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# Emerging Differentiation of Folkbiology and Folkpsychology: Attributions of Biological and Psychological Properties to Living Things

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COLEY, JOHN D. *Emerging Differentiation of Folkbiology and Folkpsychology: Attributions of Biological and Psychological Properties to Living Things*. CHILD DEVELOPMENT, 1995, 66, 1856–1874. Research suggests that for adults, “folkpsychology” and “folkbiology” represent distinct conceptual domains for reasoning about living things. However, it is not clear whether these domains are distinct for children; past work suggests that the 2 systems are confused until age 10, and that radical theory change accounts for eventual differentiation. To examine this claim, 16 subjects each at ages 6, 8, and adult were shown pictures of predatory and domestic animals and asked whether each animal displayed a variety of biological properties (e.g., has blood) and psychological properties (e.g., can think, can feel angry). Subjects at all ages showed clearly different attribution patterns for biological versus psychological properties. This dissociation of attribution patterns provides evidence that by kindergarten, notions of folkpsychology and folkbiology are sufficiently differentiated to constitute distinct and independent conceptual domains. This in turn suggests that radical theory change regarding living things either occurs prior to the beginning of formal education, or does not explain the development of folkbiological knowledge.

More and more, researchers in cognitive psychology and in cognitive development are acknowledging the possibility that all concepts are not created equal. How we understand categories of human-made artifacts may differ fundamentally from how we understand categories of naturally occurring objects. The causal principles believed to operate on physical objects may differ fundamentally from the causal principles believed to operate on human behavior. In contrast to classical domain-general theories of cognitive development (e.g., Bruner, Goodnow, & Austin, 1956; Inhelder & Piaget, 1964; Vygotsky, 1986), many developmentalists now adopt a domain-specific approach to conceptual development (Atran & Sperber, 1991; Carey, 1985; R. Gelman, 1990; S. Gelman & Coley, 1991; Hirschfeld & S. Gelman, 1994; Keil, 1989; Markman, 1989). Domain specificity is the proposal that humans have qualitatively different ways of thinking about different aspects of the world around them.

## *Folkpsychology and Folkbiology as Distinct Conceptual Domains*

Although there are different approaches to domain specificity, two areas of human cognition that consistently emerge as potentially important domains are folkpsychology and folkbiology. Folkpsychology, often under the title of “theory of mind,” involves folk notions of how the mind works and the role of thoughts and emotions in motivating behavior. For most Americans, things like beliefs, desires, thoughts, and emotions qualify as psychological entities. Things like drawings of bicycles, or bicycles, or armadillos do not. Research by Wellman and colleagues (Estes, Wellman, & Woolley, 1989; Wellman & Estes, 1986) shows that by age 4, children can reliably distinguish between, for example, a ball and a thought about a ball, saying that they could touch the ball with their hands, but not the thought. A great deal of work has addressed children’s emerging understanding of human psychol-

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logical processes. By age 3, children understand that other humans have beliefs and desires that can differ from their own (Wellman, 1990), and by age 4 children understand that the beliefs of others can run counter to what the child knows to be true (e.g., Perner, Leekham, & Wimmer, 1987). Children also understand that people's behavior can be predicted on the basis of their beliefs and desires (Wellman & Bartsch, 1988).

Folkbiology has been proposed as another basic conceptual domain. Being able to understand the growth and natural processes of other living things is a critical cognitive task for humans from an evolutionary standpoint. Even members of modern, industrial, urbanized societies are surrounded by plants and animals. Thus, it is reasonable to expect that living things occupy a central position in human cognition. Indeed, a growing body of research suggests that there is a set of principles or properties that adults, and apparently even young children, think apply primarily to living organisms. For example, both adults and children know that behavior and appearance of living things are diagnostic of their identity (Gutheil, Backscheider, & Coley, 1993; Keil, 1989). However, children as well as adults appear to be essentialists (Medin & Ortony, 1989). That is, they believe that the ultimately critical—and unseen—causal mechanisms responsible for appearance and behavior reside inside the organism (see S. Gelman, Coley, & Gottfried, 1994, for a review). Living things are also thought to have innate potential for the development of particular characteristics (S. Gelman & Wellman, 1991). The actions of a living thing are thought to be caused by the thing itself rather than some outside agent (R. Gelman, 1990; Massey & R. Gelman, 1988). Children know that living things, unlike other kinds of objects, spontaneously grow and heal themselves (Backscheider, Shatz, & S. Gelman, 1993; Rosengren, S. Gelman, Kalish, & McCormick, 1991). They also believe that anatomical and physiological, but not social, properties are inherited from parents (Springer & Keil, 1989). Finally, categories of living things seem to provide especially rich inductive potential for the projection of newly acquired knowledge about one instance to an entire class (S. Gelman & Coley, 1990; S. Gelman & Markman, 1986).

While the domains of folkpsychology and folkbiology seem distinct for adults, debate continues as to their developmental ori-

gins. This debate centers on how to characterize the differences between preschoolers' and adults' conceptions of living things, and what mechanism best accounts for developmental change. Specifically, researchers disagree on whether folkbiology is a distinct conceptual domain by the beginning of the school years (e.g., Keil, 1989, 1994; Wellman & S. Gelman, 1992), or whether it is initially conflated with other forms of knowledge, namely, folkpsychology (e.g., Carey, 1985). These two positions have very different implications for how children arrive at an adult understanding of the natural world. If children fail to distinguish the two domains until relatively late in development, then some sort of radical theory change or major restructuring must be invoked to explain how the two are ultimately disentangled. However, if the two domains are distinct by the time children begin school, then either radical theory change and domain differentiation take place during the preschool years, or they do not take place at all. On this view, development may consist of a more gradual elaboration of existing basic conceptual distinctions.

Investigation of the emergence of children's conceptions of folkbiology and folkpsychology provides a strong test of domain specificity. Unlike other oft-cited interdomain comparisons (e.g., living things vs. human-made artifacts), this particular domain differentiation does not involve thinking differently about distinct, and perhaps even mutually exclusive, sets of objects. Rather, it involves applying two distinctive modes of reasoning to the same objects. People, animals, and plants are biological entities; people, and arguably some animals, are psychological entities. Thus, comparing folkbiology and folkpsychology avoids problems caused by differences in complexity, salience, or intrinsic interest in different kinds of objects by examining different ways of thinking about the very same objects.

#### *Differentiation of Folkbiology from Folkpsychology*

Carey, in her influential volume on conceptual change in children (1985), suggests that for children, biology is not initially an autonomous domain, but one that emerges from the domain of naive psychology. She further argues that the development of knowledge about living things is an example of radical theory change. I would like to argue that children may not conflate these two domains to nearly the degree that Carey suggests. This in turn has implications for the

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radical theory change view of developmental change in these domains.

Carey (1985) describes several ways in which younger children's notions of folkbiology differ from those of older children and adults. In one set of studies (presented in Carey, 1985, chap. 3), subjects at ages 4, 5, 7 years, and adult were shown pictures of the following items: aardvark, dodo, hammerhead shark, stinkbug, orchid, baobab, and worm. Subjects were asked whether each exhibited properties such as *eats*, *breathes*, *can get hurt*, *sleeps*, *has a heart*, and *thinks*. Two results are of interest. First, subjects showed a regular decline in the attribution of properties to animals in an order that roughly corresponded to phylogenetic distance from humans. Subjects attributed the most properties to people, followed in order by aardvark, dodo, stinkbug, shark, and worm. Four- and 5-year-olds showed a significant break between people and all other animals; by age 7 there was no longer a significant break between humans and higher animals. Thus, up to about age 10, children decided whether an organism possessed a certain property based on their knowledge of whether humans had that property and the perceived similarity of the organism to humans.

The second important result was a lack of differentiation among properties for the younger age groups. Four-year-olds showed no differentiation among properties, and 5- and 7-year-olds showed only a little. For example, younger children did not differentiate between *has bones*, which should be attributed only to vertebrates, and *has babies*, which should be attributed uniformly to all living things. In contrast, adults showed a property type by animal interaction, suggesting that properties were attributed differently for different animals. For younger children, then, patterns of property attribution depended little on which specific property was being considered.

In another set of studies, Carey (1985) found that children show a marked asymmetry of projection of novel properties. For unfamiliar properties, such as *has an omentum inside*, children were much more likely to project properties taught about humans than to project those same properties taught about other species. For example, when taught that humans have an omentum inside of them, younger children were willing to project that property to other nonhuman animals, like dogs, or even bees. However,

when taught an unfamiliar property about a nonhuman species, such as dogs, children seldom projected the property to humans or even to other animal species. Strikingly, young children were more willing to project a property from humans to stinkbugs than from bees to stinkbugs. Based on these results, Carey argues that "the prototypicality of people plays a much larger role in determining 4-year-olds' projection of [biological properties] than does similarity among animals" (1985, p. 128).

