The Role of Appearance and Category Membership in the Attribution of Biological and Mental Properties in Children and Adults

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ABSTRACT

The Role of Appearance and Category Membership in the Attribution of Biological and Mental Properties in Children and Adults

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The effect of perceptual similarity and category membership on the attribution of two classes of properties (internal anatomical/physiological and mental) was investigated in 4- and 6-year-old children and adults. In Experiment 1, similarity ratings were obtained from 6-year-olds and adults in order to select category exemplars to be used in Experiment 2. The 4 stimulus sets generated included animate and inanimate category exemplars rated perceptually similar to people, and animates and inanimates rated dissimilar. Similarity to humans was found to affect the attribution of mental and anatomical/physiological properties in both 4- and 6-year-olds, though similarity had a more pronounced effect on the younger children's judgements. In adults, a similarity-based pattern was observed for mental properties only. Use of categorical knowledge by 4- and 6-year-olds was evidenced by the negligible attribution of properties to inanimates, both similar and dissimilar. No confirmation was obtained for the hypothesis that the animate-inanimate distinction is acquired before the sentient-nonsentient distinction. Consistent with previous findings, 6-year-olds overattributed the capacity to feel sad to lower animals relative to adults.

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TABLE OF CONTENTS

List of Figures

List of Tables

List of Appendices

A perceptual or conceptual basis of concepts and categories?

One area of substantial controversy in the study of children's conceptual development concerns the question of whether perceptual or conceptual similarity forms the basis of children's concepts. Perceptual similarity is frequently viewed as the uninterpreted tabulation of features and feature clusters that people derive from observation of the world around them (e.g. Keil, 1989). Categorizing objects according to perceptual similarity is problematic, since objects that look the same (e.g. fish and whales) are often fundamentally different. For this reason, it has been suggested that there is a developmental progression away from perceptually-bound representations of objects to representations that are principled and articulated along abstract dimensions.

Keil (1989) has obtained evidence to suggest that the purported shift away from perceptually-based categories occurs before the age of 5, since children of this age know that biological entities belonging to the same ontological category (e.g. animal or plant) are grouped according to underlying principles that can conflict with perceptual appearance. He demonstrated this by telling children stories about an exemplar from one ontological category (e.g. animal) whose surface appearance was transformed by an "operation" to that typical of another exemplar from the same category, or to that of an exemplar of a different ontological category (e.g. plant). The child's task was to decide whether the object's identity was altered by the operation. While 5-year-olds and a few 7-year-olds accepted transformations within the animal category, none of the children allowed transformations that cut across ontological boundaries.

Other developmentalists argue against a shift from perceptual categories to conceptual ones, positing that categories are conceptually structured from the very beginning. Evidence for this view comes from experiments in which children made category inductions along conceptual rather than perceptual lines. For example, Gelman (1988) presented 3-year-olds with an object and taught them a property of that object in order to see whether children could infer that other category exemplars would likely share that property, regardless of their perceptual similarity to the object. Following presentation of the target object, children were presented with two objects, one resembling the target but from a contrasting category, and another from the same category but perceptually unlike the target. Gelman found that 3 1/2 year-olds chose to base inferences on category membership when a category label was provided. Gelman and Coley (1990) extended this investigation to 2 1/2-year-olds and found that even children this young can overlook salient perceptual appearances when drawing inferences.

Recently, Smith and Heise (in press) proposed that the presentation of perceptual and conceptual categorization as mutually exclusive processes is inaccurate. Conceptual structure does not replace perceptual categories, they argue, but is based on them. According to Smith and Heise, perceptual similarity has been wrongly viewed as a static relation between objects. Instead, they posit that there is no single similarity "landscape", but rather several context-dependent landscapes. The subjective similarity between objects does not remain constant, but varies in accordance with the attentional changes, which in turn depend on the attributes being considered. According to this view, perceptual similarity is best viewed formulaically, as a weighted combination of dimensional similarities.

Rosch (1973) noted that perceptual features occur in causally related clusters in the world. Even young children possess some knowledge of which features tend to cluster together, and this knowledge influences attention by increasing attention to certain properties or dimensions in the presence of others. To demonstrate this point, Jones, Smith, and Landau (1990) conducted a study in which 3-year-olds were shown an exemplar of a novel category (Dax) and were asked to decide whether additional objects differing from the original exemplar in overall shape, texture, or size were of the same category. In the control condition, children classified objects as Daxes as long as they did not differ in overall shape from the original exemplar. In a second condition, in which small eyes were attached to the exemplar and test objects, both shape and texture were viewed as important criterial features by children. These results were taken to suggest that the presence of eyes activates implicit knowledge of feature correlations that guides attention, changing the importance accorded to various dimensions, thus shifting the perceptual similarity among the objects. Jones et al. claim that children need not have a causal understanding of why textures matter for objects with eyes, arguing that perceptual similarity may embody causal beliefs and explanations without representing them.

Studies designed to assess the basis of children's concepts have mainly focussed on biological concepts for the reason that biological categories, in adults at least, often include exemplars which are perceptually dissimilar to one another, but which nevertheless share important similarities. By examining the biological concepts possessed by children at different ages it is possible to evaluate when during development the basis for concepts changes, if such a shift occurs. One way in which children's biological concepts have often been studied is using a property judgement task, since the pattern of property attributions to different stimuli is thought to reflect the nature of the child's concepts.

Knowledge of the animate-inanimate distinction in children

Gelman and Spelke (1981) have proposed a taxonomy of characteristics that differentiate animate from inanimate objects. While these two classes of objects share physical dimensions and other properties, only animate objects possess the capacity for self-generated movement, can grow, reproduce, and experience mental states. In addition, animate objects are comprised of different substances and parts.

Piaget (1929) was one of the first to examine the development of the animate-inanimate distinction in children. He believed there were four stages through which the child progresses in arriving at the adult's distinction between living and nonliving things. In the first stage, life is assigned to anything that is in any way active, even if the object is stationary. During the second stage, life is attributed to objects which move. At the third stage, the child will attribute life to objects with the capacity for self-generated movement. In the final stage, corresponding to the concrete operational period, children understand life as being independent of autonomous motion and instead as defined by such qualities as respiration and reproduction. Piaget found that animistic responses (i.e. attributing properties of living things to inanimate objects) persisted even beyond the age of 8 years.

Certain methodological flaws in Piaget's studies have brought the validity of his findings into doubt. For example, the format of Piaget's questions has been criticized on the grounds that questions had a predicate-complement structure for which there is no real yes-no answer (Gelman, Spelke, & Meck, 1983). This format is likely to induce a play mode, in which the child treats the task as a game of make-believe. In addition, the inanimates about which children had to make property judgements were relatively unfamiliar objects, such as the sun, the moon and the wind. Gelman et al. (1983) proposed that children demonstrate greater understanding of the animate-inanimate distinction when more familiar objects are used.

More recently, Richards and Siegler (1986) investigated the acquisition of the animate-inanimate distinction by asking adults and children (aged 4 to 11 years) to list life-defining properties. The main finding of this study was that younger children cited more characteristic features (i.e. features present in only some living things) while older children and adults cited more defining features. For children 4 and 5 years of age, movement was the only property of living things mentioned by at least 25% of subjects. At 6 and 7 years of age, both movement and speech were mentioned. In this study, the first defining attributes to be produced by children were eating, breathing and dying. Despite the increased emphasis on defining features with age, even adults provided some characteristic features (e.g feeling and thinking) rather than defining ones when asked to give properties of living things.

The effect of life status and similarity to humans on the attribution of animal properties by children and adults

Richards (1989) studied knowledge of the animate-inanimate distinction by having children (ages 5, 7 and 9) and adults judge whether a series of animate and inanimate objects (woman, girl, rabbit, pigeon, tree, tulip, stone and chair) were alive, and whether they possessed a series of mental, sensory, anatomical, and physiological attributes. Five-year-olds were generally very good at denying "life", as well as anatomical and physiological properties to inanimate objects, suggesting that they possess good knowledge of the animate-inanimate distinction. In contrast, 5-year-olds were found to underattribute physiological properties to non-human animals, and "life" to plants. By the age of 7, children attributed these properties only slightly more often to people than to the other animals tested.

Dolgin and Behrend (1984) asked children (aged 3, 4, 5, 7, and 9 years) and adults to judge whether a series of animate and inanimate objects possessed various anatomical, physiological, mental and observable properties. Children's property attribution data were compared to the adults, rather than to a technically correct criterion. Errors were defined as responses different from the adults consensus. The results of this study indicated that animism is not a pervasive phenomenon, even in preschoolers. Like adults, children attributed all the properties tested to humans, and denied them to immobile inanimate objects that did not resemble animates.

Animistic responses seemed to occur with greater frequency when the target object was similar to humans, either in its perceptual appearance or by having a capacity for movement. For example, 3-, 4-, and 5-year-olds made more errors on questions involving animate-appearing inanimates (e.g. dolls) than on their animate counterparts. Children diverged most from the adult pattern of attribution in judgements concerning fish, insects, and dolls. While 3-, 4- and 5-year-olds all tended to overattribute properties to the doll, preschoolers and 5-year-olds differed in the kind of error made in relation to animate objects, in that preschoolers underattributed, whereas 5-year-olds overattributed properties to non-human animates (relative to adults).

Carey (1985) conducted several experiments in which she asked children to decide whether a series of animate and inanimate objects possessed various animal properties (is alive, eats, sleeps, has bones, has a heart, can get hurt, has babies, and thinks). Both adults and children attributed all these properties to humans and denied them to inanimate objects that did not resemble people (e.g.

harvester, garlic press). Children, but not adults, showed some tendency to overattribute "is alive" to inanimates. While adults did not consider that all of the animals have hearts or that they all think, they did judge that virtually all the animals eat, breathe, sleep, and can get hurt, suggesting that the concept *animal* organizes the adult's attribution of these properties. For children, a different pattern of attribution of properties to animate objects was found. Until the age of 7, children underattributed animal properties to nonhuman animals. For example, 4-year-olds denied the universal animal property of eating to nonhuman animals 20% of the time, and the ability to have babies 40% of the time. By the age of 7, these properties were credited to all animals. Findings concerning children's attribution patterns for particular properties were contradictory. While a lack of differentiation among properties was found in one experiment, another experiment showed eating and sleeping to be more widely attributed across animal species than has bones, has a heart, has babies, and thinks.

Although children's attributions to animates did not appear to be organized according to the animal concept, there was nevertheless consistency in their responses. A regular decline was observed in attribution of properties to animals when ordered: people, dog, bird, insect, fish, worm, suggesting that young children are more likely to attribute animal properties to animals that resemble people than to those that do not.

