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On the Possibilities of Detecting Intentions Prior to Understanding Them

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Most authors in this volume are united in the opinion that the ability to conceive of intentions is a fundamental and universal aspect of how our species thinks about the social world. The question of how and when human infants and children develop this ability, however, inspires a good deal less harmony.

What scientific techniques can be brought to bear on this question? There are many, of course, but perhaps the most interesting—and most controversial—involves use of visual habituation-dishabituation procedures and related techniques. In such research, infants are allowed to repeatedly observe a stimulus that embodies some conceptual principle (e.g., that unsupported objects fall) until their visual attention to the stimulus wanes. Generally, it is assumed that this decline in visual attention signals infant's habituation to both their own visual experience of the stimulus and whatever conceptual interpretation of the stimulus they may possess. Once habituated (as measured by their viewing time), the infants are typically divided into an experimental group and a control group. These groups observe slightly different stimuli. The experimental group is typically presented with a stimulus that violates the conceptual principle embodied in the original stimulus but, significantly, is designed to be visually quite similar to the original stimulus. The control group is presented with a stimulus that is perceptually different from the original stimulus but which embodies the same conceptual principle. If the experimental group exhibits a greater rebound in visual attention than the control group, many researchers feel comfortable arguing that the infants are sensitive to the particular concept instantiated by the original stimulus. Although the general reasoning behind such procedures (offering pre-linguistic infants the opportunity to express what they know through their nonverbal behavior) is clear, in practice these techniques have elicited considerable controversy—see, for example, the debate between Haith (1998) and Spelke (1998).

In this chapter, I address the controversy over how to interpret the results of such research as it applies to the development of intentional understanding. (In this volume, see the chapter by Baird and Baldwin, that by Wellman and Phillips, and that by Woodward, Sommerville, and Guajardo.) In particular, I explore the possible ways in which the kinds of knowledge or "sensitivities" revealed through visual habituation-dishabituation procedures (and related techniques) can be interpreted. To begin, I identify three distinct possibilities for any given dishabituation effect:

- The visual dishabituation effect may be evidence that infants possess second-order mental states (i.e., that they reason about intentions).

- Although the dishabituation effect is not unequivocal evidence that infants reason about intentions, it is good evidence that infants have begun the process of constructing the system that will ultimately be capable of reasoning about intentions. (There are several ways in which these early abilities could be causal precursors to the ability to explicitly reason about intentions, and I shall flesh these out later in the chapter.)

- The dishabituation effect may be evidence that infants possess a system for detecting the intentional structure of action, but this system may be separate (both developmentally and evolutionarily) from a later-developing system for understanding of intention as a mental state.[1] These early dishabituation effects may reflect the operation of ancient, low-level mechanisms that evolved separately from a psychological system, unique to humans, that interprets the structure of behavior in mentalistic terms.

In the remainder of the chapter, I present my reasons for believing that the third possibility must be taken just as seriously as the first and the second. I begin by briefly describing a theory that my colleagues and I have developed concerning the evolution of second-order mental states (Povinelli and Prince 1998; Povinelli and Giambrone 1999; Povinelli, Bering, and Giambrone 2000). This theory argues that long before the ability to sustain second-order mental states evolved, the sensory and brain systems of many species evolved the ability to detect and process the statistical regularities of the behaviors of others. In other words, psychological mechanisms unrelated to reasoning about intentions may have evolved to detect the same kinds of regularities in behavior that adult human folk psychology now explains in terms of intentions. Our theory directly establishes credibility for the alternative described above in that it raises the specter that the abilities revealed by habituation-dishabituation studies in human infants and in nonhuman primates may not play a direct causal role in fostering the development or evolution of the psychological system that reasons about intentions (or any other mental states, for that matter).[2]

Although the purpose of this chapter is to grapple with the development of human intentional understanding, I begin (for reasons that will become obvious) by considering a different question: whether other species develop such an understanding.

Do Other Species Reason about Intentions?

Because they are our nearest relatives, chimpanzees may be the species most likely to share with us an explicit understanding of intention. Indeed, Premack and Woodruff (1978) argued that chimpanzees are capable of reasoning about the intentions of others. In their study, an adult female chimpanzee observed videotaped sequences of a human struggling to solve a staged problem. She was then presented with photographs, some of which depicted the solution to the problem and others of which were distracters. Premack and Woodruff argued that the chimpanzee's ability to select the photograph that depicted the solution to problem demonstrated that she was capable of inferring the intention of the actor from the sequence of video images, and thus she understood that only one of the test options represented the fulfillment of the actor's intentions. They concluded that chimpanzees possess the ability to reason about the unobservable mental states of others—an ability they dubbed a *theory of mind*. "A system of inferences of this kind," they observed (ibid., p. 515), "may be properly 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."

In the late 1980s, inspired by this and by related work concerning the ability of many great apes (but not other nonhuman primates) to recognize themselves in mirrors (Gallup 1970, 1982), my colleagues and I designed a series of comparative experimental studies to explore whether chimpanzees were somehow special among nonhuman primates with respect to the ability to reason about mental states.[3] Rather than providing strong support for a difference between great apes and other nonhuman primates, a critical analysis of these and other results led many researchers to question whether even chimpanzees are capable of reasoning about mental states (Povinelli 1993, 1994; Tomasello, Kruger, and Ratner 1993; Heyes 1993). However, much of this early work had been designed to probe for the existence of quite advanced second-order mental states—at least from the perspective of human development. For example, several of our early studies explored the ability of chimpanzees and other nonhuman primates to reason about the knowledge states of others.[4] Thus, it stood to reason that chimpanzees and other nonhuman primates might exhibit stronger evidence for understanding mental states if we were to question them about their ability to reason about the perceptions, desires, or intentions of others.

