complementary aspects of this phenomenon. Thus, there is great potential for integration in the study of both the proximate mechanisms and the evolutionary aspects of altruism. Primate research on altruism is firmly grounded in evolutionary theory and has made much progress in the use of sophisticated game theory models to predict the occurrence and distribution of altruistic acts among individuals and over time. Little is known, however, about the cognitive and emotional aspects of altruism in primates, and this is an area of research that could benefit considerably from importing both conceptual models and relevant empirical information from human research.

Human research on altruism and prosocial behavior could make significant progress by focusing on whether altruistic tendencies are governed by experience, specifically designed cognitive mechanisms, or more general emotional states. Although some anthropologists have consistently studied human altruism from an evolutionary perspective, such an approach is still vastly underused in much research within social psychology. Thus, the use of theoretical models imported from evolutionary theory and primate research (as well as other disciplines such as economics) in the study of human altruism could strengthen the conceptual foundations of this research and allow investigators to assess whether the empirical findings obtained with human and nonhuman primates have cross-species validity.

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Comparing Cognitive Development

Jesse M. Bering and Daniel J. Povinelli

People who study the intellectual abilities of chimpanzees or other great apes are frequently asked some version of the following, somewhat impatient question: "Yes, yes, all of your experiments and data are very interesting, but let us cut to the chase: How smart, exactly, are your apes? Are they are smart as a two-year-old child? A three-year-old? A four-year-old?" This question, graphically presented in Figure 8.1, naturally tempts an answer—especially because it is framed in terms of a notion already common among students of cognitive evolution; namely, that mental evolution invariably proceeds through the progressive addition of new stages to the end of a monolithic, domain-general ancestral pathway of cognitive development. Even Jean Piaget, the famed Swiss epistemologist, was tempted by the apparent allure of answering this question. "[Chimpanzees] are superior to one-year-old babies," he once replied during an interview, "but they don't progress much beyond that."

By the end of this chapter, we hope to show why the question depicted in Figure 8.1 may be unanswerable: not because it is too difficult but, rather, because it is incoherent. By way of foreshadowing, the reason is simple. In addition to whatever quantitative modifications may have occurred in the various cognitive systems that were present in the common ancestor of humans

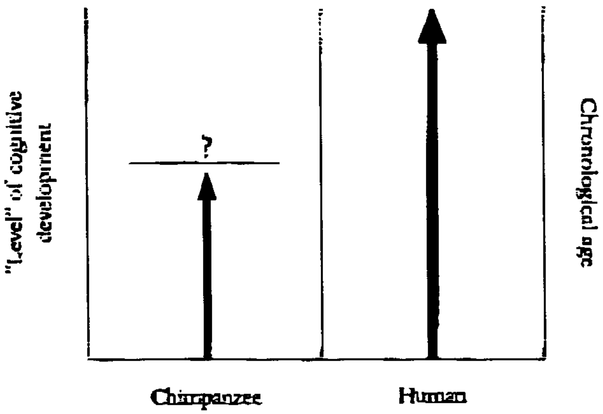

Figure 8.1 "How smart is your ape compared to a human child?" This question assumes that cognitive evolution is best depicted as the addition of new "stages" or "levels" to the end of a monolithic linear pathway of the common ancestor. In the tradition of Darwin and Romanes, notions about cognitive evolution are even more divorced from modern biological thinking in that species can be arranged in an ordered fashion from the "lowest" worm to the "highest" ape in a kind of "phylogenetic scale" (see Hodos & Campbell, 1969). Compare to Figure 8.8.

and chimpanzees, humans appear to have evolved additional, qualitatively new abilities (ones not found in other species). More important, the system or systems that support such abilities were not tacked onto the end of the general developmental pathway found in the common ancestor but rather were woven into development early on, so that they now develop in parallel to the systems we share in common with other species. We shall argue that one of the most important features (or consequences) of these systems is the human ability to form concepts about purely abstract things: concepts about things that cannot be directly observed by the senses; concepts about the "hidden" world—the world of forces and causes that lie behind the surface appearance of things. In the domain of animate beings, we are referring to things like emotions, intentions, perceptions, and beliefs; in the domain of inanimate, physical objects, we are referring to things like gravity, force, mass, physical connection, and the like. Indeed, we suspect that this core difference between

humans and chimpanzees may have such sweeping effects on our commonsense understanding of the world that it may mask our very ability to recognize its existence.

Continuity and Discontinuity: From Bridging Gaps to Accepting Diversity

Our starting assertion, then, is that humans may be the only species on this planet that possesses the natural ability to reason about unobservable entities, and furthermore that the systems which support these differences are already manifest during the earliest moments of infancy. Curiously, the possibility of the existence of a fundamental difference such as this has only rarely captured the attention or interests of researchers who have compared the cognitive development of humans and apes, for at least two reasons. First is the idea that cognitive evolution occurs exclusively by gradual, quantitative modification—by a periodic swelling and receding of psychological competencies within particular phylogenetic lineages. Even Darwin himself, otherwise a champion of evolution as a branching process of diversification, caricatured psychological evolution as having produced a kind of phylogenetic scale in which animals could be arranged along a continuum from "lower" to "higher," with humans anchoring the highest (most psychically developed) point (for discussions of Darwin's gradualist and scale-like views on the evolution of the brain and mind, see Povinelli & Giambrone, 1999; Preuss, 1995). This intellectual framework emphasized commonality and continuity among species, with each adjacent species up the scale possessing just a little more of the same basic faculties as the ones just below it (see Spencer, 1887, for a historically influential version of the idea of the phylogenetic "scale"). There can be no cognitive traits, according to this logic, which exist in a fully functioning form in one species (e.g., humans) but not in another, closely related one. There must at least be some trace, some vestige, some meager but nevertheless present semblance of the particular cognitive trait in the sister species. Indeed, this logic has led to something of a recrudescence of recapitulation theory, with apes seen as progressing farther than monkeys, humans getting farther than apes, and human ontogeny reflecting the same general pattern of emergence (e.g., Langer, 1998, 2000; McKinney, 1998; Parker & Gibson, 1979; Parker & McKinney, 1999; Suddendorf, 1999; Whiten, 1996).

In principle, of course, there is nothing inherently problematic about the idea of some kind of psychological continuity among species (or even, in some cases, recapitulationist patterns of development). Indeed, it follows as a virtual truism of modern biology that sibling species such as humans and chimpanzees will share many behaviors in common, and that these shared behaviors (and at least some aspects of the psychological systems generating and attending them) will be genuinely homologous (see also Povinelli et al., 2000, 2002; Povinelli & Giambrone, 1999). What is problematic is the simplistic misapplication of such notions. Particularly problematic is the centerpiece of the agenda laid out by early philosophers such as Hume and the founders of comparative psychology, Darwin and Romanes, that the presence of homologous behaviors necessitates strong similarity in the underlying cognitive systems which produce and/or represent the behavior (for a detailed discussion of this history, see Povinelli & Giambrone, 1999). This, of course, is an extreme form of continuity theory. It is a view that promotes the idea that the agenda of studies of comparative cognitive development should be a focus on understanding how "far along" certain species get with respect to the "most evolved" species, *Homo sapiens*. Further, it is an idea that is still alive and well among researchers who compare the psychological systems of humans and chimpanzees (see Chapter 9).