In order to determine whether similarity to people affected children's attributions to inanimate objects, another experiment was conducted in which an object resembling a human - a mechanical monkey - was included among the stimuli. From the age of 7 on, subjects almost never attributed animal properties to the mechanical monkey. The findings of this study were inconclusive for the 4-year-olds, since attribution of properties to the mechanical monkey varied as function of the familiarity of the other stimuli presented. In the unfamiliar condition, children showed a lower level of attribution to the mechanical monkey (25%) than they did to their most peripheral animal, the annelid (60%). In contrast, the children in the familiar series treated the mechanical monkey (52%) the way they did other nonhuman animals.

In light of these findings, Carey concluded that it is likely that "pre-school children do condition their projection of these (animal) properties from people to other objects by considering whether the object is an animal or not", however, the adjustment of perceptually salient similarity with conceptual knowledge is problematic for some preschool children.

Gelman, Spelke, and Meck (1983) had children judge whether people, dolls (similar inanimate) and rocks (dissimilar inanimate) possessed a variety of properties. Because no stimulus materials were used, children had to rely on their stored representations of these objects. Three-year-olds and 4-year-olds in the study correctly attributed all biological properties to people, and had little inclination to attribute them to dolls or rocks.

Attribution of mental versus biological properties in children and adults

Although questions about both mental and biological properties have been included in the design of many studies, very few studies have compared these two types of properties directly.

Inagaki & Sugiyama (1988) predicted that similarity of the target object to humans would have a more persistent effect for mental properties than for biological properties over the course of development. To test this hypothesis, they asked 4-, 5-, 7-, and 9-year-old children and adults to attribute properties to a series of objects varying in their judged similarity to people (person, rabbit, pigeon, fish, grasshopper, tulip, tree, and rock - listed in descending order of judged similarity). The properties tested included unobservable anatomical/physiological properties (heart, bones, breathing, growth), mental properties (think, feel sad, feel pain), and observable properties (has eyes, can move, can speak).

In each age group, the proportion of "yes" responses to the eight targets was computed for each property separately. The patterns obtained were then classified according to whether they were similarity-based, category-based, or "intermediate", meaning that they were influenced both by similarity and by category. Similarity-based attribution patterns were those in which the property was attributed to the different target objects in proportion to their judged similarity to humans. Category-based attribution patterns were defined as those in which the property in question was either restricted to humans, to all animals, or to all living things. Intermediate patterns were those, for example, in which a property was attributed to animals according to their judged similarity to people, but denied to nonanimals.

For the anatomical/physiological properties, 4-year-olds seemed to base their judgements totally on similarity, whereas from the age of 5 years, intermediate and categorical patterns predominated. For mental properties, subjects seemed to base their judgements on similarity alone until the 4th grade, from which point intermediate patterns were observed, implying that similarity and category membership determined subjects' responses.

Because overall similarity and location of the target on the evolutionary continuum are normally correlated, it has been suggested that the effect of similarity on adults' attributions of mental properties is only an apparent one, resulting from the tendency of adults to credit mental properties to animals as a function of phylogenetic development. A more recent study by Inagaki & Hatano (cited in Inagaki, 1989) suggests that adults do not base their judgements about mental properties on similarity when this confound is controlled for experimentally. In this study, children (7, 9 and 11 years) and adults were presented with pairs of animals (e.g. penguin and swallow) belonging to the same category but differing in judged similarity to people. It was held that category-based attributions should generate identical sets of responses to both members of the pair, while similarity-based attributions should result in systematically different responses in the pair. Of interest was whether properties were attributed more often to the similar member for pairs in which the property was denied to one of the members (about 10% of pairs for all age groups).

The results demonstrated that when phylogenetic development was controlled for, there was an effect of similarity on the attribution of biological properties for 7- and 9-year-old children, but not for adults. For mental properties, only 7-year-olds were significantly affected by similarity, with all other age groups showing only a trend in this direction.

Tunmer (1985) has advanced another hypothesis concerning the effect of class of property on the attribution of properties. He reasoned that because intentionality and mental states are ascribable to only a subset of living things whereas "life" is possessed by a broader range of objects, children probably acquire the more general animate-inanimate distinction before they acquire the ability to distinguish objects with a mental life from objects with no mental life, a cognitive milestone he refers to as the "sentient-nonsentient distinction".

To test this hypothesis, Tunmer compared the accuracy with which children aged 4 to 6 years could detect anomalous sentences in which inanimate objects were said to perform a biological function (e.g. the pencil ate/slept ..) and in which inanimate objects were paired with a mental predicate (e.g.. the ball wants/knows ..). It was predicted that young children would be more successful in detecting anomalous sentences in which the inanimate subject was said to perform a biological function, reflecting their greater knowledge of the animate-inanimate distinction than the sentient-nonsentient distinction. This prediction was confirmed for both 4- and 5- year-olds. Children 6 years and older performed equally well with either sentence type. Based on these findings, Tunmer hypothesized that childhood animism comprises two aspects that are developmentally distinct: attributing "life" or biological properties to inanimate objects, and endowing inanimate objects with intentionality and mental states.

Kawamura (1987) also found evidence to suggest that children have more difficulty learning to attribute mental properties in an adult fashion than they do biological properties. He asked 1st to 9th graders and adults to judge whether each of a series of living and non-living objects could feel sad, have a mind, feel pain, and have a brain. The stimulus pictures included a person, gorilla, dog, frog, fish, bee, prawn, octopus, starfish, germ, flower, cushion, doll and earth. Kawamura found that the range of living things the children considered to possess a mind and the capacity to feel sad was wider than that of the adults. While adults attributed these properties to mammals only, the youngest children tended to extend them to fish, frogs, plants and even inanimate objects. In contrast, the brain was attributed in the same way by children as it was by adults, from the 2nd grade onward. Another discrepancy between the performance of adults and children consisted of a tendency among children to attribute feels sad to objects they judged as not having a brain.

Based on the observation that second graders are more inclined than adults to attribute the mind and feels sad to lower animals such as fish and frogs than are adults, Kawamura (1987) concluded that children's animism results from their belief about the presence of "mind" in lower animals, plants and nonliving things.

Acquisition of the animate-inanimate and sentient-nonsentient distinctions: Gradual or all-or-none

While many researchers have investigated children's understanding of the sentient-nonsentient distinction, the exact manner in which this distinction is learned has received little attention. While children may learn to deny all mental properties to inanimate objects at the same time, it is also possible that certain mental properties are attributed in an adult way before others.

Tunmer (1985) found children to be equally good at detecting anomalous sentences containing *know* and sentences containing *want*, from which he tentatively concluded that the sentient-nonsentient distinction involves the learning of a general rule applying to all psychological predicates. However, other researchers, investigating different mental properties, have found certain mental attributes to be overattributed to inanimates more than others, suggesting that the sentient-nonsentient distinction is learned in a gradual manner.

Inagaki (1989) found that the attribution of feeling happy produced more animistic responses in 4-year-olds than did attributions concerning the ability to think. Inagaki hypothesized that fewer errors involving the ability to think are made since children this age know the relation between thinking and having a brain, and can use their knowledge of what sort of things have brains in order to constrain their similarity-based attributions. Because young children do not realize that emotional states are also dependent on the presence of a brain (Johnson & Wellman, 1982), more errors will result. Implicit in this hypothesis is the assumption that children can use factual knowledge concerning an object to constrain or modify similarity-based inferences.

Summary of the research findings

In order to achieve a better understanding of the child's distinction between animate and inanimate objects, researchers have frequently employed a property attribution task in which children and adults are asked to decide whether a number of different animate and inanimate exemplars possess various animal properties. In general, findings from such studies suggest that children are not as animistic as was originally claimed. In other words, the tendency of young children to overattribute animal properties is not very strong, although some cultural differences exist (Siegler, 1989).

Results from several studies suggest that the attribution of animal properties to objects is more or less likely to occur, depending both on the characteristics of the object under consideration and on the nature of the property being attributed. Specifically, several researchers have found that preschoolers are more likely to *over*attribute animal properties to inanimate objects if the objects are similar to people in their salient perceptual features, and *under*attribute them to animals that are dissimilar to people (Carey, 1985; Dolgin & Behrend, 1984). In contrast to the consistent underattribution of properties to animates seen in preschoolers, some researchers have reported overattribution of certain properties to dissimilar animates by children ages 5 and 7 (Dolgin & Behrend, 1984; Kawamura, 1987).

In the few studies that have compared the attribution of mental properties to that of biological properties, perceptual similarity has sometimes been found to exert an influence on the attribution of mental properties, when it has ceased to influence the attribution of biological properties (Inagaki & Sugiyama,1988). This has been explained in terms of the greater effect of similarity on judgements in novel domains.

Tunmer has provided some evidence to suggest that children acquire the animate-inanimate distinction before they do the sentient-nonsentient distinction. It is not known whether the sentient-nonsentient distinction is acquired in an all-or-none fashion or in a more gradual way, with certain mental properties being correctly extended before others.

Models of children's and adults' property attributions

Based on the findings from property attribution and other studies, researchers have concluded that the adult's concepts of *animal*, *invertebrate*, and *mammal* , among others, organize their attribution of many properties. Therefore, when presented with a novel object, adults can rely on categorical knowledge to infer the properties of that object. Category-based attribution will generate correct responses as long as the target object is allocated to the proper category, and the attribute boundary is correct.

Because preschool children have acquired insufficient knowledge concerning the properties of different objects and often lack the kind of categorical knowledge that would permit deductive inferences to be made, it has been suggested that children rely on a different approach than adults when faced with the task of attributing a variety of animal properties. Specifically, several researchers have suggested that children's attributions are initially similarity-based (Carey, 1985; Inagaki & Sugiyama, 1988) and that there is a developmental shift from similarity-based to category-based inferences between the ages of 4 and 10.

Similarity-based attributions are defined as property attributions which depend on the judged overall similarity between the target object and some better known comparison object - usually a person. For example, when asked whether a snake breathes, the child may recall that people or dogs breathe, and then compare the snake to a person/dog, basing his/her judgement on the perceived similarity between the two. "Overall similarity", while rarely defined in the literature, seems to include aspects of similarity (e.g.. functional similarity) over and above simple perceptual similarity (Carey, 1985).

Because children are very familiar with the attributes of people and relatively novice in other domains, it is believed that they regularly compare objects to people when judging whether an object possesses a given property. Evidence that children are more knowledgeable about people than about other animals was provided by Carol Smith (cited in Carey, 1985). Smith asked subjects to list all the things they know that can bounce, eat, have a heart, think, etc. When asked about animal properties, people were mentioned first by children 78% of the time. Similarity-based attribution is alternately referred to as the "similarity-to-exemplar heuristic" (Carey, 1985), or as a "person analogy" (Inagaki & Hatano, 1987).

