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Brief article

Evidence for kind representations in the absence of language: Experiments with rhesus monkeys (*Macaca mulatta*) ☆

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Abstract

How do we come to recognize and represent different kinds of objects in the world? Some developmental psychologists have hypothesized that learning language plays a crucial role in this capacity. If this hypothesis were correct, then non-linguistic animals should lack the capacity to represent objects as kinds. Previous research with rhesus monkeys (*Macaca mulatta*) has shown that this species can successfully individuate different kinds of objects – monkeys who saw one kind of object hidden inside a box searched longer after finding a different kind of object. However, in these studies and the infant studies on which they were based, the objects to be individuated differed both in kind and in properties. Thus, subjects in these experiments may not be representing the kinds of objects per se, but instead only their immediate perceptual properties. Here, we show that rhesus monkeys successfully individuate different kinds of objects even when their perceptual properties are held constant. Although these data provide the best evidence to date that language is not necessary to represent kinds, we discuss our findings in terms of possible associative hypotheses as well.

Keywords: Kind representation; Monkey; Individuation

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1. Introduction

Our minds are constantly bombarded by a flood of perceptual input. Somehow, we manage to sort it all out. We do not experience just a jumble of colors and shapes. Instead we see things like *apples* and *bananas* and *tables* and *chairs*, we effortlessly and automatically parse the world into different kinds of objects. This impressive capacity is also incredibly useful. Knowledge about kinds of objects helps us predict what to expect from objects, and how to interact with them. When we see an apple, for example, we can think back on a lifetime of experience with apples and know that this new instance of an apple will also be white and crunchy on the inside, that it will taste sweet but a little tart, and that it possesses a core that is not good to eat. How is it that we come to represent the objects around us as being of certain kinds?

There is some evidence that infants do not possess the ability to represent objects as kinds from the start, but instead, develop this capacity between 10 and 12 months of age (Xu, 2002; Xu & Carey, 1996; Xu, Carey, & Welch, 1999; Xu, Carey, & Quint, 2004). Xu and Carey (1996), for example, explored when infants begin to use kind information to determine how many objects are present in a scene. They alternately moved two different kinds of toys (e.g., a ball and a duck) back and forth behind a screen such that the two objects were never seen at the same time. In the test event, they removed the screen to reveal either both objects (an expected event), or only one object (an unexpected event). Twelve-month-old infants looked longer at the unexpected event relative to baseline, whereas 10-month-old infants did not. When 12-month-olds see two different kinds of objects, they expect that there are two individuals, whereas 10-month-olds show no evidence of such an expectation. Xu and Carey interpreted this result as evidence that the ability to represent kinds emerges between 10 and 12 months of age.

What happens between 10 and 12 months to enable infants to succeed in these experiments? One hypothesis – offered by Xu and colleagues – proposes that infants' emerging capacity to represent kinds stems from their developing linguistic competence, a capacity that comes online around 12 months of age (see Xu, 2002; Xu & Carey, 1996; Xu et al., 1999; Xu et al., 2004). They have argued that learning a verbal label for an object helps to establish a kind representation for that object. For example, knowing the word "apple" may enable the infant to bind together the relevant information about apples into a coherent kind representation. Several important empirical results seem to support this view. First, infants tested in these individuation experiments begin to succeed around 12 months of age, a period that corresponds with the development of word comprehension (see Xu & Carey, 1996). Second, Xu et al. (2004) showed that 12-month-olds succeeded in individuating two objects when the objects were of different kinds, but failed to individuate objects of the same kind, even when the properties of these objects were very different. Most compellingly, Xu (2002) found that naming the objects during an individuation task enabled younger 9-month-old infants to perform like 12-month-olds and succeed in individuation; in contrast, labeling the same objects with emotional vocalizations, beeps, or other non-linguistic sounds did not allow younger infants to succeed. Taken together, this work suggests that language may play an important role in the development of the ability to represent kinds.