In 1991, to address these and other problems, my colleagues and I launched a long-term project to follow the cognitive development of seven 2–3-year-old chimpanzees. We have conducted dozens of experiments in an effort to explore what, if anything, these chimpanzees know about the mental states of others.[5] Some of the questions we have addressed relate quite directly to whether chimpanzees understand that others possess intentions and goals, whereas other studies have focused on their ability to reason about the attentional, belief, and perceptual states of others, as well as of themselves.[6] The combined results of this research have led us to conclude that, although chimpanzees are quite sophisticated at reasoning about the behavior of others, they do not conceptualize this behavior within a framework of folk psychology. In short, chimpanzees seem to reason about the behavior, not the mental states, of others.

Let me be bit more clear about the distinction between thinking about behavior and thinking about mental states. Consider some rather extensive research we have conducted on the question of what chimpanzees know about seeing. We began by asking a very simple question: Do chimpanzees appreciate that others see? This seemed like an excellent place to begin because it appeared intuitively obvious from their spontaneous behavior that they must have a pretty solid grasp on the fact that both they and their fellow chimpanzees can see things.

If you ever have a chance to spend an hour or two playing with a group of young chimpanzees, you will notice right away that they seek to make eye contact with you at crucial junctures in their play routines—apparently checking to make sure that you have seen their latest move or gesture. Or, if you happen to find yourself enjoying a cool soda on a summer afternoon in New Iberia, Louisiana, it is very likely that you will spy a chimpanzee reaching out a hand in your direction, palm up, looking into your eyes. These are communicative acts that chimpanzees exhibit no matter where you encounter them, and their meaning seems at once familiar and obvious. For example, the chimpanzee looks up into your eyes after gesturing at your soda, is obviously doing so in order to be sure that you have seen him. Likewise, the chimpanzee who takes a toy bucket, covers her head, and frolics around her enclosure until she bumps into something must surely know something about seeing—and about *not* seeing.

Another behavior that chimpanzees naturally exhibit similarly tempts the interpretation that they know something about seeing: They follow each other's gaze. If you make eye contact with a chimpanzee, and then look behind him, he will immediately turn and glance in the same direction. Since our first controlled experimental demonstration of this fact (Povinelli and Eddy 1996a, experiment 14), this finding has been replicated and extended on a number of different occasions, and certain aspects of the ability have been extended to other primate species (Itakura 1996; Povinelli and Eddy 1996b, 1997; Povinelli, Bierschwale, and Cech 1999; Tomasello, Call, and Hare 1998; Call, Hare, and Tomasello 1998; Emery, Lorincz, Perret, Oran, and Baker 1997). Indeed, the sophistication of gaze following in chimpanzees appears comparable to the abilities found in 18–24-month-old human infants (table 1). In any event, when a chimpanzee turns to look where you are looking, and then looks back into your eyes, it is difficult to avoid thinking that he is trying to figure out what you are looking at.

On the basis of such observations, there was a time when I felt sure that chimpanzees must understand that other beings have visual experiences. But could this issue be addressed more rigorously? Let me begin with the first idea that occurred to us. We reasoned that if we offered our chimpanzees

Table 1
Evidence that humans and chimpanzees possess a homologous psychological system controlling gaze-following. Sources: Povinelli and Eddy 1996a, 1996b, 1997; Povinelli et al. 1999; Tomasello et al. 1998; Call et al. 1998.

	18–24-month-old human infants	Juvenile and adult chimpanzees
Respond to whole head movement	Yes	Yes
Respond to eye movement alone	Yes	Yes
Left/right specificity	Yes	Yes
Follow gaze outside immediate visual field	Yes	Yes
Scan past distracter targets	Yes	Yes
Account for opaque barriers	?	Yes

the opportunity to use their natural begging gestures to request food from one familiar caretaker at a time, and then at a later stage gave them the option of choosing between two caretakers, one of whom could seem them and one of whom could not, then surely they would gesture to the caretaker who could see them. Figure 1 shows the general setting of the test; figure 2 shows several of the initial "seeing" and "not seeing" conditions we came up with to test our simple prediction. In fact, we were so confident that our apes would gesture to the caretaker who could see them that we began to think up additional questions that we could ask them about seeing. As it turned out, we had gotten ahead of ourselves. Something far more interesting occurred in the interim: Despite our interpretation of their spontaneous behavior, our apes seemed to insist that they did not grasp that one caretaker could see them whereas the other could not.

Elsewhere, my colleagues and I have published detailed reviews of the procedures and results of these studies (Povinelli 1999; Povinelli and Giambrone 1999). In brief, this research consistently revealed that our apes did not appear to possess an understanding of seeing. In virtually every case, they were initially just as likely to gesture to the caretaker who could see them as to the caretaker who could not. We did not simply test our apes on each of these conditions and accept the results at face value—mainly because we had such a difficult time believing, for example, that our apes did not realize that a blindfolded person could not see them. As a consequence, we designed and

Figure 1
Mindy approaches Roxanne and uses her species-typical begging gesture to request a food reward.

