Similarity and Difference in the Conceptual Systems of Primates:

The Unobservability Hypothesis

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The Two Faces of Diversity

Biologists readily talk of genetic, physiological, morphological, behavioral, and organismal diversity. Indeed, every taxon is ultimately defined on the basis of some combination of variation at each of these levels of description, most of which are readily apparent and uncontested. Mammals are endothermic, whereas reptiles are exothermic. Birds can fly. Fish breathe underwater. Octopi emit ink jets; whales and dolphins emit sonar signals. Curiously, however, whereas biology was more or less founded on the tenets of diversity, psychology has exhibited a strong reluctance to embrace the idea of diversity among species – particularly among groups of closely related species, such as humans and other primates – focusing instead on trying to uncover universal laws of learning (for different perspectives on this problem, see Beach, 1950; Boakes, 1984; Hodos & Campbell, 1969; Macphail, 1987). As a consequence, the idea of *psychological diversity*--qualitative differences in the mental systems of different species--has

not prominently entered the lexicon of comparative psychology, let alone become part of the general notion of biological diversity. Ironically, we believe at least part of this resistance stems from the operation of uniquely human systems that cause us to form strong empathic and intellectual identifications with other species (particularly with other primates).

From the opposite standpoint, however, humans have always possessed an unwavering interest in what makes us psychologically distinct from other species. Indeed, there is no shortage of time-honored proposals on this point. Just to list a few: humans alone have evolved natural language (a communicative system that involves deep underlying semantic and syntactical structures); humans alone construct complex inventions and alter our environment in profound ways; humans alone have a meaningful culture; and the list goes on. Surely, then, when focused on this half of the question, it is easy to embrace the idea that we are very different from even our closest living relatives.

In the abstract, of course, this tension between similarity and difference does not present a real barrier to thinking about cognition from an evolutionary perspective (for recent attempts to explore cognitive evolution in a diverse array of taxa, see Gallistel, 2000; Gaulin, 1992; Kamil, 1984; Povinelli & Preuss, 1995; Tooby & Cosmides, 1995). After all, that's what evolution is all about: similarity *and* difference. The *similarities* among taxa at each nested level of the biological hierarchy are precisely what force us to the conclusion that life on this planet ultimately constitutes a single genealogy; traced back far enough, even elephants and fruit-flies have a common ancestor. Conversely, the *differences* among taxa provide the evidence that this unbroken genealogy of life is, and has been, sculpted by natural selection and other evolutionary processes, ultimately allowing us to represent the history of life on this planet as a branching tree or bush. And, finally, the combination of similarity and difference is what gives us such great

confidence in the idea that the species we see today *evolved* on this planet, as opposed to having been specially created. In principle, then, the idea that the cognitive systems of humans and our closest living relatives are both profoundly similar *and* different should present little difficulty.

The general practice of comparative psychology has, however, largely been a deflationary one, attempting to explain away differences between species as unimportant, trivial, or simply a function of methodological artifacts. Psychologists have had a difficult time simultaneously embracing similarity and difference as equally important facets of cognitive evolution. More often than not, in the limited space that comparative psychology has given to seriously attempting to incorporate ideas about evolution, one or the other of these dimensions of evolution has been given the upper hand. Indeed, both possible mistakes have been made: (1) invoking the idea of evolution in an attempt to promote the idea of 'unbridgeable' differences (usually in the case of attempting to set humans completely apart from other species), and (2) invoking evolution to support the idea of 'unbreakable' similarities. These mistakes are exacerbated by the fact that, for much of its history, comparative psychology relied on the idea of the 'phylogenetic scale' as opposed to the 'phylogenetic tree' (Hodos & Campbell, 1969, 1991). The truth, of course, is that when it comes to entities whose ontological status is as nebulous as the 'structures' or 'systems' or 'representations' investigated by cognitive scientists, and their causal connection to various behaviors, the fact of evolution creates little or no presumption about the phylogenetic distribution of such systems among closely related species. Indeed, because it largely sees the mind as a collection of innumerable systems and subsystems, cognitive science should herald an end to the sterile similarity/difference debate by allowing psychologists to recognize that each of these psychological systems may have its own evolutionary history, in the same manner as the various organs of the body. The distribution of

these mental traits thus becomes an empirical question – just as the distribution of morphological and physiological, and behavioral traits was (and continues to be) an empirical question for those branches of biology that are interested in documenting diversity.

A Test Case: The Unobservability Hypothesis

What we have said about similarity and difference is true of cognitive evolution generally: the mental systems of closely related species can be both massively similar and massively different (depending on the degree of ecological divergence that occurred since their last common ancestor). But, the case of humans and our nearest living relatives – chimpanzees and the other great apes – would seem to constitute a vital 'test case' for the project of incorporating 'psychology' into the general list of dimensions along which species differ. After all, if we could not demonstrate that humans and chimpanzees differ from each other in fundamental ways, then the idea of psychological diversity might be harder for psychologists to take seriously – or at least harder to embrace as an important general fact about evolution, as opposed to a trivial fact about taxa that have not shared a common ancestor for many hundreds of millions of years. In other words, although many scholars might accept psychological differences between wasps and penguins, this idea is easily assimilated into the mistaken idea of evolution along a phylogenetic continuum (see Darwin, 1871). The case of humans and chimpanzees makes the point most clearly – if two such very closely related species that have evolved such radically different ways of life could not be shown to possess cognitive specializations, then psychologists (and biologists) might be convinced to politely agree with our general point about psychological diversity, but fail to see how it has much to do with their day-to-day research activities.

In this chapter, we explore the possibility that one of the important ways in which humans differ from other species is that our minds form and reason about concepts that refer to unobservable entities or processes (see Povinelli, 2004). In short, we explore the possibility that, whereas many species form concepts about observable things and use those concepts in flexible and productive ways, humans alone think about such things as God, ghosts, gravity, and other minds. Further, we speculate that, although thinking about unobservables is by no means the only way in which the human mind differs from other species, it may serve as the foundation for many of the fundamental differences between our behavior and that of our closest living relatives. We note up front that this proposal is not in conflict with other proposals that stress the importance of language in determining human uniqueness. Indeed, although we do not explore this idea at great length in this particular endeavor, we suspect that the underlying 'abstractive depth' that makes reasoning about unobservables possible co-evolved with natural language.

It is crucial to note that an ability to wield more concrete concepts may serve as the fundamental basis for much of what we deem 'higher order' cognition in humans. However, large swaths of these concepts are more than likely to be shared by other species; indeed, the more closely related the species, the more likely it is that their concepts of the observable world are similar. For example, although chimpanzees, humans, and fruit flies (*Drosophila melangaster*) all exploit bananas as an edible resource, the human and chimpanzee 'banana' concept is undoubtedly highly similar and radically different from the banana concept found in the fruit fly (probably best described as a chemical gradient of some kind). Thus, although each species may represent only certain features of objects or events in the world, and different species may overlap in the objects and events they represent, it would seem far fetched to imagine that even the same 'objects' are conceptualized in the same manner across species.

However, it is our contention that the mental systems of most species, no matter how 'abstract' the concepts they form, differ in one important respect from the human mind: they do not form concepts that refer to merely hypothetical things. Thus, we speculate that, although many minds are adapted to represent events in terms of their observable properties and are able to extrapolate certain rules from these representations, these minds do not posit unobservable entities or processes as mediating variables to explain or to predict observable events or states. We are not the first to propose that the ability to reason about causal forces is a unique specialization of humans, an ability that leads to profound differences between the cognitive systems of humans and all other primates (e.g., see Kohler, 1925; Povinelli, 2000, 2004; Tomasello, 1998). However, we wish to focus the current discussion on the ability to represent concepts for unobservables, some of which represent causal forces and some of which do not. In addition, we wish to generalize this idea to emphasize the distinction between a mind that merely predicts events versus a mind that strives to explain them (see Povinelli, 2004). In what follows, we explore the unobservability hypothesis in the context of three areas of research: concept formation, theory of mind, and physical causality. In each of these research domains, we ask whether there is evidence to contradict the hypothesis that reasoning about strictly hypothetical constructs is a uniquely human specialization.