In sum, Carey found that up to age 10, children's inferences about known biological properties, such as having bones and having babies, were based on similarity to humans, rather than on taxonomic similarity among animals. Further, young children did not differentiate among kinds of properties in their attributions. Finally, in terms of patterns of inferences of unfamiliar properties, humans seem to occupy a central position that overrides salient similarity relations among animals. Carey (1985) argues that, taken together, these findings show that children have a very different understanding of biology than adults. She contends that older children's and adults' knowledge about living things is embedded in a "biological" explanatory theory wherein organisms are seen as systems of internal parts working to solve certain universal problems of survival. This theory allows older children and adults to acknowledge important biological similarities between plants and animals. For younger children, however, Carey argues that living kinds are embedded in a "psychological" explanatory theory, wherein biological functions are seen as analogous to the beliefs and desires that govern human psychological functioning. It is from this folkpsychological framework that an autonomous domain of folkbiology eventually emerges.

Thus, Carey (1985) argues that before the age of 10, children do not have autonomous conceptual domains of folkpsychology and folkbiology, and that this differentiation is eventually achieved through the mechanism of radical theory change, around age 10. When children have learned enough about biological functions to realize that they are common to all living things, their thinking undergoes a radical reorganization, resulting in two independent domains of biology and psychology. The radical theory change view of the acquisition of biological knowledge makes several strong developmental predictions.

One consequence of Carey's position is that children should attribute properties to living things with gradually decreasing frequency corresponding to gradually decreasing similarity to humans (although this response pattern is neither necessary nor sufficient for the claim that folkbiology and folkpsychology are initially undifferentiated; see Hatano & Inagaki, 1987). It is possible that Carey's choice of items may have increased the likelihood of obtaining patterns of regularly decreasing attributions with decreasing similarity to humans. In her first study, Carey used a human, a quadrupedal mammal, a bird, a fish, and one (in some cases two) invertebrate. In her second study, Carey dropped the bird, using two mammals (counting the human), two invertebrates, and a fish. A more representative sampling of living things might reveal a different pattern of attributions and, specifically, might reveal a less regular drop-off in attributions.

A clearer implication of the view that early folkbiology and folkpsychology are undifferentiated is that younger children should not show different patterns of attribution for psychological versus biological properties, since they cannot make any principled distinction between biological and psychological construals of living things. Although this lack of differentiation among properties is one cornerstone of the theory-change argument, there are nonetheless suggestions of property differences in Carey's (1985) results. For instance, *thinks* was attributed at consistently lower levels than other properties. In addition, the range of properties limits the generality of Carey's conclusions. Carey used predominantly biological properties (*eats, sleeps, has bones, has a heart, has babies*), along with one psychological property (*thinks*). Thus, whereas her results demonstrate that children may not differentiate among kinds of biological properties, her findings leave open the possibility that children make a principled distinction between biological and psychological properties.

There is evidence that adults exhibit different patterns of attribution for different kinds of properties. Recently, Heit and Rubinstein (1994) showed that adults' attributions of anatomical and behavioral properties were predicted by different similarity ratings of species with respect to biological kind and behavior. Specifically, for pairs of animals that were taxonomically related but behaviorally dissimilar (e.g., a shark and a goldfish), subjects were more willing to infer

shared anatomical properties (e.g., "its liver has two chambers that act as one") than shared behavioral properties (e.g., "it usually travels in a back-and-forth trajectory"). Conversely, for pairs that were behaviorally similar but taxonomically distant (e.g., a shark and a wolf), subjects were more willing to infer shared behavioral properties than shared anatomical properties. Heit and Rubinstein argue that it is logically impossible for a single similarity metric to underlie both patterns of inferences; for adults, multiple similarity metrics underlie property attributions for living kinds, and different kinds of properties prime different similarity metrics.

Vera and Keil (1988) present evidence suggesting that preschoolers may have access to a biological explanatory system independent of folkpsychology, based on patterns of attribution of properties presented in "biological" versus other (e.g., "social-psychological") contexts. For example, a biological context for the property *eats* stressed that people eat food because they need it to live and grow. The social-psychological context for *eats* emphasized the enjoyable social aspect of being at meals with one's family. Overall, attributions for properties presented in a biological context were higher than those presented in other contexts. This suggests that context helped children access an existing, distinct biological explanatory system.

Inagaki and Sugiyama (1988) explicitly examined developmental changes in the patterns of inferences for familiar psychological and biological properties. They found that developmental patterns differed for inferences about biological versus psychological properties. Five-year-olds and adults were shown five exemplars each of mammals, birds, fish, insects, and plants, plus a human and a stone. They were asked whether each exhibited biological properties (*has bones, has a heart*) and psychological properties (*can feel happy, can feel pain*). Individual subjects' responses were classified as "category-based" if attributions dropped off sharply between higher-order categories (e.g., between mammals and birds), or "similarity-based" if responses gradually decreased with phylogenetic distance from humans.

For biological properties, most adults exhibited a category-based pattern, whereas most kindergartners showed a similarity-based pattern. For psychological properties,

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however, adults had no consensus response (42% category-based pattern, 56% similarity-based pattern). For kindergartners, 12% showed a category-based pattern, 48% were similarity-based, but a full 40% showed "other" unclassifiable patterns. Although kindergartners' performance for the two kinds of properties was not directly compared in the study, there are hints that children's attribution patterns for biological versus psychological properties differed. Children exhibited a higher proportion of "similarity-based" patterns for the biological properties than for psychological properties, and a much higher proportion of "other" patterns for the psychological properties.

In sum, Inagaki and Sugiyama (1988) asked children about biological and psychological properties, but found that a large proportion of children's patterns of projection of psychological properties was not classifiable within their system. This might reflect children's general confusion about the distribution of psychological properties. More likely, it could reflect the fact that there was no intuitively appropriate "psychological" dimension present in Inagaki and Sugiyama's stimuli to guide projection of psychological properties.

More generally, previous research clearly shows evidence for conceptual change and differentiation within the domain of biology. As children get older they increasingly differentiate among superordinate categories of organisms, and increasingly differentiate among biological properties with respect to their distribution across living things. However, previous research does not unequivocally show that folkbiology and folkpsychology are initially undifferentiated conceptual domains, nor does it unequivocally show that the mechanism of developmental change is radical theory change, for several reasons. First, as argued by Hatano and Inagaki (1987), whether children's inferences are based on similarity to humans and whether folkbiology and folkpsychology are differentiated can be seen as independent questions. Second, as argued above, despite hints of systematic differentiation in the results of both Carey (1985) and Inagaki and Sugiyama (1988), the issue of domain differentiation with respect to attribution patterns has not been directly addressed. One way to more directly address the question of whether children differentiate folkbiology from folkpsychology would be to examine patterns of attribution of biological and psychological properties over a

set of stimuli with inherent biological and psychological dimensions.

Multidimensional scaling research on the semantic organization of mammal names consistently reveals a dimension of "predatoriness," or "ferocity" (Henley, 1969; Howard & Howard, 1977). This dimension does not clearly map onto any biological taxon; most biological groups include both predators and nonpredators. Using this dimension, animals may be divided into "dispositional groups." Two such groups falling at either end of the predatoriness spectrum would be ferocious, wild predators and docile, domestic pets. Further, it seems especially likely that this ferocity-predatoriness dimension could be seen as having psychological implications. Animals falling into the two groups are predicted to have different perceived psychological makeups. Specifically, animals that have to find, stalk, catch, and kill their prey (e.g., tigers or hawks) may be perceived as being smarter than those who need not stalk their food. Also, the ferocious disposition of these animals may make it more likely for them to be perceived as being able to be angry. Conversely, domestic pets (e.g., guinea pigs or parakeets), given their relatively timid and gentle nature, may be perceived as more likely to be able to be happy, and more able to be scared, than the predators. Thus, by choosing species falling into these two dispositional groups, a priori predictions about the distribution of specific psychological properties may be made. If children project biological properties based on phylogenetic status but project psychological properties based on disposition, this can be taken as evidence for a principled distinction between folkbiology and folkpsychology.

Finally, if, as Carey (1985) argues, development of biological knowledge amounts to radical theory change, and children's conceptions of living things are based on a very different—in fact, incommensurate—theory, then a very different underlying model should characterize children's patterns of inferences as compared to those of adults. Thus, another way to look at the differentiation of folkbiology and folkpsychology is to ask whether children and adults share the same underlying body of folkbiological knowledge. A recent methodological innovation in cognitive anthropology, the Cultural Consensus Model, makes an examination of this issue possible. The Cultural Consensus Model (Romney, Weller, & Batchelder, 1986) provides a tool to discover

whether a single body of knowledge representing "cultural consensus" underlies subjects' responses to a set of questions. The cultural consensus model assumes that widely shared information is reflected by high, uniformly distributed agreement among individuals. The model is implemented by means of a factor analysis of a matrix of interinformant agreement in a given domain. If the factor analysis results in a single factor solution, then, according to Romney et al., one can conclude that a single model, or "cultural consensus," underlies the responses of the informants in that domain. In other words, if a single dimension underlies patterns of agreement within a domain, then consensus can be assumed for that domain. In contrast, if multiple dimensions underlie agreement patterns, this would suggest clusters of subjects who agree with each other rather than a single consensus.