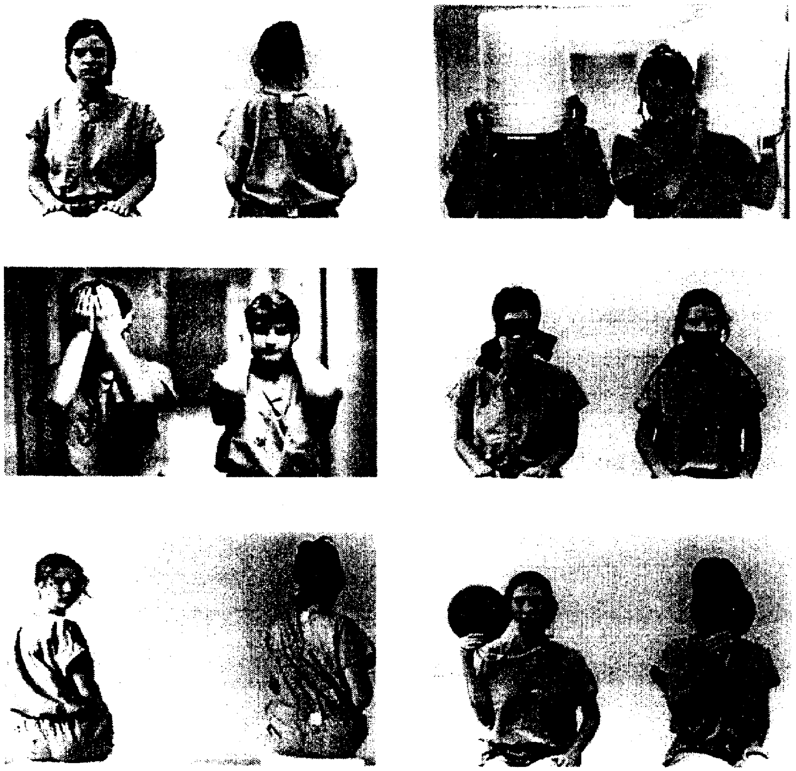

Figure 2
Conditions used to determine if chimpanzees would selectively gesture to the person who could see them.

conducted more than 20 experiments using variations of this procedure, offering our apes every opportunity to show us that our initial results were mistaken. We even went as far as conducting longitudinal assessments of their understanding of this kind of situation as they matured from juveniles to adolescents and finally to full adults (Reaux, Theall, and Povinelli 1999). However, the results continued to suggest that our apes did not appreciate that only one of these caretakers could see them.

It is not that our apes were unable to *learn* in these situations. After enough experiences of gesturing to someone with a bucket over her head and then not being handed a banana, our apes learned to select the other option. Did this mean that they were learning something about 'seeing'

per se? Quite to the contrary. Our results suggested that the apes were not focusing on the *psychological* attributes of the two individuals ("Gesture to the human who can see me"), but rather that they had learned rules related to the *physical postures* of the persons involved (i.e., "Gesture to the person who is facing me" or "Gesture to the person whose face is visible"). Even as full adults, our chimpanzees appeared to be relying on these kinds of procedural rules, even in situations that they had experienced on dozens of previous occasions. (See especially Reaux, Theall, and Povinelli 1999, experiment 4.)

Of course, one's conclusions should never rest on a single experimental procedure, no matter how extensively it is elaborated. Recognizing this, we developed several other techniques for asking our apes about seeing. (See, e.g., Povinelli, Bierschwale, and Cech 1999; Theall and Povinelli 1999.) However, these studies too supported the idea that our chimpanzees failed to grasp that others see. Furthermore, other aspects of our research suggest an even broader conclusion: Chimpanzees may not reason about mental states at all. To date, we have asked our apes about their understanding of pointing, the distinction between accidental and intentional actions, their understanding of cooperation, and their understanding of the referential aspect of emotional outbursts. Consistently, the results have supported the idea that, although chimpanzees are adept at learning about the behavior of others, and about its relationship to the world, they do not think (as we do) that behavior is prompted by unobservable mental states or processes. Research by Michael Tomasello and his colleagues has suggested a similar conclusion (Tomasello, Call, and Gluckman 1997; Call, and Tomasello 1999; Nagell, Olguin, and Tomasello 1993). To put it simply, we have concluded that, although chimpanzees (and many other animals) are experts at understanding behavioral propensities, they do not appear to reason about mental states.[7]

The Reinterpretation Hypothesis

Many researchers have found our experimental results difficult to believe. For one thing, they fly in the face of common sense. One common reaction goes something like this: "But chimpanzees *must* have a theory of mind. After all, it would be very useful. Anyhow, in view of what you say they do naturally, how could they not have one?" I understand this reaction; before undertaking the bulk of the studies to which I have just alluded, my experiences with chimpanzees had convinced me that this was an animal that understood more about me than just my behavior—an animal that was in contact with my mind Thus, for a while I experienced an uncomfortable tension between the extensive set of experimental results that we (and others) were obtaining and what my common sense was telling me. It was not possible to simply shrug off the similarities between our chimpanzees' behavior and my own as the results of dumb learning or mindless imitation on their part. No, the detailed patterns of behavioral similarities implied deep, psychological similarities as well. And because I believed that I could identify the psychological states that caused the behaviors in me, it was difficult to deny that the same psychological states were not also at work in chimpanzees. Indeed, from the British philosopher David Hume to the founder of modern biology, Charles Darwin, there was a long and distinguished history of using this approach to infer the likely mental states of animals. Hume (1739) had even once quipped that only the "most stupid and ignorant" of individuals could attempt to deny this "evident truth."