One question that remains unclear is the degree to which children can use their knowledge of the animate-inanimate distinction to constrain their similarity-based inferences. Gelman, Spelke and Meck (1983) and Dolgin and Behrend (1984) found that a wide variety of animal properties were not attributed to inanimates resembling people, suggesting that perceptual appearance can be overridden by knowledge of the animate-inanimate distinction. In contrast, many children in Carey's study (1985) attributed animal properties to a mechanical monkey, leading Carey to propose that, while preschoolers do consider whether an object is an animal when ascribing properties to it, adjustment of perceptually salient similarity with conceptual knowledge is problematic for some children. Carey explains the discrepancy between her own findings and those obtained in other studies in terms of differing task demands, stating that success on her task required a better knowledge of the animate-inanimate distinction.

While the similarity-to-exemplar model has explanatory value, there are several findings to suggest that children consider more than just the appearance and category membership of an object when attributing animal properties to it. Specifically, the attribution pattern observed in children seems to depend to some degree on the property tested, suggesting that definitions children have for particular properties also play a role in attribution tasks. For example, 4-year-olds in one study (Carey, 1985) attributed eating and sleeping to a wider range of animal species than other properties. If children relied on overall similarity and category membership alone, then properties of different kinds would be extended equally to a given object.

Further evidence that children's property definitions influence their judgements comes from studies in which children were asked to provide explanations for their decisions. When asked to justify their property attributions, 4-year-olds in Carey's study mentioned similarity to humans in their explanations only 8% of the time. More commonly, they made statements about the presence or absence of specific anatomical features related to the property in question (35%) (e.g.. it breathes because it has a nose). While such explanations do imply a comparison to humans, it is not "overall similarity" to people that seems important, but shared features of functional significance. Gelman, Spelke and Meck (1983) also found that the primary kind of attribution justification from age 3 through 5 involved references to the presence or absence of supporting parts, except in the case of inanimates that looked like people, where children tended to refer to the object's not being real, etc.

Inagaki and Hatano (1991) recently proposed a "constrained person analogy" model which seems better able to account for findings related to children's property attributions. It is proposed that by the age of 6 years, children can adjust their use of the person analogy with a "feasibility constraint". In other words, children are able to examine whether their similarity-based inferences are tenable on the basis of property definitions children possess and factual knowledge about the target object.

One strength of this model is its ability to explain change in children's attribution patterns with property type. The wider attribution of certain properties, such as eating, can be explained in terms of the ease with which children can perform a factual check of their similarity-based inference. The model is also consistent with the explanations children provide for their judgements, in which both similarity to people and the presence of certain parts are sometimes mentioned. The fact that part explanations are the predominant type of justification given by preschoolers (Gelman, Spelke and Meck,1983) suggests that constrained use of a person analogy may appear in children as young as three years.

Carey considered a model similar to Inagaki and Hatano's (Carey, 1985) in which the child retrieves a definition of the property in question, and then examines the target object with respect to the applicability of the definition. Carey rejected this model partially because it is hard to conceive what definition of properties such as having a heart and feeling pain would result in these properties being attributed in the pattern usually observed. However, if similarity-based attribution is viewed as a kind of default form of attribution, as it is in Inagaki and Hatano's model, then a similarity-based attribution pattern should be expected in preschoolers when, for whatever reason, a feasibility check can not be carried out.

Goals of the Present Study

The first goal of this study was to assess the roles played by category membership and perceptual similarity to humans in the attribution of animal properties by children and adults. The ability of children under 7 to make category-based inferences in the face of conflicting perceptual information remains unclear for several reasons. First, in many of the studies conducted to date (e.g. Inagaki & Sugiyama, 1988), few inanimate target objects were used, and these did not vary in their similarity to humans. In addition, degree of similarity to humans has been poorly quantified and controlled for. For example, while Carey (1985) included both similar animates and a similar inanimate (a mechanical monkey), the similar inanimate was a three-dimensional toy that moved, while the remaining stimuli were pictures. Since the monkey was seen as more similar to people by children than the other stimuli (it received an average similarity rating of 7.4, while the highest rating given any other item was 2.2), degree of similarity to people was not controlled for adequately.

Another reason why the role of perceptual similarity remains unclear is that in most studies conducted so far, "overall similarity" has been investigated. Because overall similarity encompasses many kinds of similarity, such as categorical-relatedness, phylogenetic closeness, capacity for movement, and functional similarity, the unique effect of perceptual similarity on children's and adults' property judgements remains unclear.

By focussing on perceptual similarity and controlling for degree of similarity (as judged by independent raters), and by including an equal number of similar animate and similar inanimate objects in the stimulus set, a better evaluation of the influence of similarity versus life status on subjects' judgements was made possible.

The second goal of this study was to assess the effect of type of property on the property judgements of adults and children. Property effects were examined both at the global level (biological versus mental properties) and at the level of individual mental properties. One property-related question concerned the effect of similarity on the attribution of mental versus biological properties. Inagaki (1989) claims that whereas the shift from similarity-based to category-based attribution occurs during the elementary school years for anatomical/physiological properties, it occurs later for mental properties, so that even adults rely partially on similarity-based attribution for mental properties. In contrast, other researchers think that while adult's attribution appear to be similarity-based, they are in fact based on a more advanced inference process (Siegler, 1989). Of interest in this study was to what degree the claims of Inagaki (1989) would be supported.

A second question involving property type concerned Tunmer's (1985) hypothesis that the animate-inanimate distinction is acquired before the sentient-nonsentient distinction. If this hypothesis is correct, then children should learn to deny biological properties to inanimates before they do mental properties. One methodological problem with Tunmer's study was that property type and "observability" of the properties were confounded, in that the biological properties studied (eating and sleeping) were relatively more observable processes than the mental properties (knowing and wanting). An "observable property" is defined here as one which may either be observed by children or else easily inferred from some observable characteristic of the organism. For example, eating could be inferred from the presence of a mouth or a face.

Children under the age of 6 in Tunmer's study may have done better on sentences involving the life properties, not because the sentient-nonsentient distinction is a later event in cognitive development, but because children make more errors when less observable properties are concerned, be they unobservable biological properties (e.g. heart or brain) or mental properties. In the present study, observability of properties was controlled for by comparing mental properties to internal anatomical properties (heart, brain) and rarely observed physiological properties (growth, reproduction).

Two additional hypotheses involving property type, one holding that mental properties are overattributed to lower animals (Kawamura, 1987), and a second holding that the sentient-nonsentient distinction is acquired in an all-or-none manner (Tunmer, 1985) were investigated by assessing the pattern of attribution for individual mental properties at different ages.

In order to address the goals of this study, two experiments were devised. Experiment 1 was conducted for the purpose of selecting a stimulus set to be used in experiment 2, comprising animates and inanimates rated perceptually similar to people, and animates and inanimates rated perceptually dissimilar to people. Since the animate stimuli employed in this study consisted of animals only and plants were not investigated, the terms "animate" and "animal" are used interchangeably throughout this document. In Experiment 2, the role of appearance, category membership and property type on children's and adults' property judgements was investigated.

Experiment 1

In order to generate a series of stimulus pictures that varied in their judged perceptual similarity to people, an experiment was conducted in which child and adult raters were shown a series of photographed objects, and were asked to rate how much each one looked like a person. The purpose of this rating task was to identify a subset of 12 target pictures which included 6 animals (3 perceptually similar to people and 3 perceptually dissimilar), and 6 inanimate objects (3 perceptually similar to people and 3 perceptually dissimilar).

Method

Subjects

Twenty English-speaking children (13 males and 7 females) with a mean age of 6.5 years, and 20 English-speaking adults (8 males and 13 females; mean age = 29 years) were tested. The children were recruited from a private school and a YMCA after school program. The adults were undergraduate and graduate students enrolled in different departments at Concordia University. Adults were paid $3.00 for their participation in this experiment.

Materials

The stimulus set consisted of 48 color photographs (28 animates and 20 inanimates), all of which were mounted on white bristol board and laminated. (See list of categories in Appendix A). The photographs were selected to encompass a wide range of animals and inanimate objects that differed with respect to how much they perceptually resembled people. A scale (48 inches long x

8 inches in height) made from white foam board was used with children. This scale was divided into 8 boxes (6 x 8 inches) outlined in red, 7 of which were response boxes. A velcro strip was placed in the top region of each box, so that the pictures could be fastened directly to the scale. The adult scale consisted of the numbers 1-7 printed from left to right on a questionnaire form (see Appendix D).

Procedure

Children were first administered some practice trials in order to familiarize them with the scale and to ensure that they were oriented to perceptual similarity as opposed to category membership. During the practice trials, children were told that they were going to play a game in which they had to think about the way things look. First, the experimenter asked the child to describe what a banana looks like. A picture of a banana was placed by the experimenter in the box at the extreme left of the rating scale. Children were then presented with 3 objects (apple, telephone receiver, toothbrush), and were asked to rate how much each of them looks like a banana. It was explained that the more the picture looks like a banana, the closer to the banana on the board the child should stick the picture. Following each trial, the picture was removed from the board. Children were corrected by the experimenter when necessary. (See Appendix B for more detailed instructions).

Following the warm-up session, the experimenter placed a photograph of a person at the end of the scale, where the banana had been. The child was then told that he/she would now play a different game in which similarity to a person had to be assessed for a new set of pictures. It was emphasized that the comparison was to be made to any person, not just the man in the picture (See Appendix C for full instructions). The 48 pictures were presented one at a time, with each child receiving a different randomized order. On each trial, children and adults were asked to label the object in the picture, in order to verify that the stimuli were all familiar objects that subjects could label. As in the practice task, children responded by sticking each picture in one of the seven response boxes. The scale regions were defined the same way as in the practice task.

Adults were shown the same series of photographed objects and asked to judge how much each object looks like a person. As with the children, it was emphasized that the comparison was to any person. Each adult viewed the 48 stimuli in a different random order. On each trial, adults rated how much the photographed object looked like a person by circling a number from 1 to 7 on a scale in their questionnaire booklet. The scale regions were defined in an identical manner to the children's scale (see Appendix D).

Results

The objective of this experiment was to generate a set of stimulus pictures to be used in the property judgement experiment, encompassing both animate and inanimate exemplars that varied in their judged perceptual similarity to humans. To this end, the initial pool of 48 items for which similarity ratings had been obtained was reduced through the elimination of any items that were not rated high or low in perceptual similarity to humans. Two criterion values were set, so that only items with a mean similarity rating greater than 6.0 (dissimilar) or with a rating of less than or equal to 5.0 (similar) were retained. The criterion value for identifying items perceptually similar to people had to be set at the relatively high value of 5.0, because very few of the 48 items rated were given low (very similar) ratings, including primates.