The cultural consensus model has been widely applied to the categorization of folkbiological species (e.g., Atran, 1994; Boster, 1986; Boster & Johnson, 1989; Johnson, Mervis, & Boster, 1992). In the present study, a radical theory-change view predicts that a single underlying model of the distribution of biological and psychological properties over living kinds *should not* underlie all responses; children's and adults' knowledge should look very different, because they are organized by very different theories. Alternatively, if adults and children show strong consensus, this would weaken the radical theory-change account of developmental changes within this domain. (See Johnson, Mervis, & Boster, 1992, for a comparable use of the Cultural Consensus Model.)

This study was designed to address these three issues. First, the question of whether property attributions drop off regularly with dissimilarity to humans is examined. The addition of more intermediate taxa than used in previous research (e.g., a primate and reptiles) makes for a more continuous sampling from the phylogenetic spectrum, thus addressing the issue of whether findings of a significant drop-off between humans and nonhuman mammals, and a regular drop-off of property attributions along the phylogenetic spectrum, could be an artifact of the stimulus items used.

Second, the critical question of differential attribution of biological versus psychological properties is directly addressed. This is done using stimuli that fall into orthogonal dispositional groups (predatory vs. domestic) and taxonomic groups (mammal, bird, reptile, fish), and by employing a greater range of properties, including biological and psychological properties. Unlike in previous developmental research on this issue, a priori predictions exist regarding distinct patterns of attribution for biological versus specific psychological properties. If young children conflate the domains of folkpsychology and folkbiology, then they should not in principle differentiate patterns of attribution for psychological versus biological properties. Evidence that children do differentially attribute psychological and biological properties would suggest that they are capable of making a principled distinction between the two domains.

Third, the radical theory-change view predicts that different bodies of knowledge underlie the responses of children and adults, because they are organized by different theories. Alternatively, if adults and children seem to be drawing their responses from the same body of knowledge, this would suggest a less radical account of the developmental changes within this domain. The Cultural Consensus Model will be used to test this hypothesis.

## Method

### Subjects

Sixteen kindergartners (ages 5-6 to 6-8, mean age 6-1, eight male and eight female), 16 second and third graders<sup>1</sup> (ages 7-4 to 9-5, mean age 8-5, 10 male, six female), and 16 college students (ages 18 to 28 years, mean age 22 years, six males and 10 females) participated in this study. Subjects were from mixed ethnic backgrounds, and were predominantly middle to upper middle class. Children were recruited from a parochial elementary school; college students were paid for their participation.

### Materials

Materials consisted of pictures of 12 different living things, taken from the Peabody Picture Collection (Dunn, Dunn, Smith, Smith, & Horton, 1983). A complete list of stimulus materials is presented in Table 1.

<sup>1</sup> Throughout the rest of the article I refer to the second and third graders as "8-year-olds" for brevity's sake and because more of the children in this group were 8 years old ( $N = 8$ ) than either 7 or 9 ( $N_s = 4$ ).

TABLE 1  
STIMULUS ITEMS

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Critical items:
Predatory animals:
Tiger ( <i>Panthera tigris</i> )
Red-tailed hawk ( <i>Buteo jamaicensis</i> )
North American alligator ( <i>Alligator mississippiensis</i> )
Tiger shark ( <i>Galeocerdo cuvieri</i> )
Domestic animals:
Guinea pig ( <i>Cavia porcellus</i> )
Parakeet ( <i>Melopsittacus undulatus</i> )
Painted turtle ( <i>Chrysemys picta</i> )
Fantail goldfish ( <i>Carassius auratus</i> )
Noncritical items:
Human (Caucasian girl)
Chimpanzee ( <i>Pan troglodytes</i> )
Earthworm ( <i>Lumbricus terrestris</i> )
Sunflower ( <i>Helianthus annuus</i> )

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Each picture was a large (20 × 23 cm), detailed, realistic, full-color drawing of a living thing. Items were chosen so that four superordinate taxonomic groups (mammals, birds, reptiles, fish) were each represented by two organisms. In each of these pairs, the first member is a ferocious wild predator (e.g., tiger or alligator) and the second is a docile domestic pet (e.g., guinea pig or turtle). The predator-pet pairs each belong to the same superordinate biological taxon, and therefore can be seen as biologically similar, while at the same time members could be perceived as having different dispositions, and therefore as being psychologically different. The human, chimpanzee, worm, and plant items were not intended to fit into this cross-classification system, and were included to investigate overall attribution patterns.

#### Procedure

Children were tested individually, during school hours, in a quiet room away from their classroom. They were first given a warm-up task, in which they were shown a geometric shape (e.g., a red circle) and asked a "yes" question (e.g., "Is it a circle?") and a "no" question (e.g., "Is it blue?") about it. Children were then shown a picture, and asked to name it. If correct, they were told so; if not, the correct label was provided. Subjects were then asked nine questions about the picture, falling into four categories: Biological ("Do X's have blood?" "Do X's have bones?" "Do X's sleep?"), General Psychological ("Can X's think?" "Can X's feel pain?"), Predatory Psychological ("Are X's smart?" "Can X's feel angry?"), and Do-

mestic Psychological ("Can X's feel happy?" "Can X's feel scared?"). Questions were asked about the category in general rather than the single exemplar depicted. Subjects' responses (yes or no) were noted for each question; after all questions were asked about one picture, the next was presented. Subjects' responses to each question were scored 1 for a "yes" response (attributing the property in question to the living kind in question), and 0 for a "no" response. Order of picture and question presentation was completely randomized for each subject. Because of the number of items and questions, younger subjects were allowed to take periodic breaks during which they made pictures with rubber stamps.

Adults were tested individually or in small groups in a classroom. They were shown color transparencies of the same pictures that were shown to the children. Pictures were presented to adults in four different random orders. Adults read the questions and wrote down their responses in a booklet.

#### Results

Three sets of analyses are presented. The first examines the overall pattern of attributions of biological versus psychological properties to all taxonomic groups. This provides continuity with previous research, but does not directly address the issue of domain differentiation. The second directly addresses the question of domain differentiation by examining the critical subset of the stimuli to test whether taxonomic group or dispositional group predicts attribution of property clusters. The final set further addresses the question of radical conceptual change by testing the fit of the Cultural Consensus Model to these data, and examining age differences in levels of knowledge and patterns of residual agreement.

#### Overall Attribution of Properties

For the first analysis, each subject's scores were computed by collapsing yes/no responses to individual questions across taxonomic groups for nonprimate mammals (tiger and guinea pig, hereafter referred to as "mammals"), birds (hawk and parakeet), reptiles (alligator and turtle), and fish (shark and goldfish), and across properties for biological (has blood, has bones, sleeps) and psychological (can think, can feel pain, is smart, can feel angry, can feel happy, can feel scared) properties. Thus, each subject was given a composite score representing



the proportion of questions they responded "yes" to for biological and psychological properties, respectively, for the following categories of organisms: *human*, *chimpanzee*, *mammals*, *birds*, *reptiles*, *fish*, *worm*, *flower*. These scores could range from 0 (no properties attributed) to 1 (all properties attributed), and were analyzed using a 3 (age)  $\times$  2 (property type)  $\times$  8 (taxonomic group) ANOVA. The latter two variables were within-subject. Expectations were that overall attributions should drop off regularly with increasing phylogenetic distance from humans (although this effect might be attenuated by the presence of additional intermediate taxa), and that the different properties might show different patterns.

**Overall ANOVA.**—As predicted, there was a significant effect of taxonomic group,  $F(7, 315) = 301.68, p < .001$ . Consistent with previous research, subjects attributed the most properties to *human*, followed in order by *chimpanzee*, *mammals*, *birds*, *reptiles*, *fish*, *worm*, and *sunflower*. This main effect interacted with age,  $F(14, 315) = 3.50, p < .001$ ; attributions dropped off more gradually for kindergartners, who made significantly more attributions to *worm* than did adults (Tukey HSD post-hoc test,  $p < .05$ ). Taxonomic group also interacted with property type,  $F(7, 315) = 4.59, p < .001$ . Planned comparisons show that biological attributions were higher than psychological attributions for *chimpanzee*, *mammals*, *birds*, and *reptiles*,  $F_s(1, 45) > 5.66, p_s < .05$ . Finally, an age  $\times$  taxonomic group  $\times$  property type interaction,  $F(14, 315) = 2.84, p < .001$ , was found. Because of the complexity of this interaction, it was further explored using separate 8 (taxonomic group)  $\times$  2 (property type) within-subject ANOVAs.

