains. If the exact same behaviors can be produced without such explicit representation of mental states, why did the capacity for such representations evolve in the first place? If the view we have outlined here and elsewhere is correct, then the evolution of second-order intentional states may have initially occurred because of their advantage in subtle reorganizations of existing, ancient behavioral propensities, as opposed to the generation of entirely new classes of basic behavioral units. In this sense, the evolution of second-order intentional states may have allowed humans to reinterpret existing, extremely complicated social behaviors that evolved long before we did. Of course, once this new representational device was in place, there may well have been cascading effects on larger aspects of the system—in this case, material and social culture including pedagogy and ethics, to name but a few (for differing perspectives on these issues, see Premack, 1984; Tomasello, Kruger & Ratner, 1993; Povinelli & Godfrey, 1993). Figure 12 offers a model of both the traditional view of the relation between
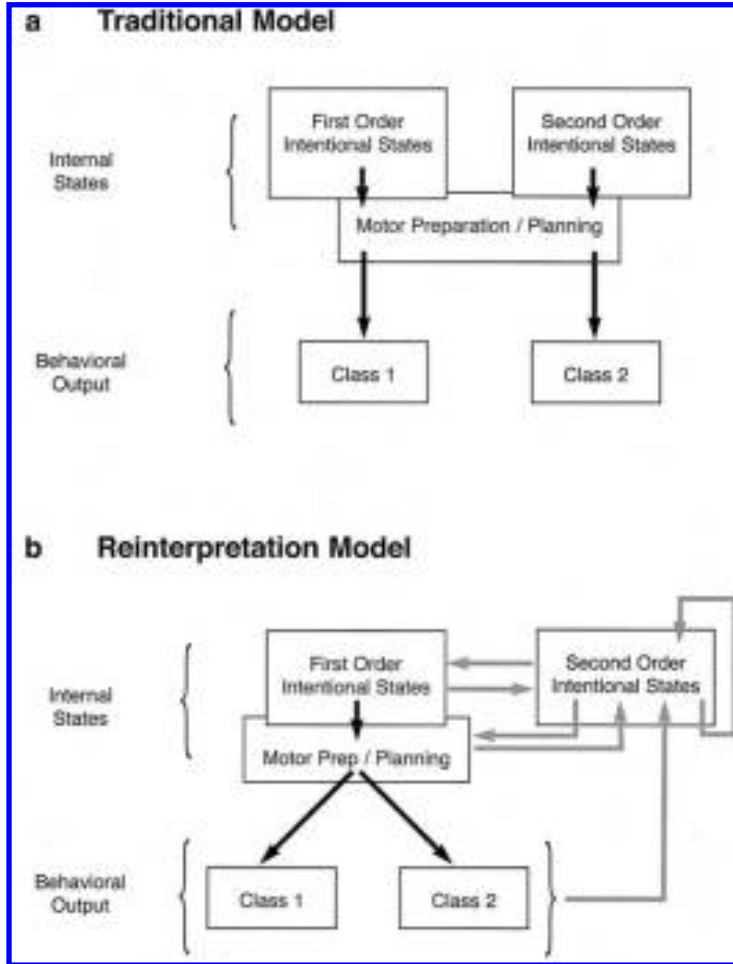
Figure 12.   Two models of the causal role of second-order intentional states. (a) On a traditional view, second-order intentional states are seen as directly generating a unique class of complex social behaviors (class 2); (b) The reinterpretation model supposes that the most complex social behaviors shared by humans and chimpanzees are directly generated by first-order intentional states, but that second-order intentional states sometimes prompt the internal states that produce those behaviors. This model allows that in many cases, second-order intentional states may be generated after the execution of behavioral actions that they purport to explain. Second-order intentional states are seen as playing a causal role in regulating, organizing, and planning behaviors that evolved long before such states did. The uniquely human aspects of this system are connected by shaded arrows.

second-order intentional states and behavior, along with a simplistic model of our alternative view.

Finally, some will want to know more about the evolutionary history of second-order intentional states, and in particular the fitness advantages that it confers. A complete reconstruction of the evolution of theory of mind would specify the selective forces that initially favored it. However, the novel aspects of our proposal show how such a question

may be somewhat misplaced. After all, if we are correct in asserting that the emergence of second-order intentional states was not initially associated with the appearance of new behavioral units per se, but rather with new efficiencies in organizing, planning, and deploying already-existing ones, then we may have already answered the question. After all, if theory of mind and related representational systems may simply have initially offered only marginal—but not negligible—improvements in the efficiency of ancestral behaviors. Evolutionary biologists have long known that innovations which confer even slight advantages over their alternatives, can result in rapid selection and ultimately lead to fixation of the trait in question (Fisher, 1930; Haldane, 1932; Wright, 1931, 1932). If we are correct, once the ability to represent mental states was introduced into the human lineage, it was selected for not because it was the only means to be a successful, social primate (witness other social primates), but because once introduced it was just a bit better than its alternatives.