The next step involved eliminating the items for which the mean similarity ratings given by children and adults were significantly different as indicated by independent t-tests. Items were also excluded if they were not easily identifiable by most children in the rating task. Of the original pool of 48 photographs, a set of 12 items was selected with 3 items per condition: 1) <u>similar animates</u>: chimpanzee, bear, penguin; 2) <u>dissimilar animates</u>: fish, fly, snake; 3) <u>similar inanimates</u>: toy owl, stuffed dog, puppet; and 4) <u>dissimilar inanimates</u>: ball, pencil, rock. The average similarity rating within each subset is provided in Table 1. A set of independent t-tests revealed no age differences in the mean ratings given for each of the 4 subsets of items.

Table 1

Mean Similarity Rating Score within each Stimulus Set by Age Group

	Age Group	
Stimulus Set	Children	Adults
Similar Animates		
M	4.07	3.95
SD	(1.60)	(1.15)
Dissimilar Animates		
M	6.43	6.80
SD	(0.82)	(0.29)
Similar Inanimates		
M	3.52	4.08
SD	(1.54)	(0.85)
Dissimilar Inanimates		
M	6.62	6.88
SD	(0.70)	(0.45)

To ensure that the subset of similar animate items and the subset of similar inanimate items did not differ with respect to judged similarity, correlated t-tests were conducted for children and adults separately. Within both age groups, the mean rating for the three similar animate items (chimpanzee, bear, penguin) and the mean rating for the three similar inanimate items (toy owl, stuffed dog, puppet) did not differ, $t(19) = 1.84$, $p > .05$ and $t(19) = -.56$, $p > .05$ for children and adults respectively. The same procedure was followed using dissimilar items, revealing no difference associated with category (animate versus inanimate) within each age group, $t(19) = -.78$, $p > .05$ and $t(19) = -.64$, $p > .05$ for children and adults respectively.

To verify that items meeting our criterion for "similar" and "dissimilar" were given significantly different ratings, correlated t-tests were conducted. First, the mean rating given to similar animate items was compared with the mean rating given to dissimilar animate items, for children and adults separately. This test revealed that both children, $t(19) = -7.16$, $p < .001$, and adults $t(19) = -12.06$, $p < .001$, gave significantly higher similarity ratings to animate items identified as similar using the criterion values than they did to animate items identified as dissimilar. Children and adults also gave significantly higher similarity ratings to similar inanimate items than they did to dissimilar inanimate items, $t(19) = -9.61$, $p < .001$ and $t(19) = -14.21$, $p < .001$, for children and adults, respectively.

Experiment 2

The primary objective of this experiment was to investigate developmental changes in the relative influence of perceptual similarity and category membership (animate versus inanimate) on the attribution of two classes of properties, biological properties and mental properties.

Method

Subjects

The total sample included 63 subjects. Twenty-one 4 year-olds (14 male and 7 female; mean age= 4.75 years), 21 6 year-olds (9 male and 12 female; mean age = 6.5 years) and 21 adults (11 male and 10 female; mean age = 22) were tested. The children were recruited from private schools in the Montreal area. The adults were university undergraduate and graduate students in disciplines other than psychology. They were paid $3.00 for their participation.

Stimuli

The stimulus set consisted of an anchor photograph of a woman, and 12 color photographs drawn from the original pool of 48 pictures, rated in Experiment 1. These 12 photographs included three animate and three inanimate objects rated similar in appearance to humans by children and adults, and the same number of animate and inanimate objects rated dissimilar to people (see Table 1 for mean similarity ratings). In sum, the stimuli consisted of a person and 4 stimulus sets or conditions comprised of 3 items each. These stimulus sets were 1) similar animates: chimpanzee, bear, penguin; 2) dissimilar animates: fish, fly, snake; 3) similar inanimates: toy owl, puppet, stuffed dog; 4) dissimilar inanimates: pencil, ball, rock.

Procedure

At the beginning of the session, every subject was asked to label the 13 stimuli so as to verify that the objects were familiar to both children and adults. If a subject provided an incorrect label, he/she was corrected by the experimenter who provided the correct label. Subjects were then asked to decide whether each of the thirteen stimuli possessed 8 different properties, 4 mental and 4 biological, for a total of 104 questions. For each target picture they were asked the following questions: (1) Does X have a brain? (2) Does X have a heart? (3) Does X start out smaller and grow? (4) Can X have babies? (5) Can X think? (6) Can X want something? (7) Can X know something? (8) Can X feel sad sometimes?

Questions concerning each property were administered in blocks, so that questions concerning a given property were administered for all stimuli before proceeding to the next property. Due to the length of the task, children were tested over two sessions about a week apart. Property order was randomized for each subject, and the stimulus order was randomized for each property for each subject. Subjects were instructed that they would be asked a series of questions concerning the properties of various objects. (See Appendix G for the adults' instructions). They were told to respond to each question with a "yes" or a "no". If they were not certain whether or not the pictured object had the property, they were instructed to give it their best guess. Children were also asked to respond verbally with a "yes" or "no" to each property question and in addition were asked to place the pictures into one of two boxes, depending on whether they thought it had the given property or not (see Appendix F). Prior to the property judgement task, children were administered a brief practice task (see Appendix E) in which they had to decide whether a series of objects possessed an observable property (has eyes). This was done to clarify the purpose of the judgement task and to familiarize the children with the response boxes.

Results

The effect of perceptual similarity to humans, category membership and property type on the attribution of animal properties by 4- and 6-year-olds

In order to examine the effect of perceptual similarity (similar versus dissimilar), life status (animate versus inanimate), and type of property (biological versus mental) on property attribution judgements, a 2 (age) x 2 (property type) x 2 (category) x 2 (similarity) ANOVA with repeated measures on the last 3 factors was performed. Because adults denied biological and mental properties to whole categories of objects, there was an absence of variance in several cells, making it impossible to include adults in this analysis.

The dependent variables consisted of the number of mental properties (maximum= 4) and the number of biological properties (maximum= 4), expressed as a percentage, attributed to each of the different stimulus sets: animate similar, animate dissimilar, inanimate similar and inanimate dissimilar. A child's responses concerning a given property were retained for analysis only if he/she attributed the property in question to the woman in the stimulus set. If the property was denied to the woman (a comprehension failure) or if the child refused to respond for a specific property, his/her data for that property were eliminated. Due to the lack of complete data for some subjects, scores were converted into percentages.

Most of the children and all the adults in this study attributed all the properties tested to the woman, indicating an understanding that these properties are possessed by people. "Has a heart" and "can want something" were each denied to the woman by one child in the 6-year-old sample. The remaining properties were attributed to the woman by every 6-year-old. Comprehension failures were more prevalent among 4-year-olds. "Has a brain" and "has a heart" were each denied to a woman by four 4-year-olds. "Can have babies" and "can know something" were denied by one child each, while "can feel sad" was denied by two 4-year-olds. All 4-year-olds stated that a woman starts out "smaller and grows", "can think", and "can want something".

Results of this ANOVA indicated main effects of Age $F(1, 39) = 9.19$, $p < .01$), Category $F(1, 39) = 533.80$, $p < .01$), and Similarity $F(1, 39) = 56.81$, $p < .01$. In addition, the following interactions were significant: Age x Category $F(1, 39) = 20.85$, $p < .01$; Age x Similarity $F(1, 39) = 20.48$, $p < .01$; and Category x Similarity $F(1, 39) = 25.11$, $p < .01$. No other main effects or interactions were found.

In order to investigate the Age x Category interaction effect, planned comparisons were conducted comparing the mean percent property attribution for the two age groups within each category separately. As shown in Figure 1, 4-year-olds attributed significantly fewer properties (biological and mental combined) to animates than did 6-year-olds (M= 64.88, SD= 20.43 and M= 89.42, SD= 13.79, respectively) $t(40)= -4.56$, $p < .01$, while there was no significant difference between the two age groups in the number of properties attributed to inanimate objects (M= 8.93, SD= 11.17 and M= 3.17, SD= 7.47 for 4- and 6-year-olds, respectively) $t(40)= 1.83$, $p > .05$.

To evaluate the Age x Similarity interaction effect, two planned comparisons were computed to determine whether or not there was an age difference in the mean percent property attribution for items judged to look similar or dissimilar to people. As seen in Figure 2, 4-year-olds were found to attribute significantly fewer properties (M= 28.11, SD= 14.03) than 6-year-olds (M= 44.15, SD= 9.42) to items judged perceptually dissimilar to people, $t(40)= -4.35$, $p < .01$, In contrast, an age difference was not found when property attribution to similar items was compared across age groups $t(40)= -1.09$, $p > .05$. These tests demonstrate that the attribution of properties is more affected by similarity for 4-year-olds than for 6-year-olds. However, 6-year-olds continue to be influenced to some degree by similarity as a second set of post-hoc tests revealed. When attribution to similar versus dissimilar items was examined within each age group using correlated t-tests, a

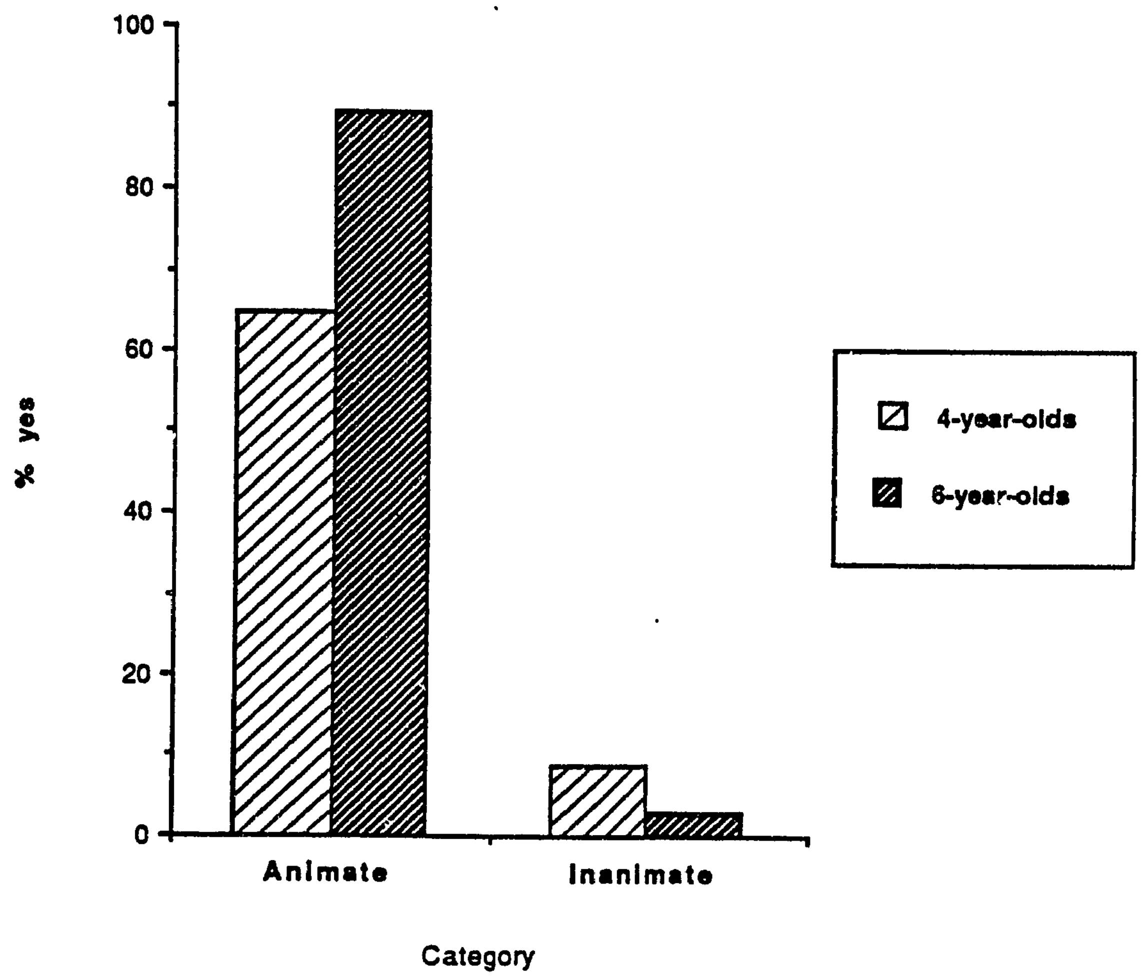

Figure 1. Mean percentage of property attribution as a function of category and age.