As we shall see, in each domain, the challenge lies in the tendency to conflate the outward manifestation of an unobservable construct with the construct itself. How does one determine when an organism is wielding concepts generalized from what he or she can directly perceive (the outward manifestation), as opposed to wielding those concepts plus additional, theoretical concepts which have no observable referent – concepts invoked both to explain *why* an observed event occurred, as well as to assist in the prediction of future events (the underlying

cause)? Viewed in this light, it should be readily apparent that teasing apart these two systems (one that reasons about unobservable causal forces and one that reasons about observables) will be far from a simple enterprise. Because of the close relationship between an event and its purported underlying cause, it is difficult to specify contrasting predictions of such systems. This point emphasizes another important fact that is often overlooked – a system that reasons about observables alone provides an organism with immense predictive abilities.

Concept Formation

In asking whether reasoning about unobservable entities is a human specialization, a natural place to turn is to the literature on concept formation in animals. In this section, we address two main questions. First, do animals form the kinds of concepts that constitute theoretical class categories as well as concepts for tangible entities? For example, do they represent foods as a general category of items that encapsulates many different kinds of foods or do they form only representations of individual food items, which may be associated to some degree by virtue of their obvious similarities, but are not represented as belonging to a unitary conceptual class? Second, is there any direct evidence to suggest that species other than humans form concepts about things that are so inherently abstract that they can be said to refer to 'unobservables'? Our attempt here is not to review the literature on concept formation (see Jitsumori, 2001; Pearce, 1994); rather, in what follows, we examine some representative research in this area from the perspective of the unobservability hypothesis outlined above.

Exploring Animal Concepts

Studies that directly attempt to investigate the type and nature of concepts held by other species face great difficulty in determining whether subjects are responding on the basis of readily observable perceptual information or whether, in addition, they are able to reason about

more abstract concepts which subsume those perceptual regularities. Typically, such studies involve the use of two-choice discrimination paradigms in which an animal responds in one way to a member of a (positive) class and in a different way to members of another (negative) class. Once a high level of performance is reached with training stimuli, novel members of the 'positive' and 'negative' classes are presented as a test of transfer. Another popular experimental design is the match-to-sample (MTS), or non-match-to-sample (NMTS) paradigm, in which an animal is shown a sample stimulus and either concurrently or successively (in delayed MTS or DMTS designs) is shown two or more comparison stimuli; the animal is then required to select the comparison stimulus that matches (or does not match) the sample. An animal may learn to make the correct response in such paradigms without utilizing the experimenter-defined categories. The basis for correct categorization may depend more strongly on shared perceptual features and less on an overriding concept.

This distinction between categorizing on a conceptual versus a perceptual basis is a difficult one to make, particularly because conception is generally considered to be grounded in perception (e.g., Goldstone & Barsalou, 1988, Huber & Aust, this volume). Experiments testing for the presence of natural concepts, which consist of groupings of "infinite or open-ended classes of things that occur in nature" (Schrier, Angarella & Povar, 1984, p. 564), make use of stimuli that must be discriminated perceptually. However, it is possible to construct categories whose members are visually dissimilar and yet are linked by virtue of an abstract construct that itself is not directly observable, as in the case of a category of items that are related by their function, not by the fact that they look, smell, feel, sound, or taste alike (e.g., categories such as 'things that make good gifts' or 'things that attract romantic partners'). In such cases, it would be

difficult to understand the conceptual fabric binding the various category members together without a notion about constructs which cannot be directly perceived through the senses.

The extent to which other animals share the ability to form concepts in the more abstract sense just described has yet to be resolved. Indeed, it is difficult even to define what is meant by 'abstract.' The most commonly agreed upon convention is to refer to abstract concepts as those which are not tied to directly perceivable features and to highlight the ability to create coherent conceptual categories across significant perceptual variance (Spalding & Ross, 2000). An 'abstract concept' may then be a representation of constructs or theoretical entities as well as of material objects.

In practice, however, given the kinds of concepts that are typically explored with animals, common perceptual features between training and transfer stimuli must be present in order for subjects to make the discrimination in the first place. For instance, concepts such as 'water' are typically exemplified by predominantly bluish-colored photographs, whereas stimuli exemplifying the concept 'tree' typically consist of brown trunk and branch-like appendages with green leaves. Thus, it becomes difficult to distinguish between accounts whereby, for example, an animal learns to 'choose blue' versus 'choose water'. Of interest is the extent to which the amount of transfer is affected by the degree of perceptual overlap between the training and transfer stimuli (or between the sample and comparison stimuli in MTS designs). For instance, subjects may show less transfer to pictures of green, or black water, or to trees without leaves. Thus, researchers have presented various animal subjects with categories that vary along a continuum of abstraction (with 'abstraction' referring to the breadth of the category and the variance of physical features between the exemplars), testing the hypothesis that the most abstract categories will be more difficult to learn relative to more concrete level categories that

share many perceptual features (e.g. Roberts & Mazmanian, 1988; Tanaka, 2001; Vonk & MacDonald, 2002, 2004). For instance, Vonk and MacDonald presented a gorilla (2002) and six orangutans (2004) with a sequence of two-choice discrimination tasks in which the most concrete level category included members of only their own species and the most abstract category included diverse members of the animal kingdom, such as insects, birds, fish, mammals, and reptiles. Although the orangutans seemed to have the most difficulty learning the most abstract concepts, as expected (Vonk & MacDonald, 2004), surprisingly, the gorilla (Vonk & MacDonald, 2002), along with pigeons and squirrel monkeys that were presented with similar discriminations by Roberts and Mazmanian (1988), acquired the most abstract category discrimination more readily than an intermediate level category discrimination. Vonk and MacDonald (2002) concluded that perhaps the degree of abstractness or breadth of the categories is not a reliable predictor of how readily nonhumans will form experimenter-defined categories and that the degree of perceptual overlap both within and between categories in any given stimulus set may more strongly influence categorization.

Whereas some researchers have encountered difficulty determining the exact features used by their subjects to make the discriminations (Roberts & Mazmanian, 1988; Vonk & MacDonald, 2002; 2004), others have identified the use of features that are irrelevant to category membership, causing them to question the extent to which their subjects formed true concepts (D'Amato & Van Sant, 1988; Jitsumori & Matsuzawa, 1991; Shrier & Brady, 1986). Therefore, natural concept experiments may demonstrate little more than the fact that nonhuman primates are exceptionally skilled at tracking the presence or absence of various observable physical features of the stimuli presented to them. Indeed, such results suggest the possibility that nonhuman primates may operate on the basis of observing perceptual patterns rather than by

forming overarching concepts, although the final assessment of this hypothesis awaits resolution. Note that we are not suggesting that humans use concepts in the absence of, or to the exclusion of, relying on perceptual patterns; rather both humans and nonhumans may rely upon purely perceptual feature-analyses to solve many discrimination problems. In fact, parallel studies with human infants and pigeons have revealed that these species sometimes make stimulus discriminations via parallel perceptual processes (Wasserman & Rovee-Collier, 2001). However, we speculate that humans may be uniquely capable of additionally reasoning about constructs that have no directly observable correlates.