VII. CONCLUSIONS

The theoretical framework offered here suggests a very different view of nonhuman primate cognition than the one typically espoused by comparative psychologists, or for that matter, the popular imagination. For example, we believe that the best available evidence suggests that chimpanzees do not understand seeing as attention—an under-standing that may be among the most basic aspects of theory of mind. Furthermore, this empirical research simultaneously demonstrates that the fundamental behaviors once thought to be in question can be generated without second-order intentional states. Thus, there is no easy way of making an a priori transition from behavioral similarity to psychological similarity. Our model clearly shows how the kind of psychological conti-nuity that many comparative psychologists have sought to document may remain eternally elusive.

For more than a century, Darwin's view of psychological continuity has placed severe a priori restrictions upon our perception of the psychology of chimpanzees and other nonhuman primates. Rather than allowing these animals to tell us how their psychological structures are simultaneously similar to and different from our own, such a view has inadvertently held them hostage to a theoretical framework that, though intuitively appealing, can be shown to be inherently suspect. Furthermore, this view of continuity has left researchers with little alternative but to develop models of psychological evolution in which new psychological structures are tacked on to the end of the developmental sequences of ancestral species (e.g., Parker & Gibson, 1979)—ultimately leading to the idea that chimpanzees can be described as reaching some general level psychological development (such as that exemplified by 2- or 3-year-old children: Premack & Dasser, 1988; Parker & Russon, 1996). In contrast, the view we have advocated demonstrates how Darwin's commitment to psychological continuity among species may have been both right *and* wrong. On the one hand, he was correct in asserting that the behavioral similarity between humans and other animals reveals a kind of unbroken continuity at some level of psychological functioning. On the other hand, he was wrong in assuming that introspec-

tion could reveal the nature of this similarity. The major landmarks in psychological evolution may turn out to have been successive restructurings (or redescriptions) of ancestral behavioral patterns. On this view, the evolution of an ability to interpret the rich network of ancestral primate behaviors in mentalistic terms (our so-called theory of mind) may simply turn out to be a specialization of a single bipedal hominid lineage that began to emerge about four million years ago. And it was this specialization that may ultimately have left humans and chimpanzees understanding nearly identical behaviors in radically different ways.

NOTES

1. Indeed, we suspect that even more broadly the argument by analogy fails to consider the possibility that the interpretation of behavior in terms of mental states is just one aspect of a much more fundamental human cognitive specialization—a specialization in postulating unobservable, intervening variables to explain events in general. Recent research in our laboratory lends some support to this hypothesis.
2. Some research suggests that 3-year-olds may understand the seeing-knowing relation (e.g., Pillow, 1989; Pratt & Bryant, 1990; Wooley & Wellman, 1993). In addition to methodological problems associated with some of these studies (see Povinelli & deBlois, 1992), research by Lyon (1993) suggests that 3-year-olds conflate desire and perceptual access, and hence may in some circumstances attribute knowledge not based on relevant perceptual access, but on overt display of interest.
3. Indeed, chimpanzees generally use visually-based gestures only when others are oriented toward them (see Tomasello, Call, Nagell, Olguin, & Carpenter, 1994). Before automatically concluding that this supports the idea that chimpanzees understand attention, we should reflect on the evolution of such social signals. From insects to birds to mammals, visually-based signals could only have evolved if they are displayed within the visual field of the recipient. There is no way they could be selected for otherwise. Our tests, however, decompose the problem by asking the apes which factors control the deployment of their visually based gestures.
4. Some may be troubled by our use of an analogy in an essay dedicated to questioning an argument by analogy. However, we use this example merely to illustrate how a system might operate in a particular manner, not as an a priori argument that it does operate in this manner. More generally, our indictment of using the argument by analogy to conclude that other species possess second-order mental states is not a general indictment of arguments by analogy—many such arguments are quite strong. Rather, we have shown that this particular argument by analogy is quite weak (for a more formal treatment, see Povinelli & Giambrone, 1999).

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