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The Human First Hypothesis: Identification of Conspecifics and Individuation of Objects in the Young Infant

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How do infants individuate and track objects, and among them objects belonging to their species, when they can only rely on information about the properties of those objects? We propose the Human First Hypothesis (HFH), which posits that infants possess information about their conspecifics and use it to identify and count objects. F. Xu and S. Carey [*Cognitive Psychology*, **30**(2), 111–153, 1996] argued that before the age of 1 year, infants fail to use property information. To explain their results, Xu and Carey proposed the Object First Hypothesis (OFH), according to which infants under 1 year of age have only the general concept of physical object to identify and count objects. We show that infants have a more extensive knowledge of sortals than that claimed by the OFH. When 10-month-olds see one humanlike and one non-humanlike object, they successfully identify and count them by using the contrast in their properties, as predicted by the HFH. We also show that infants succeed even when they make a decision based on differences between two close basic-level categories such as humanlike objects and doglike objects, but fail when they have to use differences within the human category. Thus, infants treat ‘‘human’’ as a basic sortal, as predicted by the HFH. We argue that our results

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cannot be accounted for by general purpose mechanisms. Neither the strong version of the OFH and its explanation in terms of object indexing mechanisms [A. M. Leslie, F. Xu, P. Tremoulet, & B. J. Scholl, *Trends in Cognitive Sciences,* **2**(1), 10–18, 1998] nor explanations in terms of task demands [T. Wilcox & R. Baillargeon, *Cognitive Psychology,* **37**(2), 97–155, 1998] are sufficient to explain our results.

Key Words: object individuation; object identification; recognition of congenerics; human faces; age differences; cognitive development; object permanence; infants.

There are things in the world that interact with us better than any others, feed us when we need to be fed, love us, hate us, and help us to pass on our genetic endowment. To be able to identify them and tell them apart is fundamental for us.

How, then, do humans identify objects and separate conspecifics from all the rest? Using object properties is a reliable way of doing this because objects with different properties are likely to be different objects. But not all properties will work, for a dark stone and a light stone may be the same stone under different lighting conditions. Yet properties typical of different kinds will. For example, if we see an object that has human properties and subsequently something that has the properties of a chair, we know that we have seen two different objects because humans and chairs belong to different kinds. We can thus track, name, remember, and reindividuate the two things differently and interact properly with them; we do not talk to chairs, and we do not sit on people. Let us call this method of identification the *property method.*

Adults exploit the property method ubiquitously. However, little is known about what makes this ability possible and how it develops. Experience certainly plays a role in its acquisition; sometimes we just have to learn that certain properties are reliably correlated with certain kinds. But in some cases, detection of kind properties may be made directly available by the architecture of the brain. Adult imagery studies suggest that certain kinds are segregated in their cortical representation. Dedicated cerebral tissue exists to process properties of at least three broad classes of objects: members of our species, animals, and other things (e.g., Kanwisher, McDermott, & Chun, 1997; Kanwisher, Stanley, & Harris, 1999; Kanwisher, Tong, & Nakayama, 1998; Martin, Wiggs, Ungerleider, & Haxby, 1996; Perani et al., 1995).

In this threefold broad classification, members of our species are particularly important. There are various properties that may allow us to uniquely identify conspecifics and segregate them from everything else, such as having a particular kind of face or body schema or speaking a natural language. Accordingly, we possess special systems and dedicated cerebral tissue for handling such properties (e.g., Bertenthal, Proffitt, & Kramer, 1987; Dehaene et al., 1997; Kanwisher et al., 1999).

Thus, the brain seems to be designed to specially treat humans, animals, and inanimate objects. Of these three classes, identifying humans has been proposed to rely on special mechanisms in the adult (e.g., Kanwisher et al., 1997, 1999). It is reasonable to suppose that infants, like adults, can distinguish humans from other objects and living creatures very early on. Indeed, research over the past 15 years has established that very young infants have the ability to discriminate a wide array of properties. Such abilities are not limited to basic low-level stimulus features but rather extend to the complex properties that could allow them to uniquely single out conspecifics (e.g., Bertenthal, Proffitt, Spetner, & Thomas, 1985; Bertoncini et al., 1989; Johnson & Morton, 1991; Meltzoff & Kuhl, 1994). Furthermore, such abilities are not just ''perceptual.'' Infants know something about the objects that possess those properties. For example, not only can they discriminate animate objects from inanimate ones (e.g., Meltzoff, 1995; Spelke, Phillips, & Woodward, 1995), or animals from artifacts (e.g., Mandler & McDonough, 1993, 1998), or intentional objects from nonintentional objects (Csibra, Gergely, Biro, Koos, & Brockbank, 1999), but they can also apply different psychological principles to the objects of such classes. They form specific expectations of what an animal, or an intentional object, can and cannot do and of what they can do with it (e.g., Csibra et al., 1999; Mandler & McDonough, 1998; Premack, 1990; Premack & Premack, 1995a, 1995b; Premack & Premack, 1997; Woodward, 1998; Woodward & Sommerville, 2000).

In short, it seems that infants are equipped with all of the necessary cognitive mechanisms for applying the property method at least to humans, animals, and objects. Nonetheless, we do not know whether they actually *use* the concepts and property detectors to *identify* objects. It is one thing to be able to discriminate properties or even to sort objects in different categories according to such properties. It is another thing to use category memberships as conditions for object identification. For example, we could class *x* in the *cow* category and *y* in the *truck* category because they have different properties, but does this mean that we will consider *x* and *y* as different objects? That depends on our metaphysics. We may think that because *x* and *y* are so different in properties, they also must be two distinct objects. But we may also have a more liberal metaphysics and think that *x* and *y* are the same object, which first appeared to us as a cow and then as a *truck*. We know that infants are surprisingly good at detecting property changes and at categorizing, but we do not know what they think for this specific matter. We do not know what their metaphysics of object identification looks like.

To our knowledge, the first study that directly investigated this question during early infancy was Xu and Carey (1996). The authors devised a paradigm, which we describe below, to specifically test whether infants can identify objects by using the property method. Surprisingly, Xu and Carey found that 10-month-olds, unlike 12-month-olds, fail to do so. When 10-month-olds are first shown a cow and then a truck, they do not behave as if they have been shown two objects unless they have seen them appearing simultaneously in different spatial locations at some point during the experiment.

To account for their findings, Xu and Carey (1996) proposed what they called the Object First Hypothesis (OFH). According to the OFH, young infants represent objects as physically bounded, spatially separated entities persistent over time regardless of their differences in properties. Only in a successive stage can they use properties for identifying objects. Thus, during a first stage, infants may possess only the general sortal concept of ‘‘physical object.’’ They may be able to individuate and track objects if they are given spatiotemporal information, but they may disregard any other kind of information to that purpose, including differences in objects’ sortal properties that can be detected by them and that would be relevant to tell the objects apart.

If the OFH is correct, the way we understand infants’ early knowledge will have to be radically revised. Proofs of extensive early abilities in infants have been taken to support the view that the cognitive endowments of infants and adults are substantially identical (e.g., Baillargeon, Spelke, & Wasserman, 1985; Mehler, Dupoux, & Southgate, 1994; Spelke, 1994). The OFH, however, suggests that an infant of 10 months may, like adults, have concepts such as ‘‘cow’’ and ‘‘truck’’ but, unlike adults, may use them in much the same way as we use ‘‘water’’ and ‘‘vapor.’’ ‘‘Water’’ does not individuate one object; it is simply a mass term. And just as water can become vapor in only a few seconds, so for the 10-month-old, ‘‘truckness’’ can become ‘‘cowness’’ in a split moment. Thus, the OFH suggests that even if the infant may be endowed with concepts such as ‘‘truck’’ and ‘‘cow,’’ such concepts are useless for identifying individuals. In its extreme formulation, the hypothesis entails that infants may possess a great deal of adultlike knowledge but live in a world that is completely different from that of adults. Accordingly, Carey (1995) held that the passage from the infant’s world of before and after 1 year is a powerful case of discontinuity—a case of conceptual change.

We favor a qualified continuity position. The research we present suggests that, at least for the classes of humans, animals, and inanimate things, there is no conceptual change. We submit that the organization of the human brain representing humans, animals, and other things can be found at the initial state and can be recruited directly for the purpose of object identification. We thus predict that infants can use properties of conspecifics very early on to identify humanlike objects and keep them separate from other objects. For expository purposes, we call our thesis the Human First Hypothesis (HFH), and we leave the extent to which the HFH conflicts with the OFH for later discussion.