Understanding first-order object relations

Because of the difficulty in determining when natural classes of objects are discriminated on the basis of shared perceptual regularities between the objects, rather than by concepts defining the class itself, researchers have turned to studying the formation of relational concepts. It has been suggested that the concept of relatedness between items is independent of their physical properties and must be represented abstractly in the form of an analogy (Premack, 1983). For example, 'darker' and 'bigger' are relative concepts. Grey is darker than white, but black is darker than grey, so the idea of the 'darker' color is relative and is not tied to a specific stimulus in a fixed manner. However, the stimulus differences are still *perceived*, regardless of whether the difference is absolute or relative. In fact, in the discussion that follows, we shall see that there are perceptual processes that allow animals to make discriminations that humans perceive as conceptually 'same' or 'different'. Thus, although the theoretical notions of 'sameness' and 'difference' cannot themselves be directly perceived, these relations can take the form of physical identity. An animal might perceive two objects that look similar as belonging together without representing the general concept of 'sameness'. In fact, some researchers have

argued that, in order to demonstrate that an animal is classifying two stimuli as 'conceptually' the same, one must first demonstrate that the stimuli are actually perceived as perceptually distinct (Vauclair & Fagot, 1996). Conceptual categorization thus requires that stimuli are perceived as being distinct and yet are still classified as functionally or categorically equivalent. Without such evidence, one would not know whether the animal simply failed to discriminate between perceptually similar stimuli. Unfortunately, few researchers have incorporated such tests as an initial step in their categorization experiments.

Many researchers have demonstrated repeatedly that both pigeons and baboons can learn to discriminate large arrays in which all of the items are the same from those in which all or some of the items are unique (Cook, this volume; Cook, Cavoto, & Cavoto, 1995; Cook, Katz, & Cavoto, 1997; Wasserman, Hugart, & Kirkpatrick-Steger, 1995; Wasserman, Young, & Fagot, 2001; Young, Wasserman, & Garner, 1997). However, both species are unable to do so when the array contains fewer items, suggesting that the subjects rely on entropy to perform the tasks (Wasserman, Fagot, & Young, 2001; Wasserman, Young, & Nolan, 2000; Young & Wasserman, 1997; Young, Wasserman, & Dalrymple, 1997). In other words, animals perceive the amount of perceptual variance to be greater in the 'different' arrays relative to the 'same' arrays; this variance decreases as the number of items in the array decrease, causing deterioration in their ability to discriminate. These results suggest that the animals are in fact not relying on same/different concepts, and instead, are basing their responses on the perceived perceptual regularity of the stimulus.

Results from a slightly different procedure revealed that if pigeons were shown an entire list of items, either comprised of identical or unique items, and made their discriminative responses at the end of the lists, they were able to do so at above chance levels (Young, et al.,

1997; Young, Wasserman, Hilfers, & Dalrymple, 1999). At first glance, it might seem less likely that a perception of entropy could account for these results, because the individual components were presented successively in list form as opposed to being visible simultaneously as components of a single stimulus at the time of the response. However, if the pigeons are using a perceptual detector that is sensitive to variation among the stimuli, then ultimately it should not matter if the items are presented all at once or in succession. In fact, computational analyses done by Young et al. (1999) revealed that sensitivity to entropy remained a critical factor in accounting for the pigeons' performance with successively presented items. Still, in addition to entropy, memory was also revealed to be an important factor.

Young et al. (1997) argued that their results constituted compelling evidence of memory-based conceptualization in nonhuman animals. However, although the temporal organization of the list required the animals to remember what had been previously presented, there is no clear evidence that what was held in memory was conceptual versus perceptual information. Furthermore, because viewing only the last two items provided all of the relevant information to make the same/different discrimination, given that none of the items were repeated in 'different' lists and all of the items were repeated in 'same' lists, and because the intertrial intervals were less than 10 seconds, the memory demand fell well within the range of short-term memory, in which the processing of perceptual information alone is sufficient to maintain a memory trace. It is wholly possible for the pigeons to succeed at these tasks by relying on processing perceptual information, regardless of how the items are spatially or temporally configured. Although humans can be shown to rely on similar perceptual processing when performing the same or analogous tasks, it is not clear that these tasks possess the resolving power to disentangle the two accounts of performance; the representation of a concept of 'sameness' versus a perceptual

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feature-matching process, because high levels of performance can be achieved using either mechanism.

The research discussed up to this point can be interpreted as showing that both pigeons and monkeys can perceive first-order relations – how two or more items are related to each other. However 'perceive' may be the key word. Success on such tasks can be achieved by attending solely to which items are visually more similar. In other words, animals may have a concept of 'sameness' to the extent that one item is perceived as looking like another by virtue of shared physical features. However, there is a more abstract sense in which the concept of 'same' may be represented – that is whether both items belong to the same conceptual class of items, class being defined by potentially unobservable properties. That is, 'same' can be represented perceptually as two or more things that visually match, lack variance, or present an impression of perceptual regularity, or 'same' can be represented conceptually as a class of things bound by properties that may or may not be directly observed.

Understanding second-order relations

In contrast, handling *second-order* relations – relations between relations – is thought to depend on an ability to understand that the relationship between two objects is the same as (or different from) the relationship between two other objects. Understanding second-order relations may thus require not only the perception of the physical relationships between objects, but also the analogical relationship between pairs of objects that are perceptually dissimilar.

Early studies with chimpanzees suggested that only 'language'-trained animals could conceive of second-order relations (Gillan, Premack, & Woodruff, 1981; Premack, 1983). However, later experiments with adult chimpanzees who had not received formal language training, but who had learned abstract symbols representing the concepts 'same' and 'different',

showed them to be capable of making explicit judgments about second-order relations (Thompson & Oden, 1996, 2000; Thompson, Oden, & Boysen, 1997). In addition, other researchers found that chimpanzees spontaneously sorted objects according to second-order classification schemes (Spinozzi, 1993; Tanaka, 1996).

Premack and Dasser (1991) suggested that requiring animals to make an instrumental response instantiating a categorical judgment satisfied the criteria for conceptually based behavior. One question we wish to pose is whether an instrumental response, in the case of matching or sorting based on second-order relations, demands that the response be shaped by conceptual versus perceptual processes. Is it not possible that animals perceive variance discrepancies, or some other perceptual regularity or irregularity, between pairs of items without evoking a true concept for the perceived relations? Interestingly, experiments involving spontaneous handling of object-object pairs suggested that infant chimpanzees who had not received any 'language' or token training were capable of at least *perceiving* the relationships between objects, although they failed to make instrumental use of these observations (Oden, Thompson & Premack, 1988, 1990). Clearly then, the capacity to perceive second-order relations can be dissociated from the ability to apply the concept operationally. Thus, one hypothesis is that infant chimpanzees perceive the relations, but have not yet formed an abstract representation of them, which they will ultimately develop. Another hypothesis is that, although young chimpanzees cannot yet use their perceptions to guide their responses instrumentally, older chimpanzees can use these same perceptions to sculpt their instrumental responses, albeit still in the absence of having acquired a relational concept. If the infant chimpanzees can perceive the relations sufficiently to handle pairs of objects instantiating different relations for different lengths of time, then perhaps the adult chimpanzees use the same strictly perceptual information

to succeed at the MTS tasks. Still, this leaves us with the question of what, other than a relational concept, would allow them to do so?

Although we are unable to resolve the issue as to whether sensitivity to second-order relations is based on more than perceptual processing, some evidence suggests that this sensitivity is greater in apes than in monkeys. Notably, Thompson and Oden (1996) claim that adult rhesus macaques tested in the same 'preference for novelty tasks' failed to perceive these relations (although these data have not been published). Furthermore, the same authors claim that human infants do not express tacit knowledge in relational MTS tasks, suggesting that the ability to make operational use of perceived second-order relations may be slow to develop in both chimpanzees and humans. Thus, there may be a gradient of relational understanding both ontogenetically and phylogenetically.