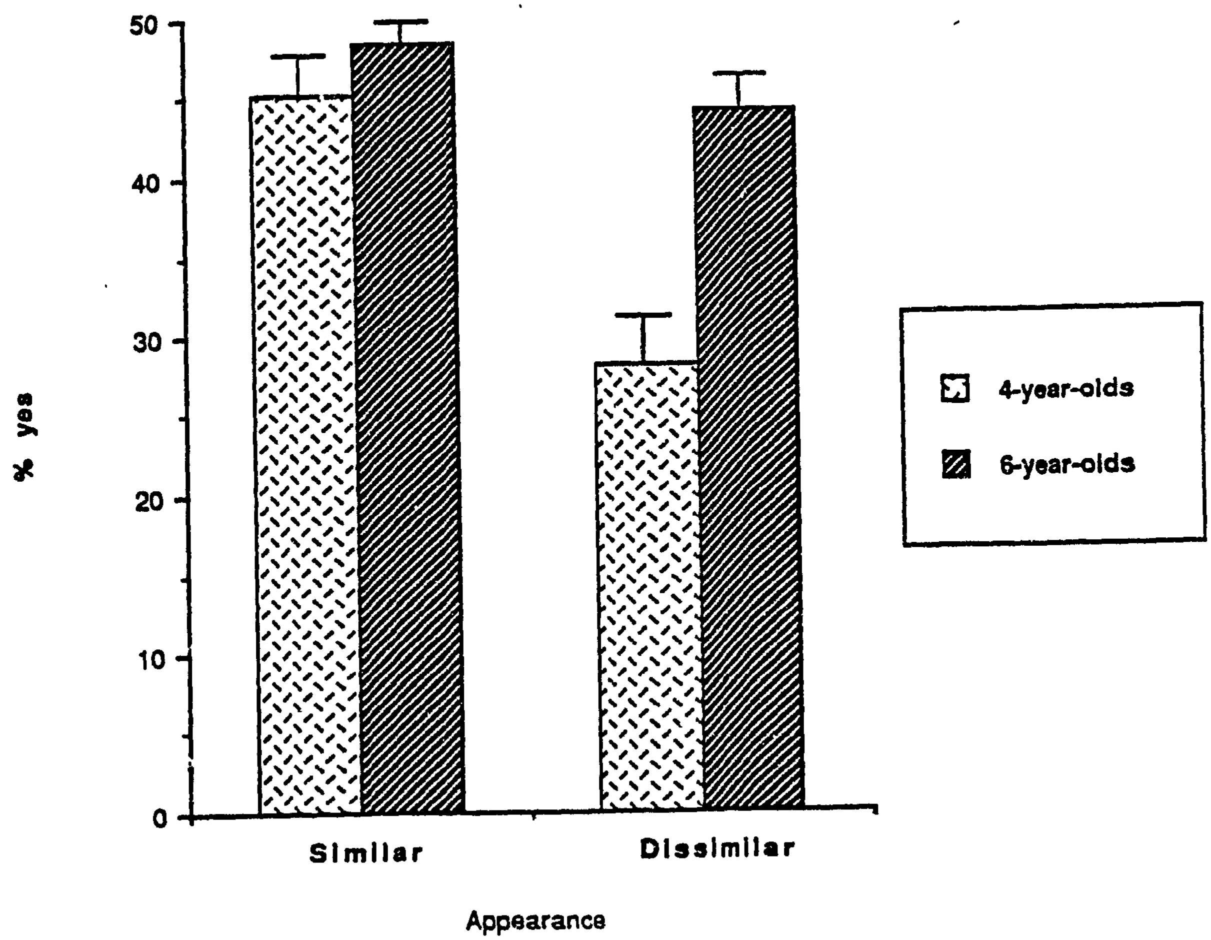

Figure 2. Mean percentage of property attributions as a function of perceptual similarity to humans and age.

significant effect of similarity was found for 4-year-olds $t(20) = 7.29$, $p < .01$ and for 6-year-olds $t(20) = 2.91$, $p < .01$. However, the effect size as indicated by the difference between the means was far greater in the younger children.

The Category x Similarity interaction effect was explored by conducting two post-hoc correlated t-tests comparing percent attribution to similar versus dissimilar items within each category. While there was greater attribution to similar than to dissimilar items both within the animate $t(41) = 5.91$, $p < .01$ and the inanimate category $t(41) = 2.80$, $p < .01$, a comparison of the means suggested a stronger effect of similarity in the animate category, as depicted in Figure 3.

In sum, 4-year-olds attributed fewer properties to animates than 6-year-olds, while no age difference was found for inanimates. Another finding was that similarity had a greater influence on the judgements of 4-year-olds than it did for 6-year-olds, although 6-year-olds were nevertheless significantly affected by similarity. Reflecting the greater effect of similarity for younger children, 4-year-olds attributed fewer properties than 6-year-olds to animates judged dissimilar to humans. In addition, similarity had a more profound effect on attribution to animates than to inanimates.

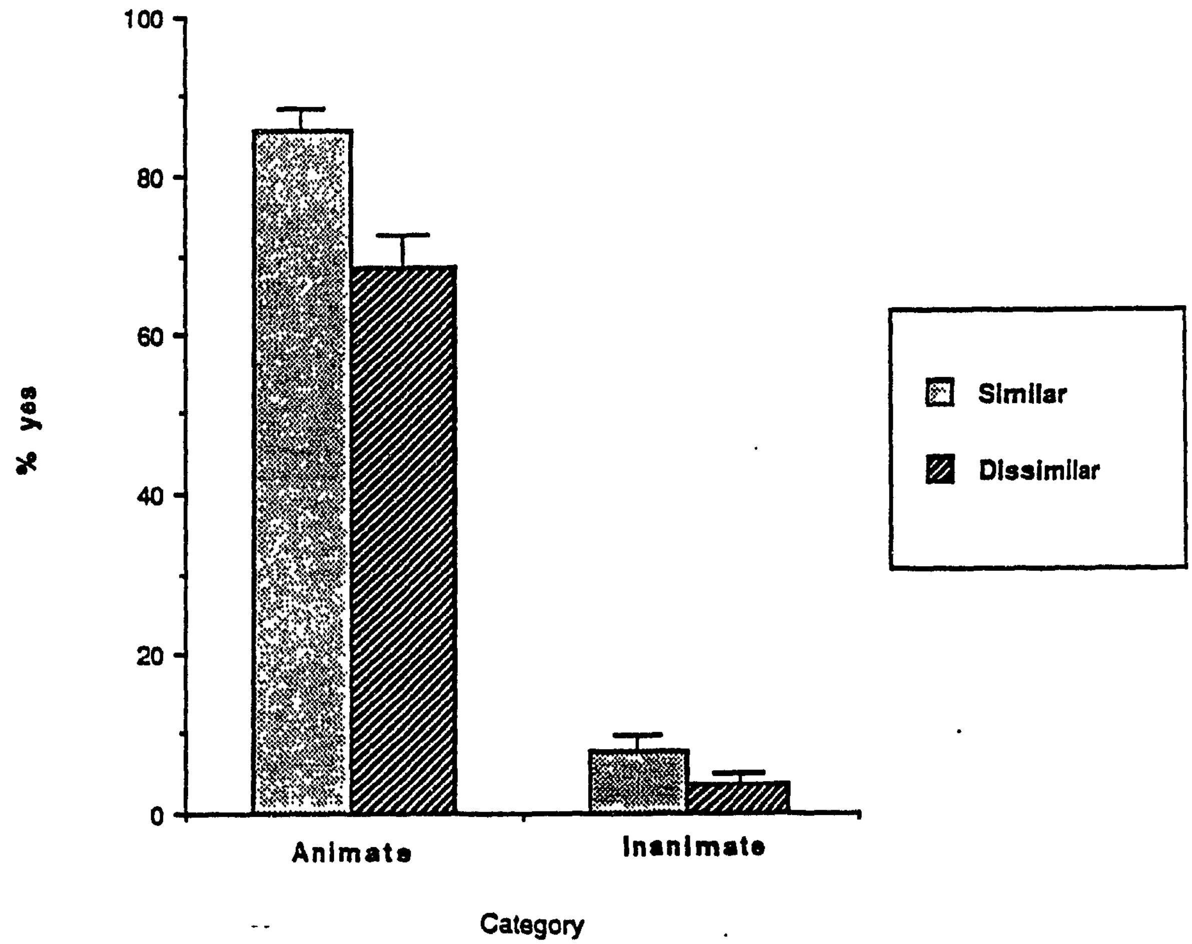

Figure 3. Mean percentage of property attribution as a function of category and perceptual similarity to humans.

The effect of category membership on the attribution of all properties by 4-year-olds, 6-year-olds, and adults

While adults could not be included in the main analysis, it was possible to explore developmental changes in the effect of category on the attribution of properties using a 3 (Age) x 2 (Category) ANOVA, with Category as the repeated measure. Mean percent attribution, reflecting the attribution of properties to animates and to inanimates, was used as the dependent variable. Results of this analysis revealed main effects of Age $F(2, 60) = 8.47$, $p < .01$, and of Category $F(1, 60) = 1240.38$, $p < .01$. In addition, a Age x Category interaction $F(2, 60) = 23.77$, $p < .01$ was found.