Testing Numerical Expectations from Property Changes

Suppose that an infant sees a truck disappear behind an occluder and a cow appearing from behind it. The infant will be surprised. We can interpret this as a sign that the infant conjectured that there is only one object behind the occluder and was surprised to discover that there are two (see, e.g., Wilcox & Baillargeon, 1998). Xu and Carey (1996), however, argued that the infant could be surprised without ever concluding that there are two objects. Indeed, the infant may think that there is only one object and be surprised that its properties have changed. Or, the infant might simply be surprised at the property change without making any definite numerical judgment. In short, if we need to know whether the infant has individuated two objects, surprise at changes in properties alone will not do. We need to investigate the infant's numerical expectations.[1]

This is what Xu and Carey's (1996) paradigm does. The paradigm works as follows. One object comes out from one side of an occluder and disappears behind it. Then, another one appears on the opposite side of the occluder and also disappears behind it. The infant never sees the two objects together, so any inference that might be made about their number can be based only on their difference in properties. Finally, the occluder is removed and looking time for either one or two objects is measured and compared to a baseline condition in which the infant's natural preferences for the same objects are evaluated.

Xu and Carey reasoned as follows. If the infant applies the property method and concludes that there are two objects behind the occluder, he or she will be surprised to find only one object. Therefore, natural preference as measured by looking time will be modified. The expected outcome (two objects) will tend to be looked at less than before the experimental manipulation (as measured by a baseline), and the unexpected outcome (one object) will tend to be looked at longer. This modification will yield an interaction between outcome (one or two objects) and experimental condition (baseline or property presentation), which signals that the infant has successfully applied the property method and drawn a conclusion about the number of objects behind the occluder on the basis of the difference in their (nonspatial) properties. Absence of such an interaction, instead, is more difficult to interpret,[2] but it may signal that for the child the difference in properties between

[1] In this article, we talk about infants' ''surprise'' and infants' ''numerical expectations'' freely. In fact, we are not convinced that we are measuring surprise if surprise involves a conscious central thought process. Neither are we quite convinced that our paradigm reveals *numerical* expectations. It is possible that longer looking times in the unexpected outcomes are the result of low-level processes that never percolate to consciousness and that infants' expectations are not about the number of objects involved but rather derive from states of brain activation that do not involve explicit numerical judgments.

[2] It is possible, of course, that if infants fail to show surprise at the one-object outcome, this does not mean that they are unable to use the property method but rather means that they are not willing to use it in the context of the experiment. They may still identify objects on the basis of their properties but have a different explanation about why the second object is missing. For example, they may think that the second object has been removed from the scene and therefore are not surprised when they find only one object behind the screen. Although

a cow and a truck, which the infant surely detected, was not sufficient to identify two separate objects.

The paradigm is well-suited to test the HFH. The HFH predicts that even 10-month-olds faced with things that possess typical human properties and things that possess typical nonhuman properties should count and track the objects independently using the property method. Thus, they should succeed where Xu and Carey's 10-month-olds, exposed to property contrasts that did not cross this basic category boundary, failed. Experiment 1 is designed to test this prediction.

EXPERIMENT 1

There are various pieces of evidence suggesting that dedicated cerebral tissue exists to treat human faces (e.g., Kanwisher et al., 1997, 1999). Furthermore, even for infants, faces are a special kind of stimulus (e.g., Johnson & Morton, 1991; Valenza, Simion, Cassia, & Umiltà, 1996).

We thus began testing the HFH by contrasting dolls with realistic faces and objects deprived of humanlike features. Although dolls' faces are not real faces, up to a certain level of processing they are likely to engage the same neurological mechanisms, as imaging studies in the monkey suggest (Wang, Tanifuji, & Tanaka, 1998). The HFH predicts that 10-month-old infants should be able to apply the property method when presented with this contrast.

Experiment 1 was also designed to replicate the results of Xu and Carey (1996) by using our methodology and apparatus, which differ in various respects from theirs. To this purpose, we also tested a group of 12-month-olds. Xu, Carey, and Welch (1999) and Xu (1999) held that infants of that age apply the property method provided that objects differ in kinds. In this experiment, our objects were different in kinds, and thus we predicted that if our methodology is adequate, 12-month-old infants should succeed with our stimuli.

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we acknowledge that such an interpretation is possible, we find it at odds with the whole of Xu and Carey's results as well as our results. Sometimes infants succeed in a property identification task (as we show), and sometimes they do not. Furthermore, infants always succeed at identifying two objects when they are given spatiotemporal evidence that the scene contains two objects. We do not see why they should at times think that one object has been removed from the scene and at times expect to find it there. Unless a principled explanation of these changes is provided, we find it more coherent to assume that infants always expect to find the objects they have actually individuated during the trial behind the screen. We thus think that the default interpretation of infants' behavior has to appeal to conditions of individuation. When infants are not surprised to find only one object behind the screen at the end of a trial, it is because they failed to individuate more than one object on the basis of the difference in properties.

Methods

Subjects

We tested 32 infants. Of these, 16 were 10-month-olds (12 boys and 4 girls, mean age = 10 months 5 days, *SD* = 6 days) and 16 were 12-month-olds (11 boys and 5 girls, mean age = 12 months 8 days, *SD* = 5 days). An additional 22 infants were tested but not retained (3 for experimenter's error, 6 for material failure, 9 became fussy, 2 crawled onto the theater during the experiment, and 2 parents did not follow the instructions). For this as well as all of the reported studies in this article, subjects were recruited by obtaining their birth records from the birth register of the city of Paris and subsequently contacting the families who responded to our letters by telephone. Participation was not compensated.

Apparatus

We used a wooden theater with a stage 100 cm wide, 100 cm high, and 70 cm deep. A computer controlled the movements of two objects on the stage and a screen. Timing of events and kinds of movement could thus be programmed exactly, and only one person was needed to run the experiment.

Under the theater, two metal tracks 100 cm long were positioned horizontally at an angle of 150 degrees, converging toward the back center of the stage. They guided two pairs of magnets activated by two electric motors.

A third motor lifted the screen vertically as needed. The screen was made of violet fabric 37 cm long and 30 cm high, attached to a 40-cm-long metal bar that could be lifted and lowered automatically. In its lowered position, the screen was positioned in the middle of the stage, 20 cm off its front end.

The three motors were commanded by a card (Sidena Impack 07.95) inserted into a personal computer running under the DOS operating system. The card was programmed with an extension module of EXPE, a freeware modular programming language optimized for running experiments (Pallier, Dupoux, & Jeannin, 1997). EXPE also controlled a button box with three buttons connected to the parallel port of the computer. With it, the experimenter could both command the motors and record infants' looking time as needed.

The sides and back of the theater were covered with black tissue. At the back, a 25-cm-wide and 20-cm-high masked hole allowed the experimenter to remove objects without being seen. We tested several adult subjects whose eyes were positioned at the height of the infants' eyes, and none noticed when the experimenter surreptitiously removed objects through the trap behind the screen.

At the back of the stage, a camera placed behind a small hole recorded the infant's face, which the experimenter could see from behind the theater through a monitor. The monitor, the computer, and all of the recording devices were placed behind the theater, out of the infant's sight.

Two small wheel carts 14 cm wide and 10 cm long could be placed on the stage. Two magnets attached under the carts ''glued'' them to the tracks under the theater and moved them when the motors moved. On the carts, a 7-cm-high support—an inverted plastic champagne goblet—allowed objects to be placed or changed as required.

Two 60-watt lamps illuminated the stage from above. Another small lamp was placed behind the stage. The room was otherwise dark during the experiment.

Materials

Four different pairs of objects were used. Each one paired one doll's head (''humanlike'' object) with one manmade artifact (''non-humanlike'' object). The material, size, and expression of the dolls were different. They consisted of one rubber red-haired girl (approximate dimensions: 9 by 7 by 7 cm), one plastic blond child with a broad smile (10 by 9 by 8 cm), one American Indian black-haired woman looking blank (8 by 6 by 6 cm), and one porcelain blond short-haired woman looking surprised (12 by 10 by 9 cm). The non-humanlike objects consisted of one pair of yellow and light blue glued rings (diameters: 11 and 9 cm), one small yellow and black motorcar (10 by 5 cm), one metal red paper punch (11 by 7 by 5 cm), and one light red wax strawberry (7 by 7 by 7 cm). Each pair was chosen to make it hard to imagine that one object might be hidden inside the other.