Fagot, Wasserman, and Young (2001) have recently demonstrated that baboons may also be sensitive to second-order relations. In a MTS task in which all of the items within the sample were either unique or the same, baboons chose at above-chance levels a matching stimulus in which the different objects within that stimulus were likewise either the same or different. However, again, this ability dissipated when only two items appeared in the stimulus array. It can be argued that the discrimination can still be made on a purely perceptual basis. 'All same' displays appear perceptually more regular than 'mixed' or 'all different' displays, even when the components within the array are randomly arranged (Wasserman et al., 2000; Young & Wasserman, 1997). The fact that the performance of both baboons and pigeons falls apart when only two items appear in the array indicates that these animals are not representing 'sameness' in the same sense that humans are capable of representing the concept 'same'. For humans, the case of two identical items would in fact be the most salient case of 'same'. The fact that this is

not the case for nonhumans implies that different concepts are represented across species in these tasks.

A recent study by Vonk (2003) revealed that three orangutans and one gorilla were able to match stimuli containing only two components in a MTS task on the basis of a second-order relation: shared color or shape between items. Not only were the apes able to succeed at the task with only two items in the stimulus arrays, but they reached above chance levels of responding much more quickly (i.e., within the first 24 trials) than Fagot et al.'s (2001) baboons, who required hundreds of trials to match same and different arrays with multiple items within the array. The results of this study could be taken to suggest that both gorillas and orangutans, with no explicit 'language' or token training, may be capable of representing second-order relations. One possible interpretation of these findings is that second-order relational information may be perceived only by the great apes, and not by the monkey species tested to date. This should be considered a testable hypothesis.

However, it is difficult to escape the problem discussed above in the context of first-order relations: the stimuli are almost always presented visually (slides or photographs) and the subjects can rely on only the perceptual features present in the stimuli in order to extrapolate the rule about which stimuli are 'correct' or 'reinforced' in a given experimental set. Thus, it becomes nearly impossible to surmise when the animals have gone beyond learning about perceptual regularities to form a more general concept. Transfer tests with discriminably different stimuli are important in this context because they provide a basis for surmising the generalization of learning from individual exemplars to novel examples of the same category. However, transfer tests do not allow one to determine whether the subject is generalizing based on observable features or on the basis of constructs that may not be directly observable. For

instance, an animal could generalize responding to photos of particular humans to novel photos of different humans, but they may not be representing the concept 'human'. Instead they may be generalizing a more concrete list of features such as "two eyes, pale face, sparse hair etc". Even novel photos must preserve the observable features that define the categories being discriminated, thus allowing transfer to be mediated by representations of physical features and not concepts per se. For example, in another study, two orangutans and one gorilla matched stimuli that were created based on the experimenter's conception of social relationships between individual animals depicted in the stimuli (Vonk, 2002). For instance, they matched photos in a DMTS task based on whether the photographs depicted mother/offspring pairs, social groups of animals, mated pairs, or siblings. In this study, it is difficult to determine whether the high levels of performance were mediated by concepts for the relationships between the individuals depicted, such as 'mother/offspring', versus non-relational concepts, such as 'young and old member of same species'. This problem is pervasive in studies of concept formation. Even when abstract symbols, such as lexigrams, are presented instead of the actual objects that they represent (as in Savage-Rumbaugh, Rumbaugh, Smith, & Lawson, 1980), the animal may base its response to those symbols on learned associations between the symbol and its referent, both of which must have been visually connected during training. Thus, it is only when the concept being wielded deals with properties that have no observable correlates that one can conclude that the concept is, in this strict sense, 'theoretical.'

Social concepts

Researchers have also investigated whether nonhumans form social concepts about emotions and relationships, such as dominance, and have used evidence for such concepts to marshal the idea that these primates are capable of representing concepts for unobservable

constructs. However, even emotions have outward manifestations. Fear can be represented by the image of bristling hair, wide eyes, and shaking body. Anger can be represented in the form of bared teeth and scream vocalizations. Even love can be linked to the behaviors it evokes. When someone is in love, they presumably act differently than when they are not. Although humans might *describe* 'love' in terms of its outward manifestations, they would *define* the concept as a subjective feeling that varies between individuals. Indeed, they would consider the concept somewhat nebulous and difficult to define. It is unclear how a nonhuman would define any emotion, given that they are incapable of communicating such thoughts to us. A limited number of studies have nonetheless sought to examine the nature of the primates' concept of emotions.

Parr (2001) demonstrated that chimpanzees could correctly match photographs of chimpanzees expressing various emotions to the emotional valences of previously shown video. For instance, after being shown a video of chimpanzees being darted by veterinarians, the chimpanzees correctly selected the image of a chimpanzee presenting a bared teeth or scream expression over one presenting a neutral or positive expression. However, it is not possible to determine the nature of the subjects' underlying representations of the stimuli. Surely, these chimpanzees had the necessary experience to form associations between various scenarios and the expressions present on the faces of their conspecifics during those episodes, without necessarily forming any representation of the underlying emotional experience of their counterparts. Furthermore, in order to comprehend the task, it is absolutely necessary that the chimpanzees had formed representations about the various behaviors depicted in the video, regardless of whether they had additionally mapped any concepts of 'emotions', as internal states, on to those behaviors. Our point is that emotions could not be depicted in the video in the absence of the observable behaviors with which they are correlated. Behaviors, on the other

hand, can clearly be represented in a manner that would allow the chimpanzees to match them to facial expressions, without necessarily also representing any underlying mental states.

The concept of dominance can likewise be represented as a series of behaviors that lead to similar outcomes – an unpleasant experience for the subordinate. A recent study by Bovet and Washburn (2003) exposed baboons to a series of short video clips depicting various scenes in which dominant unknown baboons interacted with other unknown group members. The monkeys were then rewarded for selecting the image of the dominant animal, based on the information available in the last still frame of the clip. Once criterion was reached with the initial category of video (e.g., 'chasing'), the subjects were shown various clips exemplifying a different scenario (e.g., 'avoidance' or 'presentation'), up to a total of eight categories. The baboons were shown several different clips within each category. After the first two or three categories, two of the three subjects showed transfer on the very first opportunity with stimuli from a novel class of behavior, suggesting that they had extrapolated from the video clips a more general concept tying these clips together. At the very least, the baboons were able to accurately select those individuals whose attributes or behaviors resembled those of the 'correct' individual from prior categories.

Bovet and Washburn's (2003) study experimentally corroborates observations of field researchers who have long noted the ability of group living primates to assess the dominance relations of their peers (Cheney, Seyfarth & Silk, 1995; Silk, 1999). Because these subjects were observing strangers, this experiment extends the conclusions based on field observations to more neutral scenarios by eliminating the opportunity for the baboons to rely on specific associations between the animals in the videos and representations of interactions directly witnessed in the past. The subjects' ability to select the image of the 'dominant' animal in this case was

independent of prior experience, in the sense that it was not a behavioral response with a long history of reinforcement through experiences with the particular conspecifics involved, such as displaying a submissive posture to a specific dominant. Having said that, however, the concept of 'dominance' revealed in this experiment could still be described solely by appealing to the various observable behaviors of the dominant (and perhaps the subordinate) animal, and thus may constitute nothing more than a general category of behaviors that 'go together' without a more abstract concept defining *why* this is so.[1] Thus, even in these cases, there is no unique evidence to suggest that the primates' understanding is tied to 'abstract' social concepts about unobservables that underlie the observable behaviors, as opposed to concepts about strictly observable perceptual regularities apparent in the behaviors.