In this chapter we outline a different, more pluralistic idea. We argue that the existence of massive homology in the behavioral and psychological systems of humans and chimpanzees in no way precludes the possibility that humans have evolved either one or many pathways not found in other species—pathways that develop in parallel to these ancestral systems and that now reside alongside and interact with the more ancient ones. Further, we show how this idea seems increasingly supported by mounting empirical evidence. Note that there is nothing about this view which rejects profound similarities between humans and chimpanzees, nor anything which rejects the idea that each species may tweak ancestral systems in certain quantitative ways depending on the particular socioecology of its evolutionary history. Nor, for that matter, is there anything in this account which denies the possibility that chimpanzees have evolved their own, peculiarly chimpanzee-like cognitive systems.

Similarity and Difference: Is One More Important than the Other?

At this point one might reasonably ask why we appear to be so concerned with the possible differences (as opposed to the similarities) between chimpanzees and humans. More directly, one might ask, "Aren't the similarities profoundly important as well—perhaps even more important than any minor differences that might exist between the species?"

The first part of the question demands an unequivocal yes. Indeed, many will be startled by how similar the spontaneous, natural behavior of chimpanzees is to our own. A short, nonexhaustive list includes the following: complex alliance formations (de Waal, 1982), conflict resolutions (Baker & Smuts, 1994; de Waal, 1989a), tool-using technologies (Boesch & Boesch, 1990; McGrew, 1992), subtle regional behavioral differences (i.e., local "dialects" of behavior; Whiten et al., 1999), political maneuvering and fluid social hierarchies (de Waal, 1982), sex differences in group-living tasks (Boesch & Boesch-Achermann, 2000; Wrangham, 1986), juvenile play (Mendoza-Granados & Sommer, 1995), and strong maternal attachment (Goodall, 1986). Thus, the one thing we certainly do not wish to do is minimize the extent of overlap between human and chimpanzee behavior. It is important and immense.

Unfortunately, the enormous similarity in the spontaneous behavior of humans tosses up blinding, and at present almost intractable, distractions from what we believe is the core task: the project of formulating a genuinely evolutionary science of other minds—a science dedicated to understanding both the similarities and the differences between the two species. This is because the very mind (the human one) that seeks to analyze objectively the behavior of other species in order to determine the nature of their cognitive systems is already wired to interpret their behavior from a human standpoint—regardless of the objective reality. Put another way, here is one thing of which we can be sure: the human mind is extremely adept at seeing the world through its own lens, and indeed, the more that the things it sees physically resemble human beings, the more powerful and complete that transformation will be. This means that the work of comparative psychology must be converted from the easy task of simply cataloguing behavioral similarities among species to the very hard task of grappling with the ways in which fundamental patterns of behaviors can interact with multiple systems which have evolved for representing and interpreting them. Elsewhere we have shown analytically that when it comes to certain classes of conceptual cognitive systems, the mere presence of a given spontaneous behavior can never reveal, without careful experimental analysis, whether such systems are actually present (see Povinelli et al., 2000; Povinelli & Giambrone, 1999).

Perhaps by now the answer to the second part of the question—whether the similarities between humans and chimpanzees are actually more important than the minor differences—should be obvious. If aspects of the reorganization of the human cognitive system over the past 5 to 7 million years have been so colossal, so jarringly dissimilar from anything the natural world has yet known, then it would stand to reason that this state of affairs should demand at least some attention from all of those who wish to understand the true nature of the minds of humans and chimpanzees.

Reasoning about the Hidden World

Our laboratory has conducted an extensive amount of investigation designed to explore the psychological systems of a cohort of seven chimpanzees that we have followed from infancy to adulthood. The results of these studies have emphasized two themes. First, they have underscored the already well-established conclusion that chimpanzees share with humans an impressive ability to represent and reason about the observable contingencies that exist in the world. Second, and far more interesting, they have pointed to the possibility that, unlike humans, chimpanzees may not impose on observable events explanations for why they exist in the first place. That is, the search for underlying, unobservable causal mechanisms may be a uniquely human cognitive specialization.

This hypothesis has profound implications for understanding what is fundamentally human about the human mind. Because both humans and other closely related species share vast networks of homologous psychological mechanisms for uncovering and representing the observable regularities in the world, it is virtually guaranteed that both humans and chimpanzees will possess many of the same behaviors for coping with similar problems they encounter in the social and physical domains. Less obvious, perhaps, is that the same spontaneous behavior, whether produced by a human and a chimpanzee, two different humans, or even the same human at different time points, may have very different psychological causes. This new system (one undoubtedly tied up with the evolution of the universal human capacity for language) did not replace the operation of these ancestral systems but rather resides alongside them, both modulating and being modulated by them (see Povinelli et al., 2000).

We shall explore this idea further, but for now we turn to an examination of some of the empirical data which, we believe, strongly support the existence of precisely the mosaic pattern to which we have been alluding: the existence of profound similarity in the cognitive developmental pathways of humans and other species (see, for example, contributions in Antinucci, 1989) right alongside profound differences. In particular, we examine what can be thought of as the quintessential case of the human capacity to reason about things which cannot be directly perceived—namely, the human ability to conceive of internal, unobservable mental states.

Social Understanding in Chimpanzees and Children

At some point humans develop the ability to reason about the mental states of themselves and others. This capacity has been referred to as "theory of mind" (Premack & Woodruff, 1978). The exact age at which various aspects of these abilities emerge, and the mechanisms responsible for their emergence, is a matter of considerable controversy (for review, see Mitchell, 1997). Proposals for how children get from their initial understanding of the world to some more mature state abound, and they differ in important and subtle ways in (1) the nature of the starting state of the system that is present at birth, (2) which aspects of the system are not reducible, and (3) the mechanisms by which new aspects of the systems are produced (Carey & Spelke, 1994; Gopnik, 1993; Gopnik & Meltzoff, 1997; Gopnik & Wellman, 1992; Harris, 1991; Leslie, 1994; Perner, 1991). Regardless of the outcomes of these ongoing debates, however, two statements seem uncontroversial: large aspects of this "intentionality system" are cross-cultural (e.g., Avis & Harris, 1991; Povinelli & Godfrey, 1993; Lillard, 1998; Vinden & Astington, 2000), and its application is very general indeed, with humans attributing emotions, desires, thoughts, and feelings to a dramatic range of other animals and even objects (Eddy et al., 1993). In short, whatever the evolutionary forces that sculpted it, the human theory of mind is not particularly sensitive to the particular animal before it.

Humans may therefore simply be built in such a way that we will attribute mental states to chimpanzees, and further, we will attribute to chimpanzees the ability to do the same. This fact, of course, has no bearing on whether chimpanzees really possess a system for attributing mental states to others; it only bears on the far less interesting claim that humans possess such a system. Thus, the difficult, nontrivial empirical problem still looms large and unsolved: Do chimpanzees actually possess such a system?

Knowledge about Visual Perception

In what follows, we focus on the question of whether chimpanzees reason about mental states (such as perceptions, beliefs, desires, intentions, and emotions) by asking whether chimpanzees understand one of the earliest emerging aspects of social understanding in young children: the understanding of "seeing"—that is, the understanding that other individuals have unobservable visual experiences.