**Kindergartners.**—Kindergarten subjects showed a significant effect of taxonomic group on overall attributions,  $F(7, 105) = 61.76, p < .001$ , attributing most properties to *human*, followed by *chimpanzee*, *mammals*, *birds*, *reptiles*, *fish*, *worm*, and *sunflower*. However, Tukey HSD post-hoc tests revealed no significant differences in overall attribution levels between humans and other mammals, birds, or even reptiles. There was also a taxonomic group  $\times$  property type interaction,  $F(7, 105) = 2.92, p < .01$  (see Fig. 1). Attributions for psychological properties begin to drop off earlier, yet seem to do so more gradually than those for biological properties. Based on Tukey HSD post-hoc tests, differences in biological attributions were not significantly different from

*human* until *worm* and *sunflower*, whereas psychological attributions to *reptiles*, *fish*, *worm*, and *sunflower* were all significantly lower than to *human* (all  $p_s < .05$ ).

**Eight-year-olds.**—Eight-year-olds also showed a significant effect of taxonomic group,  $F(7, 105) = 65.40, p < .001$ , attributing most properties to *human*, followed by *chimpanzee*, *mammals*, *birds*, *reptiles*, *fish*, *worm*, and *sunflower*. Like kindergartners, their overall attributions did not differ for humans versus other mammals, birds, or reptiles, based on Tukey HSD post-hoc tests. Eight-year-olds also showed a taxonomic group  $\times$  property type interaction,  $F(7, 105) = 3.20, p < .005$  (see Fig. 1). Again, psychological attributions begin to drop off earlier but do so much more gradually than biological attributions. Based on Tukey HSD post-hoc tests, biological attributions to *fish* are significantly lower than to any other phylogenetically more advanced group, whereas psychological attributions to *fish* differ only from those to *human* (all  $p_s < .05$ ).

**Adults.**—Adults also demonstrated a significant effect of taxonomic group,  $F(7, 105) = 164.25, p < .001$ , attributing most properties to *human*, followed by *chimpanzee*, *mammals*, *birds*, *reptiles*, *fish*, *worm*, and *sunflower*. Again, Tukey HSD post-hoc tests revealed that overall attributions did not differ significantly from humans for mammals, birds, or reptiles. Unlike either group of children, adults were more likely to attribute biological properties ( $M = .80, SD = .04$ ) than psychological properties ( $M = .73, SD = .13$ ),  $F(1, 15) = 5.43, p < .05$ . Finally, like both groups of children, adults showed a living kind  $\times$  property type interaction,  $F(7, 105) = 4.12, p < .001$  (see Fig. 1). This interaction presents a more pronounced version of that seen for children. For adults, the curve for biological attributions is almost flat through *reptiles*, after which it drops sharply. For psychological attributions, the descent starts earlier and is more gradual. Planned comparisons support this; biological attributions are higher than psychological attributions for *mammals*, *birds*, and *reptiles* ( $p_s < .02$ ), but these differences disappear for *fish* and *worm*. Likewise, based on Tukey HSD post-hoc tests, *reptiles* differ from *human* and *chimpanzee* with respect to psychological, but not biological attributions (all  $p_s < .05$ ).

Overall, these results reveal several patterns. First, as in Carey (1985), attributions dropped off with increasing phylogenetic dis-

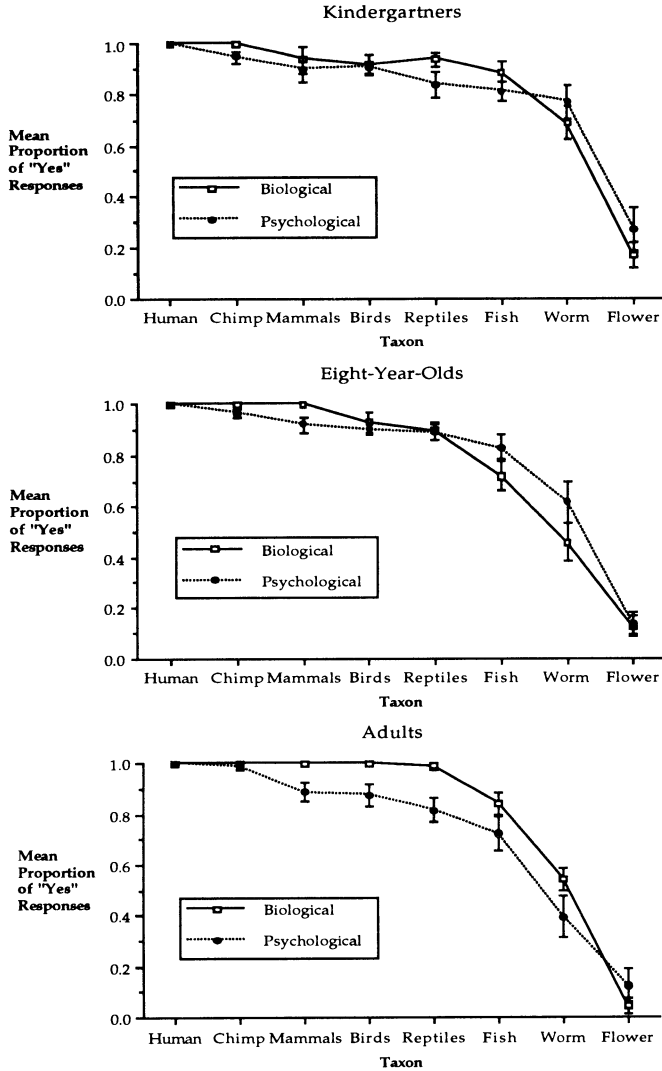


FIG. 1. Taxonomic group by property interaction for each age group

tance from humans. However, the decrease is neither as regular nor as dramatic as that found by Carey. Second, and more importantly, attribution patterns differed for biological versus psychological properties. In fact, the patterns look remarkably similar to those found by Inagaki and Sugiyama (1988): relatively flat curves with sharp drops for biological properties, and more gradual decreases for psychological properties. This raises the possibility that even kindergartners were making principled distinctions between biological and psychological properties. This possibility is directly addressed in the next section, using an analysis of critical item pairs and property clusters.

*Differential Attribution of Biological and Psychological Properties*

For this analysis, only responses to the critical predatory-domestic pairs of items (tiger-guinea pig, hawk-parakeet, alligator-turtle, and shark-goldfish) were considered. These organisms fall into two orthogonal groups: *taxonomic groups* (mammals, birds, reptiles, and fish) and *"dispositional" groups* (predatory animals [tiger, hawk, alligator, shark] and domestic animals [guinea pig, parakeet, turtle, goldfish]). (See Table 1.) Scores were calculated for each of four clusters of properties, based on predictions for the dispositional groups: Biological properties (*has blood, has bones, sleeps*), General

Psychological properties (*can think, can feel pain*), Predatory Psychological properties (*is smart, can feel angry*), and Domestic Psychological properties (*can feel happy, can feel scared*). Scores for each cluster were calculated by averaging the scores for the properties within that cluster. Higher scores indicate a greater willingness to attribute the properties within the given cluster to the organism in question.

Because of the age  $\times$  taxonomic group  $\times$  property interactions found in the previous analyses, scores were analyzed separately for the three age groups. Three 4 (taxonomic group)  $\times$  2 (dispositional group)  $\times$  4 (property cluster) within-subject ANOVAs were performed. If young children conflate the domains of folkpsychology and folkbiology, they should not in principle differentiate patterns of attribution for psychological versus biological properties. Alternately, if children differentiate these domains, then they should show different patterns of attribution for biological versus psychological properties. Thus, the primary prediction for each age group is a significant dispositional group  $\times$  property cluster interaction; if the domains are differentiated, predators and domestic animals should differ on psychological but not biological properties.

*Kindergartners.*—In contrast to past findings, kindergartners systematically differentiated between patterns of attribution for biological versus psychological properties, as shown by a significant dispositional group  $\times$  property cluster interaction,  $F(3, 45) = 6.84, p < .001$ . Planned comparisons show that as predicted, kindergartners attributed the biological cluster equally to predatory and domestic animals (see Fig. 2). Nor did they differ in their attribution of the general psychological cluster, or the predatory psychological cluster to these two groups. However, as predicted, kindergartners were more likely to attribute the domestic psychological cluster to domestic animals than to predatory animals,  $F(1, 15) = 9.30, p < .01$ . A significant taxonomic group  $\times$  dispositional group  $\times$  property cluster interaction,  $F(9, 135) = 1.98, p < .05$ , suggests that this pattern may vary in strength for the different taxonomic pairs. No other significant effects were found.