Theory of Mind

It is, in part, for the above reasons that researchers interested in the question of whether other species reason about unobservable entities have recently focused much of their energy on exploring concepts that, by their very nature, *require* inferences about unobservables. A central battleground for such questions is the current debate over whether the ability to reason about mental states is a uniquely human trait. Premack and Woodruff (1978) coined the term 'theory of mind' to describe this ability to make inferences about inherently unobservable mental states, such as desires, emotions, perceptions, and beliefs. Although inferences about mental states can lead to predictions about observable behavior (and hence presumably play some causal role in one's behavior), the mental states themselves cannot be directly observed. As in the case of our discussion of concept formation, the intimate connection between the directly observable aspects of behavior ('avoiding a dominant whose hair is bristling') and an inferred unobservable mental state ('the dominant is *<angry>*'), makes it difficult to empirically disentangle whether a given

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animal is reasoning only about concepts abstracted from behavior (what we refer to as 'behavioral abstractions') or whether, *in addition*, they are reasoning about the underlying mental states that (from the perspective of our folk psychology) give rise to those behaviors (see Povinelli & Vonk, 2003, 2004). We emphasize 'in addition,' because a trivial, but often overlooked fact is that *a system for reasoning about mental states presupposes the presence and full operation of a system for reasoning about behaviors* – a fact which, when carefully considered, magnifies the challenge of disentangling the causal work that each representation performs (Povinelli & Vonk, 2004).

Do nonhuman primates reason about mental states?

Following Premack and Woodruff's (1978) initial report, early research investigated the degree to which chimpanzees could make inferences about the knowledge states of others, and in particular, if they understood the connection between *<seeing>* and *<knowing>* (Premack, 1988; Povinelli, Nelson, & Boysen, 1990; Povinelli, Rulf, & Bierschwale, 1994; Call & Tomasello, 1999). The results of these empirical studies largely disconfirmed the hypothesis that other apes share the human ability to reason about epistemic states. Similar attempts with several monkey species led to similar conclusions (e.g., Cheney & Seyfarth 1990; Povinelli, Parks, & Novak, 1992). Since this time, numerous methodologies have been deployed to explore whether various facets of theory of mind are present in nonhuman primates (see Cheney & Seyfarth, 1991, 1992; Heyes, 1998; Suddendorf & Whiten, 2001).

After initial attempts failed to clearly establish that chimpanzees or other primates were reasoning about knowledge states, we turned our attention to the possibility that humans and chimpanzees (for example) might share only certain aspects of theory of mind, with humans having elaborated on the system after the human lineage diverged from the chimpanzee lineage

(see especially: Chapter 5, Povinelli & Eddy, 1996a; Povinelli, 1996; for more recent views on this idea, see Tomasello, Call, & Hare, 2003a). In the context of our own research, we reasoned that our earlier studies investigating nonhuman primates' understanding that *<seeing>* something hidden leads to *<knowing>* its location, for example, had been constructed in such a way as to presuppose that they understood *<seeing>*. It followed then, that although chimpanzees had failed to demonstrate that they could make inferences about *<knowing>* in such contexts, they might nonetheless be capable of reasoning about *<seeing>* alone. In other words, chimpanzees might possess an ability to construe the movements and postures of the head and eyes in terms of the unobservable state of *<seeing>*, without having any idea about epistemic states (like *<knowing>*) that might be generated by such perceptual acts (for example, see John Flavell's Level 1/Level 2 visual perspective-taking distinction; e.g., Flavell, Everett, Croft, & Flavell, 1981).

To this end, in a lengthy series of cross-sectional and longitudinal studies, we systematically explored our chimpanzees' understanding of *<seeing>* (Povinelli & Eddy, 1996a, b, c, 1997; Povinelli, Reaux, Bierschwale, & Cech, 1999; Povinelli, Dunphy-Lelii, Reaux, & Mazza, 2002; Reaux, Theall, & Povinelli, 1999; Theall & Povinelli, 1999). First, we were able to reliably demonstrate our chimpanzees' capacity to follow the gaze of others (Povinelli & Eddy, 1996a, b, 1997), a finding that has also been demonstrated and extended to other species in many other labs (e.g., Anderson & Mitchell, 1999; Emery & Clayton, 2001; Emery et al., 1997; Kaplan & Rogers, 2002; Tomasello, Hare, & Agnetta, 1999; Tomasello, Call, & Hare, 1998;). Not only did our chimpanzees follow gaze in response to the movement of the head and eyes in concert, but they also did so in reaction to eye movements alone. Furthermore, in certain contexts, they appeared to account for the opacity of the object at which the experimenter gazed (see Povinelli

& Eddy, 1996c). For instance, they attempted to follow an experimenter's gaze to the other side of a solid partition as if they understood its obstructive properties, rather than looking past the partition for an interesting object to which the experimenter was apparently orienting. In this context, we also demonstrated that chimpanzees could exploit gaze cues to locate hidden food (Povinelli et al., 1999, 2002; see also Barth, Reaux, & Povinelli, in review). Thus, our results, taken in concert with those from other labs, provided strong evidence that chimpanzees (and other nonhuman primates) were very adept at monitoring and using the gaze of others.

[Insert Figure 1 about here]

At the same time, however, we discovered robust evidence that these same chimpanzees did not appreciate the psychological aspect of 'seeing' – for example, the different visual experiences of someone with blindfolds over their eyes versus someone with blindfolds over their mouth. The chimpanzees were trained to use their species-typical begging gesture to request food from an experimenter (see Figure 1). Probe trials, in which the chimpanzees were required to choose between two experimenters, one of whom could see them and one of whom could not (see Figure 2), were interspersed with these single-experimenter trials. If the chimpanzees genuinely understood that in each case only one of the experimenters could see their gesture, then they should have preferentially gestured to that person. Chimpanzees were presented with a variety of different conditions in which the experimenters were generally matched except for the critical variable ('able to see' versus 'not able to see'). None of the chimpanzees spontaneously chose correctly from the first trial forward, except for the condition where one experimenter faced forward and the other had her back turned to the chimpanzee (Povinelli & Eddy, 1996a). The results of a lengthy and carefully constructed series of over a dozen follow-up studies consistently supported the conclusion that the chimpanzees were not making inferences about the

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experimenters' abilities to see them, but were instead learning to predict who would respond to them on the basis of a prioritized set of observable features related to the experimenters' postures. For instance, chimpanzees first attended to the general frontal orientation of the experimenters' bodies, then to whether the experimenter's face was present, then to whether or not the experimenter's eyes were visible. Over time, they learned to discriminate correctly across even the most initially difficult conditions. However, this learning did not seem to be retained when they were re-tested in a new series of tests several years later (Reaux et al., 1999). In addition, the chimpanzees did not succeed at certain mixed conditions in which the previously 'correct' experimenter posture from one condition was paired with the previously 'incorrect' experimenter posture from a different condition (Reaux et al. 1999). Instead, the chimpanzees used their prioritized rule structure – even when it led them to choose the experimenter who could not see them! Thus, the chimpanzees started with some general rules about postural orientation, learned to understand the importance of still others, but never appeared to understand them as indicators of unobservable visual attentional states. This pattern of results has been replicated in other species as well (Vick & Anderson, 2003), suggesting that a strategy of attending to prioritized rules about observable features is not an idiosyncratic adaptation of chimpanzees alone.

[Insert Figure 2 about here]

To be sure, our conclusion is controversial. Although initially concurring with these findings, more recently Tomasello's research group has argued that new studies warrant the conclusion that chimpanzees do, in fact, reason about perceptual states such as *<seeing>*. Hare, Call, and Tomasello (2000) reported the results of several studies using a competitive paradigm which they believe support the conclusion that chimpanzees do infer mental states such as

<*seeing*> (see also Hare, 2001; Hare, Call, & Tomasello, 2001; Tomasello, Call, & Hare, 2003a, b). However, foundational aspects of the results of those studies were not independently replicated (Karin-D'Arcy & Povinelli, 2002), and, more importantly, alternative interpretations of the results of such studies are possible (for a detailed discussion, see Povinelli & Vonk, 2003, 2004). Indeed, a logical analysis of these (and other studies) has shown that the observed outcomes can be just as easily produced by an organism that reasons solely about the observable behavioral features of the experiment – precisely because those are the observable features on which the chimpanzees are supposed to infer underlying states. In short, there is no unique causal or predictive work to be performed by the inference of <*seeing*> in these studies (see Povinelli and Vonk, 2004).