We focus on what chimpanzees know about seeing for several reasons. First, it is the most widely explored facet of nonhuman primates' understanding of the mental states (e.g., Call et al., 2000; Cheney & Seyfarth, 1990a; Hare et al., 2000, 2001; Kummer et al., 1996; Povinelli & Eddy, 1996a, b; Povinelli et al., 1990, 1991, 1999, 2002; Povinelli, Theall, et al., in press; Premack, 1988; Reaux et al., 1999; Theall & Povinelli, 1999; Tomasello et al., 1999). Furthermore, substantial enough research has been conducted with chimpanzees, in particular, to take stock of the database, allowing us to make some meaningful assessments. Several reliable findings have emerged, and several other, still controversial findings crisply illustrate the main theoretical point we wish to make in this chapter. Second, an understanding that others "see" things emerges fairly early in human development—somewhere around the child's second birthday—and a mentalistic understanding of visual reference or attention may emerge even earlier. A related point is that this kind of understanding seems fundamental to our mature representation of others as psychological agents. And finally, based on our assessment of the current empirical evidence, we believe that this is an excellent example of how profoundly similar humans and chimpanzees can be in their spontaneous, everyday behavioral interactions while still remaining radically different in their interpretation of such behaviors.

Sensitivity to the Eyes

A variety of birds, reptiles, fish, and mammals have been shown to be sensitive to the presence of eyes or eye-like stimuli (e.g., Burger et al., 1991; Burghardt & Greene, 1988; Gallup et al., 1971; Ristau, 1991b; review by Argyle & Cook, 1976). For example, Blest (1957) showed that birds were less likely to prey on moths with eyespots than on those without. In general, of course, such sensitivity is to be expected. After all, from the potential prey's perspective, what could be more ecologically relevant than a pair of eyes looming in your visual field? But such sensitivities would not seem to qualify as unambiguous evidence that the bird is reasoning about "seeing."

A moment's reflection will reveal that the same logic applies in the context of highly social organisms for which vision is an important sensory modality. Nonhuman primates, in particular, appear quite sensitive to the movements of the head and eyes of others (see Figure 8.2). The basic capacity to follow the gaze direction of others, for example, has now been demonstrated in a wide range of nonhuman primate species (e.g., Emery et al., 1997; Ferrari et al., 2000; Itakura, 1996; Povinelli & Eddy, 1996b, c; Povinelli et al., 1999, 2002; Tomasello et al., 1999). Chimpanzees have been examined most thoroughly, and have exhibited the same range of complexity of components of the gaze-following system that is present in human infants aged eighteen to twenty-four months (see Povinelli, 2001). Aspects of these findings suggest that the neuropsychological system controlling these behaviors is a shared primitive feature of the chimpanzee-human clade (and, most likely, an even larger clade).

Inferences about Seeing

But does this tell us anything about whether chimpanzees understand that others have unobservable internal perceptual states of "seeing" things? An intensive longitudinal investigation of a group of seven chimpanzees conducted by our research group has provided convergent evidence that despite their remarkable gaze-following skills, they do not understand the perspectival, subjective experience associated with the orientation and movement of the head and eyes of other individuals, despite the fact that these very same subjects have robustly exhibited the most complex aspects of gaze-following for which this species (or human infants, for that matter!) has been tested.

Figure 8.2 A five-year-old chimpanzee following the gaze direction of an experimenter who turns her head and eyes in concert with a predetermined target above and behind the chimpanzee.

For example, in one series of experiments, we probed whether, when faced with two familiar human experimenters, our chimpanzees would selectively deploy their visually based, species-typical begging gesture to the person who could see them (see Figure 8.3). Assessments were made when the apes were five to six, seven, and eight to nine years of age (for results, see Povinelli & Eddy, 1996a; Reaux et al., 1999). The results of nearly twenty experiments showed that although our chimpanzees actively used their communicative gestures, they did not seem to appreciate that only one of the two people

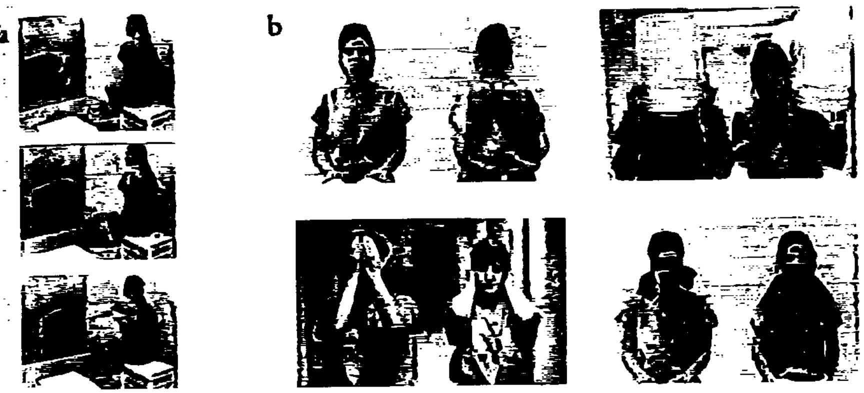

Figure 8.3 Do chimpanzees understand "seeing"? (a) On standard (background) trials, Mindy uses her natural begging gesture to "request" food from a familiar experimenter. (b) On probe trials, various conditions instantiating the seeing/not seeing distinction require the chimpanzee to choose to whom it will gesture. Although the chimpanzees are correct from trial 1 forward on back versus front, they do not appear to understand any of the other conditions. Follow-up tests revealed that their understanding was about the observable postures of the experimenters, not who could see them.

could see them. It is essential to note, however, that in virtually every instance, the chimpanzees learned the contingencies involved quite rapidly. Thus, with enough experience and feedback, the animals learned to gesture to the person who could see them. But it is equally important to note that follow-up tests consistently revealed that the hypotheses that best predicted which experimenter the ape chose were about the postures, not the mental states, of the people involved (see Figure 8.4). Furthermore, in a longitudinal project with these same animals, we assessed their understanding of seeing when they were juveniles, adolescents, and young adults. The results consistently yielded the same pattern described above: they were reasoning about the postures, not the perceptual states, of their communicative partners. Other research with these same animals, using quite different methodologies, has converged on a similar interpretation (review by Povinelli & Giambrone, 2001).

Other researchers have questioned this conclusion, and have suggested that tests involving competition may reveal the presence of an ability to reason, at some primitive representational level at least, about "seeing" (e.g., Chapter 9). Perhaps the most direct evidence for this view comes from a study by Hare et al. (2000), who placed subordinate chimpanzees in one-on-one