The Age x Category interaction effect was examined using Tukey post-hocs comparing age groups to one another on the attribution of properties to animates and inanimates separately. As shown in Figure 4, the post-hoc tests indicated that 4-year-old subjects attributed fewer properties to animates ($M = 64.88$, $SD = 20.43$) than did 6-year-olds ($M = 89.42$, $SD = 13.79$) or adults ($M = 91.07$, $SD = 10.17$), $p < .05$, who did not differ from one another. When attribution of properties to inanimates was considered, 4-year-olds were found to attribute significantly more properties to inanimates ($M = 8.53$, $SD = 11.17$) than adults ($M = .50$, $SD = 1.30$). 6-year-olds ($M = 3.18$, $SD = 7.47$) did not differ significantly from either the 4-year-olds or the adults in the number of properties they attributed to inanimates.

In sum, this analyses revealed age differences in the degree to which animal properties are attributed to both animate and

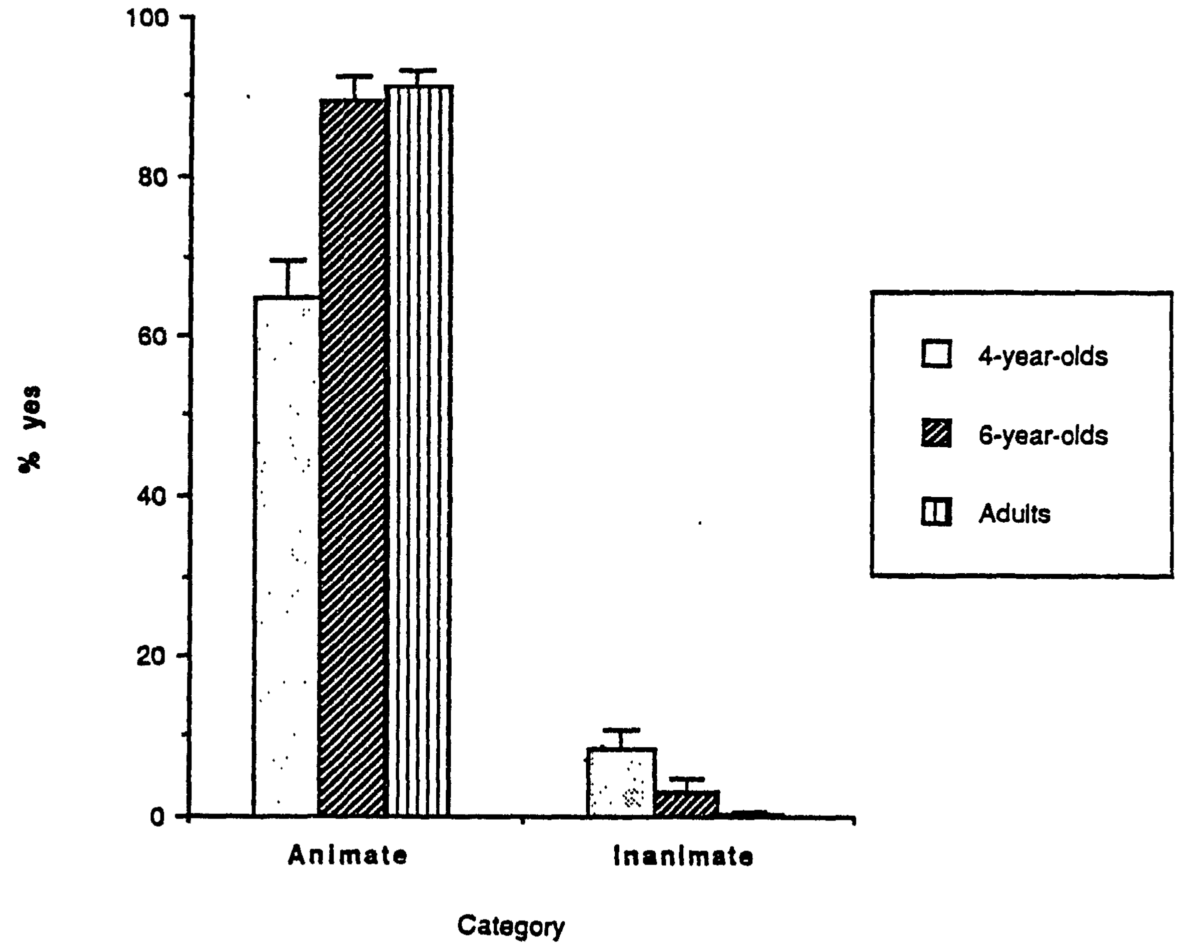

Figure 4. Mean percentage of property attribution as a function of category and age.

inanimate objects. Specifically, 4-year-olds attributed fewer properties (biological and mental combined) to animates than did either 6-year-old or adults, who do not differ with respect to the number of properties attributed to animates. In addition, 4-year-olds attributed more properties to inanimates than did adults.

<u>The effect of similarity to humans on the attribution of mental properties in children and adults</u>

Change in the effect of similarity on property attribution from age 4 to adulthood could be investigated only for mental properties and for the animate category, owing to the lack of variance for biological property responses among adults. Therefore, a 3 (Age) x 2 (Similarity) ANOVA, with Similarity as the repeated measure, was conducted. Mean percentage scores, reflecting the mean attribution of mental properties to similar and dissimilar animates, served as the dependent variables.

Results of this analysis included a significant main effect of Age $F(2, 60) = 12.41$, $p < .01$; a main effect of Similarity $F(1, 60) = 41.73$, $p < .01$; and a *marginally* significant Age x Similarity effect $F(2, 60) = 3.02$, $p = .06$. Tukey post-hoc tests aimed at evaluating the Age main effect revealed that 4-year-old children attributed fewer mental properties (combined) to animate items ($M = 62.5$, $SD = 21.70$) than did both the 6-year-olds ($M = 88.49$, $SD = 15.42$) $p < .05$ and the adults ($M = 84.52$, $SD = 16.93$), $p < .05$. The main effect of Similarity was due to the greater attribution of mental properties to human-similar ($M = 87.43$, $SD = 18.45$) than to dissimilar animals ($M = 69.58$, $SD = 28.70$).

Post-hoc analyses were conducted to explore the marginally significant Age x Similarity interaction. Correlated t-tests comparing the attribution of mental properties to similar versus dissimilar animates within each of the three age groups indicated an ordinal interaction in which more mental properties were attributed to human-similar animates than to dissimilar animates at all ages, with the effect of similarity being greater for 4-year-olds and for the adults than it was for 6-year-olds, as indicated by the difference between means and illustrated in Figure 5. Tukey tests examining differences across the age groups within each similarity condition showed that 4-year-olds attributed fewer mental properties both to similar animates and to dissimilar animates than did either 6-year-olds or adults, $p < .05$. Six-year-olds and adults did not differ significantly from each other in attributing mental properties to similar or dissimilar animates, $p > .05$.

In sum, 4-year-olds were found to attribute significantly fewer mental properties to animates than either 6-year-olds or adults, who did not differ from one another. Similarity affected the attribution of mental properties at all ages, but had a greater effect on the attributions of 4-year-olds and adults than on those of 6-year-olds. When attribution of mental properties was examined within similarity condition, for each age group, it was discovered that 4-year-olds attributed fewer mental properties than 6-year-olds or adults, both to similar and dissimilar animates.

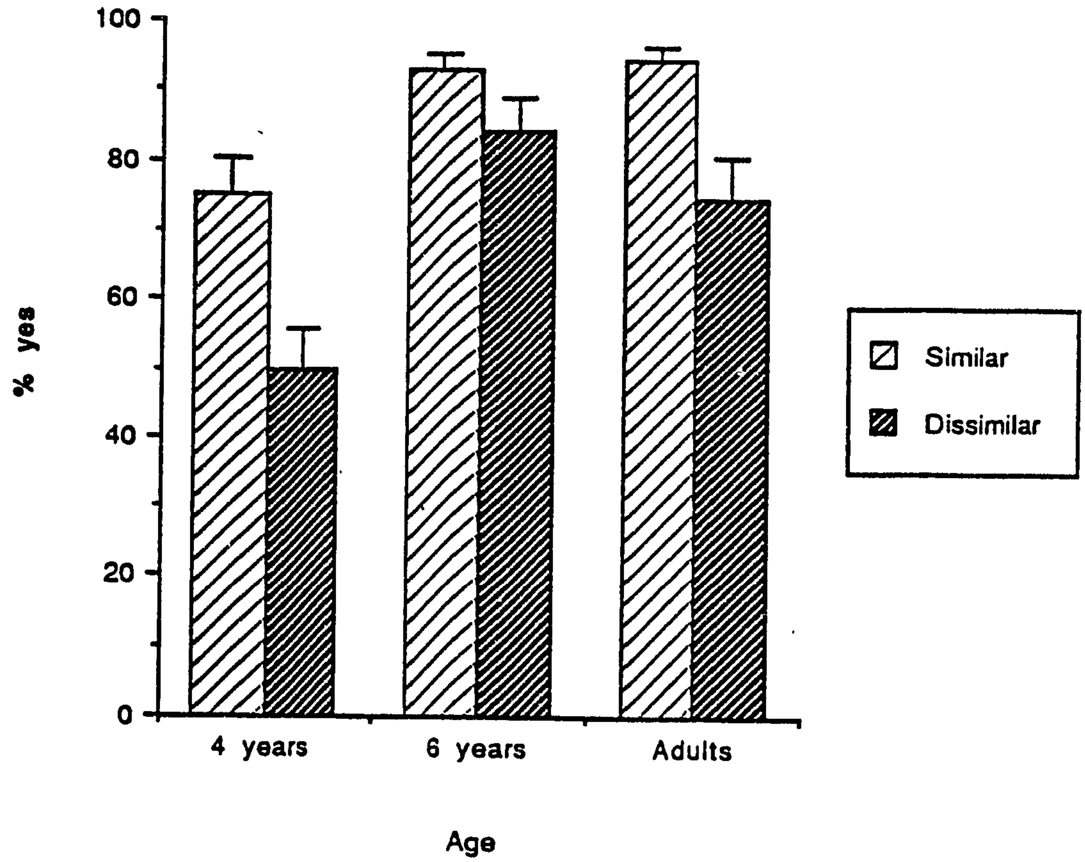

Figure 5. Mean percentage attribution of mental properties to animates as a function of age and similarity.

Property type and the attribution of properties by adults

In the main analysis with children described above, no effect of Property or interaction involving Property was found. In order to determine whether there was an effect of Property type on adults property attributions, a correlated t-test was conducted, comparing the attribution by adults of mental versus biological properties to animates. Adults were found to attribute mental properties to animates (M= 84.52, SD= 16.93) significantly less often than they did biological properties (M= 97.62, SD= 6.12), $t(20)$= -3.92, p < .01. A similar t-test comparing the effect of property type for inanimates could not be conducted due to a lack of variance, however, adults did not seem much more likely to attribute mental properties (M= 0.99, SD= 2.60) than biological properties (M= 0, SD= 0) to inanimates.