Gradually, however, this tension was released as I began to see the behavioral similarities between chimpanzees and humans in a different light. Soon the following idea took shape: What if the ability to reason about mental states was not only a unique specialization of the human species but one whose initial function was to give us the ability to understand ancient behaviors in novel ways—not one that endowed our species with a whole set of novel behaviors? In short, what if human evolution had been characterized by the emergence of a qualitatively new psychological system for reasoning about mental states—one that was initially selected for because it increased flexibility in the planning and execution of useful, but already-existing, ancient behavioral abilities? If so, then the initial advantage of having a theory of mind was not the generation of a large set of fundamentally new behaviors but the ability to put old behavioral patterns to slightly new uses. The significance of this framework is that it leads one to *expect* chimpanzees and humans to share numerous, nearly identical behavioral patterns, and yet to interpret them in different ways (chimpanzees reasoning strictly about the behavioral propensities of others, and humans reasoning about both behavioral propensities and underlying mental states). Because

this idea envisioned that humans had evolved a cognitive specialization that allowed the species to interpret existing behaviors in new ways, we labeled it the *reinterpretation hypothesis* (Povinelli 1996; Povinelli and Prince 1998; Povinelli 1999; Povinelli and Giambrone 1999).

Implications for Chimpanzee Cognition

The reinterpretation hypothesis has at least two broad implications, one for chimpanzees and the other for humans. For chimpanzees (and many other species), it implies that when we see them engage in gaze following, deception, or other social behaviors that look remarkably like our own, we should resist the reflexive urge to assume that psychological states like the ones that would be present in us are likewise present in them. Indeed, the reinterpretation hypothesis leads us to expect that the spontaneous behavioral patterns of humans and chimpanzees will structurally resemble each other, precisely because, in an evolutionary sense, they are the same behaviors. Thus, the model leads us to expect humans and chimpanzees to differ in the high-level psychological systems that interpret the behaviors, not in the low-level systems that produce and respond to them.

An example concerning the attention-getting behaviors of humans and chimpanzees may help to clarify this point: Chimpanzees know how to get your attention. For example, if you are passing out juice to chimpanzees, the ones who are waiting will tug on your shirt, tap on the mesh fence, slap the floor, or even make distinctive vocalizations. Chimpanzees display these attention-getting behaviors in much the same way that children do—indeed, many visitors to our chimpanzee colony remark that these actions remind them of the behavior of their 2-year-olds (or even their teenagers). But what about the psychological states underpinning these behaviors? Are the apes reasoning strictly about your behavior ("Hurry up and give me some juice!"), or are they reasoning about both your behavior and your internal attentional state ("Look at me! Now, hurry up and give me some juice!")?

Despite the structural similarity between these kinds of attention-getting behaviors in humans and chimpanzees, our experimental research suggests that the two species differ dramatically in their understanding of what these gestures are for. In one experiment, we confronted our chimpanzees with a familiar human who was sometimes attentive to them and sometimes not (Theall and Povinelli 1999). On most trials, the chimpanzee approached the person, gestured, and was handed a food reward. However, on certain trials, as soon as the chimpanzee gestured, the person activated a 20-second timer hidden in her ear. For 20 seconds, the person engaged in one of four behaviors: (1) She stared directly at the ape and attempted to maintain direct eye contact. (2) She made direct eye contact with the ape while engaging in slight back-and-forth movements of the head (a signal of 'attention' in chimpanzees). (3) She closed her eyes and waited. (4) She looked above and behind the ape. The first two of these conditions were "attentive" cases (after all, the person maintained a state of visual attention with the ape during the 20-second period). The latter two conditions were "inattentive" cases (the person was visually inattentive to the ape during the waiting period). If the apes appreciated this difference, they should have displayed more nonvisual attention-getting behaviors (i.e., touching or slapping at the person, banging on the fence, or vocalizing) in the inattentive conditions, and displayed them sooner than in the attentive cases. On the other hand, if the apes were reasoning strictly about the relevant behavioral states and outcomes (e.g., "She hasn't handed me any food yet"), there should have been no difference in the overall level or in the temporal patterning of gestures during the waiting periods of the attentive and inattentive cases.

What did the apes actually do? First, they readily engaged in the relevant attention-getting behaviors—in fact, they displayed at least one such behavior on more than 70 percent of the trials (figure 3). However, they did not exhibit more of them, longer episodes of them, or display them any sooner in the inattentive cases as compared to the attentive ones (figure 4). Thus, although the apes exhibited actions that were structurally identical to actions exhibited by humans, they did not seem to understand their behavior as an appeal to an inner, psychological state of attention. This finding illustrates our broader point: Chimpanzees and humans share attention-getting behaviors because they inherited the same psychological systems for generating such behavior from a common ancestor. We humans, however, understand the behaviors in light of a cognitive specialization that evolved some time after our lineage split off from that of chimpanzees. If the ability to reason about mental states evolved in the manner we have suggested, this qualitative difference between humans and

Figure 3
Apollo displays a typical attention-getting gesture during the 20-second waiting period.