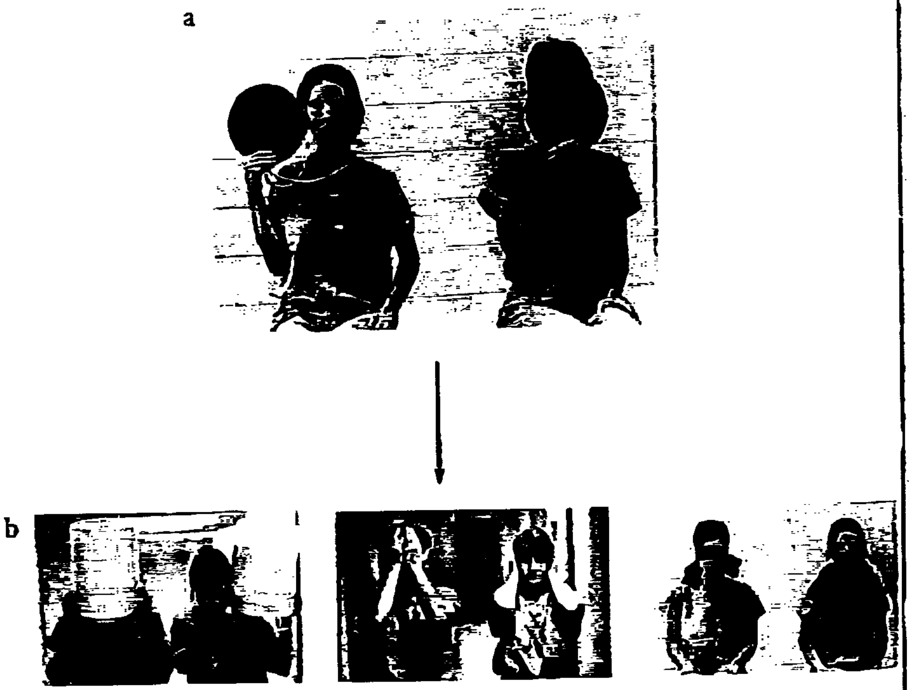

Figure 8.4 An important example of what our chimpanzees learned in the seeing/not seeing tes[ts]. After many trials of screen over the face (a), the subjects learned to choose whichever experimenter was holding the screen beside the face. Had they learned that that person could see them, or simply "Gesture in front of the person whose face is visible"? In (b) we tested them on several of the original conditions. If, on the one hand, they had learned something about seeing, they should have transferred their understanding of the screen condition equally to all of these old conditions. On the other hand, if they were just using the rule about the presence or absence of a face, they should have performed well in the buckets and hands-over-the-face conditions but not in the blindfold condition (because an equal amount of the face was visible)—which was exactly the pattern of results we obtained.

competitive situations with dominant rivals over two food items, in which one item was visible to both participants but the other was visible only to the subordinate (e.g., food placed behind an opaque barrier). These tests were designed to determine if the subordinate animals were capable of reasoning about which food items their dominant rival could and could not see. The most compelling of their tests involved positioning the chimpanzees directly across from each other in holding cages with a testing arena between them (see Figure 8.5). With the doors to the two holding cages closed, two food

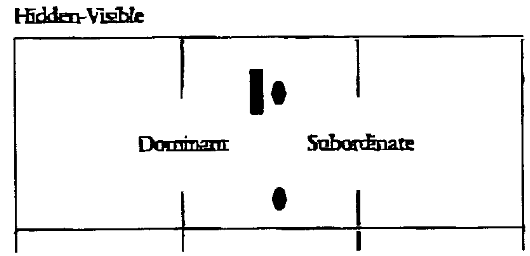

Figure 8.5 The hidden-visible condition used by Hare et al. (2000) to test subordinate chimpanzees for their understanding of what a dominant rival can or cannot see. (Redrawn from Hare et al., 2000)

items were placed on the floor of the testing arena an equal distance from both animals. One of the food items was in the open (and therefore would be visible to both the dominant and the subordinate animal when the doors were opened), whereas the other was behind an opaque barrier (so that the subordinate but not the dominant could see it). Next, the doors were opened slightly, allowing both animals to look into the enclosure. Finally, the subordinate was released and allowed to enter the testing arena. As soon as he or she took a couple of steps toward one of the food items, the dominant's door was opened as well. The logic of this procedure was that the subordinates would use their perspective-taking abilities to infer that the dominant did not see the food behind the barrier (and therefore did not know that it was there). Thus, according to Hare et al. (2000), they ought to prefer to take the hidden food.

Hare et al. (2000) reported that the subordinates tended to approach the hidden items first, and obtained more hidden items than visible ones by the end of each trial. Although both measures are of some interest, it should be noted that with respect to the question of visual perspective-taking, the crucial question is whether the subordinates approach the hidden item first, because only this finding supports the idea that they are reasoning about what their rival can or cannot see. After all, the subordinates might obtain more hidden items by the end of the trial simply because the dominant typically takes the visible one, leaving only the hidden one for the subordinate.

How are we to integrate these findings with our extensive previous work? Should all previous research be considered "overturned by an elegant experiment more intuitive for chimpanzees," as Whiten (2001, p. 133) has claimed?

Although there are a number of a priori concerns about the logic of the study, we were nonetheless prepared to reconsider the generality of our conclusions about what chimpanzees know about seeing. First, however, we concurred with Hare (2001) that "if an experiment is controlled well, a positive result (rejection of the null hypothesis) reflects the ability of the test subjects and should be replicable," and thus we sought to satisfy ourselves that the results could, in fact, be replicated. Second, we wanted to determine if they would hold up in some simple variations of the procedures that could tease apart the visual perspective-taking model from some rather obvious alternative interpretations.

So that our animals would have the same experiences as the ones used by Hare et al. (2000), Karin-D'Arcy and Povinelli (in review) initially attempted to replicate several studies they reported which they acknowledged were difficult to interpret. Interestingly, we completely replicated those effects. When the diagnostic "hidden-visible" tests (described above) were conducted, however, a very different pattern of results emerged. First, the end-of-the-trial effect was consistently replicated. That is, in a series of studies, our subordinates consistently obtained more of the hidden food than the visible food by the end of the trials. Recall, however, that this effect may simply be due to the fact that once the dominant is released and takes the food in the open, the only food left for the subordinate is the hidden one.

Strikingly, in each experiment, the first-choice effect was consistently not replicated. Despite several variations, there was no evidence that the subordinates were reliably selecting the hidden food first. Thus, the initial studies consistently found patterns of results that were inconsistent with the idea that the subordinates were reasoning about what the dominant could or could not see. Further studies revealed that even the subordinates who showed a marginal tendency to approach the hidden food first did not differentiate between identical occluders which were simply turned in ways that did and did not result in obscuring the dominant's view (Figure 8.6; see Karin-D'Arcy & Povinelli, in review, experiments 6–7). Indeed, in some cases our subordinates showed a statistically significant preference when the barrier was turned to the side so that the food was equally visible to both the dominant and subordinate!

In summary, the only reliable finding to emerge from the Hare et al. research is one which has no real bearing on the question of visual perspective-

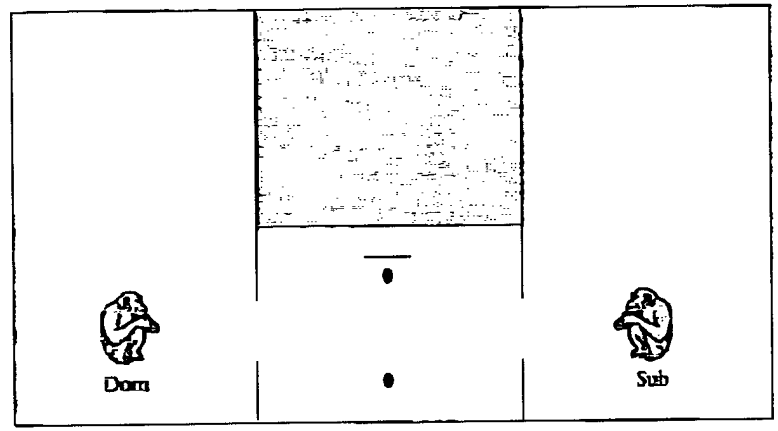

Figure 8.6 Modification of the Hare et al. (2000) design used by Karin-D'Arcy and Povinelli (under review) to determine whether subordinates' choices were due to reasoning about what the dominant could see or a preference for the food near the structure.

taking. Clearly, additional studies are needed to assess further the robustness of the effects reported by Hare et al. (2000).

"Pointing" out the Differences: How Chimpanzees and Children Understand Gestures

Our initial studies on chimpanzees' understanding of the visual perspectives of human experimenters relied on our apes' use of their natural begging gestures. But how, exactly, were our subjects representing these gestures?