During the experiment, the objects were placed on the two moving supports. The one holding the doll's head was covered with a light blue fabric to give the impression of a doll wearing a long dress. The other support was left uncovered.

Procedure

Infants sat on a high chair positioned in front of the theater. Their eyes were at a distance of approximately 45 cm from the theater, and their line of vision was kept approximately 15 cm above the theater floor by adjusting the height of the chair. One parent was instructed to sit on a chair positioned on one side of each infant, facing away from the theater. The parent was instructed to smile at the infant and, if necessary, when the screen was down, to invite the infant to look at the theater. If the screen was up, the parent was instructed not to interact with the infant or to look at the theater. Infants whose parents did not follow the instructions were excluded from the analysis. Half of the parents sat on their infants' right, and the other half sat on their infants' left.

We used a modified version of the ''property/kind'' design introduced by Xu and Carey (1996). At the beginning of the experiment and of each trial, the screen was down. The experimenter appeared from behind the theater carrying a carton box and drew the infant's attention toward it without revealing its contents. The experimenter then placed the objects on the supports behind the screen, spending roughly the same amount of time irrespective of how many objects were placed. Finally, the experimenter turned toward the infant, invited him or her to look at the stage, and returned behind the theater to run the computer and monitor the infant's looking time. There were six trials in the experiment: two baseline and four experimental.

Baseline trials. The purpose of the baseline was to measure the infants' spontaneous interest for either one or two objects of the kinds studied. In the two baseline trials, after placing the object(s) on the theater, the experimenter went behind it, the screen was lifted, and looking time was measured.

For each of the two baseline trials, objects belonging to two different pairs were used. The object shown in the one-object trials was counterbalanced between subjects with the other object of its couple.

Experimental trials. In the four experimental trials, the two remaining pairs of objects were used. Trials 3 and 4 used one of the remaining couples, once with a one-object outcome and once with a two-object outcome. Trials 5 and 6 used the other couple, always once with a one-object outcome and once with a two-object outcome.

In each experimental trial, the objects alternatively emerged from or vanished behind the screen. When one object appeared, it stopped in full view for 4 s, moved back toward the edge of the screen without hiding behind it, moved forward again, stopped for 1 s in full view, and finally returned behind the screen. Then, 1 s after the first object disappeared, the other object emerged from the opposite side of the screen performing the same series of movements. Then, 1 s after the second object vanished, the first object reappeared, stayed visible and still for 1 s, and then disappeared behind the screen. Finally, the second object repeated the same movements emerging from the opposite side. Thus, the infant saw each object for a total of 5.5 s. The objects moved at a maximum speed of 10 cm per second, accelerating and decelerating at the beginning and end of their trajectories.

We varied the movements and the displacements of the objects for two reasons. First, we wanted to ensure that infants had enough time to encode properties. Second, we hoped that varying objects' movements would naturally attract the infants' attention. Indeed, in nearly all cases, infants were fully attentive to the objects without any external intervention. In a few cases, the experimenter attracted the infants' attention to the objects by tapping on the back of the stage and saying ''Look baby, look what's happening.''

In the one-object outcome trials, after all of the movements had been completed, the experimenter surreptitiously removed one of the two objects. The screen was then lifted, and looking time was recorded exactly as in the baseline trials. The two-object outcome trials were identical to the one-object trials except that no object was removed.

For the six trials in the experiment, two orders of outcomes were counterbalanced across subjects (122112 and 211221) as well as four orders of presentation of the four couples (1234, 2413, 3142, and 4321).

Looking Time Monitoring and Detection of Time-Out

When the screen was raised at the end of each trial, the experimenter monitored looking time by pressing a button when the infant looked at where the objects were placed and releasing it when the infant saccaded away. When the infant looked away for 2 consecutive seconds, the computer signaled a time-out. To avoid experimenter errors in detecting time-outs, recording always continued until a very clear second time-out was detected. The tapes were successively coded offline, frame by frame, and only the period before the first time-out was considered for analysis.

Dependent Variables

We coded two dependent variables. One is looking time, which for us is the sum of the periods when the infant's gaze is directed toward the objects before a time-out is detected. The second variable, which we call ''looking episodes,'' counts how many times the infant looks at the objects before a time-out is detected. For clarity of presentation, in the following experiments, we report only analyses of looking time and discuss the second variable in a later section (''Further Analyses and Confirmations'').

Results

Separate analyses of variance (ANOVAs) with sex, pairs of objects, order of presentation of the pairs, and order of trials as fixed independent variables showed that such factors are not significant.

Results for the main variables, namely number of objects presented (one or two) and experimental condition (baseline or experimental), are now discussed. Figure 1 presents the main results for both 10- and 12-month-old infants.[3]

Let us first analyze each age group separately. For the 12-month-old infants, a 2 by 2 within-subjects design ANOVA with condition (baseline or experimental) and number of objects (one or two) as fixed independent variables, subjects as random factor, and mean looking time as dependent variable was carried out. The 12-month-olds looked slightly longer at two objects ($M = 7.8$ s, $SD = 3.4$) than at one object ($M = 6.5$ s, $SD = 3.5$), but the effect of object number was not significant, $F(1, 15) = 4.1$, $p \geq .06$. There

[3] For ease of comparison, all graphs in this article are drawn at the same scale.

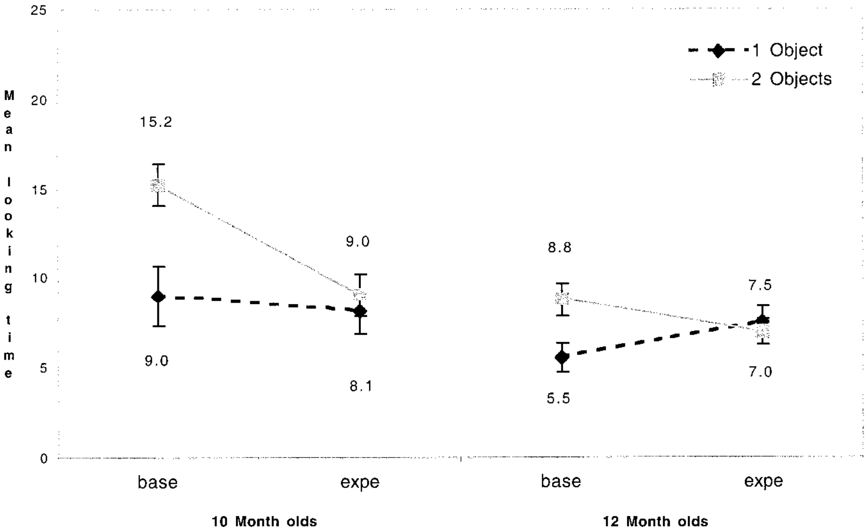

FIG. 1. Experiment 1 (head/object contrast). Mean looking times to one and two objects for 10-month-olds ($n = 16$) and 12-month-olds ($n = 16$), by experimental condition.

was no condition effect either. However, the interaction between the two variables was significant, $F(1, 15) = 7.9$, $p \leq .01$.

Post hoc analyses using the Scheffé criterion revealed that while 12-month-olds looked significantly longer at two objects in the baseline ($p \leq .003$), this preference disappeared in the experimental trials ($p \geq .50$). Looking time for two objects tended to diminish in the experimental trials as compared to the baseline trials, and looking time for one object tended to increase, although not significantly ($p \geq .07$ and $p \geq .06$, respectively). Thus, the interaction seemed to be caused by a concomitant reduction of looking time for two objects and an increase for one object from the baseline to the experimental condition.

The analysis for the 10-month-old group revealed a main effect of both condition, $F(1, 15) = 9.9$, $p \leq .006$, and object number, $F(1, 15) = 13.3$, $p \leq .002$. Overall, 10-month-old infants preferred to look at two objects ($M = 12.1$ s, $SD = 5.7$) rather than at one object ($M = 8.5$ s, $SD = 5.7$). They also looked longer during baseline trials ($M = 12.1$ s, $SD = 6.5$) than during experimental trials ($M = 8.5$ s, $SD = 4.8$). However, most important, there was an interaction between number of objects and condition, $F(1, 15) = 6.1$, $p \leq .02$.