In sum, with the primate, worm, and plant items removed, kindergartners did not show the overall similarity-to-humans attribution pattern. They did, however, show different patterns of attribution for different

property clusters. Dispositional group did not predict differences in the biological, general psychological, or predatory psychological cluster, but did do so for the domestic psychological cluster.

*Eight-year-olds.*—Eight-year-olds displayed highly systematic differentiation of biological and psychological properties. As predicted, the 8-year-olds showed a significant dispositional group  $\times$  property cluster interaction,  $F(3, 45) = 12.75, p < .001$  (see Fig. 2). Planned comparisons revealed that, like kindergartners, 8-year-olds attributed the biological cluster equally to predatory animals and domestic animals. However, they were more likely to attribute the predatory psychological cluster to predators,  $F(1, 15) = 10.91, p < .005$ , and more likely to attribute the domestic psychological cluster to domestic animals,  $F(1, 15) = 11.87, p < .005$ . Eight-year-olds were also more likely to attribute the general psychological cluster to predators,  $F(1, 15) = 7.74, p < .05$ .

Eight-year-olds also showed a significant overall effect of taxonomic group,  $F(3, 45) = 16.76, p < .001$ . Overall attributions again diminished in the predicted order (*mammals, birds, reptiles, fish*). Tukey HSD post-hoc tests reveal that this age group made significantly more attributions to *mammals* ( $M = .94, SD = .09$ ), *birds* ( $M = .91, SD = .09$ ), and *reptiles* ( $M = .89, SD = .11$ ) than they did to *fish* ( $M = .80, SD = .16$ ) ( $p < .01$ ). Importantly, this was qualified by a taxonomic group  $\times$  property cluster interaction,  $F(9, 135) = 2.21, p < .05$ . Tukey HSD post-hoc tests suggest that the only cluster to be consistently predicted by taxonomic group was the biological cluster. Specifically, *mammals, birds, and reptiles* were each attributed more biological properties than *fish* ( $ps < .05$ ). No other significant effects were found.

To summarize, 8-year-olds showed a stronger pattern of differential attribution of biological versus psychological properties than kindergartners. They attributed the biological cluster, but none of the psychological clusters, on the basis of taxonomic group. In contrast, they attributed all three psychological clusters, but not the biological cluster, on the basis of dispositional group.

*Adults.*—Adults also displayed different attribution patterns for biological versus psychological properties. Like both groups of children, adults showed a dispositional group  $\times$  property cluster interaction,  $F(3, 45) = 7.02, p < .001$  (see Fig. 2). Again, there

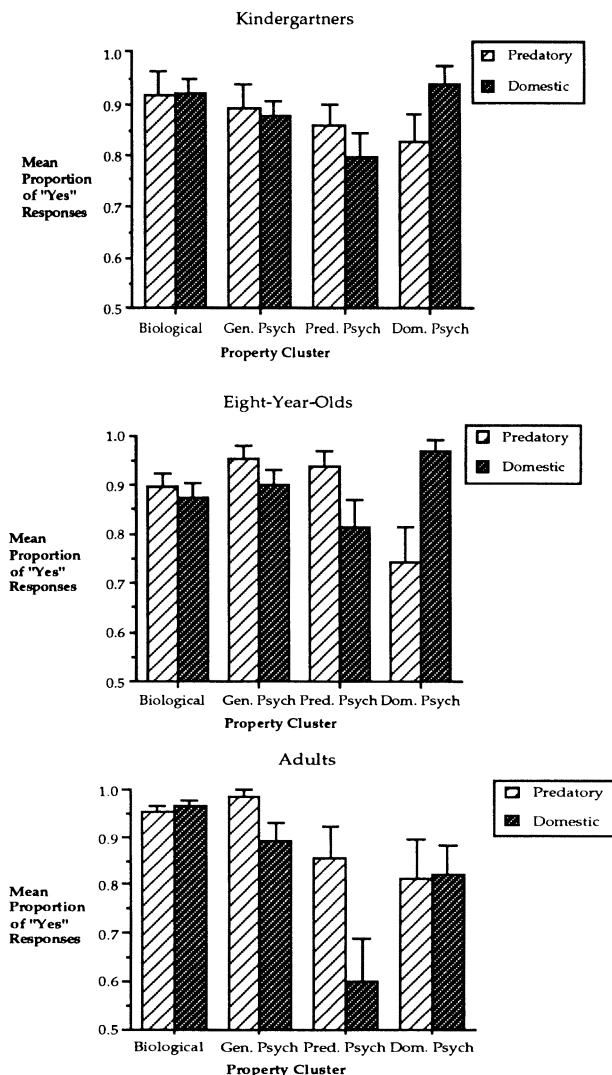


FIG. 2. Dispositional group by property cluster interaction for each age group

was no difference between predators and domestic animals in attributions of biological properties. However, adults were more likely to attribute the predatory psychological cluster to predators,  $F(18, 270) = 3.77$ ,  $p < .001$ . They were also more likely to attribute the general psychological cluster to predators,  $F(18, 270) = 3.77$ ,  $p < .001$ . Finally, in contrast to children, adults were not more likely to attribute the domestic psychological cluster to domestic animals. A significant taxonomic group  $\times$  dispositional group  $\times$  property cluster interaction,  $F(9, 135) = 2.30$ ,  $p < .05$ , suggests that this pattern may vary in strength for the different taxonomic pairs.

Additionally, adults showed an overall effect of taxonomic group,  $F(3, 45) = 11.24$ ,  $p < .001$ . According to Tukey HSD tests, adults attributed more properties each to *mammals* ( $M = .92$ ,  $SD = .12$ ), *birds* ( $M = .91$ ,  $SD = .13$ ), and *reptiles* ( $M = .86$ ,  $SD = .14$ ) than to *fish* ( $M = .75$ ,  $SD = .21$ ) ( $p < .01$ ). There was also a main effect of dispositional group,  $F(1, 15) = 6.75$ ,  $p < .05$ ; adults made more attributions to predators ( $M = .90$ ,  $SD = .13$ ) than to domestic animals ( $M = .82$ ,  $SD = .17$ ). However, these are qualified by a taxonomic group  $\times$  dispositional group interaction  $F(3, 45) = 4.74$ ,  $p < .01$ . Tukey HSD tests suggest that overall, adults were less likely to attribute properties to

*goldfish* than to any other animal ( $ps < .01$ ). Finally, adults showed a main effect of property cluster,  $F(3, 45) = 7.21, p < .001$ . According to Tukey HSD post-hoc tests, adults attributed biological properties ( $M = .96, SD = .05$ ) or general psychological properties ( $M = .94, SD = .10$ ) more often than predatory psychological properties ( $M = .73, SD = .27$ ) ( $p < .01$ ).

To summarize, the adults used dispositional group to attribute predatory psychological and general psychological clusters, but not biological or domestic psychological clusters. They were more likely to attribute biological or general psychological properties than predatory psychological properties. Finally, adults attributed many fewer properties to *goldfish* than to any other species. Although this pattern of results is more complex than was seen for children, the same basic finding emerged at all three ages: subjects differentially attributed psychological—but not biological—properties to predators versus domestic animals.

*Individual response patterns.*—To augment group analyses, individual response patterns were examined in two ways. First, for each property cluster, subjects' attributions to predatory and domestic animals were summed. Subjects were then classified as having made more attributions to predatory animals, or more to domestic animals, or as having made an equal number to both, for each cluster. The binomial probability was then calculated for observed number of subjects who made more attributions to predatory animals than domestic animals out of the total number of subjects, excluding ties. This tests whether the number of subjects showing differences in a particular direction is greater than expected by chance. Chance was set at .50, assuming that if there were no systematic preference for attribut-

ing properties to one or another group, half of the differences should be in either direction.

Results of this analysis are perfectly parallel to those of the ANOVAs (for details see Table 2). Specifically, significant differences are seen for kindergartners on the domestic psychological cluster (along with a nonsignificant trend in the predicted direction for predatory psychological properties), for 8-year-olds on all three psychological clusters, and for adults on the general and predatory psychological cluster. No significant differences are seen for the biological properties. Thus, patterns of individual performance mirror the results of the group analyses.

A second analysis of individual response patterns was performed to examine differentiation independent of direction. For instance, if half of the subjects attributed more general psychological properties to predators, and half attributed more to domestic animals, the preceding analyses would show little differentiation, while in reality subjects would be differentiating a great deal, albeit not in a consistent direction. For this analysis, each predator-domestic animal pair (e.g., *tiger-guinea pig*) was considered separately, for each property cluster. For each subject, the number of pairs to which that subject differentially attributed properties of a given cluster was tallied. This could range from 0 (if a subject showed the same pattern of attribution to members of each pair) to 4 (if subjects showed different patterns of attribution for all pairs). For example, if a subject attributed both predatory psychological properties to *tiger, guinea pig, hawk, parakeet, alligator, turtle, and shark*, but attributed neither to *goldfish*, that subject would be scored as having differentiated one pair (*shark-goldfish*) for predatory psychological cluster.