Even if one were to accept uncritically the findings from our seeing/not seeing tests described earlier, one should still wonder if the robust use of directed begging gestures by our apes might reflect some understanding of the communicative intent behind them. In other words, they might deploy their gestures in a "proto-declarative" fashion, in which they are directed at the actual internal, representational states of the communicative partner, without any immediate, instrumental function (Bates et al., 1975; Camaioni, 1991). For instance, if Kevin and Mary are sitting by the lake, and Kevin suddenly taps Mary on the shoulder and then points behind her at a rare black swan swimming by, it would be because he wants her to share in the experience with him. His representation of her representation does not consist of the perceptual experience of seeing the black swan. Thus, the referent of the pointing gesture in this case is not, per se, the swan itself, but rather it subsumes and is "about" Kevin's entire communicative intent (i.e., "I want you to look at that, Mary"). In humans, the first pointing gestures emerge around nine to twelve months of age (Desrochers et al., 1995; Franco & Butterworth, 1996). But at this age there appear to be some dissociations between the production and comprehension of the pointing gesture (Baldwin, 1993; Franco & Butterworth, 1996). The infants may be deploying the gesture without truly understanding its referential significance, perhaps acquiring it through imitation or some form of ritualization (e.g., Tomasello, 1999). Thus, young infants (and, we hypothesized, perhaps other species) may understand and use pointing in a starkly "proto-imperative" fashion (*sensu* Bates et al., 1975), in which gestures are used to manipulate actors in the environment to perform certain activities in the external world. The complete absence of proto-declarative gesturing of any kind whatsoever among wild populations of chimpanzees that have been studied for over forty years is simply so striking and overwhelming that the ambiguity of the one published report of what might or might not be a single, isolated instance of pointing (see Vea & Sabater-Pi, 1998) to our minds simply further highlights the robust nature of this difference in the natural gestural systems of humans and chimpanzees.

But what about conditions in which chimpanzees interact frequently with humans and are exposed to their caregivers' pointing behaviors on a fairly regular basis? Might an understanding of the referential nature of the gesture emerge? Findings from various researchers, in fact, confirm the appearance of spontaneous "pointing" gestures in captive apes, and many researchers have interpreted these gestures as evidence of apes' understanding of the mental states of the humans with whom they are interacting (see Chapter 12; Gómez, 1998; Krause & Fouts, 1997; Leavens et al., 1996; Miles, 1990; Whiten, 2000b). In most of these cases, however, it is difficult to rule out the possibility that these gestures are proto-imperative in nature; indeed, this is difficult in the case of human infancy as well. This interpretive difficulty is underscored by one final point about chimpanzees' production of such "pointing" gestures: despite years of reliably using them in (mostly food- or grooming-related) situations with humans, to our knowledge they have never been reported to use them with one another. This raises the distinct possibility that they have no general understanding of their proto-declarative function, but only a limited understanding of how they affect the behavior of human beings (creatures that invariably respond as if the apes did mean them in some more mentalistic manner).

Because of the difficulty in disentangling proto-imperative and proto-declarative pointing (both conceptually and practically), in our own laboratory we have instead investigated what chimpanzees understand about the referential nature of the gestures of others. That is, when observing the intentional communicative attempts of other agents, do chimpanzees comprehend these attempts as such, or do they merely learn, over time, how these actions "tag" important aspects of the environment? We conducted a series of experiments with our seven chimpanzees that was explicitly designed to determine whether they understood the referential significance of the human pointing gestures which they had been exposed to since birth (see Povinelli et al., 1998). To begin, we simply trained our apes to pick a box to which an experimenter pointed. Over time, they learned that only the box to which the experimenter pointed contained food. For these initial training trials, the experimenter placed his or her hand a distance of 5 cm from the correct box (see Figure 8.7a). Interestingly, our apes did not appear to grasp the referential nature of the experimenter's actions from the start, initially choosing at random between the two boxes. Eventually, however, all seven of our animals succeeded in learning to select reliably the box to which the experimenter pointed.

But what, precisely, did this tell us about how the chimpanzees comprehended the gestures? One possibility was that even though they required some experience in the testing conditions, they did in fact come to understand the referential intent of the gesture, thus demonstrating an appreciation of the proto-declarative function of the experimenter's pointing gesture. Alternatively, perhaps the animals did not understand the referential function of the gestures, but instead had learned to exploit certain contingent relations associated with the experimenter's actions. That is, maybe the apes were employing some heuristic in the form of "Open the box closest to the experimenter's hand" (distance-based rule) or "Open the box + finger/hand configuration" (local-cue rule), thus obviating any need for representing the experimenter's actual communicative intent of conveying information.

To tease apart the subtleties inherent in these conflicting models, we devised several test conditions designed to identify which strategy would be used by both chimpanzees and two- to three-year-old children in retrieving rewards. In one study we merely moved the experimenter's hand so that instead of having it placed 5 cm from the correct container and 75 cm from the incorrect one (as it had been in the training and standard trials), it was now 120 cm from the correct container and 150 from the incorrect one in the probe trials (Figure 8.7b). If the subjects were relying on the local-cue rule, their performance should be crippled by this new configuration. Indeed, for five of the seven animals this proved true: the likelihood of these apes' choosing the box to which the experimenter pointed was at chance, despite the fact that on standard trials they continued having no difficulty. Two of the apes, Apollo and Kara, however, continued to make the correct choice on the majority of the new probe trials. Did this mean that Apollo and Kara, unlike their peers, understood the referential nature of the gestures? Recall that we had hypothesized that there were two heuristic strategies relying on readily observable spatiotemporal patterns that the apes could be employing: the distance-based rule and the local-cue rule. While we had demonstrated that five of the apes had in fact been using the local-cue heuristic, we could not be certain whether the remaining two animals were relying on the distance-based rule or the communicative intent model. Although the experimenter now sat away from the correct box, there was still a marked difference in the distance between his extended hand and the correct box and his extended hand and the incorrect box. Thus, Apollo and Kara might just have been better at judging which box was closer to the experimenter's hand—better at connecting the observable dots, as it were.

After we introduced additional configurations in which the experimenter's hand was closer to the incorrect container but referencing the correct container with the index finger (Figure 8.7c), and the tip of the index finger was equidistant between the two boxes but clearly referencing the correct container (Figure 8.7d), all of the animals (including Apollo and Kara) chose at random between the boxes. In direct and striking contrast, twenty-six-month-old human children were virtually at ceiling on even the most difficult of these conditions.

Similar experiments (which have carefully dissected the variables influencing apes' performance on object-choice tasks) involving intentional communi-