Post hoc analyses using the Scheffé method confirmed that the preference for two objects in the baseline was significant ($p \leq .0008$) but disappeared in the experimental trials ($p \geq .50$). Looking time for one object remained roughly the same in the baseline and experimental trials ($p \geq .50$).

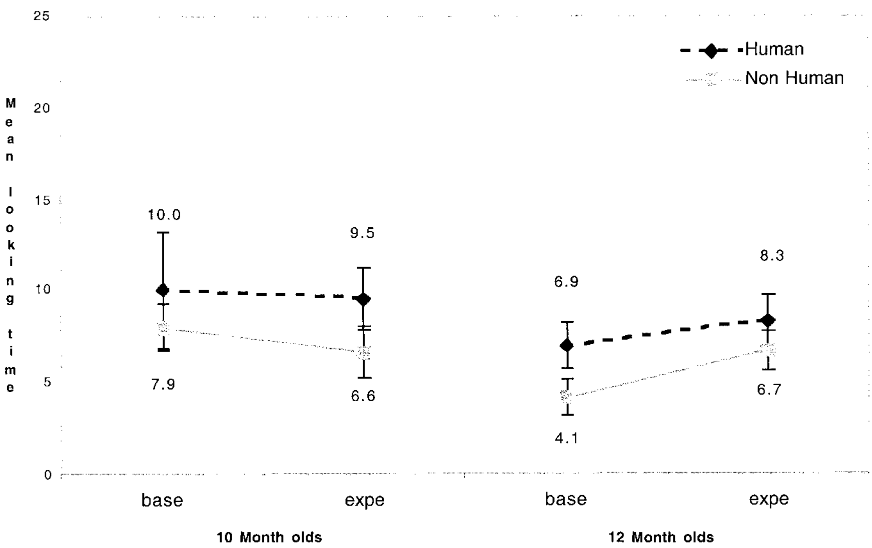

FIG. 2. Mean looking times to humanlike and non-humanlike objects in the one-object trials of Experiment 1 for 10-month-olds (n = 16) and 12-month-olds (n = 16), by experimental condition.

Reactions to Humanlike and Non-Humanlike Properties

How do the humanlike and non-humanlike properties of objects affect infants' looking time? To investigate this question, we ran restricted analyses on the three trials in which infants saw only one object in a three-way ANOVA with object kind (human or nonhuman), group (10-year-olds or 12-year-olds), and experimental condition (baseline or experiment) as independent variables; subjects nested within groups; and looking time as a dependent variable. Figure 2 presents these data for both 10- and 12-month-olds.

Overall, infants significantly preferred to look at humanlike rather than non-humanlike objects, $F(1, 30) = 7.5$, $p \leq .01$. For our subjects, objects with a humanlike face were more interesting, or required more processing time, than did objects from other artifactual categories. However, such a difference did not interact with experimental condition ($p \geq .90$) or group ($p \geq .30$). Thus, the interest that infants had in humanlike objects did not interfere with their ability to apply the property method. Infants succeeded both when they found a humanlike object and when they found a non-humanlike object on the stage. They seemed to respond to the humanlike/non-humanlike contrast as such and not to the nature of the object that remained on or disappeared from the theater in the experimental trials.

The Difference between 10- and 12-Month-Old Infants and the Property Identification Task

Although both 10- and 12-month-olds succeeded on the property task, the overall looking time patterns of the two groups were different. It could be argued that although both groups succeeded in the task, they still used the property method in a way that revealed a fundamental discontinuity. To clarify this point, we ran analyses including both groups.

First, consider natural baseline preferences. A 2 by 2 mixed design ANOVA with group as between-subjects variable (10-month-olds or 12-month-olds), number of objects as within-subjects variable, and subjects nested within group was carried out on the baseline trials alone. The analysis showed a main effect of group, $F(1, 30) = 12.6$, $p \leq .001$. Overall, 10-month-old infants looked longer than did 12-month-olds (12.1 vs 7.1 s). There was also a main effect of object number, $F(1, 30) = 23.52$, $p \leq .0001$. Infants preferred to look at two objects rather than at one object (12. vs 7.2 s). However, the two variables did not interact, $F(1, 30) = 2.5$, $p \geq .12$. This analysis shows that although 10-month-olds looked longer at the objects, infants of both groups had the same baseline preferences.

Next, consider looking patterns across the whole experiment. A 2 (Group) by 2 (Object Number) by 2 (Condition) mixed design ANOVA with subjects as a random factor nested within groups was carried out. There was a significant main effect of group, $F(1, 30) = 8.3$, $p \leq .007$, of condition, $F(1, 30)$, $p \leq .02$, and of object number, $F(1, 30) = 17.3$, $p \leq .0002$. There was also a significant double interaction between condition and object number, $F(1, 30) = 12.9$, $p \leq .001$. However, there was no triple interaction among group, condition, and object number, $F(1, 30) = 0.37$, $p \geq .54$. These analyses confirm that the two groups have the same ability to use the property method. The double interaction between condition and object number confirm that subjects, as a whole, succeeded in our task, whereas the absence of a triple interaction suggests that both 10- and 12-month-olds can identify objects equally well for the property contrast we tested. In sum, both groups had the same baseline preferences and showed the same surprise at the experimental manipulation. Therefore, there is no stage-like difference between the two groups, and the main effect of group in the experiment is not due to differences in how infants conceive the human and nonhuman category boundary or in how they use this boundary to identify objects.

Discussion

Experiment 1 allows us to draw several conclusions. First, 12-month-old infants use the difference between humanlike and non-humanlike properties to form expectations about the number of objects they see, even when no spatiotemporal evidence is available. This result validates our methodology and experimental apparatus because it replicates Xu and Carey's (1996) result with infants of the same age. Second, and most important, Experiment 1 shows that 10-month-olds, unlike Xu and Carey's subjects of the same age, are also able to apply the property strategy and use differences between humanlike and non-humanlike objects to form numerical expectations in the absence of spatiotemporal information. This is predicted by the HFH but not by the OFH. Third, infants respond to the humanlike/non-humanlike contrast as a whole and not to the nature of the object that remains on or disappears from the theater. This is shown by the fact that although there was a significant preference for humanlike objects in one-object trials, this preference did not interact with experimental conditions or age group. Infants succeeded in applying the property method both when they found humanlike objects and when they found non-humanlike objects. Fourth, we showed that the main effect of group on looking time does not affect infants' abilities to use the property method. The contrast between humanlike and non-humanlike properties allows infants of both groups to draw numerical expectations by using object properties. This allows us to conclude that for the humanlike/non-humanlike contrast, there is no radical conceptual change, at least between the two ages that were tested.

What, then, does the difference between the two groups consist in? We suggest that it has to do with encoding time. For the objects presented, 10-month-old infants are slower encoders. This hypothesis predicts that if we look at a measure of surprise that factors out encoding time, 10- and 12-month-olds should behave identically (i.e., group differences should be statistically irrelevant). We test this prediction by analyzing looking episodes in a later section of this article (''Further Analyses and Confirmations''), and we show that the prediction is borne out.

We can foresee two possible reservations about these conclusions. The first objection concerns the nature of the interaction between object number and condition in the 10-month-old group. It can be argued that because the interaction is mostly due to a reduction of looking time for two objects in the experimental trials rather than to a concomitant reduction for two objects and an increase for one object (as in the 12-month-old group), there is no real surprise when one object disappears, but there is a floor effect of looking time for one object.

We consider this possibility unlikely for the following reasons. First, not only do infants see the objects in the experimental trials longer than in the baseline trials, but they also see them repeatedly. Hence, one should expect that looking time for both the one- and two-object outcomes will decrease in the test trials. In fact, looking time decreases only for the two-object outcome. We attribute this result to two underlying effects. When an outcome is unexpected in the test trials, familiarity tends to reduce looking time, and surprise tends to raise it. The result is a substantially flat looking time for one object. In the case of an expected outcome, no surprise counters the effect of familiarity, and looking time for two objects diminishes. In short, the form of the interaction in the 10-month-old group is foreseeable if one considers the familiarization effect. Further confirming evidence for this interpretation comes from a subgroup of 10-month-olds who succeeded in the task in Xu and Carey's Experiments 5 and 6. In this subgroup, the looking pattern was similar to the one we found with our 10-month-olds (i.e., there was a reduction of looking time for two objects in the experimental trials but no reduction of looking time for one object [see Xu & Carey, 1996, Table 2]).