TABLE 2  
NUMBER OF SUBJECTS AT EACH AGE MAKING MORE ATTRIBUTIONS TO  
PREDATORY ANIMALS THAN DOMESTIC ANIMALS

Age Group	Biological Cluster	General Psychological Cluster	Predatory Psychological Cluster	Domestic Psychological Cluster
Kindergartners .....	5 (8) $p = .361$	5 (8) $p = .361$	8 (11) $p = .113$	1 (10) $p = .011$
8-year-olds .....	5 (9) $p = .497$	6 (6) $p = .016$	8 (8) $p = .004$	0 (10) $p = .001$
Adults .....	2 (6) $p = .344$	7 (7) $p = .008$	10 (10) $p = .002$	5 (9) $p = .497$

NOTE.— $N = 16$  for each age group. Entries represent the number of subjects who attributed more properties to predatory than domestic animals, followed by the number of subjects who showed any differences, in parentheses (i.e., the number of subjects who did not tie), followed by the binomial probability of obtaining the observed or more extreme results.

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The scoring would be the same if the subject had attributed both properties to *goldfish* and only one to *shark*. Thus, the approach measures the differential attribution of properties to members of a pair of animals from the same taxonomic group, regardless of the direction or magnitude of the difference. Based on these scores, subjects were classified into one of three response patterns for each property cluster: no differentiation (subject differentiated no pairs), moderate differentiation (subject differentiated 1–2 pairs), or consistent differentiation (subject differentiated 3–4 pairs). Results of this classification are presented in Table 3.

Inspection of Table 3 reveals several patterns. First, more subjects consistently differentiated animal pairs on the basis of the predatory psychological and domestic psychological clusters (a total of 25 instances) than on the basis of the biological or general psychological clusters (a total of nine instances). Second, a substantial number of subjects showed moderate or consistent differentiation, even for biological prop-

erties. However, based on the analyses presented above, the differential attribution of biological properties did not systematically favor one dispositional group over another, whereas differential attribution of psychological properties did. Thus, biological attributions were not guided by dispositional group membership. Finally, chi-square analyses show no age differences. For these analyses, moderate and consistent differentiation categories were collapsed. A 3 (age)  $\times$  2 (differentiation status) chi-square was performed for each property cluster. Results show no significant age differences in individual patterns,  $\chi^2(2, N = 48) < 2.37$ ,  $ps > .31$ .

Further analyses were conducted to see whether differential attribution of one property cluster predicted differential attribution of others. Separate 2  $\times$  2 chi-square analyses were performed for each pair of clusters, revealing extensive interrelations among psychological clusters. Specifically, subjects who tended to differentially attribute the general psychological cluster also tended to

TABLE 3  
NUMBER OF SUBJECTS DIFFERENTIALLY ATTRIBUTING PROPERTIES TO  
PREDATOR-DOMESTIC PAIRS AT EACH AGE

Degree of Differentiation <sup>a</sup>	None (0)	Moderate (1–2)	Consistent (3–4)
<b>Biological cluster:</b>			
Kindergartners .....	7	5	4
8-year-olds .....	4	10	2
Adults .....	8	8	0
Total .....	19	23	6
<b>General-psychological cluster:</b>			
Kindergartners .....	7	8	1
8-year-olds .....	8	6	2
Adults .....	9	7	0
Total .....	24	21	3
<b>Predatory-psychological cluster:</b>			
Kindergartners .....	4	7	5
8-year-olds .....	8	4	4
Adults .....	5	5	6
Total .....	17	16	15
<b>Domestic-psychological cluster:</b>			
Kindergartners .....	6	7	3
8-year-olds .....	6	5	5
Adults .....	7	7	2
Total .....	19	19	10

NOTE.— $N = 16$  for each age group.

<sup>a</sup> Maximum possible differentiation = 4 out of 4 pairs.

differentially attribute the predatory psychological cluster,  $\chi^2(1, N = 48) = 4.46, p < .05$ . Likewise, subjects who tended to differentially attribute the predatory psychological cluster also tended to differentially attribute the domestic psychological cluster,  $\chi^2(1, N = 48) = 4.08, p < .05$ . An even stronger relation emerged between the general psychological cluster and the domestic psychological cluster. Those who tended to differentially attribute the general psychological cluster also tended to differentially attribute the predatory psychological cluster; those who tended not to differentiate the former also tended not to differentiate the latter,  $\chi^2(1, N = 48) = 14.72, p < .001$ . In contrast, differentiation of the biological cluster was related only to differentiation of the predatory psychological cluster. Subjects who tended to differentiate pairs with respect to biological properties also tended to differentiate pairs with respect to predatory psychological properties,  $\chi^2(1, N = 48) = 4.08, p < .05$ .

Overall, results show that by kindergarten, children attribute biological and psychological properties differently to living things, and by age 8 this differentiation is quite systematic. Furthermore, differential attribution of various psychological clusters is highly interrelated, but only weakly related to differential attribution of the biological cluster. These results strengthen the proposal that folkbiology and folkpsychology are differentiated, and reduces the need for a radical theory-change account of development. However, this analysis considers only a select subset of the data. The following analysis looks for qualitative differences in responses of children and adults to the full set of items.

#### *Cross-Age Consensus on Patterns of Attribution*

The radical theory-change view predicts that the bodies of knowledge underlying the responses of children and adults should look very different, because they are organized by very different theories. Alternatively, if adults and children seem to be drawing their responses from the same body of knowledge,

it would suggest that a less radical account of the developmental changes within this domain may be more accurate. The Cultural Consensus Model (Romney et al., 1986) will be used to address this final question.

The Cultural Consensus Model provides a tool to discover the degree to which a group of informants agree on the answers to a set of questions, and to assess each individual's agreement with the consensus. The model works on the assumption that informants are answering questions from a single body of shared knowledge, and that none of them knows the body of knowledge completely. Romney et al. (1986) argue that this set of assumptions is met if, when responses are subjected to principle components factor analysis, a single-factor solution emerges. The eigenvalue for the first factor should be much greater than subsequent eigenvalues, which should trail off gradually; the first factor should account for much more variance than the next, and all values on the first factor should be positive, while some values on the other factors should be negative. If the results fit these criteria, we can conclude that the answers of individual informants are the product of a single underlying body of shared cultural knowledge.

In the analyses below, the model is employed in two ways. First, the CCM is used to test the hypothesis that there is indeed a single underlying model of the distribution of biological and psychological properties to nonhuman species across the age groups tested. Evidence of such a shared model, as indicated by a good fit of the CCM, would provide counterevidence to a radical theory-change account of the acquisition of biological knowledge. Second, patterns of residual agreement not explained by the consensus model are examined.

*Consensus on patterns of attribution.*—The CCM was employed as detailed in Romney et al. (1986). Agreement scores, representing the proportion of items for which identical answers were given, were computed for all pairs of subjects. Next, these scores were adjusted for guessing,<sup>2</sup> and the

<sup>2</sup> According to Romney et al. (1986), the observed agreement of two informants on a set of questions is the sum of (1) the number of questions they both know the "culturally accepted" answer to plus (2) the number of questions that neither know but both guess the same answer. Thus, some agreement represents true agreement and some represents chance responding. In order to correct observed agreement scores for chance responding, Romney et al. (1986) give the equation  $M^*_{ij} = (LM_{ij} - 1)/(L - 1)$ , where  $M^*_{ij}$  = "the estimation of the proportion of matches between informants  $i$  and  $j$  corrected for guessing" (Romney et al., 1986, p. 320),  $L$  = the number of alternative answers to the question, and  $M_{ij}$  = the observed proportion of matches

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resulting subject by subject agreement matrix was submitted to a principal components factor analysis. The resulting first factor eigenvalue was 31.10, and this factor accounted for 65% of the variance. The eigenvalues for the next three factors were 2.99, 1.43, and 1.13, accounting for 6%, 3%, and 2% of the variance, respectively. Unrotated factor scores for each subject on the first factor were all positive and ranged from .223 to .957 ( $M = .792$ ), whereas all other factors had negative scores. These results strongly indicate a one-factor solution, and clearly fit the assumptions of the CCM. The first eigenvalue is over 10 times larger than the next, and there are no negative scores on this factor, while there are on all others. Thus, we can conclude that there is a single factor representing a single shared body of knowledge underlying patterns of property attributions for all three age groups. In contrast to previous assertions, these results suggest that kindergartners' patterns of attributions do not reflect folkbiological knowledge that differs radically from that of adults.