Another finding regarding property type for adults was that similarity of the target object to humans did not seem to influence attributions of biological properties to animates (M= 100, SD= 0 and M= 95.24, SD= 12.24 to similar and dissimilar animates respectively), whereas similarity did influence adults' attributions of mental properties, as seen in the previous analysis.

Therefore, adults attributed fewer mental than biological properties to animate objects. In addition, similarity seems to influence attributions of mental, but not biological properties.

The attribution pattern for particular mental properties by adults and children

One goal of this experiment was to investigate the pattern of attribution for individual properties. To investigate age differences in the attribution of individual mental properties (think, want, know feel sad) to dissimilar animates, a 3 (Age) x 4 (Mental Property) ANOVA was conducted, with percent attribution of individual properties to dissimilar animates as the dependent variable. Because adults attributed the capacity of knowing to all similar animates, the attribution of individual mental properties to similar animates could not be assessed in this analysis.

The results of this analysis indicated a main effect of Age $F(2, 56) = 8.89$, $p < .01$, and a main effect of Mental Property Type $F(3, 168) = 2.78$, $p < .05$. In addition, there was a significant Age x Mental Property Type interaction $F(6, 168) = 3.85$, $p < .01$.

Tukey tests were conducted to examine the significant Age x Mental Property Type interaction. When the attribution of specific mental properties to dissimilar animates was compared across the 3 age groups, several differences emerged. Four-year-olds attributed the properties know, want, and think to dissimilar animals less than did 6-year-olds and adults, $p < .05$, who did not differ in the extent to which they attributed either of these properties. Another pattern was found for the property feels sad. The capacity to feel sad was attributed to dissimilar animates by 6-year-olds more often than by adults, $p < .05$. Mean percent attribution of particular mental properties to dissimilar animates are shown in Table 2.

Table 2

Mean percent attribution of individual mental properties to dissimilar animates as a function of age.

Mental Property	Age Group: 4 years	6 years	Adults
Know			
M	46.30	83.33	95.24
SD	(45.93)	(29.62)	(15.94)
Want			
M	51.85	81.67	82.54
SD	(41.57)	(33.29)	(35.93)
Think			
M	44.44	88.33	73.02
SD	(37.92)	(19.57)	(42.97)
Feels Sad			
M	53.70	80.00	47.62
SD	(34.56)	(31.34)	(48.96)

To investigate age differences in the attribution of different mental properties to inanimates, a 2 (Age) x 4 (Mental Property) ANOVA was conducted. No main effect of Age or Mental Property, or significant interaction was found.

In sum, this analysis demonstrated that 4-year-olds underattribute "know", "want" and "think" to lower animals relative to older children and adults. In contrast, 6-year-olds overattributed the capacity "to feel sad" relative to adults, and showed a trend in this direction for thinking.

Discussion

One of the primary goals of this research project was to assess the roles played by category membership and perceptual similarity to humans in the attribution of animal properties by children aged four and six, and by adults. Based on previous research (e.g. Gelman, Spelke & Meck, 1983; Dolgin & Behrend, 1984; Carey, 1985), it was expected that 4-year-olds would successfully deny animal properties to inanimate objects rated perceptually dissimilar to humans, and attribute them to animals in proportion to their judged similarity to people, resulting in underattribution errors. Because of methodological problems with previous studies, it was not known whether children would erroneously attribute animal properties to inanimate objects resembling people, or to what degree. The older children were expected to make more use of category knowledge and be less influenced by similarity than the 4-year-olds, at least when attributing biological properties.

Another set of questions concerned the type of property being tested. Adults were expected to show a category-based pattern of attribution when biological properties were concerned, and an apparently similarity-based attribution pattern for mental properties (Inagaki & Sugiyama,1988). Confirmation of Tunmer's (1985) hypothesis that the animate-animate distinction is learned before the sentient-nonsentient distinction while controlling for the observability of properties was also sought. If his findings were due to the confound of observability, then children should be no more likely to make animistic responses involving mental properties than biological ones. If mental properties are overattributed significantly more than biological properties, then converging evidence for Tunmer's hypothesis would be provided. Finally, the mode of acquisition of the sentient-nonsentient distinction and the possibility of overattribution of mental properties to lower animals by children were also investigated.

Given that 4-year-olds were little inclined to attribute animal properties to inanimate objects that look like people, it appears that preschool children can base their property judgements on category membership even when it is pitted against striking perceptual similarity. At all ages, subjects were much more inclined to attribute animal properties to animals than to inanimate objects. This result is somewhat discrepant with Carey's (1985) finding that some 4-year-olds are unable to adjust their similarity-based inferences with conceptual knowledge. The discrepancy may be related to differing task demands and/or to the fact that degree of similarity was not controlled for in Carey's study. The finding that children are largely successful in denying animal properties to inanimates is consistent with research demonstrating that children rely more on category membership than on appearance when drawing inferences about an object's properties (Gelman, 1988; Gelman & Coley, 1991).

While 4-year-olds were generally good at denying animal properties to inanimate objects, they nevertheless attributed more animal properties to inanimates than did adults, providing support for the idea that preschoolers do have some tendency to be animistic. By the age of 6 years, children in this study no longer overattributed significantly more animal properties to inanimates than adults. In contrast, Piaget and Kawamura have found children to make animistic errors as late as eight or nine years of age. This difference is likely to be explained in terms of the methodological shortcomings in Piaget's studies, and cultural factors in Kawamura's (1987) study. Cultural differences in children's biological knowledge seem to be quite strong. One notable difference is that far more Japanese than American kindergartners attribute "is alive" and other properties of living things to inanimate objects (Siegler, 1989).

An age difference was also observed in the degree to which animal properties were attributed to animates, with 4-year-olds attributing significantly fewer properties to animates than either 6-year-olds or adults, who did not differ from one another. This underattribution of properties to animates by 4-year-olds is largely due to the tendency of 4-year-olds to deny properties to dissimilar animates. This finding was expected on the basis of previous work, in which underattribution errors to animates in preschoolers are well-documented.

Despite the fact that preschoolers demonstrated use of conceptual knowledge, they were also influenced by the perceptual similarity of target objects to humans. Consistent with Carey's (1985) findings, both 4- and 6-year-olds attributed significantly fewer properties to items which did not look like human beings than to items that did. This effect was much more pronounced for the younger age group, suggesting that a substantial shift away from the use of similarity-based inferences occurs between the ages of 4 and 6 years.

In the main analysis of the children's data, perceptual similarity was found to have a greater impact for the animate category than for the inanimate category. This suggests that learning which objects do not possess animal properties is a simpler task than learning all of the objects that do. Just as children may be able to constrain their use of the person analogy by checking whether a similarity-based inference is tenable on the basis of factual knowledge about the target object (Inagaki & Hatano,1991), they can also apparently constrain similarity-based inferences with knowledge of the animate-inanimate distinction.

Consistent with Inagaki & Sugiyama (1988), there was an apparent effect of similarity on the attribution of mental properties found at each age level tested, whereas similarity did not seem to affect the attribution of biological properties by adults. However, there was also evidence to suggest that the pattern of attribution in adults does not represent a simple continuation of the similarity-based inference seen in 4-year-olds, but rather a refinement of the categorical-type attribution seen in 6-year-olds. In particular, the effect of similarity on the attribution of mental properties varied across the age groups in an unexpected way. Similarity had a significantly smaller influence on the attributions of 6-year-olds than on those of adults and 4-year-olds. If, as Inagaki and Hatano (1988) proposed, adults make similarity-based inferences for mental properties because they are novices in this domain, then one would expect similarity to have an equal influence at each age level, or that there would be gradual, ever-decreasing effect of similarity with age, as more knowledge regarding mental properties is acquired. Neither of these patterns was found.

In this study, no support was obtained for the idea that children learn the animate-inanimate distinction before they do the sentient-nonsentient distinction. First, the rate of animistic responding (i.e. the attribution of animal properties to inanimate objects) was very low in general, suggesting that both the animate-inanimate and sentient-nonsentient distinctions have been acquired by the age of 4 years. Moreover, when animistic errors were made, errors involving mental properties were not observed more frequently than those involving biological properties, as was indicated by the lack of any property effect in children. These results suggest that Tunmer's findings may, indeed, have been due to the confounding of property type and observability of properties. In order to conclude this with any certainty, however, it would be necessary to include both easily observable and less observable biological properties in a future study.

Another hypothesis concerning childhood animism was partially confirmed in the present study. Kawamura (1987) proposed that children's animism consists not only of the overattribution of animal properties to inanimates, but also of the child's tendency to overattribute the "mind" to lower animals such as fish and insects. In this study, the possibility that children may overattribute mental abilities to lower animals was evaluated by investigating the attribution of the specific mental properties (e.g. want) to dissimilar animates (fish, fly, snake) by subjects in the three age groups.

It was discovered that children aged 6 years attribute feels sad to dissimilar animates significantly more often than adults. In contrast, wanting and knowing were not overattributed by any of the children in this study relative to adults. These findings suggest that 6-year-olds overattribute some, but not all mental attributes, relative to adults. Importantly, the 4-year-olds did not attribute any mental property to dissimilar animates more often than adults, showing if anything an inclination to underattribute properties. From this it can be concluded that the tendency for children to overattribute some mental properties to lower animals represents a developmentally more mature pattern, that is preceded by a phase in which the child underattributes some mental properties to lower animals and overattributes them to inanimates. As such, it is probably not accurate to refer to the overattribution of mental properties to lower animals as animism per se (e.g. Kawamura, 1987), since it coincides in development with better understanding of the animate-inanimate distinction, as reflected in the level of attribution to inanimates.

Inagaki and Hatano's finding (cited in Inagaki, 1989) that young children were more likely to overattribute feelings to inanimates than properties such as thinking, which are closely associated with the brain by preschoolers, was not replicated in this study, suggesting that the sentient-nonsentient distinction may, indeed, be acquired in an all or none fashion, as Tunmer suggested.

The present findings suggest that preschool children tend to be overly selective in attributing biological and mental properties, restricting them to animals with a human appearance, but that around the sixth year this tendency has been replaced with another one in which all properties are attributed more categorically. This account explains the overattribution of "feels sad" by 6-year-olds relative to adults whose attributions of this property are apparently similarity-based. Development of the animal concept after 6 years, then, should consist partly of learning which mental properties are typically attributed to all animals and which are denied to lower animals.