A second possible criticism of Experiment 1 focuses on our methodology. In the two baseline trials, our subjects saw objects from different pairs; that is, they saw a total of three different objects. In Xu and Carey's (1996) experiments, the two baseline trials used two objects coming from the same pair. We introduced this change to avoid repetition of objects in the baseline, with the aim of collecting a clearer baseline of intuitive preferences. However, given that we show more objects in the baseline than did Xu and Carey, it could be argued that we artificially increased looking time for two objects in the baseline trials and that the interaction we found is an artifact of our baseline. To address this concern, and to provide a replication of the main result of Experiment 1 with a methodology closer to that of Xu and Carey, we ran Experiment 2.

EXPERIMENT 2

Methods

Subjects

We tested 12 10-month-old infants (8 girls and 4 boys, mean age = 10 months 6 days, *SD* = 6 days). An additional 7 infants were tested but not retained for analysis (6 became fussy and 1 had at least one data point that exceeded 3 standard deviations).

Procedure and Materials

The procedure and materials were identical to those in Experiment 1, with two important differences. First, we used only one pair of objects in the two baseline trials and a total of three pairs across the experiment. Second, we simplified the movement of the objects during the experimental trials. Instead of appearing twice on the screen and remaining in full view for a total of 5.5 s, each object made a single appearance, remained fully visible for only 1 s, and then disappeared behind the screen. For the six trials, two orders of outcome (122112 and 211221) and three orders of presentation of the couples (123, 312, and 213) were counterbalanced between subjects.

Results

Separate ANOVAs with sex, pairs of objects, order of presentation of the pairs, and order of trials as fixed independent variables showed that such factors are not significant. Figure 3 presents the main results of the experiment.

A 2 by 2 within-subjects design ANOVA with condition and number of objects as fixed independent variables, subjects as random factor, and mean looking time as dependent variable revealed a main effect of number of objects, $F(1, 11) = 21.303$, $p \leq .0007$, but no effect of condition, $F(1, 11) =$

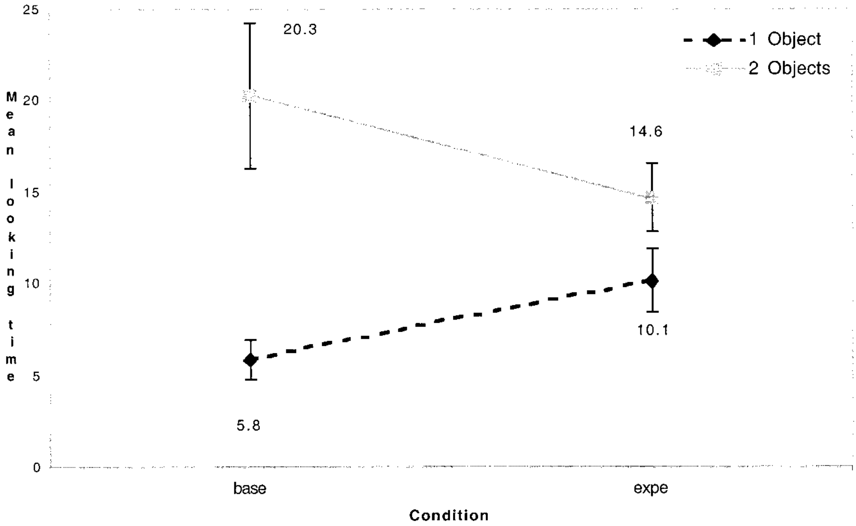

FIG. 3. Experiment 2 (head/object contrast). Mean looking times to one and two objects for 10-month-olds ($n = 12$), by experimental condition.

0.11, $p \geq .70$. Most important, number of objects interacted with type of outcome, $F(1, 11) = 5.4$, $p \leq .03$, as in Experiment 1.

Post hoc analyses with the Scheffé method confirmed that, as in Experiment 1, the preference for two objects in baseline was significant ($p \leq .003$) but disappeared in the experimental trials ($p \geq .60$).

Discussion

Experiment 2 replicated the results of Experiment 1 with 10-month-olds, even though the baseline was collected differently and time of presentation of the objects changed. This finding shows that one cannot attribute the results of Experiment 1 to the way we collected baseline data. It also shows that 10-month-olds' success in applying the property method is quite robust in that even a brief exposure to the humanlike/non-humanlike contrast suffices for infants to identify and code objects as different.

Now, the question was whether we would be successful in using our methods irrespective of the properties of the objects used in Experiments 1 and 2. The methodology we used in Experiments 1 and 2 may be more sensitive than that of Xu and Carey (1996). In this case, 10-month-olds should succeed at using the property method even when tested with objects not containing the humanlike/non-humanlike contrast. Alternatively, if the explanation for the success in Experiments 1 and 2 has to do with the specific contrast we tested, once the contrast is removed, 10-month-olds should fail, as in Xu and Carey's experiments.

To decide between these two options, in Experiment 3 we substituted the dolls' heads with other artifactual objects.

EXPERIMENT 3

Methods

Subjects

In this experiment, 12 10-month-old full-term infants (9 boys and 3 girls, mean age = 10 month 5 days, *SD* = 6 days) were used. An additional 5 infants were tested but became fussy and were not retained for analysis.

Procedure and Materials

The procedure and materials were the same as in Experiment 2, with one main difference. We removed the three humanlike objects and substituted three non-humanlike objects. The new objects consisted of one pencil sharpener with a metal base and a spherical frame attached onto it (approximate dimensions: 6 by 7 by 4 cm); one plastic yellow toy handle with three little round balls (blue, red, and green) attached on its axis (9 by 7 by 3 cm); and one plastic light green, purple, and rose gun tilted upside down (14 by 10 by 4 cm).

We also modified exposure time. When in full view in the experimental trials, each object remained still and visible for 2 s.

Results

Separate ANOVAs with sex, pairs of objects, order of presentation of the pairs, and order of trials as fixed independent variables showed that such factors are not significant. Figure 4 presents the main results of Experiment 3.

A 2 by 2 within-subjects design ANOVA with condition and object number as independent variables and subjects as random variable showed no main effect of either number of objects, $F(1, 11) = 1.5$, $p \geq .24$, or condition, $F(1, 11) = 1.2$, $p \geq .28$. More important, there was no hint of interaction between the two variables, $F(1, 11) = 0.42$, $p \geq .52$.

Discussion

Confronted with two objects with non-humanlike properties, 10-month-old infants, unlike adults and unlike infants of the same age tested with the humanlike/non-humanlike contrast, do not manifest surprise when an object is surreptitiously removed from the scene. This result replicates Xu and Carey's (1996) findings with 10-month-old infants and thus excludes the possibility that the positive results of Experiments 1 and 2 were due to differences in apparatus or methodology. Besides replicating Xu and Carey's findings, the result of Experiment 3 strengthens the HFH because it limits the possibility that success in Experiments 1 and 2 may have been due not to the humanlike/non-humanlike contrast but rather to other very noticeable differ-

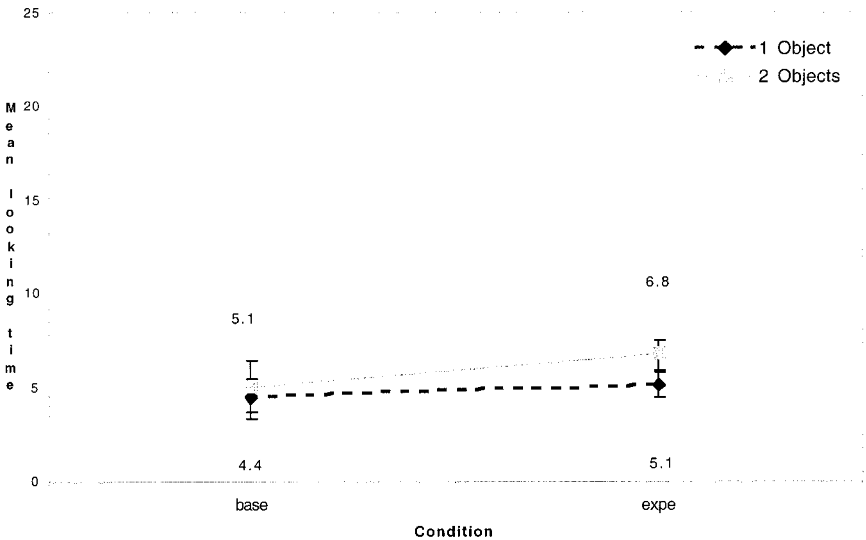

FIG. 4. Experiment 3 (object/object contrast). Mean looking times to one and two objects for 10-month-olds ($n = 12$), by experimental condition.

ences between the stimuli. Indeed, in Experiments 1 and 2, humanlike objects were placed on supports covered by a small blue tissue, whereas the non-humanlike objects were placed on an uncovered support. It might be argued that in those experiments, infants were responding to such a difference, which is very noticeable, and not to the presence of the human heads. Experiment 3 showed that this is not the case. Although one of the objects in each pair was placed on a covered support while the other was placed on an uncovered support, infants failed to apply the property method. Experiment 3 thus increases the likelihood that it is the humanlike/non-humanlike contrast, rather than other extraneous factors, that predicts 10-month-olds' success in a task requiring them to use the property method.