Our purpose here is not to review the growing and controversial literature in detail (a good summary of the current controversy in this area can be found in the debate between Povinelli & Vonk [2003, 2004] and Tomasello et al. [2003a, 2003b]). However, by illustrating the general state of the controversy, we have sufficiently outlined our reasons for believing that, at present, there is no strong reason to think that nonhuman primates reason about unobservable mental states – a possibility consistent with our conclusion from the concept formation literature. At the same time, there is ample evidence to conclude what we already knew: chimpanzees are keen observers of readily perceivable features of the social world, and make predictions about future states of that world on the basis of such features.

The reinterpretation hypothesis

If we are to seriously consider the possibility that chimpanzees and other species might not reason about mental states, then it is necessary to explain why, in our unstudied interactions with them, we readily attribute such abilities to them. Povinelli and colleagues have offered an

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evolutionary solution to this apparent tension and labeled it the 'reinterpretation hypothesis.' They have proposed that theory of mind may be a human specialization that was grafted into existing cognitive systems for reasoning about social behavior that they inherited from their ancestor with the African apes (Povinelli, Bering, & Giambrone, 2001; Povinelli & Giambrone, 1999). Importantly, this new system for representing mental states did not replace the ancestral systems for representing behavioral abstractions, but was integrated with such systems. At a broader level, the model suggests that, whereas evolution has sculpted the minds of virtually all social species to detect and reason about behavior, the ability to explain behaviors in terms of unobservable mental states is an innovation peculiar to humans. On this view, theory of mind can best be thought of as an additional social cognitive ability, unique to humans, that allows us to attribute mental states as the causes of overt behavioral acts – acts which all primates (and probably most vertebrates) have the ability to perceive.

Thus, the reinterpretation hypothesis clarifies an important confusion that pervades much of the writing about the evolution of theory of mind: the tendency to contrast the possibility that chimpanzees possess a theory of mind with a 'behaviorist' straw man alternative account. On the 'behaviorist' account, chimpanzees are seen as systems which form 'simple' rules or learned associations (see Baldwin, 1988; Tomasello & Call, in press). And, after such an account is dismissed as being an intuitively unappealing explanation for their complex social behavior, the 'alternative,' that they construe behavior in terms of mental states, is held up as more plausible. For instance, in reference to the performance of Sarah, the chimpanzee who participated in the first attempts to investigate theory of mind in chimpanzees (see Premack & Woodruff, 1978), Tomasello writes: "This raises the possibility that what Sarah was doing was something cognitively much simpler than understanding the intentionality/mentality of other animate

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beings" (1999, p. 19). Sarah had been required to choose a picture that depicted the logical next step in the completion of an intentional act performed by a human whom she had observed on video. Although Premack and Woodruff (1978) interpreted Sarah's ability to do so as evidence that she understood the intentions of the actor, it was later suggested that her choices may have been determined by knowledge of a logical sequence of events or pairing of objects, such as locks and keys, based on her prior experience in the world (Savage-Rumbaugh, Rumbaugh & Boysen, 1978). The latter account of her behavior is generally deemed less cognitively interesting or sophisticated. The point often missed in such analyses is that the ability to reason about mental states *depends on* the ability to represent the behavioral associations. A human watching the same video clips would need to make use of the same behavioral information and form the same associations. The construction of such behavioral abstractions is exactly what the human theory of mind system 'reads' in mentalistic terms. Thus, the human system for interpreting behaviors in mentalistic fashion is not independent of the behavior-reading system, but instead depends on it.

The key insight of the reinterpretation hypothesis is that it *expects* humans and their nearest living relatives to behave in a highly similar manner, regardless of whether theory of mind is a human specialization. Furthermore, because the hypothesis posits that the theory of mind system was grafted into existing, highly 'sophisticated' and 'complex' systems for reasoning about behavior, it further expects that a large number of behaviors that become intimately connected with the theory of mind system in human development would be present in strictly hypothetical 'theory-of-mind-less' chimpanzees. On this view, it should be clear that the mere fact that we effortlessly attribute theory of mind to chimpanzees on the basis of the presence of such behaviors, has no bearing whatsoever on whether they actually possess such a

system. And, finally, in anticipation of our conclusion, the generalized version of the reinterpretation hypothesis is that in each 'domain' of knowledge, the human mind has evolved specializations for 're-interpreting' observables in terms of unobservables, with the foundation being ancient mechanisms for forming abstractions about the manifest features of the world (see also Povinelli, 2004).

Physical Causality

The distinction between concepts that refer to observable versus unobservable aspects of the world has also been investigated in the context of research exploring nonhuman primates' (especially chimpanzees') naïve or folk physics. Humans regularly invoke concepts about physical forces to explain events in the physical realm. At the most extreme level, humans have created theories about the observable world which rely on the causal power of unobservable entities or forces such as God, gravity, mass, quarks, and electricity. The idea of gravity, for example, was posited as a theoretical construct to explain observable interactions of objects, not a description of an observable feature of those interactions. One can observe that an object falls when it is released above the ground and one can observe the relative effects of dropping objects of various sizes. However, in humans, at least, these representations of the observable features of the world are linked to systems which represent and reason about *unobserved* features of the world. The distinction between the abstractions formed from the observable features of the world versus the theoretical notions we map onto those abstractions is illustrated in Table 1. Importantly, these theoretical notions are not present only in adults, they appear to emerge at a very young age in human children (see review by Povinelli, 2000, Chapter 3). In a series of exceptionally clever studies, for example, Shultz and colleagues have shown that by 2 or 3 years of age, children's causal explanations of simple events prioritize the unobserved features of the

situation (e.g. 'force' transfer) over the readily observed features (proximity, order of movement, etc.) (Shultz, Altmann, & Asselin, 1986).

Over the past decade or so, there has been a resurgence of interest in nonhuman primates' understanding of objects, both in the context of tool use and in the context of their systems for object representation in general (Boesch & Boesch, 1990; Cacchione & Krist, in press; Fujita, Kuroshima, & Asai, 2003; Hauser, 1997; Hauser, Kralik, & Botto-Mahan, 1999; Hauser, Pearson, & Seelig, 2002; Hauser, Santos, Spaepan, & Pearson, 2002; Kohler, 1925; Matsuzawa, 1996, 2001; Munakata, Santos, Spelke, Hauser, & O'Reilly, 2001; Santos & Hauser, 2002, Santos, Ericson, & Hauser, 1999; Santos, Miller, & Hauser, 2003; Visalberghi & Tomasello, 1998). Much of this work has explored the generalization abilities of nonhuman primates and their understanding of means-ends relationships (e.g., Hauser, 1997; Hauser et al., 1999; Hauser, Santos, et al., 2002). A subset of this work, however, has specifically targeted the question of whether species other than humans are unique in their ability to reason about unobservable aspects of objects and their interactions (see Kralik & Hauser, 2002; Limongelli, Boysen, & Visalberghi, 1995; Povinelli, 2000; Santos & Hauser, 2002; Visalberghi, 1997, 2002; Visalberghi & Limongelli, 1994, 1996; Visalberghi & Trinca, 1989; Visalberghi & Tomasello, 1998).

For example, in the mid-1990s, we began confronting our chimpanzees with simple tool-using problems that were designed to explore their representation of the underlying causal structure of tool use, and in particular, whether they recruit folk concepts about things like gravity, weight, shape, and physical connection to predict the behavior of tools in novel situations. We introduced our chimpanzees to numerous problems through which we could probe their understanding of the role that various factors played in the behavior of the objects (Povinelli, 2000). Although our apes were quite good at learning the problems with which we

confronted them, they demonstrated little evidence that they understood the relevant, but unobservable properties of gravity, transfer of force, physical connection, etc. Rather, consistent with their performance in the tasks designed to evaluate their understanding of abstract mental states such as <*seeing*>, they appeared to learn rules about the tasks directly based on observable features associated with success. For the chimpanzees, one of the most powerful of these heuristics derived from observable features of the world was the notion of 'contact' (see also Cacchione & Krist, in press; Kohler, 1925).