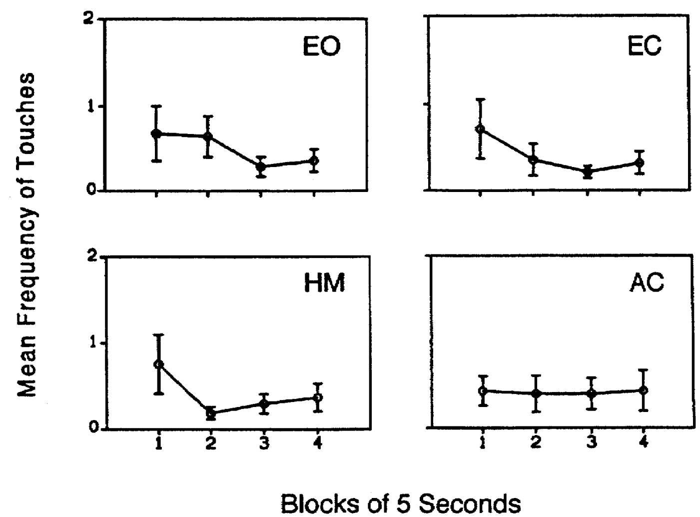

Figure 4
The temporal structure, overall frequency, and (not shown here) mean duration of the chimpanzees' attention-getting gestures do not vary with the attentional state of the person. EO: experimenter with eyes open. HM: experimenter displaying attentive head movement. EC: experimenter with eyes closed. AC: experimenter gazing above chimp (condition shown in figure 3).

apes will be very difficult to detect by observing their *spontaneous* behavioral interactions. Rather, experiments will always be needed to reveal the differing ways in which the two species interpret the same basic behavioral patterns (Povinelli and Giambrone 1999).

It follows from the above considerations that chimpanzees should be very good at detecting and responding to the behavioral manifestations of intentions, and hence should display sensitivities very similar to those of human infants on habituation-dishabituation tasks. And yet, if our view is correct, they do so in the absence of an understanding of intentions.

Implications for Human Cognition

At this point, one might be puzzled: If a particular behavior is homologous between humans and chimpanzees, doesn't it stand to reason that there is a homologous psychological system involved in controlling the behavior? The answer to this question leads directly to the implication of our theory for human cognition. The reinterpretation hypothesis argues that humans have a unique psychological system that now resides alongside lower-level systems that we share in common with chimpanzees. In this sense, for any particular behavior that chimpanzees and humans share, there are likely to be at least two systems at work: a low-level one (which both species possess) and a high-level one (found only in humans). Human introspection, however, may only have access to the more recently evolved, higher-level system. Thus, one implication for human cognition is that our private acts of introspection may simply be unsuited to diagnose which system (the ancient or the new) has caused a particular behavior.[8]

So what causal role do second-order mental states play in generating human behavior? The reinterpretation hypothesis suggests that there is no single, simple answer to this question. Indeed, I suspect that most of the *possible* causal relationships between second-order mental states and behavior are, in fact, realized. Here are just a few of them:

- In some cases, our second-order mental states may be rapid, after-the-fact "redescriptions" (Karmiloff-Smith 1992) of behaviors that are actually prompted by psychological systems that are impenetrable to our higher-order cognitive systems.

- In other cases, our second-order mental states may be generated before the execution of a particular behavior but still play no direct causal role in launching it. However, the fact that the second-order mental state occurs before the act may create a cognitive illusion that it has caused the behavior. For example, in many cases, relevant external stimuli may initiate two parallel psychological operations: one related to the generation of second-order mental-state descriptors of the stimuli and one that generates the neurophysiological activities that ultimately launch the behavior. The relationship between these parallel operations may be quite complicated. In some cases, the two systems may function independent of each other; in other cases, the two systems may begin independently but the higher-level system may later inhibit (or excite) the lower-level system.

- In some instances in which second-order mental states are generated before the execution of the behavior, the second-order mental state may indeed play a necessary causal role in launching the behavior.

If the first two sets of possibilities do in fact occur frequently, then many complex social behaviors that, in our species, are *accompanied* by second-order mental states may also be found in other species that do not possess second-order mental states at all. Furthermore, because the reinterpretation model postulates that the human specialization in reasoning about mental states was woven into our neural circuitry right alongside ancestral psychological systems, our introspections may often misdiagnose the causes of our behaviors (Povinelli and Giambrone 1999).

Implications for the Development of Human Intentional Understanding

At this point, I can return to the problem I addressed at the outset of this chapter: What are the alternative ways of interpreting the results of recent research using habituation-dishabituation (and related) procedures? As we shall now see, the reinterpretation hypothesis bolsters the plausibility of at least one of the alternatives. Briefly, let me recall and elaborate on the three alternatives.

First, the visual dishabituation effect may, by itself, be evidence for the infant's understanding of intention. This is the position adopted by strong nativists such as Premack (1990) and Gergely, Nádasdy, Csibra, and Bíró (1995) and one consistent with the theoretical speculations of strong modularity theorists such as Fodor (1983, 1992).