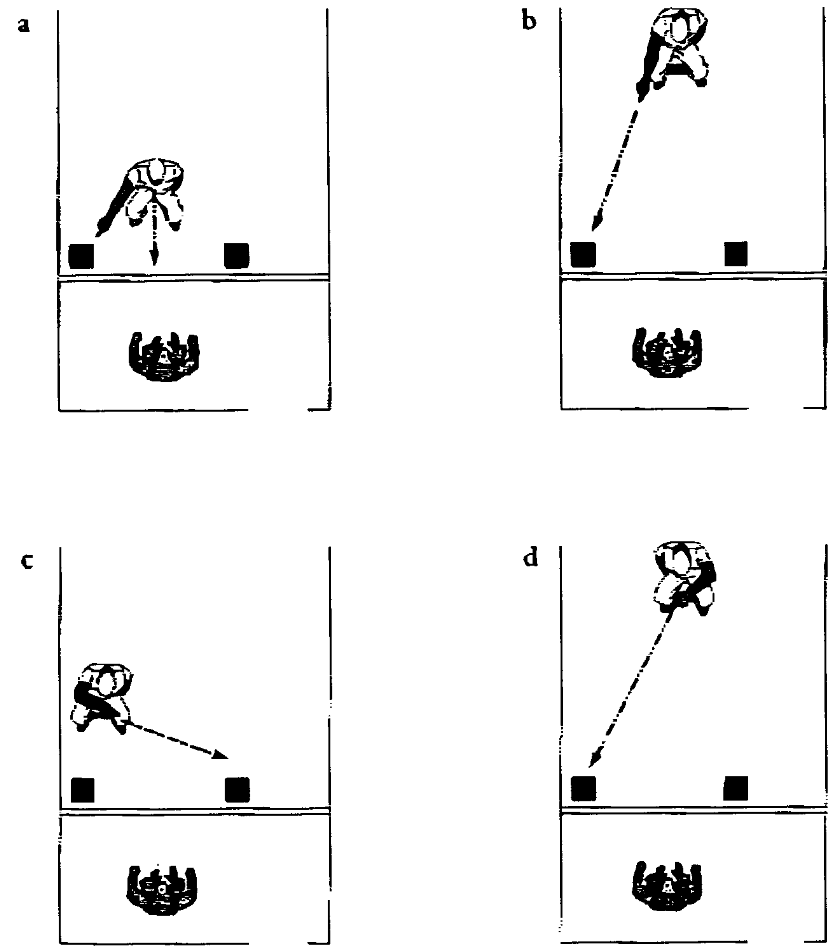

Figure 8.7 Conditions (a–d) used to test chimpanzees for the understanding of the communicative intent and referential significance of pointing gestures.

cation have found converging evidence of a lack of referential comprehension, regardless of the particular communicative device used. Povinelli and colleagues (1999) showed that chimpanzees do not appear to understand the intentionally communicative referential aspect of gaze (see also Call et al., 2000), while three-year-old children have no trouble understanding that an individual's gaze directed toward an external referent is "about" that object. And Tomasello, Call, and Gluckman (1997) reported that, while children two to three years of age were immediately able to infer novel signals (e.g., a marker placed on top of the correct box) as communicative symbols, their apes' performance was, at the beginning, dramatically unimpressive for the same conditions, only appearing to improve across trials as a result of the apes' using them as discriminative cues.

Comparative Investigations of the Attribution of Goals, Intentions, Knowledge, and Belief

In humans, the conception of others as animate, goal-directed agents emerges surprisingly early in development. Researchers have discovered that infants as young as nine months appear to appreciate, in some fashion of another, the goal-directed nature of human action, and even abstract computer animations engaging in sequential movement patterns (e.g., Gergely et al., 1995; Leslie, 1984; Phillips et al., 2002; Woodward, 1998; for review, see Flavell, 1999). Thus, early in life, infants appear sensitive to the goal-directed nature of action, an aspect of the human cognitive system that may be built into the way we perceive certain classes of object motion (e.g., Premack, 1990). Infants seem to treat other agents not merely as objects jetting about in haphazard ways but as beings with intentional states. While few researchers will claim that infants this age are necessarily explicitly representing goals and intentions as such, most conclude that at the very least the existing data demonstrate that infants are "on the right track" and are using precisely the right information from which later-developing, explicit understandings of goals and intentions will develop (e.g., Wellman & Phillips, 2001; Woodward et al., 2001). Additional evidence of such competence can be found in infants' ability to parse the behavior stream at its intentional joints (Baldwin & Baird, 1999). At around eighteen months of age, children appear able to appreciate that others have wants and desires that are different from one's own (e.g., Repacholi & Gopnik, 1997). Later, during the preschool years, the notion of belief emerges (e.g., see review and meta-analysis by Wellman et al., 2001).

Hauser (1998b), and to a lesser extent Tomasello and Call (1997), have proposed that other primate species may understand agents in a somewhat more primitive manner, reasoning that, at a very basic level at least, other species clearly segregate the animate from the inanimate world on the basis of superficial properties such as self-propelledness and irregular movement (see Premack, 1990). Hauser (1998b) found support for this in a modified "looking time" paradigm, in which tamarins were observed to spend more time looking at an inanimate object (e.g., cereal) that moved between two box chambers than they did at an animate one (e.g., live mouse). According to Hauser, this demonstrated that the monkeys were "surprised" by this breach of agency laws. Of course, this tells us little about how the animals were reasoning about the mediating cognitive forces generating the behavior of the inanimate objects, only that it violated some set of expectations they possessed about the things they observed.

What about chimpanzees' and other nonhuman primates' understanding of intentions? Some researchers have attempted to use imitation to determine whether chimpanzees, for instance, reason about the intentions underlying behavior (e.g., Adams-Curtis & Fragaszy, 1995; Bjorklund et al., 2002; Call & Tomasello, 1994, 1996; Myowa & Matsuzawa, 2000; Nagell et al., 1993; Tomasello, Savage-Rumbaugh, & Kruger, 1993; Visalberghi & Fragaszy, 1990; Whiten et al., 1996). Although the conceptual issues are notoriously slippery, Tomasello (1990, 1996) has argued that in order for an organism to engage in true imitation, it must take the perspective and represent the intentions of the model from whom it learns how to perform an action (for critical considerations of the animal imitation literature, see Galef, 1992; also Whiten & Ham, 1992; Zentall, 1996). That is, the organism must demonstrate that it understands what the model is trying to do, not simply that the model is doing something to achieve some goal. Alternatively, an organism can be said to engage in emulation whenever the means for achieving a goal are essentially ignored and the organism only reproduces, through a different set of actions (perhaps through trial and error), the same end state. Emulation is envisioned as occurring through a form of stimulus enhancement in which the model's achieving some goal (e.g., getting termites from under a log) captures the attention of the observer and brings the observer to discover the same goal on its own, using different behavioral means to get there (e.g., rolling a log instead of poking through it). Unfortunately, the distinction between true imitation and emulation is sharper in theory than in practice, and has itself been the subject of considerable disagreement.

Nonetheless, the emulation-imitation distinction has led to experiments that have been somewhat effective in pulling apart these forms of social learning, and which have produced findings converging on the conclusion that nonhuman primates do not view others as mental agents. When properly controlled to rule out lower-level processes of social learning, no monkey species has been found either to imitate or emulate (Adams-Curtis & Fragaszy, 1995; Galef, 1992; Visalberghi & Fragaszy, 1990; for review, see Whiten & Ham, 1992), and while chimpanzees may be proficient emulators (see Toma- sello, 1996), and may actually be more efficient (at times) in their social learning than human children, they appear mostly to ignore the behavioral mechanisms used to get there. According to Tomasello, they ignore the under- lying reason these behaviors are performed, precisely because they do not rea- son about intentions per se. The best evidence of imitation in apes comes from several human-reared subjects (e.g., Bering et al., 2000; Tomasello, Kruger, et al., 1993), a topic we shall discuss shortly.

Myowa and Matsuzawa (2000) used a procedure originally designed for human infants (e.g., Meltzoff, 1995) in an attempt to show that chimpanzees could infer the intentions of a human model when observing actors un- successfully attempting goal-directed tasks (e.g., removing a lid from a tube). Eighteen-month-old human infants successfully accomplished the goal, thus demonstrating that they could read through the surface behavior (the literal, unsuccessful act) down to the intended (undemonstrated) act. Although Myowa and Matsuzawa (2000) report preliminary evidence of this form of intentionality attribution in their chimpanzees, the majority of the apes' "suc- cessful" attempts occurred at baseline (before witnessing the demonstrations), precluding any definitive statements on what the animals actually learned by watching the model.