As one example of our chimpanzees' lack of use of a concept commonly utilized by humans to succeed at similar problems, consider their performance in the trap-tube problem, in which they had to insert, or push an already inserted tool, through a tube in order to eject a food reward (see Limongelli, Boysen, & Visalberghi, 1995; Visalberghi, 1993; Visalberghi & Limongelli, 1994, 1996; Visalberghi & Trinca, 1989). In this series of experiments, a number of our chimpanzees learned to insert the tool into the tube opening farthest from the reward (see Figure 3); but having learned this, in later variations of the task, they did not appear to give any consideration to the 'up' versus 'down' orientation of the trap (see Figure 4; Povinelli, 2000, Chapter 4). Even when we made it quite costly for them to use representations like 'insert the stick into the end farthest from the reward' (see Figure 5), or when the representations were either irrelevant (the trap was in the 'up' position) or led to losing the reward, the chimpanzees still relied on those heuristics. Thus, the subjects had apparently not learned something about the deep causal structure of the task.

[Insert Figures 3, 4 and 5 about here]

Likewise, in an analogous procedure utilizing a table with a trap (a large hole), although the chimpanzees learned to attend to specific relations among the tool, reward, and substrate,

their patterns of acquisition suggested that they did not seem to appreciate the relevant factors within a framework of unobservable causal forces (Povinelli, 2000, Chapter 5). In a related experiment, Hood, Hauser, Anderson and Santos (1999) applied Hood's (1995) 'gravity-rules task' to the behavior of cotton-top tamarins. In this task, objects were dropped down a chimney connected to various containers by an opaque tube. It was found that the tamarins continued to search in the container where the food was dropped on the first trial, regardless of whether the chimney was connected to that container, demonstrating a lack of understanding of the physical constraints operating in the task.

Hauser and colleagues have repeatedly shown that monkeys (cotton-top tamarins), after being trained how to use a tool, will readily transfer this learning to novel tools of different shapes and colors (Hauser 1997; Hauser et al., 1999; Hauser, Pearson, et al., 2002; Hauser, Santos, et al., 2002; for similar findings with chimpanzees, see Povinelli, 2000). A recent study with capuchin monkeys replicated this finding, but, in addition, showed that these monkeys, while not being distracted by those particular irrelevant features of the tools, still failed to attend to relevant task variables. For instance, like our chimpanzees, they did not learn to pull in the appropriate tool to procure a reward when obstacles or traps impeded performance (Fujita et al., 2003).

Although some authors have suggested that parallel representational abilities underwrite the tool-using abilities of capuchins and chimpanzees (Westergaard, Liv, Chavanne, & Suomi, 1998), others have implied that capuchins do not use tools with the same degree of cognitive complexity as chimpanzees (Westergaard, 1999). Some have hypothesized that the success of apes, but not capuchins, is based on an ability of apes to represent the causal relations between tool use and its consequence (Limongelli et al., 1995, Visalberghi, 1990; Visalberghi, Fragaszy,

& Savage-Rumbaugh, 1995). However, our own studies have given strong reason to doubt such a construal on the part of even chimpanzees. For instance, in addition to the studies just described, in over two dozen studies, our chimpanzees: (a) did not initially understand that the base of a tool used to procure reward would need to make contact with the reward, (b) failed to understand that they should select a rigid versus a malleable rake, (c) exhibited virtually no understanding of the distinction between 'contact' and 'physical connection,' and (d) in simple tool-construction situations, they failed to match the tool form to the problem type (Povinelli, 2000). Instead, although the chimpanzees appeared to form general concepts about observable features of the tests ('contact' versus 'no contact'), they rarely if ever performed in a way consistent with the predictions of a model which posited that they were using unobservable causal concepts to predict how the objects would behave when they acted on them.

More recently, our laboratory has targeted a particular object property, weight, for analysis under the framework of the unobservability hypothesis in an extensive series of studies. Thus far, we are finding that chimpanzees' notions of weight and support are vastly different from our own. The chimpanzees' concept of weight appears to be tied directly to the kinesthetic sensations directly perceived by the lifting of objects of various weights, and in direct contrast to human adults and children, chimpanzees do not appear to reason about weight as an independent and unobserved object property (e.g., Smith, Carey & Wiser, 1985).

Finally, it is also worth noting that chimpanzees may not seek causal explanations for physical events at all. There is a great paucity of experimental research attempting to investigate this possibility. One relevant set of studies comparing the behavior of chimpanzees and children demonstrated that children, but not chimpanzees, attempted to seek an explanation for their failure to perform certain tasks (Povinelli & Dunphy-Lelii, 2001). For example, both species

were trained to stand a wooden L-shaped block vertically upright. On occasion, probe trials were presented in which a visually identical block could not be stood upright by virtue of a hidden lead weight that made that block unbalanced. Children tended to turn the block over in an apparent attempt to investigate whether there was some property of the block that made it dysfunctional. Chimpanzees did not do so, but did persist in attempting to stand the block upright for the full duration of the trial.

Thus, although chimpanzees and other nonhuman primates seem adept at attending to and learning about the observable features and propensities of objects, they do not appear to recruit unobservable forces or entities to explain *or* predict their behavior.

Diversity Without Hierarchy

We have limited the preceding review to three areas of research (concept formation, theory of mind, and physical causality). From this brief review, we conclude that there is little evidence that chimpanzees (or other primates) represent the world in ways which would suggest they posit 'unobservable' entities or processes to explain or predict observable events. On the other hand, there is overwhelming evidence to suggest that closely related species share homologous mechanisms for forming abstract concepts about observable aspects of the world (in the case of humans and chimpanzees, for example, our respective species undoubtedly represent many macroscopic objects and events in similar ways). Likewise, in thinking about domains that we have not explored in this essay, (e.g. time, number, self), one could assert that humans and chimpanzees are extraordinarily similar in how they represent overt aspects of the world, but remain skeptical of the evidence that chimpanzees objectify these things as hypothetical entities in their own right. Finally, there are still other concepts that may be even farther removed from the observable features of the world (e.g., the concept of 'memory'), such that at the present it is

difficult to imagine how evidence that nonhumans reason about such things could ever be obtained. This observation should not be confused with the claim that no such evidence will ever be obtained, or that it is impossible to obtain such evidence (for example, in the context of the current debate over theory of mind, although we have argued that there is no good evidence at present that chimpanzees reason about mental states, and that current techniques are not adequate to resolve such questions, we have positively highlighted techniques that could potentially provide such evidence; see Povinelli and Vonk, 2003, 2004).

If what we have just said is true, then the unobservability hypothesis becomes more complicated. It means that there are ontologically important distinctions in the ways in which humans reason about things that have no straightforward physical embodiments. We reason about God, ghosts, and other supernatural phenomena; as children, we engage in pretend relationships with imaginary objects; we create fantasy worlds populated by unicorns, Martians, and hobbits; in our folk ontologies, we treat 'time', 'memory' and 'consciousness' as real entities or processes. The variety of such 'unobservables' raises two questions: First, are all of these concepts equally 'theoretical' under the framework of the unobservability hypothesis, and second, to what extent is our day-to-day behavior causally influenced by representations of unobservables like mental states and physical forces, as opposed to representations of their observable manifestations? We end this chapter by briefly reflecting on each of these questions.

Are 'unobservables' a homogenous class?