Second, it is possible that such studies do not offer evidence that infants are reasoning about intentions, but that they do reveal an early stage in infants' ongoing construction of a system that will ultimately be capable of reasoning about intentions. This seems to be the cautious view favored by at least two of the research teams contributing to this volume (Woodward, Sommerville, and Guajardo; Wellman and Phillips). Wellman and Phillips argue that their findings indicate that infants possess "key competencies that lead to preschoolers' later more developed conceptions" and that such competencies "must be central to developing intentional understandings." They conclude by suggesting that the infant's ability to analyze the observable aspects of human behavior "would constitute an important source, perhaps the critical source, for the development of intentional understandings." Similarly, Woodward, Sommerville, and Guajardo argue that our adult folk psychology has its "roots" in infancy, and ask "do infants have ways of making sense of intentional action that are continuous with adult understandings?" Woodward et al. acknowledge that infants may first understand the actions of others in purely behavioral terms, but they maintain that their results reveal that infants are "on the right track, in that they are attending to just those aspects of actions that are relevant to goals in the adult sense." Perhaps because it is not their central concern, these authors have left a certain ambiguity about what they mean by claiming that the infants are "on the right track" toward the development of an understanding of intentions. Nonetheless, the idea that the early detection of the structural regularities of behavior is the first step in the construction of the psychological system for reasoning about the intentions of other beings would seem to be common to these viewpoints.

The third alternative, however, posits that the abilities revealed by habituation-dishabituation research (and related research) reflect the operation of only one of several psychological systems which are developing concurrently in human infancy—systems that are both evolutionarily and developmentally dissociable. This alternative highlights the possibility that the early detection of the structural regularities of behavior are not, strictly speaking, the early manifestation of the uniquely human system for reasoning about intentions. To be sure, this early system will become intimately linked with the system that generates the representation of intentions, but the third alternative specifies that these two systems have separate evolutionary and developmental origins. If so, then infants do not construct an understanding of intention from an overt analysis of behavior. Rather, these two systems are envisioned as maturing independently and only later becoming intertwined.

The reinterpretation hypothesis provides theoretical grounding for the third alternative just described. Recall that the key idea behind the reinterpretation model is that, although the capacity to generate second-order mental states is a unique attribute of the human species, its initial appearance was not associated with the emergence of myriad new behavioral elements. Rather, the model argues that it was initially selected for because it offered more flexibility in organizing and deploying existing behavioral elements, thus putting old behaviors to new uses.

One assumption of this model is that long before second-order mental states evolved, many species already possessed complex nervous systems that could detect the various statistical regularities in the behavior of others. To understand the broad implications of this simple fact, we must consider the evolutionary history of the central nervous system. The initial brain organ was quite limited in comparison to the more elaborate structures found in many modern descendant species. Indeed, in many conservative living species the central nervous system is no more than a small cluster of nerve cells at the anterior portion of the organism (Bullock, Orkand, and Grinnell 1977). However, as the central nervous system diversified and enlarged in certain lineages, an intimate coevolution occurred between the sensory and brain systems. Indeed, the sensory systems of organisms can be thought of as gateways that control the flow of information into the brain organ. In other words, the sensory systems act as initial filters on the kinds of external stimuli that can be detected. Clearly, natural selection favored sensory and brain systems that could detect and process the important temporal regularities in the world of a particular species. Indeed, this must be the very process that gave rise to the brain's first psychological functions: habituation and associative learning (MacPhail 1987).

What regularities in the world were among the first to be discovered? The answer undoubtedly depends on the ecology of the species in question.

However, for many social species one of the most important temporal regularities was the behavior of other conspecifics. In solitary living species, of course, the behavior of other organisms may have been largely irrelevant, hardly demanding the evolution of brain systems specifically designed for reasoning about social events. However, as some lineages evolved increasingly complicated social interactions, brain systems dedicated to detecting and processing information about the regularities of the behavior of others must have begun to emerge as well. In many sexually reproducing organisms, for example, the act of mating requires attention to the posture, motion, and communicative signals of the potential mate (Tinbergen 1951). More generally, however, most vertebrates have a range of communicative postures and actions that must be detected and correctly processed not just during mating displays but also during aggression encounters over scarce resources (figure 5). Our general point is that for hundreds of millions of years the sensory and brain systems (and the visual systems in particular) of vertebrates and other taxa have been detecting, filtering, and processing information about the regularities in the behavior of others that is important to their reproductive fitness. The reinterpretation hypothesis, however, argues that it was not until the advent of humans that these abilities were accompanied by an understanding that these behaviors are grounded in mental states such as intentions.