In conclusion, it seems that children make use of perceptual information and knowledge of the animate-inanimate distinction when attributing properties. While their categories seem to have a conceptual basis, young children still consider how perceptually similar category exemplars are to a prototypical animate (humans) when attributing properties to them. In contrast, adults tend to rely mainly on category knowledge when making property judgements, at least when biological properties are concerned. Children's attribution patterns did not vary systematically with property type, suggesting that the animate-inanimate distinction is not acquired earlier than the sentient-nonsentient distinction. However, it is still very possible that children can use their property definitions in combination with factual knowledge about particular objects to constrain their property judgements.

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Appendix A

Stimuli used in similarity rating task

Animates:

1. CHIMP ______
2. CRAB ______
3. ELEPHANT ______
4. FISH ______
5. FLY ______
6. FROG ______
7. GIRAFFE ______
8. GORILLA ______
9. GRASSHOP ______
10. BEAR ______
11. HAMSTER ______
12. HIPPO ______
13. KOALA ______
14. LIZARD ______
15. MONKEY ______
16. ORANGUT ______
17. PANDA ______
18. PENGUIN ______
19. PIGEON ______
20. PROBISCUS ______
21. RABBIT ______
22. SNAIL ______
23. SNAKE ______
24. SPIDER ______
25. SQUIRREL ______
26. TURTLE ______
27. WORM ______
28. ZEBRA ______

Inanimates:

29. BALL ______
30. BICYCLE ______
31. CAR ______
32. CHAIR ______
33. CUP ______
34. CUSHION ______
35. TOY DINO. ______
36. GUITAR ______
37. HAMMER ______
38. TOY OWL ______
39. METAL DOLL ______
40. PENCIL ______
41. PUPPET ______
42. RAG DOLL ______
43. ROCK ______
44. ROBOT ______
45. STATUE ______
46. STUFF DOG ______
47. TEDDYBEAR ______
48. TOY SOLDIER ______

Appendix B

Instructions for similarity rating practice task

Similarity Rating Practice Task Instructions

Hi, we're going to play a game where we stick pictures on the board. First, let's look at the board I have. See these fuzzy places. That's where you can stick pictures. On the back of the pictures there's a little circle that sticks to this fuzzy stuff, so I just press the circle like this and it sticks. (Demonstrate). The pictures go in these red boxes. Can you count the boxes for me? How many are there? That's right, there are 7 boxes plus this one (point to box at extreme left), and the pictures go in the boxes.

Now I'll tell you how we're going to play this game. First we're going to think about bananas. Can you tell me what a banana looks like? .... It's long and bent. It's yellow too, isn't it? ..... So that's what a banana looks like. Now I'm going to stick a picture of a banana here.

I'm going to give you some pictures and you get to stick them on the board. But before you stick your picture on the board, you should look at the picture to see how much it looks like a banana. If the picture I give you looks almost the same as a banana, then you should put it right beside the banana, here (box 1). If the picture looks a lot like a banana, then you should stick it close to this banana, around here (box 2-3). If the picture kind of looks like a banana, put it here in the middle (box 4). If the picture looks only a tiny bit like a banana, then you should stick it far away from the banana, around here (box 5-6). And if the picture does not look like a banana at all, then you should put it all the way over here, (box 7), far away from where the banana is. You can put the picture in any of the red boxes, just remember the more the picture looks like a banana, the closer to the banana you should put the picture.

Let's look at the first picture. Hand child picture of the apple (box 7 correct), the telephone (box 2 or 3 correct), and the toothbrush (box 5 or 6 correct). When child is correct, discuss why correct. If incorrect, explain why correct and demonstrate correct answer.

Appendix C

Children's instructions for similarity rating task

Children's instructions for similarity rating task

Now we're going to play a different game. This time it's about people not bananas. Can you tell me what people look like? (Discuss the fact that people can vary in shape and size. Place man in box 1). Here's a person. This time when I give you a picture, you should look at the picture to see how much it looks like a person. If the picture I give you looks almost the same as a person, then you should put it right beside the person, here (in box 1). If the picture looks a lot like a person, then you should stick it close to the person, around here (box 2-3). If the picture looks kind of like a person, put it in the middle here (box 4). If the picture looks only a tiny bit like a person, then you should stick it far away from the person, around here (box 5-6). And if the picture does not look like a person at all, then you should put it all the way over here, (box 7), far away from where the person is. You can put the picture in any of the red boxes, just remember the more the picture looks like a person, the closer to the person you should put the picture. Do you understand?

Appendix D

Adult instructions and questionnaire
for similarity rating task

Similarity Rating Task

Please provide us with the following information:
Sex : M___ F___ Age: ____

In this study you will be shown a series of photographed objects and asked to judge how similar in appearance each object is to a person. The photographs will be presented one by one by the experimenter. Each photograph will be presented alongside a photograph of a person to remind you of your task - to rate how much the object in question looks like a person. Keep in mind that the photographed person is only one example of a person. When you make your judgement, you should rate how similar the object looks to any person, not just how similar it looks to the particular man in the photograph.

After looking carefully at each object, you should indicate how much it looks like a person using the 7-point rating scale provided on this questionnaire. If you think the object looks almost the same as a person, then you should circle the number **1**. If the object looks a lot like a person, then circle **2** or **3**. If the object looks kind of like a person, circle **4**. If the object looks a tiny bit like a person then circle **5** or **6**. And if the object does not look like a person at all, then circle **7**.

You can circle any one of the numbers from 1 through 7, just remember the <u>more</u> the object looks like a person, the <u>lower</u> the number you should circle. You should begin with question number 1 at the top of the next page and proceed downwards.

	Looks almost the same as a person	Looks a lot like a person		Looks kind of like a person	Looks a tiny bit like a person		Does not look like a person at all
1)	1	2	3	4	5	6	7
2)	1	2	3	4	5	6	7
3)	1	2	3	4	5	6	7
4)	1	2	3	4	5	6	7
5)	1	2	3	4	5	6	7
6)	1	2	3	4	5	6	7
7)	1	2	3	4	5	6	7
8)	1	2	3	4	5	6	7
9)	1	2	3	4	5	6	7
10)	1	2	3	4	5	6	7
11)	1	2	3	4	5	6	7
12)	1	2	3	4	5	6	7
13)	1	2	3	4	5	6	7

	Looks almost the same as a person		Looks a lot like a person		Looks kind of like a person		Looks a tiny bit like a person		Does not look like a person at all
14)	1	2	3	4	5	6	7
15)	1	2	3	4	5	6	7
16)	1	2	3	4	5	6	7
17)	1	2	3	4	5	6	7
18)	1	2	3	4	5	6	7
19)	1	2	3	4	5	6	7
20)	1	2	3	4	5	6	7
21)	1	2	3	4	5	6	7
22)	1	2	3	4	5	6	7
23)	1	2	3	4	5	6	7
24)	1	2	3	4	5	6	7
25)	1	2	3	4	5	6	7
26)	1	2	3	4	5	6	7

	Looks almost the same as a person		Looks a lot like a person	Looks kind of like a person	Looks a tiny bit like a person		Does not look like a person at all
27)	1	2	3	4	5	6	7
28)	1	2	3	4	5	6	7
29)	1	2	3	4	5	6	7
30)	1	2	3	4	5	6	7
31)	1	2	3	4	5	6	7
32)	1	2	3	4	5	6	7
33)	1	2	3	4	5	6	7
34)	1	2	3	4	5	6	7
35)	1	2	3	4	5	6	7
36)	1	2	3	4	5	6	7
37)	1	2	3	4	5	6	7
38)	1	2	3	4	5	6	7
39)	1	2	3	4	5	6	7

	Looks almost the same as a person	Looks a lot like a person		Looks kind of like a person		Looks a tiny bit like a person	Does not look like a person at all
40)	1	2	3	4	5	6	7
41)	1	2	3	4	5	6	7
42)	1	2	3	4	5	6	7
43)	1	2	3	4	5	6	7
44)	1	2	3	4	5	6	7
45)	1	2	3	4	5	6	7
46)	1	2	3	4	5	6	7
47)	1	2	3	4	5	6	7
48)	1	2	3	4	5	6	7

Appendix E

Instructions for property judgement practice task

Property Judgement Practice Task

Today we're going to play some games with pictures. I'm going to show you some pictures and I want you to help me by putting the pictures into two special boxes. In the first game, I'm going to show you some pictures and I want you to tell me if what you see in the picture has eyes or not. If you think it has eyes, then you should put it in this box here (right hand box). If you think it does not have eyes, then you should put it in this box, here (point to left-hand box). Do you understand?

Ok. Let's start. Hand child the goat, watch, hamster, and cup in that order. Place the picture directly in the child's hand. If child is correct, praise and proceed to next item. If incorrect, remove card from box and holding it before child say "Does a _____ have eyes?" Where should it go, then?" Let child correct self.

Appendix F

Children's instructions for property judgement task

Children's instructions for property judgement task

Now we're going to play another game. Before we start, I want you to tell me the names for what you see in the pictures I have. Present all 13 stimulus pictures, asking: What is this called? Correct the child if he/she labels a picture incorrectly. For example, if the child calls the stuffed dog a "doggie", say "it's a stuffed doggie". If the child provides an acceptable alternative label (e.g. monkey for chimpanzee), do not correct him/her.

Now we're ready to start. I'm going to show you the pictures one at a time, and I want you to tell me if what you see in each of the pictures:

has a heart or not.
has a brain or not.
can have babies or not.
starts out smaller and grows or not.
can think or not.
can want something or not.
can know something or not.
can feel sad sometimes or not.

If you think it has/can/starts ... , then put it in this box here (right hand box). If you think it does not have... /can not .../does not start out .... then put it in this box, here (point to left-hand box). If you're not sure, just put the picture where you think it should go.

Present first picture and say:

Does a X have a brain / heart?

Can an X have babies / think / want something / know something, feel sad sometimes?

Does an X start out smaller and grow?

Appendix G

Adult instructions for property judgement task

Adult instructions for property judgement task

Before we start, I want you to tell me the names for what you see in the pictures I have. Present all 13 stimulus pictures, asking: What is this called? Correct subject when items are incorrectly labelled. Subjects are not corrected if they provide an acceptable alternative label (e.g. monkey for chimpanzee).

In this session, I'm going to show you some pictures and ask you if what you see in each the pictures possesses a given property or not. You will be asked to make judgements about a variety of properties. You should respond to each question I ask you with a "yes" or a "no". If you are not sure if what you see in the picture has the property or not, then give it your best guess. Do you have any questions?

Ok, let's start. In the first task, I'm going to show you the pictures one at a time, and I want you to tell me if what you see in each of the pictures:

has a heart or not.
has a brain or not.
can have babies or not.
starts out smaller and grows or not.
can think or not.
can want something or not.
can know something or not.
can feel sad sometimes or not.

Present the first picture and say:

Does a X have a heart / brain?
Can a X have babies / think / want something / know something / feel sad sometimes?
Does a X start out smaller and grow?