To begin, we need to emphasize that the distinction we are drawing is between things that are *in principle* unobservable versus those that are in principle observable – *not* between things that are being or have been observed versus those that have not been. Building representations of novel situations or events (i.e., imagining, predicting), as long as they are composed from

conceptual elements that are observable, would not seem to pose any special problem for nonhumans from the perspective we have adopted. We see no reason why chimpanzees, even if they do not think about mental states, could not imagine a novel consequence of some actions they have observed, or some modification of a pre-existing object. For example, Kohler's (1925) famous experiments with chimpanzees, if nothing else, showed that chimpanzees could imagine how a box could be moved into a novel position under a suspended banana, which would then allow them to reach it. We suspect such operations go on frequently in the mental workspace of chimpanzees (and an indefinitely large number of other species!). In any event, we do not see how such mental operations involving the manipulation of concepts that refer to potentially observable or tangible things has any bearing on the claim that they do not reason about unobservables (i.e., strictly theoretical entities that can have no perceptual embodiments).

Having said that, we can turn our attention to the important question, Are all 'non-referring concepts' equivalent? For example, unicorns and beliefs are both theoretical, non-real entities, but there would seem to be an important difference between them. Whereas unicorns would seem to be a minor variant of an observable entity (i.e., a horse), 'beliefs' or 'forces' or 'time' would seem to be constructs of a completely different kind, related to the entities with which they interact, to be sure, but of a qualitatively different nature. If so, then for chimpanzees that were to become familiar with both real horses and fictional portrayals of unicorns, there would be no particularly salient distinction between them. In fact, the only difference between humans and chimpanzees, in this regard, would be that, whereas humans would represent the unobservable 'real' versus 'unreal' distinction between horses and unicorns, chimpanzees would not.

Does this distinction imply that certain kinds of unobservable things might be more likely to be represented by chimpanzees than would others? At present, we have no direct answer to this question. But, from the perspective of the unobservability hypothesis, we would insist on drawing a distinction between forming concepts about things that can be observed (a physical representation of a unicorn) versus forming concepts about the aspect of these things that cannot be observed (unicorns are 'not real').

The causal role of unobservables in behavior

Humans are clearly capable of reasoning about unobservables of the most abstract kind, the kind that in principle could never be directly observed. But, how much of our own behavior is causally influenced by such representations? Are we more likely to use representations of theoretical constructs rather than representations of observables, to predict the behavior of other objects and entities in the world or to explain it – or do we invoke such constructs equally in both contexts? A recurring theme of this chapter has been the distinction between predicting events versus reasoning about and explaining the underlying causal forces involved in such events. As many scholars have noted, the world itself has an immense amount of information contained within it; systems which perceive and reason about these observable features have a large (and currently largely unspecified) power to predict future events (for examinations of how these systems might develop and operate in humans, see Baird & Baldwin, 2001; Zacks & Tversky, 2001). A critical question arises, then, as to when is it necessary to posit that a system is representing and utilizing concepts that refer to underlying (unobservable) causes of an event or behavior. Note that we are not questioning whether humans do so nor whether this ability can be demonstrated in experimental contexts; the answer to both of these questions is 'yes.' But, in what circumstances, exactly, are such concepts playing a causal role (see especially, Povinelli &

Giambrone, 1999)? Humans undoubtedly utilize such concepts when attempting to generalize their understanding of the world to novel contexts and to transfer formal knowledge to others, and there may be intimate causal connections between the human ability to reason about mental states and other aspects of human culture, such as pedagogy and ethics (see Povinelli and Godfrey, 1993; Russon et al., 1998; Tomasello, 2000; Whiten, 1998).

But, important questions remain unanswered: What is the relative degree of the use of concepts about unobservables even in humans (e.g., Zacks & Tversky, 2001)? In what contexts are concepts about unobservables most activated? Can the causal work of such representations be fully understood and disambiguated from systems that do not possess such concepts? It is fully possible that, although humans represent theoretical constructs, these constructs may not constitute the primary driving force in much of human behavior. Thus, although this additional representational capacity may lead to profound differences in the reasoning processes of humans and our closest relatives, in some contexts, the extent and specific role of such a capacity has not yet been fully specified.

Treating Similarity and Difference Equally

Some may believe that the unobservability hypothesis is just another example of 'setting the bar too high,' unnecessarily overlooking important abilities within various cognitive domains that different species have evolved, or downplaying similarities between humans and other species in order to celebrate the superiority of the human mind. "Déjà vu!," the most extreme skeptic shouts. "Every time you psychologists try to define humans by one trait, you wind up embarrassing yourself. Remember humans as the only tool using (then later, tool-making) species? Jane Goodall forever deflated that one!"

But, truly, these concerns are orthogonal to the central point of this essay – in fact, this outburst reveals the hegemony of the "phylogenetic scale" view that continues to grip comparative psychology. To make the point clearly: there is no 'bar' to set. Identifying the abilities that one monophyletic group uniquely possesses is not a 'test' for other species; it is only an attempt to fully characterize the psychology of each group. In the case at hand, we seek to identify the uniquely derived features of human cognition so that, ultimately, we can develop a more complete picture of what's *human* about the human mind. Furthermore, thinking that broad categories, such as 'tool-using', will capture meaningful differences between humans and chimpanzees, for example, misses the point that they exhibit massive differences in the number, method of construction, importance, and understanding of the tools they respectively make and use. Many of these differences may stem from tightly canalized differences between the species (see Johnson-Frey, 2004; Povinelli, 2000).

Thus, humans should not be misconstrued as some sort of cognitive benchmark by which all other species must be measured in order for us to be interested in what makes our minds unique. If, in the final analysis, it turns out that there are certain respects in which the chimpanzee's mind is massively different from our own, this would in no way imply that their mind is any less efficient or less interesting than our own. Chimpanzees need not be "inching closer to humanity" (de Waal, 1999, p. 635) in order to be of interest in their own right. We suggest that more insight will be gained by seeking and embracing the idea of psychological diversity – an idea that treats similarities and differences among species as equally important – than by treating other minds as watered-down, incomplete versions of our own.

1. For instance, the subjects may have selected the animal whose image evoked more fear or anxiety within themselves without internally describing that animal as belonging to a general category of dominance. It would be interesting to know whether the subjects would have predicted dominance for individuals previously demonstrating dominant behaviors in novel scenarios rather than basing their responses on an immediately preceding event. This is not to suggest that correct categorization by nonhuman primates never reveals evidence for understanding 'why' exemplars belong together in a category, but that the 'why' may not rely on unobservable theoretical constructs.

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Table 1. Observable versus unobservable features used to describe a small subset of physical events.

Observation	Observable Features	Unobservable Features
Collision	Proximity, order of movement, speed of movement, temporal succession	transfer of force
Falling objects	Direction of movement, speed of movement	gravity, force
Differential effects (kinesthetic sensations) caused by similarly sized objects	Deformation, noise, effects on contact with other objects, muscle tension	weight/mass
Balanced objects	Surface area, slope, contact, shape, deformation	strength/solidity, balance
Object-object correlated movement	Contact, movement patterns, containment	physical connection
Unexplained occurrences	Noncontingent events, atypical object interactions	supernatural forces

Figure Captions

Figure 1. A chimpanzee uses her species-typical begging gesture to request food from an experimenter.

Figure 2. A subset of probe trial conditions presented to the chimpanzees in Povinelli & Eddy (1996a), in which one experimenter could see the chimpanzee and the other could not. a) Front/Back, b) Buckets, c) Hands, d) Blindfolds.

Figure 3. A chimpanzee inserts the tool into the tube opening farthest from the reward.

Figure 4. a) The trap is in the 'up' orientation versus the b) 'down' orientation.

Figure 5. A cost to inserting the tool in the tube opening farthest from the reward is imposed by setting the tool closest to the tube opening closest to the reward.