There are at least two lines of evidence against this view that language is important for representing kinds. The first comes from studies showing that younger infants can in some cases individuate different kinds of objects (Leslie, Xu, Tremoulet, & Scholl, 1998; Needham, 1998, 1999; Needham & Baillargeon, 1997, 1998; Needham, Duecker, & Lockhead, 2005; Wilcox, 1999; Wilcox & Baillargeon, 1998a, 1998b; for a review see Needham & Baillargeon, 2000). A second line of evidence against Xu and colleagues' language hypothesis – the one we will focus on here – involves non-human primates. If language is necessary for the ability to represent kinds, then organisms that lack language should also lack kind representations. In contrast to this prediction, non-human animals have been shown to distinguish between different kinds of objects in a number experimental situations (Clayton & Dickinson, 1999; Munakata, Santos, Spelke, Hauser, & O'Reilly, 2001; Uller, Xu, Carey, & Hauser, 1997; Santos, Sulkowski, Spaepen, & Hauser, 2002). In one study (Santos et al., 2002), rhesus monkeys (*Macaca mulatta*) watched as an experimenter placed a grape into a box. The monkeys were then allowed to search the box for the hidden food. Like 12-month-old infants tested in a similar experiment (Van de Walle, Carey, & Prevor, 2000), monkeys searched longer when they found the wrong kind of fruit in the box (e.g., a piece of coconut) than when they found the correct kind (see Tinklepaugh, 1928 for an earlier version of this study with a similar finding). Both this result and others demonstrate that monkeys are able to individuate different kinds of objects, suggesting that language is not crucial for success in these tasks.

Xu and colleagues have countered this line of evidence by claiming that monkeys could potentially have solved these individuation tasks without using kind representations (see Xu, 2002). In all of these studies, the different kinds of objects used as stimuli also differed in their perceptual properties – they looked different from each other. Xu and colleagues argued that non-linguistic subjects, who lack kind representations, could have succeeded in individuation tasks solely through the use of property information. Unfortunately, however, this alternative hypothesis about the use of property rather than kind information could justifiably be applied not just to studies of non-linguistic subjects, but to all studies of kind individuation to date – including those testing post-linguistic 12-month-olds (e.g., Xu & Carey, 1996). All prior individuation studies have failed to reliably distinguish between property and kind individuation. That is, the stimuli to be individuated in these studies always differed both in kind (e.g., duck versus truck) and in perceptual properties (e.g., duck-shape versus truck-shape). This may seem obvious – of course different kinds of objects also look different from each other. Nonetheless, because the objects to be individuated have always varied both in perceptual properties and in kinds, it is impossible to discern whether these studies require kind representations or merely property representations. For this reason, the evidence available does not justify crediting either monkeys or 12-month-old infants with kind representations.

In order to move closer to answering the question of whether language is necessary for kind representations, we designed a searching experiment for rhesus monkeys in which subjects were required to individuate objects which varied in kind *but not in perceptual properties.* Specifically, we showed monkeys an event in which an experimenter presented a familiar fruit (e.g., a coconut) and pretended to place what looked like a small piece of that fruit inside a box. In all conditions, however, the object that the monkeys actually saw placed in the box was not a piece of fruit at all; instead it was a small piece of white plastic. The experimenter then walked away and allowed the subject to search inside the box. Subjects found either a *consistent* kind of fruit (e.g., a piece of coconut) or an *inconsistent* kind of fruit (e.g., a piece of apple). If monkeys represent objects only in terms of their immediate perceptual properties, then they should search equally across both consistent and inconsistent test conditions, as the immediate perceptual properties of the object that entered the box were identical across both. In contrast, if monkeys represent the *kind* of food placed into the box, then they should expect to find a particular type of fruit (either apple or coconut), and therefore should search longer on inconsistent than on consistent test trials.

2. Method

2.1. Participants

We tested 29 free-ranging adult rhesus macaques from the Cayo Santiago population (see Rawlins & Kessler, 1987). An additional 97 monkeys were approached but could not be tested because of interference, failure to approach the box, or experimenter error. All of these monkeys were dropped from the experiment by the cameraperson, who was blind to the experimental condition.

2.2. Apparatus and stimuli

As in previous studies (Santos et al., 2002), we used an open-topped flexible plastic cooler (15 cm × 25 cm × 15 cm) as the searching box. This box was always filled with 10 large leaves from a tree native to the island. These leaves completely covered any objects placed in the box. We used two kinds of fruit as visual stimuli: apples and coconuts. We used apples and coconuts because both types of fruit have similar white insides and are familiar to monkeys in the Cayo Santiago population. We used a whole apple and a hollow half coconut shell as stimuli; as such, subjects never saw the white insides of these stimuli during the experimental presentation (see Fig. 1). The mock piece of fruit was a white plastic rectangular solid (2.5 cm × 2.0 cm × 1.5 cm). The real foods placed inside the box were cut pieces of apple and coconut (2.5 cm × 2.0 cm × 1.5 cm). These food stimuli were stripped of any peel or rind and were identical in size and similar in color to the piece of plastic.