In another study, Bjorklund et al. (2002) exposed their group of three human-reared chimpanzees to a series of generalization of deferred imitation tasks, which included four phases. In phase 1, the chimpanzees were given two sets of objects (e.g., a pair of cymbals and a pair of trowels) and were permit- ted six minutes with the objects to determine if they would spontaneously exhibit the target behavior associated with either set of objects. In phase 2, the animals were shown six demonstrations of the target actions with one of the sets of objects from the baseline (e.g., clanging the cymbals together by hold- ing the outside knobs). A ten-minute delay followed the demonstration. In phase 3, the animals were given either the set of objects witnessed in the demonstration (standard deferred imitation) or the other set of objects from baseline not demonstrated in the previous phase (generalized deferred imita- tion). Finally, in phase 4, the set of objects not used in phase 3 was given to the subject. Bjorklund et al. (2002) argued that successful generalization of de-

ferred imitation (e.g., clanging the trowels together by holding the outside wooden handles) required the apes to represent the actual purpose, or goal, of the model's actions in the demonstration phase, because instead of simply reproducing the actions on an identical task, the animals were asked to trans- late what they had learned to an entirely different set of materials that could be used to generate a similar outcome. All three chimpanzees displayed evi- dence of this kind of generalized deferred imitation. Interpreting these results is difficult, however, because no control was established for the perceptual sim- ilarity of the objects used; the apes may only have been mapping what they had witnessed with the objects from the demonstration phase onto the new set of objects—objects that bore the same general affordances of the origi- nal set.

Unfortunately, the exact relationship between social learning (e.g., imita- tion) and an understanding of intentions and goals remains elusive. Some authors (e.g., Bjorklund et al., 2002; Tomasello, 1999) continue to argue that evidence of true imitation, in which actions are reproduced with fairly high degrees of fidelity, is symptomatic of the ability to represent explicitly the intentions and goals of others' mental state attributions, whereas others (e.g., Heyes & Ray, 2000) maintain that imitation has no bearing on the question of mental state attribution whatsoever. Heyes (1998), for instance, has noted that the best evidence for nonhuman animal imitation comes not from primate species but rather from rats and budgerigars—species that very few researchers have claimed possess a theory of mind. In short, it is not at all apparent to us that the ability to reproduce another agent's actions, at any level of precision, necessarily hinges on an ability to represent intentions explicitly. This is not to say, however, that organisms with the capacity to reason about intentions (e.g., humans) will not use this ability during some of their attempts to imitate the behavior of others; indeed, in species with a theory of mind, such attributions should occur regularly.

Other studies, not involving imitation, which have attempted to assess chimpanzees' ability to attribute intentions, beliefs, and knowledge have over- whelmingly found support for the hypothesis that chimpanzees do not repre- sent the mental states of others. While space prevents us from providing accurate descriptions of all of these, some of the more relevant findings in- clude the following: chimpanzees do not appear to distinguish between acci- dental and intentional actions (Povinelli et al., 1997; but see Call & Tomasello, 1998), do not instruct ignorant others how to perform novel cooperative tasks

(Povinelli & O'Neill, 2000), and fail to differentiate between a knowledgeable and a naïve experimenter (Call et al., 2000; Call & Tomasello, 1999).

Physical Causality

It is important to touch at least briefly on a related project with our chimpanzees which was designed to map their understanding of unobservable forces in the physical world (see Povinelli, 2000). The initial round of nearly thirty studies, conducted over a five-year period, was centered on the widely celebrated ability of chimpanzees to make and use simple tools. Inspired largely by some work by Elisabetta Visalberghi and her colleagues, we asked not whether chimpanzees could learn to make and use tools, nor even the level of complexity that such tool use and construction might achieve, but whether they reason about more than the mere appearances of the objects as they make and use simple tools (e.g., Limongelli et al., 1995; Visalberghi et al., 1995; Visalberghi & Limongelli, 1994; Visalberghi & Trinca, 1989). Of specific interest to us was whether chimpanzees delve into the unobservable causal structure of the objects and events they observe, and whether their understanding of the physical world is mediated by concepts about unobservable phenomena such as gravity, force, shape, physical connection, and mass—an understanding that seems robustly in place by about three years of age in human children, if not earlier (for a review, see Povinelli, 2000).

The results of these studies consistently converged on a finding strikingly analogous to what we have uncovered about chimpanzees' understanding of the social world: they are excellent at extracting from the statistical regularities about what objects do and how they behave, but appear to have little or no understanding that these observable regularities can be accounted for, or explained, in terms of unobservable causal forces. Indeed, we have speculated that for every unobservable causal concept that humans may form, the chimpanzee will rely exclusively on an analogous concept, constructed from the perceptual invariants that are readily detectable by the sensory systems (see Table 8.1). Of course, humans will rely on these same spatiotemporal regularities much of the time as well, perhaps relying on systems that are homologs of those found in chimpanzees and other primates. But unlike apes, humans, we have speculated, evolved the capacity to form additional, far more abstract concepts that posit unobservable phenomena to explain observable

Table 8.1 Examples of perceptual invariant analogs of causal concepts

Causal concept	Perceptual invariant analog
Gravity	Downward trajectories
Transfer of force	Motion/contact movement sequences
Strength	Propensity for deformation
Shape	Perceptual form
Physical connection	Degree of contact
Weight	Muscle/tendon stretch sensations

events. Indeed, we have begun to explore whether this difference between human and apes can be described more simply in terms of the widely celebrated human capacity for explanation (e.g., see contributions to Keil & Wilson, 2000)—a capacity that may be lacking in chimpanzees (see Povinelli & Dunphy-Lelii, 2001).

Thus, we have speculated that a core difference between humans and chimpanzees may be that humans have evolved a unique capacity to develop representations about unobservable causes—a difference that manifests itself equally in the two species' understanding of the social and physical worlds.

The Immersion of Apes in Human Culture

The conclusions that we have drawn above primarily concern captive chimpanzees raised by their mothers or in nursery-peer groups with human caretakers. But what about chimpanzees raised with human beings and immersed in human culture? One possibility is that although chimpanzees do not normally develop the ability to reason about unobservable causal forces in either the social or physical domains, they do have the innate capacity to develop such abilities if they receive more of the experiences that human children receive. The idea that such intimate contact with human culture might bootstrap the development of certain cognitive structures that do not normally develop in apes is an old one (e.g., Hayes, 1951; Kellogg & Kellogg, 1933), and one that was played out more recently in the context of attempts to teach home-raised chimpanzees and other great apes certain language systems (Gardner & Gardner, 1971; Miles, 1994; Patterson & Linden, 1981; Premack, 1976; Savage-Rumbaugh & Lewin, 1994; Terrace, 1979). More recently, a considerable amount of speculation has been devoted to whether human rearing reorganizes the cognitive systems of apes, causing them to develop or elabo-rate on core systems that they do not normally develop or express strongly (e.g., Bjorklund & Pellegrini, 2002; Call & Tomasello, 1996; Donald, 2000; Tomasello, Kruger, & Ratner, 1993). Aspects of this debate pivot on the issue of how these systems normally develop in humans (see Povinelli, 2000; Chapter 12). To be sure, apes raised in human homes have exhibited more human-like performance in a variety of relevant areas, including imitation (Hayes & Hayes, 1952; Russon & Galdikas, 1993), deferred imitation (Bering et al., 2000; Bjorklund et al., 2002; Tomasello, Savage-Rumbaugh, et al., 1993), joint attention (Carpenter et al., 1995; Gómez, 1990), referential comprehension (Call & Tomasello, 1994), knowledge attribution (Call et al., 2000), and even pretense (Gardner & Gardner, 1971; Hayes, 1951, Temerlin, 1975; but see Bering, 2001). Whether we should conclude, as has Donald (2000), that "this demonstrates convincingly that the enculturation process can successfully uncover and exploit cognitive potential that had remained untapped for millions of years" (p. 29) is another matter entirely.