*Patterns of residual agreement.*—Despite the strong fit of the CCM, there might still be residual agreement within age groups not explained by the consensus parameter. Indeed, given the age differences in attribution patterns discussed above, some residual agreement would be expected. In order to examine this possibility, a subject by subject residual agreement matrix was prepared, as described in Nakao and Romney (1984). First, the products of first-factor consensus scores were obtained for each pair of subjects. This represents agreement predicted by the CCM. Next, this predicted agreement matrix was subtracted from the observed agreement matrix, yielding a residual agreement matrix. This residual agreement matrix was compared to a model matrix corresponding to the prediction that within-age-group agreement should exceed between-age-group agreement. The degree of association between the model matrix and the residual agreement matrix was significant, as assessed by the Quadratic Assignment Program (Hubert & Schultz, 1976),  $z = 2.05$ ,  $p = .02$ , indicating significant residual within-group agreement not explained by the overall consensus factor.

Despite the systematic pattern of residual agreement, absolute levels of residual agreement were extremely low, as would be expected from the unambiguous results of the CCM: mean differences between predicted and observed agreement for each age group never exceeded one percentage point,  $M$  (kindergartners) =  $-0.0068$ ,  $SD = 0.003$ ;  $M$  (8-year-olds) =  $0.0057$ ,  $SD = 0.003$ ;  $M$  (adults) =  $0.0020$ ,  $SD = 0.013$ .

Thus, the Cultural Consensus Model clearly fits the data, indicating a single underlying model across age groups with respect to patterns of property attribution over living kinds. However, small but systematic patterns of residual agreement did emerge, reflecting the age differences evident in the previous analyses.

## Discussion

Results clearly show that by kindergarten, children attribute biological versus psychological properties differently to nonhuman living things. Kindergartners may not have a full-blown understanding of folkbiology, but the present results provide clear evidence for a principled distinction between folkbiology and folkpsychology. These results replicate, extend, and importantly qualify previous work on the differentiation of folkbiological and folkpsychological conceptions of living things.

### *Overall Patterns of Attributions*

The current results fit with past research suggesting that properties of living things are attributed to nonhuman species with decreasing frequency as those species increase in phylogenetic distance from humans (Carey, 1985; Dolgin & Behrend, 1984; Inagaki & Sugiyama, 1988). All ages tested attributed more properties to phylogenetically closer species, like mammals and birds, than to phylogenetically distant species, like worms and plants. However, methodological modifications in the current study led to two results that qualify the generality of this finding.

First, subjects responded to questions about a larger and more representative sampling of species between humans and invertebrates than used in previous work. This

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between informants  $i$  and  $j$ . Applying the equation to the present data set,  $L = 2$  and  $M_{ij} =$  the proportion of questions on which subjects  $i$  and  $j$  gave the same response. For example, two subjects with  $M_{ij} = .80$  would have  $M^*_{ij} = (2 \cdot .80 - 1)/(2 - 1) = .60$ . This reflects the fact that with only two alternative responses, the probability of chance agreement is relatively high. Please consult Romney et al. (1986) for more on the rationale and derivation of the correction.



led to an interesting finding; kindergartners did not show an overall effect of "similarity to humans" when responses to critical items only (all of which are vertebrates) are considered. In other words, the "similarity to humans" response pattern of the youngest age group tested was completely driven by differences in responses to phylogenetically higher animals versus worms and plants, and not by a gradually decreasing similarity to humans. This result raises the possibility that previous findings of a "similarity to humans" pattern may be driven in part by the choice of a small number of phylogenetically distant stimulus items. This finding of an attenuated similarity-to-humans-based attribution pattern does not in itself provide evidence for domain differentiation, but it does suggest a reconsideration of previous results that have been taken as evidence for a lack of differentiation.

Second, subjects answered questions about a wide range of psychological, as well as biological, properties. Consequently, property-by-living-kind interactions emerged at all ages. In accord with the findings of Inagaki and Sugiyama (1988), psychological attributions showed a similarity-based pattern, whereas biological attributions showed a category-based pattern. The question of domain differentiation is discussed in more detail below, but these differential patterns suggest that even the attributions of kindergartners, who have been exposed to little if any formal schooling, are not driven by a single, undifferentiated conception of living things.

#### *Differentiation of Folkbiology from Folkpsychology*

If young children conflate the domains of folkpsychology and folkbiology, then they should not differentiate in principle patterns of attribution of psychological and biological properties. Evidence that children do differentially attribute psychological and biological properties would in turn suggest that they are capable of making a principled distinction between the two domains. Unlike in previous research, stimuli in the present study were structured to present plausible a priori biological and psychological dimensions along which biological and psychological properties could potentially be attributed.

Results from group data and individual response patterns clearly demonstrated that adults, and children as young as age 6, show distinct patterns of attribution for biological

versus psychological properties. Kindergartners attributed biological properties to the predatory and domestic groups at the same rate, but differentially attributed the ability to be happy or scared to these groups. This suggests a dissociation of folkbiology from folkpsychology; kindergartners saw the dispositional groups as biologically equivalent but psychologically distinct. On the other hand, kindergartners did not use taxonomic group to guide biological attributions. Several factors might contribute to this finding. First, the biological properties used (*has blood, has bones, sleeps*) might plausibly be attributed to all taxonomic groups used in the study. However, note that 8-year-olds and adults both differentially attributed biological properties to taxonomic groups. Thus, the properties used cannot explain the results. More likely, the result reflects kindergartners' nascent folkbiological knowledge. Children at this age show some folkbiological sophistication (e.g., Backscheider et al., 1993; Gelman & Coley, 1991; Rosengren et al., 1991; Springer & Keil, 1991), but they still have much to learn. Although folkbiology and folkpsychology appear to be distinct conceptual domains, neither is necessarily well developed by kindergarten, and conceptual development continues in each.

For older children, differential attribution patterns were much stronger. They used taxonomic group as a basis for attributing biological properties, but not psychological properties. Conversely, they used dispositional group to attribute psychological, but not biological properties. Thus, we find a double dissociation of folkbiology from folkpsychology: groups that are biologically equivalent can be psychologically distinct, and groups that are psychologically equivalent can be biologically distinct.

This evidence for a principled distinction between attribution of psychological and biological properties goes directly against the contention that young children's folkbiological and folkpsychological conceptions of living things are conflated. By kindergarten, the distinction between folkbiology and folkpsychology is already evident. By age 8, this distinction is clear and systematic. Different relations obtain among living things, depending on whether those relations are biological or psychological in nature. This finding is in line with Keil's (1994) discussion of domain specificity as being tied to different *modes of construal*, whereby children are biased to prefer certain patterns of explanation over others for

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particular phenomena. These findings also fit well with recent work by Inagaki and Hatano (1993) showing that children distinguish notions of biological versus psychological causality. This evidence of early distinctions between folkbiology and folkpsychology has important implications for a developmental account of the acquisition of biological knowledge.

### *Developmental Implications*

On a radical theory-change view of the acquisition of biological knowledge, younger children—up to about age 10, on Carey's (1985) account—construe living things very differently than do older children and adults. Specifically, they fail to differentiate conceptions of folkbiology and folkpsychology. Around age 10—again on Carey's account—children undergo a restructuring of their concepts of living things, driven at least in part by exposure to scientific biology in school, and a true domain of biology emerges. This account makes several strong developmental predictions. First, it predicts that younger children should fail to differentiate in principle between attributions of biological and psychological properties, whereas older children and adults should differentiate between the two. As discussed above, results of the current study clearly show kindergartners making just such a principled distinction.

Second, the theory-change view predicts that the bodies of knowledge underlying the responses of children and adults should look very different from each other. In contrast to this prediction, the Cultural Consensus Model clearly demonstrated that a single underlying understanding of patterns of property attribution characterized the responses of both children and adults.

Thus, folkbiology and folkpsychology do not appear to be conflated for kindergartners. Furthermore, we can conclude that responses of kindergartners, 8-year-olds, and adults do not reflect underlying bodies of knowledge organized by radically different principles. Taken together, these findings constitute evidence that no radical conceptual restructuring of folkbiological knowledge takes place after kindergarten. This leaves two possibilities. First, radical restructuring may still take place, but at an earlier age. This would necessitate that such restructuring take place essentially by age 6, before the onset of formal schooling. Second, radical restructuring may not be the best explanation of the acquisition of knowledge about living things. Rather, the growth

of folkbiological and folkpsychological knowledge about living things may instead involve more gradual elaboration of basic conceptual distinctions that are in place by an early age.