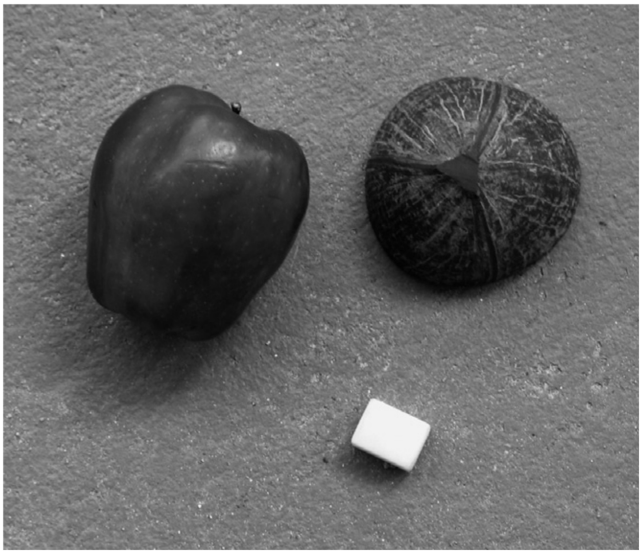

Fig. 1. A photograph of the stimuli used in this experiment. Subjects saw a white plastic piece (center) emerge from either the apple (left) or the coconut (right).

2.3. Procedure

Two researchers conducted the experiment – a presenter and a cameraperson. The presenter located a lone subject, and then stood directly in front of the subject at a distance of 3–5 m. The cameraperson positioned herself at least 3 m away from the presenter and videotaped the subject using a Sony Digital-8 Handycam. The presenter began the trial by informing the cameraperson that he was beginning the experimental presentation. The cameraperson directed the camera at the subject and did not observe the experimental presentation – the cameraperson was thus blind to the experimental condition throughout the trial.

Each subject received only one trial. The presenter began by placing the box on the ground without letting the subject see its contents (see Fig. 2). The box contained leaves, and either a preloaded coconut or apple piece (depending on the condition). The experimenter then presented the fruit – either the whole apple or the coconut shell. With this design, each subject received one of four possible conditions:

Consistent-coconut: the subject saw the plastic piece being removed from a coconut and the box contained a real piece of coconut.

Consistent-apple: the subject saw the plastic piece being removed from an apple and the box contained a real piece of apple.

Inconsistent-coconut: the subject saw the plastic piece being removed from a coconut and the box contained a real piece of apple.

Inconsistent-apple: the subject saw the plastic piece being removed from an apple and the box contained a real piece of coconut.

Fig. 2. Depiction of an example experimental presentation. The presentation began with a real piece of fruit concealed inside the box (left). The experimenter then removed a piece of plastic from one kind of fruit (center) and pretended to place the piece into the box (right).

Once the fruit was presented, the experimenter allowed the subject to view it for two seconds. He then removed the white plastic piece from behind the fruit. To a human observer, this appeared as though the presenter had removed a chunk of the fruit, despite the fact that the actual object was just a piece of white plastic. The presenter placed the plastic piece inside the box. He then surreptitiously removed the plastic piece from the box, turned around, and walked away from the box to a distance of 5–10 m, allowing the subject to approach. Subjects were then allowed to search the box, find the piece of food hidden inside the box, and then continue searching. The cameraperson (who was blind to the experimental condition) determined that the subject had completed this second period of search when either (1) the subject stopped searching for one full minute, or (2) the subject moved more than 2 m away from the box.

2.4. Data analysis

An experimenter blind to the experimental condition reviewed video footage of all trials using QuickTime Player software and measured subjects' duration of searching. Coding began when the subject first removed the food item from the box and continued until the end of the trial. As in previous studies (Santos et al., 2002), search was defined as looking into the box or through its contents.