An important difference between Experiment 3 and Experiments 1 and 2 is that looking times in Experiment 3 were considerably shorter. Perhaps differences in latencies may have been due to group differences. However, we prefer to consider two interpretations that are theoretically more interesting. One is an interest-based account. Perhaps infants *did not* look at the objects in Experiment 3 because these objects were simply uninteresting, at least as compared to those used in Experiments 1 and 2. The second account assumes that infants in Experiment 3 *could not* pay attention to the objects because these were too complex or unusual to be remembered or encoded as different.

Both accounts propose attention-based explanations of our results and those of Xu and Carey (1996). If correct, they predict that once infants are presented with objects that are more interesting or easier to encode, they should again rely on the property method even if the objects do not contain a humanlike/non-humanlike contrast.

We then tested attention-based hypotheses against the HFH by using objects with extremely simple geometrical forms. These are discriminated very early on both in development and in visual processing. We expected that the use of simple forms should facilitate encoding and memory processes.

To ensure that the simplicity of the objects does not reduce infants' interest, we test-piloted objects until we found pairs whose size and color generated consistently high baseline looking times, with ranges comparable to those elicited by the objects used in Experiments 1 and 2.

EXPERIMENT 4

Methods

Subjects

In this experiment, 12 10-month-old full-term infants (6 boys and 6 girls, M = 10 months 4 days, SD = 4 days) were used. An additional 2 infants were tested but not retained for analysis (1 for material failure and 1 became fussy).

Procedure and Materials

The procedure and materials were the same as in Experiment 2, with two main differences. First, after moving, objects remained in full view for 2 s, as in Experiment 3. Second, and most important, we used three pairs of very simple geometrical objects different in color, shape, and texture. They consisted of one polystyrene blue ball (diameter: 12 cm); one plastic foam yellow cylinder (7 by 17 cm); one brown carton, starlike regular solid composed of 16 5-cm pyramids (diameter: 15 cm); one wooden red cone with a rounded tip (5 by 15 by 5 cm); one green wooden regular parallelepiped (5 by 15 by 5 cm); and one orange paper cross (16 by 4 cm, each arm). Because of the objects' size, we removed the supports and placed the objects directly on the moving carts.

Results

Separate ANOVAs with sex, pairs of objects, order of presentation of the pairs, and order of trials as fixed independent variables showed that these factors were not significant. Figure 5 presents the main results of Experiment 4.

A 2 by 2 within-subjects design ANOVA with condition and object number as independent variables and subjects as random variable showed that infants preferred to look at two objects rather than at one object ($M = 10.9$ s, $SD = 6.7$, vs $M = 6.5$ s, $SD = 5.8$), $F(1, 11) = 22$, $p \leq .0006$. However, there was no effect of condition, $F(1, 11) = .0025$, $p \geq .97$, nor any interaction between condition and object number, $F(1, 11) = 0.025$, $p \geq .87$. Looking preferences did not change from the baseline to the experimental trials. Post hoc analyses using the Scheffé method revealed that, as in Experiments

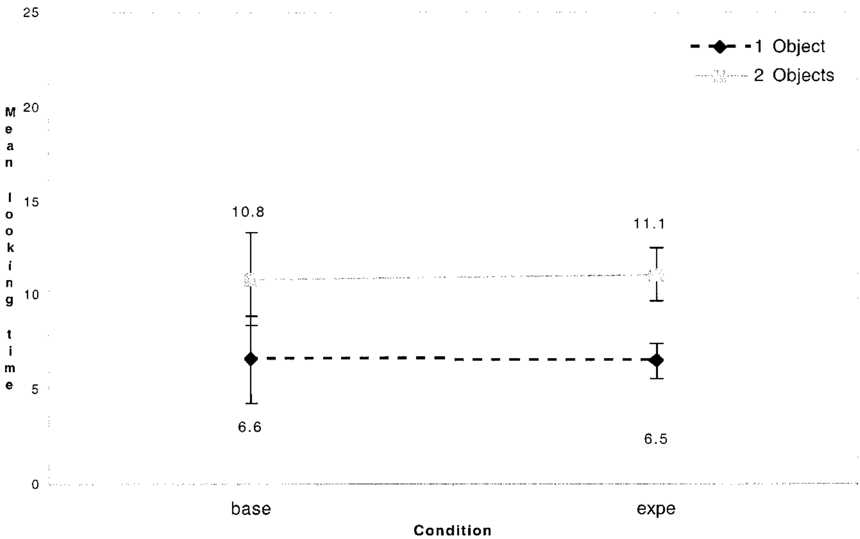

FIG. 5. Experiment 4 (big simple objects/big simple objects contrast). Mean looking times to one and two objects for 10-month-olds ($n = 12$), by experimental condition.

1 and 2, looking time was significantly greater for two objects than for one object in the baseline trials ($p \leq .02$), but it remained so also in the experimental trials ($p \leq .01$), unlike in Experiments 1 and 2.

Discussion

Baseline preferences for the objects presented in Experiment 4 are comparable to those in Experiments 1 and 2 and much greater than those in Experiment 3.[4] We take this as a sign that the large geometric objects used in Experiment 4 raised a level of interest comparable to the humanlike/nonhumanlike pairs used in Experiments 1 and 2, unlike the small unusual objects used in Experiment 3.

[4] Although the number of subjects is different in the two experiments, and the number of tokens shown is different, we can still pool the data from Experiments 1, 2, and 4 together and analyze only the baseline responses to either one or two objects in order to get an idea of the difference between groups. An ANOVA was carried out on the baseline looking times for one or two objects as within-subjects factor, type of pairs (humanlike + non-humanlike objects, as in Experiments 1 and 2, or only non-humanlike objects, as in Experiment 4) as between-subjects factor, and subjects nested within type of pairs. The analysis showed a main effect of number of objects, $F(1, 38) = 18.3$, $p = .0001$, but no significant effect of type of pairs or of the interaction between type of pairs and number of objects, $F(1, 38) = 2.863$, $p = .098$, and $F(1, 38) = 2.867$, $p = .098$, respectively. Thus, the level of attention naturally elicited by pairs containing a humanlike and a non-humanlike object and that elicited by pairs containing the big geometrically simple objects used in Experiment 4 are comparable.

Nonetheless, infants did not show signs of surprise when an object disappeared in the experimental condition in Experiment 4. They failed to apply the property method even when the objects presented were interesting, could be clearly discriminated, and could be easily encoded. This is a very strong replication of Xu and Carey's (1996) results in that it uses the same methodology and at the same time involves objects with simple properties that are certainly processed by infants at this age.

At the same time, the result makes it unlikely that explanations based on attention or on the difficulty of processing the properties of the objects used in Experiment 3 are correct. This outcome further validates the HFH. In a sense, Experiment 4 mirrors Experiment 1. Both baseline looking times were similar given that in both experiments infants looked significantly longer at two objects and the overall values were comparable, but they differed after the experimental manipulation. In Experiment 4, infants' expectations were not violated by the disappearance of an object. By contrast, infants were surprised in Experiment 1 even if the physical structure of facelike objects is more complex than that of pyramids or spheres and should, in principle, make them more difficult to code and remember if the difficulty of the task depended on perceptual complexity.