Indeed, current results also provide evidence that over time, as argued by Carey (1985), knowledge about living things continues to become more differentiated. Despite evidence of differentiation at each age, interactions with age indicated differing attribution patterns for each age group, as did patterns of small but systematic residual agreement not explained by consensus. Older subjects made more distinctions, and more subtle distinctions, among living things. Differences in overall biological versus psychological attributions became more pronounced with age. Only adults showed higher overall levels of biological attributions than psychological attributions. When only critical items were considered, differentiation of folkbiology and folkpsychology was more pronounced for older children and adults. There were significant differences between taxonomic groups for older children and adults, but none for younger children. In addition, older children and adults made more distinctions among dispositional groups with regard to psychological property clusters than younger children. In a number of ways, then, older children and adults made more distinctions among individual living kinds, among taxonomic and dispositional groups of living kinds, and among properties than did younger children. So, although they make a principled differentiation between biological and psychological properties early, children continue to discover progressively more sophisticated degrees of both psychological and biological differentiation among living things.

### *Conclusions*

Results of this study replicate, extend, and importantly qualify previous work on the development of conceptions of living things. First, results show that for children as young as kindergarten age, patterns of attribution are distinct for biological versus psychological properties. This strongly suggests that the domains of folkbiology and folkpsychology are in principle differentiated by the beginning of formal schooling. This in turn suggests that conceptual development in the domain of folkbiology may not consist of radical conceptual restructuring or deep theory change. Rather, the growth of folkbiological and folkpsychological knowledge about living things may instead involve

more gradual elaboration of the specific ways in which basic conceptual distinctions are played out.

## References

- Atran, S. (1994). Core domains versus scientific theories: Evidence from systematics and Itza-Maya folkbiology. In L. Hirschfeld & S. Gelman (Eds.), *Domain specificity in cognition and culture* (pp. 316–340). New York: Cambridge University Press.
- Atran, S., & Sperber, D. (1991). Learning without teaching: Its place in culture. In L. Landmann (Ed.), *Culture, schooling and psychological development*. Norwood, NJ: Ablex.
- Backscheider, A. B., Shatz, M., & Gelman, S. A. (1993). Preschoolers' ability to distinguish living kinds as a function of regrowth. *Child Development*, *64*, 1242–1257.
- Boster, J. (1986). Exchange of varieties and information between Aguaruna manioc cultivators. *American Anthropologist*, *88*(2), 429–436.
- Boster, J., & Johnson, J. C. (1989). Form or function: A comparison of expert and novice judgments of similarity among fish. *American Anthropologist*, *91*, 866–889.
- Bruner, J. S., Goodnow, J. J., & Austin, G. A. (1956). *A study of thinking*. New York: Wiley.
- Carey, S. (1985). *Conceptual change in childhood*. Cambridge, MA: MIT Press.
- Dolgin, K., & Behrend, D. (1984). Children's knowledge about animates and inanimates. *Child Development*, *55*, 1646–1650.
- Dunn, L. M., Dunn, L. M., Smith, J. O., Smith, D. D., & Horton, K. B. (1983). *Peabody Picture Collection*. Circle Pines, MN: American Guidance Service.
- Estes, D., Wellman, H. M., & Woolley, J. D. (1989). Children's understanding of mental phenomena. In H. Reese (Ed.), *Advances in child development and behavior*. New York: Academic Press.
- Gelman, R. (1990). First principles organize attention to and learning about relevant data: Number and the animate-inanimate distinction as examples. *Cognitive Science*, *14*, 79–106.
- Gelman, S. A., & Coley, J. D. (1990). The importance of knowing a dodo is a bird: Categories and induction in two-year-olds. *Developmental Psychology*, *26*(5), 796–804.
- Gelman, S. A., & Coley, J. D. (1991). Language and categorization: The acquisition of natural kind terms. In S. A. Gelman & J. P. Byrnes (Eds.), *Perspectives on language and thought: Interrelations in development* (pp. 146–196). New York: Cambridge University Press.
- Gelman, S. A., Coley, J. D., & Gottfried, G. M. (1994). Essentialist beliefs in children: The acquisition of concepts and theories. In L. Hirschfeld & S. Gelman (Eds.), *Domain specificity in cognition and culture* (pp. 341–365). New York: Cambridge University Press.
- Gelman, S. A., & Markman, E. M. (1986). Categories and induction in young children. *Cognition*, *23*, 183–209.
- Gelman, S. A., & Wellman, H. M. (1991). Insides and essences: Early understandings of the non-obvious. *Cognition*, *38*, 213–244.
- Gutheil, G., Backscheider, A. B., & Coley, J. D. (1993, March). *The importance of behavioral properties in judgments of category membership*. Paper presented at the biennial meeting of the Society for Research in Child Development, New Orleans.
- Hatano, G., & Inagaki, K. (1987). Everyday biology and school biology: How do they interact? *Quarterly Newsletter of the Laboratory of Comparative Human Cognition*, *9*, 120–128.
- Heit, E., & Rubinstein, J. (1994). Similarity and property effects in inductive reasoning. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *20*(2), 411–422.
- Henley, N. M. (1969). A psychological study of the semantics of animal terms. *Journal of Verbal Learning and Verbal Behavior*, *8*, 176–184.
- Hirschfeld, L., & Gelman, S. A. (Eds.). (1994). *Domain specificity in cognition and culture*. New York: Cambridge University Press.
- Howard, D. V., & Howard, J. H. (1977). A multi-dimensional scaling analysis of the development of animal names. *Developmental Psychology*, *13*(2), 108–113.
- Hubert, L., & Schultz, J. (1976). Quadratic assignment as a general data analysis strategy. *British Journal of Mathematical and Statistical Psychology*, *29*, 190–241.
- Inagaki, K., & Hatano, G. (1993). Young children's understanding of the mind-body distinction. *Child Development*, *64*, 1534–1549.
- Inagaki, K., & Sugiyama, K. (1988). Attributing human characteristics: Developmental changes in over- and under-attribution. *Cognitive Development*, *3*, 55–70.
- Inhelder, B., & Piaget, J. (1964). *The early growth of logic in the child: Classification and seriation*. London: Routledge & Kegan Paul.
- Johnson, K., Mervis, C., & Boster, J. (1992). Developmental changes within the structure of the mammal domain. *Developmental Psychology*, *28*(1), 74–83.
- Keil, F. C. (1989). *Concepts, kinds, and cognitive development*. Cambridge, MA: MIT Press.
- Keil, F. C. (1994). The birth and nurturance of concepts by domains: The origins of concepts of living things. In L. Hirschfeld & S. Gelman (Eds.), *Domain specificity in cognition and*

## 1874 Child Development

- culture* (pp. 234–254). New York: Cambridge University Press.
- Markman, E. M. (1989). *Categorization and naming in children: Problems of induction*. Cambridge, MA: MIT Press.
- Massey, C. M., & Gelman, R. (1988). Preschoolers' ability to decide whether a photographed unfamiliar object can move itself. *Developmental Psychology*, **24**(3), 307–317.
- Medin, D., & Ortony, A. (1989). Psychological essentialism. In S. Vosniadou & A. Ortony (Eds.), *Similarity and analogical reasoning* (pp. 179–195). Cambridge: Cambridge University Press.
- Nakao, K., & Romney, A. K. (1984). A method for testing alternative theories: An example from English kinship. *American Anthropologist*, **86**, 668–673.
- Perner, J., Leekham, S. R., & Wimmer, H. (1987). Three-year-olds' difficulty with false belief. *British Journal of Developmental Psychology*, **5**, 125–137.
- Romney, A. K., Weller, S., & Batchelder, W. (1986). Culture as consensus: A theory of culture and informant accuracy. *American Anthropologist*, **88**, 313–338.
- Rosengren, K. S., Gelman, S. A., Kalish, C. W., & McCormick, M. (1991). As time goes by: Children's early understanding of growth in animals. *Child Development*, **62**, 1302–1320.
- Springer, K., & Keil, F. C. (1989). On the development of biologically specific beliefs: The case of inheritance. *Child Development*, **60**, 637–648.
- Springer, K., & Keil, F. C. (1991). Early differentiation of causal mechanisms appropriate to biological and nonbiological kinds. *Child Development*, **62**, 767–781.
- Vera, A. H., & Keil, F. C. (1988, November). *Patterns of induction and intuitive belief systems for biological kinds*. Paper presented at the meeting of the Psychonomic Society, Chicago.
- Vygotsky, L. (1986). *Thought and language*. Cambridge, MA: MIT Press.
- Wellman, H. M. (1990). *The child's theory of mind*. Cambridge, MA: MIT Press.
- Wellman, H. M., & Bartsch, K. (1988). Young children's reasoning about beliefs. *Cognition*, **30**, 239–277.
- Wellman, H. M., & Estes, D. (1986). Early understanding of mental entities: A reexamination of childhood realism. *Child Development*, **57**, 910–923.
- Wellman, H. M., & Gelman, S. A. (1992). Cognitive development: Foundational theories and core domains. *Annual Review of Psychology*, **43**, 337–375.

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