Let me develop the implications of this argument for infancy research using habituation-dishabituation techniques (and related techniques). In view of the evolutionary dissociation between the ability to detect the behavioral expression of intentions and the ability to conceive of intentions, it is possible that the origins of the two systems are not intimately linked in human development either. Rather than interpreting the early detection of behavioral regularities as an early (perhaps the first) manifestation of a system that is slowly and seamlessly constructing an explicit understanding of intention, it is possible to imagine that the two systems have separate ontogenetic histories. The early competencies revealed through habituation-dishabituation and related procedures may reflect the operation of ancient evolutionary forces that selected for the ability to monitor the behavior of others and keep track of the statistical regularities embedded therein. In contrast, the later-emerging understanding of intentions may be the result of initially unrelated cognitive systems that were added during human evolution. Thus, the ability to explicitly conceive of

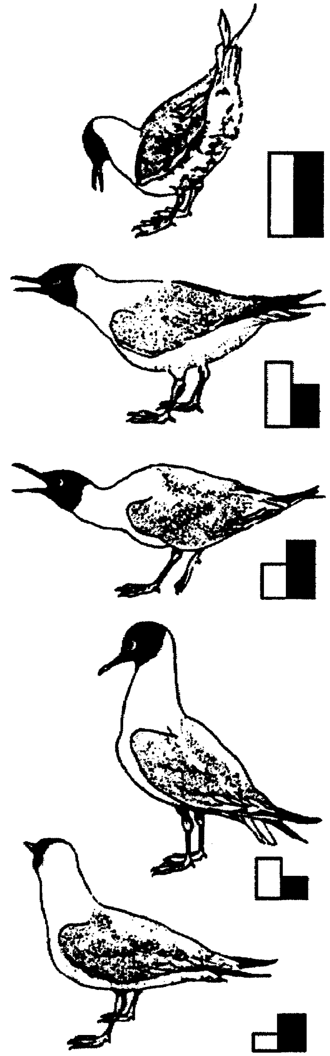

Figure 5
Threat postures of the black-headed gull (after Moynihan 1955; reprinted from McFarland 1993). Such communicative postures are widespread in animals, as they function to mediate social interactions. Clearly, such signals are effective only insofar as they are appropriately produced by the sender and detected and processed by the receiver. However, nothing about such communicative interactions forces us to conclude that the recipient understands the intentions (qua mental states) underlying the sender's behavior. Many of the sensitivities displayed by human infants in studies using visual dishabituation and related techniques are open to the same interpretive ambiguities.

intentions (and other mental states) may have its own evolutionary history—a history that may be closely linked to the emergence of the representational structures that support human language.

Consider the elegant research of Woodward and her colleagues (this volume), which has shown that infants display kinds of sensitivity to hand-object relations and rod-object relations. Woodward et al. interpret their findings as evidence of an early part of a developmental process that will ultimately lead to the construction of an ability to reason about intentions. However, it is a simple fact about the way in which the primate hand has evolved that there are visually obvious and important regularities in how the hand approaches objects, in the posture that the hand typically adopts once it has grasped an object, and in the ensuing spatial and temporal association between the hand and the object as they move off together in space. Rather than interpreting the infant's sensitivity to these specific relations as causal precursors to the development of an understanding of intention, it is possible to see these abilities as direct expressions of a primate visual system that evolved to detect certain statistical regularities in the motions of hands—a detection unrelated to an understanding of the intentions underlying the reaching hand.[9] Indeed, I suspect that for each species in which the reaching hand is involved in important social interactions (whether in the context of ritualized gestures, foraging, or aggressive acts) a distinct set of sensitivities will be uncovered through the application of habituation-dishabituation and related research techniques.

By now, the "bottom line" of the third alternative should be clear. The sensitivity to the behavioral regularities surrounding the expression of intentions is an ancient psychological phenomenon, one rooted in the very nature of the brain systems that receive and filter sensory information about the external world and ultimately use this information to direct the behavior of the organism in whose body those brain systems reside. In contrast, the ability to reason about the intentions underlying a particular behavior (in the case of the research by Woodward et al., the reaching hand) is a recent cognitive capacity that may be present in only a single living species—our own.

Our reinterpretation model, in some important ways, may be the evolutionary analogue of Karmiloff-Smith's (1992) developmental model of representational redescription. Karmiloff-Smith argues that, within certain domains, cognitive development is largely a process of processing information at increasing levels of explicitness, so that information that is initially available *in* the mind becomes increasingly available *to* the mind. Implicit knowledge is redescribed in increasingly explicit ways as the infant or child constructs its understanding of the physical and social world. Our model adds to this developmental account by putting an evolutionary face on it, thereby helping to reveal exactly why results from habituation-dishabituation research are so ambiguous with respect to the emergence of intentional understanding.

Pursuing the Third Alternative

The third alternative I have explored in this chapter argues that at least two separate psychological systems related to detection and interpretation of intentions are operating in parallel in human infancy. One is purported to be involved in detecting the statistical regularities of behavior, the other in interpreting it in psychological terms. From the developmental perspective, the third alternative bears strong similarities to the model offered by Baird and Baldwin in this volume. Indeed, after some extended discussion of the models, Dare Baldwin and I have concluded that perhaps the most notable differences between our proposals may lie in their emphases. Our proposal emphasizes an explanation for why the low-level system exists in the first place and highlights the possibility that core aspects of it evolved thousands (or perhaps hundreds) of millions of years ago. Thus, because of its evolutionary focus, our proposal sees nothing remarkable about the fact that human infants are sensitive to precisely those aspects of behavior that correspond to the initiation, execution, and/or termination of intentions. After all, these are abilities that have been honed by natural selection over untold generations in many social species, and perhaps especially so in social birds and mammals. By way of contrasting emphases, Baird and Baldwin highlight the importance of this low-level system as the input to the high-level psychological system which will, at some point, draw inferences about intentions. In doing so, they seek to emphasize the connection that must emerge between the low-level system (action-parsing mechanism) and the system for reasoning about intentions (inferential mechanism).