At present the scattered nature of the findings with apes raised in human homes prevents us from commenting intelligently on the subject. That some differences exist between home-raised versus other apes should not be surpris-ing. At the very least, chimpanzees will bring their extraordinary intellectual resources to bear on the human culture in which they are immersed. But are these changes superficial, or do they reflect deeper changes in their core cogni-tive systems? This is a question that simply cannot be answered by the current strategies of post hoc retrodiction of experimental results (e.g., Call et al., 2000; Gómez, 1996), assessments with apes raised in human homes (e.g., Bering et al., 2000), or comparisons of such apes to other animals who do not have the requisite background familiarity with comparable testing situations (e.g., Tomasello, Kruger, et al., 1993). In this context, it is worth pointing out that there has never been a systematic test of the enculturation hypothesis; namely, no one has ever reared an appropriate number of apes in different ways and then experimentally assessed the effects of this experience on their cognitive development. In brief, a project of daunting scope would be needed. Perhaps a minimum of six to eight chimpanzees would need to be raised in human home settings for the first four years or so of their lives, with adequate safeguards in place to ensure that they were indeed brought into maximum contact with human social and material culture. Further, a control group of the same number of animals reared primarily with other chimpanzees would be needed to assess the effects of this massive enrichment intervention. We recognize that such a project would be extraordinarily costly and time-consuming—perhaps impossibly so—but if it were conducted properly, such an undertaking might stand as one of the most important achievements in the history of humanity's attempt to define its very nature.

An Evolved Conclusion: Getting Used to Psychological Diversity

In recent years, several researchers have advocated abandoning the global question of whether chimpanzees have a "theory of mind" as too broad to be useful (e.g., Povinelli & Eddy, 1996a; Tomasello & Call, 1997; Whiten, 2000b; see Chapter 9). The nature of the question that will replace it is not yet univer-sally agreed on, however. Given the difficulty they have with tests of their understanding of complex epistemic states such as knowledge and belief, it seems undeniably reasonable to ask whether chimpanzees possess a better understanding of other, perhaps "less complex" mental states such as inten-tions, perceptions, goals, and desires (see Povinelli & Eddy, 1996a; Chapter 9), or whether the ability can be elicited only in certain kinds of situations (e.g., competitive ones: Hare et al., 2000).

We have in addition, however, pursued a third possibility, a possibility which, in the interests of fairness to the chimpanzees and other nonhuman species, sets aside the recapitulationist undercurrents inherent in the idea that there is some monolithic vector of cognitive development along which humans and apes and other species can be universally compared (for fuller descriptions of this approach, see Povinelli, 2001; Povinelli et al., 2000; Povinelli & Giambrone, 1999; Povinelli & Prince, 1998). In the face of parallel sets of converging experimental findings, we have come to give serious consid-eration to the possibility that humans may possess unique, specialized capaci-ties when it comes to representing mental states and other unobservable phenomena, and that these systems appear early in development, entangling themselves into ancestral systems we share in common with other systems. In

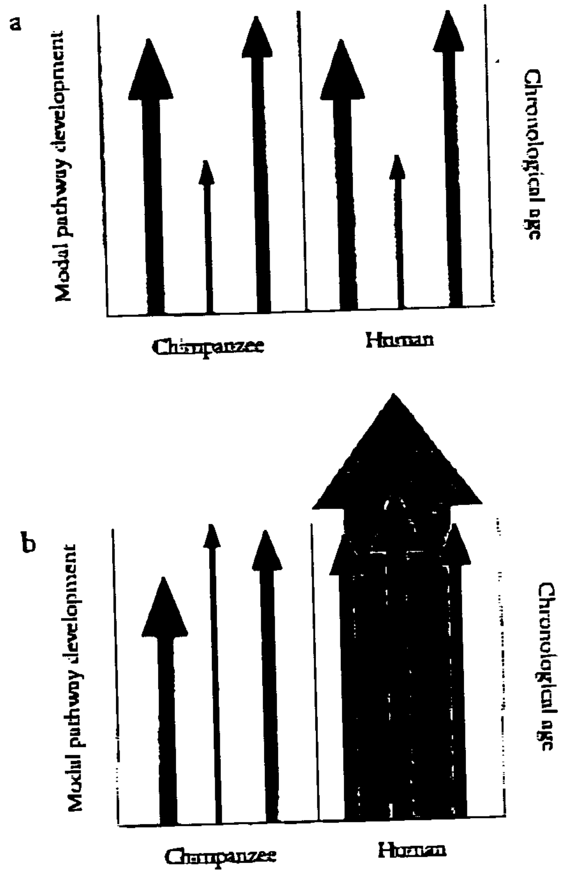

Figure 8.8 A more sensible question than the one asked in Figure 8.1 is: "How, at every stage of development, are chimpanzees and humans both similar and different?" In the example here, both humans and chimpanzees have added new systems to their development pathways (represented in "b" by novel arrows not present in "a") and expanded or contracted the functions of systems present in the common ancestor (represented by changes in the thickness of the arrows from "a" to "b"). We graphically represent the possibility that humans have woven in a new system or systems (represented by the large shaded arrow) that operates in parallel to ancestral systems, allowing for use of the older systems as input into new conceptual systems which "reinterpret" ancient behaviors in new ways.

humans, the very same action pattern—for example, following someone's gaze—may often be prompted by the mere detection of observable regularities (e.g., Driver et al., 1999; Kingstone et al., 2000; Langton & Bruce, 1999), whereas at other times it is prompted by a specialized system dedicated to representing why an event occurred in terms of unobservable variables (e.g., Adam wants me to think there's a bear behind me, so I'm going to play along)—especially when an event deviates from some canonical routine (Bruner, 1990). If true, the uniquely human system for representing unobservable causal states is parasitic on other, ancestral psychological systems that we share in common with our closest living primate relatives, and it imbues the ancestral representations of particular behaviors with psychological and causal content. For this reason, we have labeled it the "reinterpretation" hypothesis (see Povinelli et al., 2000).

By now, the incoherence of the question we graphically presented at the outset of this chapter (see Figure 8.1)—"What is the intellectual age of an adult chimpanzee in human terms?"—should be obvious. If the reinterpretation hypothesis is correct, then it is possible that there is simply no age at which humans and chimpanzees share a completely overlapping set of cognitive developmental pathways (see Figure 8.8). From birth forward the two species will share a suite of homologous systems, but also from birth forward specialized systems in the human species (and perhaps in the chimpanzee as well) will reside alongside these systems, and interact and influence them in ways that are complex and difficult to identify (see Povinelli & Giambrone, 1999). Thus, if something like the reinterpretation hypothesis turns out to have substantial merit, then the quest to find the "rudiments," the "simpler forms," the "less complex aspects" of an ability to reason about mental states in chimpanzees and other species may be nothing short of a fool's quest—one driven by the very faculty we sought to understand in the first place.

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