Our hypothesis is that infants were able to use the property method in Experiments 1 and 2 but not in Experiments 3 and 4 because only the former experiments contrasts objects with humanlike properties and objects without humanlike properties. At this point, however, we cannot know what level of categorization infants use to individuate objects. Every object can be categorized by means of any of the properties of which it is an instance. Thus, Mary may be categorized as a thing, or as a living thing, or as an animal, or as a mammal, or as a human, or as a woman, or . . . , or as the individual whose name is Mary. Our results thus far exclude that infants individuate the stimuli we presented by simply categorizing them as ''things'' or ''physical objects,'' but they do not allow us to know whether the level of categorization used for individuation is ''human'' rather than either a superordinate or subordinate of it. Infants may individuate the humanlike stimuli as living beings, or they may directly individuate them as individual tokens of humans rather than as humans. Finally, it is possible that the positive results of Experiments 1 and 2 and the negative results of Experiments 3 and 4 are based on the computation of perceptual distance between objects without there being any categorical attribution. The next experiments are designed to investigate these issues.

EXPERIMENT 5

Experiment 5 explored whether infants succeed in applying the property method because they see the human faces as belonging to superordinate classes that include humanlike objects rather than as humanlike objects proper.

To test this possibility, we showed 10-month-olds pairs of heads that have eyes and a mouth in the canonical face position, and thus could be seen as examples of canonical faces, but that belong to two different basic-level animal species: doglike heads and humanlike heads. If infants see the stimuli as belonging to some superordinate sortal such as ‘‘animal,’’ ‘‘living being,’’ or ‘‘facelike’’ things, then they should fail to apply the property method. If, instead, the HFH is correct and infants are using more sophisticated species-specific mechanisms to identify humans in these tasks, then they should still succeed.

Puppets’ heads, however, raised an additional problem. Individual variability in baseline looking time was much greater than in the previous experiments. Many infants tended to look at one object more than at two objects in the baseline trial, unlike what was found in Experiments 1, 2, and 4.[5] We attribute this increase to the fact that some subjects found some of the puppets particularly interesting, and this increased individual variability may alter baseline reliability.

To reduce variability and make the comparison with the previous experiments easier, we applied stricter criteria for selecting subjects. We analyzed only those subjects who naturally looked at two objects more than at one object in the baseline trials.

Methods

Procedure and Materials

Procedure and materials were the same as in Experiment 2, with one crucial difference. We removed the three non-humanlike objects in each pair and substituted three puppet dog heads. The doglike heads were matched for size to the humanlike heads and varied in colors, material, and texture. They consisted of one dalmatian black and white fuzzy dog (approximately 9 by 9 by 8 cm); one brown plaster lifelike shepherd dog (8 by 12 by 10 cm); and one plastic, white, brown, and yellow toy dog (5 by 7 by 7 cm).

To give our objects a uniform appearance, we covered all supports with light blue fabric.

Subjects

In this experiment, 12 10-month-old full-term infants (7 girls and 5 boys, mean age = 10 months, *SD* = 9 days) were used. An additional 11 infants were tested but not retained for analysis (1 for material failure, 4 violated the baseline criterion, 1 had at least one looking time data point that exceeded 3 standard deviations, 3 became fussy, and 2 parents did not comply with the instructions).

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[5] On a first run of 12 infants, 4 were found to violate the normal baseline preference for two objects. This compares with 2 out of 16 in Experiment 1, 1 out of 12 in Experiment 2, and 1 out of 12 in Experiment 4.

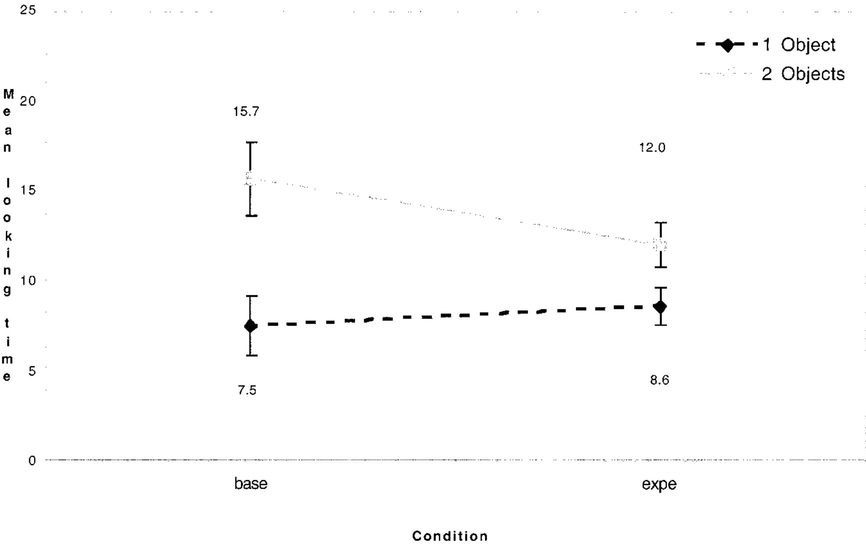

FIG. 6. Experiment 5 (head/dog contrast, preselected subjects). Mean looking times to one and two objects for 10-month-olds ($n = 12$), by experimental condition.

Results

Separate ANOVAs with sex, pairs of objects, order of presentation of the pairs, and order of trials as fixed independent variables showed that such factors are not significant. Figure 6 presents the main results of Experiment 5.

A 2 by 2 within-subject design ANOVA with condition and object number as independent variables and subjects as random variable showed a main effect of object number, $F(1, 11) = 62$, $p \leq .0001$. Infants preferred to look at two objects ($M = 14.2$ s) rather than at one object ($M = 8.5$ s). There was no effect of experimental condition, $F(1, 11) = 0.44$, $p \geq .52$, but there was a clear interaction between object number and experimental condition, $F(1, 11) = 9.5$, $p \leq .01$. Infants looked longer at two objects in the baseline, as expected given the criterion of selection ($p \leq .000$, Scheffé post hoc method), but also in the experimental trials ($p \leq .009$). Yet they looked less at two objects in the experimental trials than in the baseline trials ($p \leq .009$) and looked equally long at one object in the baseline and experimental trials ($p \geq .30$).

Discussion

Why did infants succeed at using the property method in Experiments 1 and 2 and fail in Experiments 3 and 4? The HFH holds that infants respond to faces *qua* human faces and that their success can be attributed to the fact that they see the objects as conspecific-like. However, there are at least two plausible alternative accounts. One claims that when they track humanlike objects separate from non-humanlike objects, infants may respond to the basic configuration of a face, be it humanlike or not. Mechanisms that respond to schematic faces exist at birth (Johnson & Morton, 1991), and it is not impossible that they are still active at the ages we test. Another hypothesis holds that when they succeed in inferring object number from object properties in Experiments 1 and 2, infants use concepts more refined than ‘‘generic face’’ to individuate the objects but less refined than ‘‘*human* face.’’ They may code the stimuli as faces of living beings. This would be consistent with Mandler's claim that even at later ages infants possess only broad superordinate concepts encompassing all living animals, or at most separating terrestrial animals from marine animals, but no basic-level concepts (Mandler & Bauer, 1988; Mandler & McDonough, 1993, 1998). The results of Experiment 5 are not consistent with either hypothesis.

Infants succeeded at applying the property method when they could only exploit differences between humanlike faces and doglike faces, although both objects share the basic configuration of a face. This excludes the first hypothesis, which holds that they were simply responding to a generic face-like object.

Because infants succeed in the task when confronted with two animal heads—in fact, with two mammal heads—we can also conclude that they code human heads at the level of the basic category ‘‘human’’ *contra* the second hypothesis. This is a clear demonstration that infants possess concepts of basic-level categories for animals. One can, of course, argue that Mandler and her collaborators did not test humanlike properties in the cited studies and that hence their theory is not meant to apply to humans. But this amounts to saying that humans are a category apart, treated unlike any other animal category. Hence, a taxonomy of infants' basic conceptual apparatus is doomed to be incomplete unless a special place for the HFH is made. This is all that we need to establish to support the thesis we defend in the current article.