In emphasizing the evolutionary aspects of the problem, I am not attempting to downplay the role of the low-level mechanisms in providing input to the uniquely human systems for making intentional inferences. Indeed, the proposal I have outlined here and the one outlined by Baird and Baldwin are united in the idea that the high-level and low-level systems become linked at some point in human development. In this respect, if these proposals turn out to have empirical merit, researchers interested in the development of intentional understanding should still be interested in the early-developing sensitivities displayed by infants. Nonetheless, this does not alter the central premise of the third alternative that I have outlined: Many (perhaps most) of the early abilities detected through habituation-dishabituation and related techniques in very young infants are not evidence that the uniquely human system for reasoning about intentions is under construction.

Some might follow the general line of reasoning that I have outlined in this chapter but point out that there are many possible ways of thinking about the causal relations that might exist between the low-level and high-level systems. On the one hand, they might agree that the low-level system need not inevitably generate a system that can explicitly conceive of intentions (witness chimpanzees). On the other hand, they might note that it is nonetheless possible that the human system for explicitly understanding intentions is built on the foundation of lower-level systems—thus arguing that there is a weaker sense in which the earlier system could be a causal precursor to the later one. Fair enough. But the third alternative draws direct attention to the more specific possibility that the ability to conceive of intentions may not be fostered by early action-parsing systems, or by the object-directedness and action-connectedness sensitivities described by Woodward et al. and by Wellman and Phillips. Rather, the system for generating intentional understanding may have evolved long after—and may begin to develop independent of, although in parallel to—the more ancient systems for detecting behavioral regularities. For example, if selection had favored a different low-level system—one sensitive to slightly different intentional joints in the action stream—the evolution of intentional understanding would have mapped onto *those* regularities instead. In short, it may be that the development of intentional understanding is an independent system that proceeds without respect to specific behavioral sensitivities that happen to be in place. In this chapter I have stressed the possibility (not contradicted by any empirical findings) that representational systems unique to humans (ones that may be related to language) may generate the notion of intention quite broadly, and that these concepts may then be mapped onto the structure of action that is most salient in the culture in which the infant develops.

But what about the broader claim that at least *some* kind of psychological system for detecting the statistical regularities in behavior is necessary (though not sufficient, as the chimpanzee case demonstrates) for the construction of an ability to reason about intentions? To some extent, of course, this must be true. Intentional descriptions of actions require, by definition, the demarcation of a set of distinct actions. What we really want to know is whether the kind of fine detection of the structural regularities of behavior play a critical role in the infant's and the young child's development of intentional understanding, or whether they serve as a kind of given, passive backdrop onto which such understanding is mapped. One useful way of approaching this question might be to explore cases of traumatic brain injury in humans in order to determine how the neural systems for detecting fine behavioral regularities can be dissociated from intentional understanding. The possible patterns of breakdown between these systems might ultimately help us to understand the exact nature of the causal relation between the systems that are dedicated to detecting behavioral regularities and those that generated intentional representations of actions, as well as to determine whether there are unique behavioral detectors specifically associated with intentional understanding.[10]

Conclusion

I have sought to clarify the possible causal relations that might exist between infants' detection of behavioral regularities and the development of intentional understanding. In particular, I have tried to highlight the inherent ambiguity in the claim that human infants' early sensitivities to the intentional structure of action indicates that they are "on the right track" toward developing an understanding of intentions—an ambiguity that reflects the mosaic nature of the evolution of the relevant psychological systems. Indeed, some ambiguity of this sort will always be present when we are dealing with complexly evolved systems. As an example, consider the similarity between the above claim and the claim that because infants are born into the world with two legs they are "on the right track" to walking bipedally. There is, of course, a trivial sense in which both of these statements are true and important. But there is also a deeper sense in which both may be misleading: In both cases we run the risk of focusing on abilities or structures that may have evolved in isolation from of the uniquely human abilities that captured our interests and imagination in the first place.

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Notes

1. For a related proposal, see the chapter by Baird and Baldwin.

2. In this chapter, I focus on this implications of our theory for visual habituation-dishabituation studies related to intentional understanding. However, the same line of reasoning applies to interpreting the results of similar investigations concerning infants' understanding of folk physics (see Povinelli, in press, chapter 12).

3. For a review of these early studies, see Povinelli 1993.

4. For other early research on this topic in nonhuman primates, see Premack 1988 and Cheney and Seyfarth 1990a.

5. For an overview of this research, see Povinelli and Prince 1998.

6. For an overview, see Povinelli, in press.

7. For similar conclusions see Tomasello, Kruger and Ratner 1993 and Cheney and Seyfarth 1990b.

8. For a detailed treatment of this issue, see Povinelli and Giambrone, in press.

9. With respect to the question of whether these abilities are constructed through experience or whether they are under tighter epigenetic control, our theory has no direct predictions. Clearly, this is an empirical issue that cannot be settled theoretically.

10. Although the idea may be disfavored for reasons of parsimony, it does not seem completely improbable that the human system for generating inferences about intentions has evolved its own set of capacities for detecting the structural regularities in behaviors. If so, then it is possible that the early abilities detected by habituation-dishabituation research may be completely unrelated to the human system for reasoning about intentions.