3. Results

We performed an ANOVA with test outcome (consistent or inconsistent) and fruit type (coconut or apple) as factors (see Fig. 3). We observed a main effect of test outcome ($F_{(1,25)} = 5.04$, $p = 0.03$). Subjects searched longer on inconsistent test trials

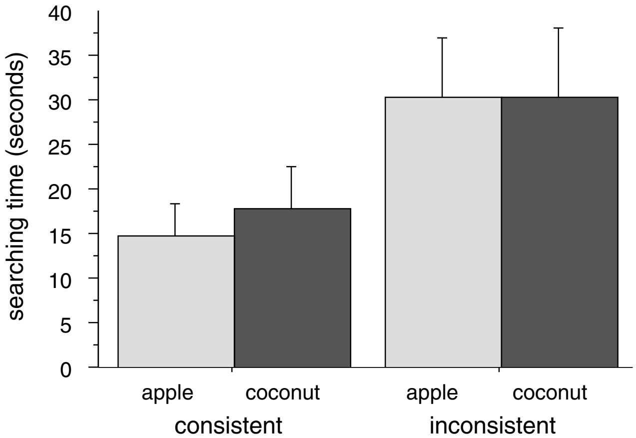

Fig. 3. Mean (± standard error) number of seconds subjects spent searching across consistent and inconsistent conditions.

($M = 30.15$ s $\pm$ $SE = 5.03$) than on consistent test trials ($M = 16.24$ s $\pm$ $SE = 2.79$). We observed no main effect of fruit type ($F_{(1,25)} = 0.06$, $p = 0.81$). Subjects searched equally across coconut and apple test trials. There was also no interaction between test outcome and fruit type ($F_{(1,25)} = 0.06$, $p = 0.82$).

4. Discussion

Subjects in the inconsistent condition searched almost twice as long as subjects in the consistent condition. Though all subjects saw the same perceptual object enter the box in every condition, those who found the wrong kind of fruit searched longer than those who found the right kind. This result coincides with the findings of previous studies examining object individuation in this population (Santos et al., 2002). Importantly, however, unlike previous studies, the object to be individuated had the same perceptual properties across both test conditions. For this reason, the present results – unlike previous studies – cannot be accounted for in terms of simple immediate property representations. As such, these results provide the best evidence yet that monkeys possess kind representations and use them in the service of object individuation. Furthermore, since monkeys lack language, these results challenge the hypothesis that linguistic labels are necessary for kind representations.

In order to more effectively compare monkeys to human infants, an important next step will be to test infants using a version of this kind individuation task, as opposed to the property individuation tasks that have been employed thus far. At present, the results of infant individuation experiments are consistent with the view that 12-month-olds begin to succeed in individuation tasks not because of any newly acquired kind representation system, but rather because of other newly developing capacities. Using the type of control employed in the present study, however, will enable researchers to better ascertain whether the developmental shift observed in 12-month-olds truly reflects an emerging capacity to represent kinds.

Although the present experiments provide the best evidence to date that a non-human primate possesses kind representations in the absence of language, the monkeys' performance in the present study need not be the result of kind representations. Perhaps what monkeys learn through interacting with coconuts and apples are not kind representations for those types of objects, but are instead clusters of properties that have become associated through experience. During prior encounters with coconuts, for example, subjects may have learned to associate the outside properties of a coconut – brownness, roundness, and fuzziness – with its inside properties – whiteness, crunchiness, and sweetness. Thus, when monkeys see brown, round, and fuzzy properties during the presentation, they expect to find the associated white, crunchy, and sweet, properties inside the box.

Note that this associative account is importantly different from property-based explanations of previous infant and primate individuation studies. Subjects in previous studies may have represented objects only in terms of their immediate properties (duck-shape), whereas in the present study subjects were required to infer one property of an object from another (coconut-color → coconut-taste). More specifically, subjects in previous studies could have successfully individuated different kinds of objects without using any long-term representations of kinds. Subjects in previous studies may have represented only the immediate perceptual properties of the objects that they saw during presentation, and then expected to find those same properties (e.g., "I saw duck-shape and now I expect duck-shape"). The present study, in contrast, tested subjects' expectations of properties that they had *never seen* during the presentation. Subjects were required to infer unobserved properties from observable ones (e.g., "I saw coconut *shape*, and now I expect coconut *taste*"). Unlike previous studies, these results require subjects to infer an unobservable property, and are thus difficult to account for without crediting subjects with some sort of long-term representations of the two kinds of objects.

The critical question now facing cognitive scientists is whether and how monkeys' long-term representations of different types of objects are like and unlike our own. It is possible that adult humans and non-human primates learn and represent different types of objects in radically different ways, with the human system for kind representation requiring language. An equally consistent (and more parsimonious) explanation, however, is that humans and non-humans represent different kinds of objects in much the same way. Although our results can be accounted for by crediting the monkeys with either kind representations or with clusters of associated properties, we suspect that the correct account will turn out to be that monkeys, like humans, represent objects as kinds.

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