Experiment 5 also allows us to discard another possible interpretation of our results, according to which infants' behavior may be explained by assuming that they compute only a measure of perceptual similarity or distance between objects. It is worth comparing this experiment to Experiments 3 and 4. Although the physical differences between the objects presented in those earlier experiments are much more extreme than those between a dog's head and a human head, infants failed to apply the property method. By contrast, they succeeded in Experiment 5 with far more similar objects. This suggests that success in a task requiring the use of the property method is not due to simple calculations of similarities between objects. If the mechanism driving infants' responses was a generic physical similarity matching system (acting on general shape, texture, or other basic features of objects), in light of the two failures of Experiments 3 and 4, one would expect an even more marked failure in Experiment 5. Infants' success shows that no simple, general purpose, perceptual similarity account explains our results. Infants' responses seem to depend on a specific system tuned to specific traits of human faces, for which the minor differences between human faces and dogs' faces are more telling than the differences between a metal motorcar and a wooden cube.

EXPERIMENT 6

When object properties cross the category boundaries separating a humanlike and a non-humanlike object, infants use the property method to identify them. But to what extent are differences *within* the humanlike category used for object identification? Is a mere difference between two faces (same category objects) enough for an infant to decide that he or she is looking at two different objects? We have established that 10-month-olds respond to human faces and not to superordinate categories when they identify two objects in our task, but we have not determined whether they respond to some subordinate class of human faces or directly to individual faces.

We approached this question by showing infants pairs of dolls' heads. According to Johnson and Morton (1991), different mechanisms are responsible for face recognition, none of which is specifically dedicated to human face recognition. One, Conspec, is essentially a subcortical reflex, active at birth and responding to generic facelike forms, that fades away by the 2nd month. The second, Conlern, is probably made up of a series of (cortical) mechanisms that become active only after the 2nd month. Conlern involves learning, and Johnson and Morton described its overall role as that of recognizing and memorizing individual faces. Given the age we are investigating, and the fact that it begins developing after 2 months, one might expect that Conlern was fully available to our subjects. So, if differences in still humanlike faces are sufficient to activate it, infants should use such differences to identify two dolls' faces as being different. However, it is also possible that infants respond only to generic human faces, either because Conlern is not yet fully available to them at 10 months or because they use some mechanism of attribution that distinguishes major categories such as humans, animals, and artifacts but not items within those categories. In either case, we would not expect success at applying the property method.

Methods

Procedure and Materials

The procedure and materials were the same as those in Experiment 5, with one crucial difference. We removed the three doglike objects and replaced them with three new humanlike objects. The new heads consisted of one plastic male head, with a slightly caricatured expres-

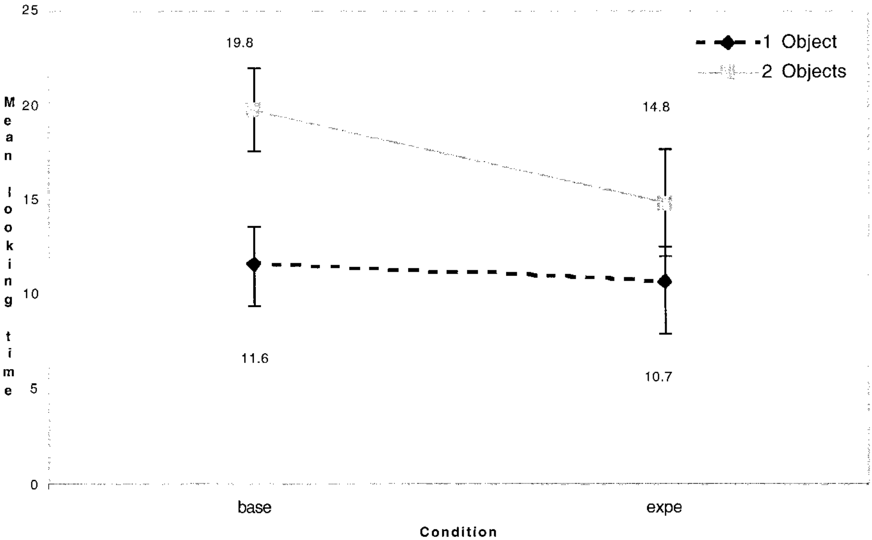

FIG. 7. Experiment 6 (head/head contrast, preselected subjects). Mean looking times to one and two objects for 10-month-olds ($n = 12$), by experimental condition.

sion, wearing a black hat (approximate dimensions: 10 by 7 by 7 cm); one rubber dark-skinned, black-haired male head (9 by 7 by 6 cm); and one plaster, blond-haired angel head, with a natural expression (10 by 7 by 5 cm). We also applied the same baseline selection criterion that we used in Experiment 5.[6]

Subjects

In this experiment, 12 10-month-old infants (9 boys and 3 girls, mean age = 9 months 22 days, *SD* = 9 days) were used. An additional 12 infants were tested but not retained for analysis (1 for material failure, 7 violated the baseline criterion, 1 had at least one looking time data point that exceeded 3 standard deviations, and 3 became fussy).

Results

Separate ANOVAs with sex, pairs of objects, order of presentation of the pairs, and order of trials as fixed independent variables showed that such factors are not significant. Figure 7 presents the main results of Experiment 6.

A 2 by 2 within-subjects design ANOVA with condition and object number as independent variables and subjects as random variable showed a main effect of object number, $F(1, 11) = 13.8$, $p \leq .0034$, and no effect of condi-

[6] Interestingly, in this experiment the tendency found in Experiment 5 is even more marked. On a first run of 12 infants, 6 were found to violate the normal baseline preference for two objects. This shows that the presence of all human heads further increases individual variability.

tion, $F(1, 11) = 1.89$, $p \geq .19$. The interaction between object number and condition, although not negligible, did not reach significance even with the more stringent subject selection criterion, $F(1, 11) = 3.63$, $p \geq .08$.

Discussion

Although infants use the property method when they are exposed to the contrast between an object and a humanlike object or between a mammal-like object and a humanlike object, they do not seem to be able to use it when they are presented with two different tokens from the same humanlike category.

This failure may have several different explanations. One type of explanation focuses on processes of identification of conspecifics. The other is more general and focuses on the within-category nature of the objects.

According to the latter, the failure is caused by the fact that infants are shown same-category objects. Xu (1999) and Xu et al. (1999) argued that, even at 12 months, infants can use only sortal properties to individuate objects and that within-sortal differences do not suffice. This thesis, which is not incompatible with the HFH, holds that even if 10-month-olds can identify objects A and B as human, they are bound to disregard any additional difference. There is nothing special to conspecifics here; the distinction between tokens within the conspecific category is as inefficient as every other within-category distinction.

Other explanations point to the recognition system for conspecifics and its development. At 10 months, when stimulated for a short period of time by unfamiliar exemplars, Conlern may be developed enough to attain a very generic representation of a face but nothing finer than that. Or, it may be able to represent differences between individual faces but only when other cues to human-ness are provided. Even if the human brain treats dolls' faces as real faces (as made plausible by Wang et al.'s [1998] result that real faces and dolls' faces activate the same neural tissue in the monkey's inferotemporal area), it may need more obvious cues to human-ness in order to process differences among individual faces. At 10 months, the objects we used may fall short of activating representations of differences between conspecifics that are apparent when different expressions, movements, or voices co-occur with the still, visual perceptual cues provided by dolls. Finally, it is also possible that infants fail in this task not because they use a developing Conlern but rather because they possess a fixed system of recognition of conspecifics whose role is just to signal the presence of conspecifics without further distinctions. The current data do not allow us to choose among these alternatives.[7]

[7] The current results allow us also to conclude that the selection criterion used in Experiments 5 and 6 is not influencing the results but only eliminating excessive noise. Although the selection criterion is the same, we find success in Experiment 5 and failure in Experiment 6.

FURTHER ANALYSES AND CONFIRMATIONS: ANALYZING INFANTS' EXPLORATORY BEHAVIOR

As is customary, we used looking time as the dependent variable for analysis.[8] However, there are other ways of looking at the data that may reveal infants' mental processes as well. Here, we report analyses of another dependent variable that we call *looking episodes.* These correspond to measuring how often infants look at the objects before a time-out is detected instead of how long they actually look at them.

The two variables are obviously correlated, but not as strongly as one might expect (across the entire pool of subjects analyzed in this series of experiments, the Pearson product–moment correlation is .40). Conceptually, looking time and looking episodes may vary independently, and why this may be is intuitively clear. If one looks at an object for, say, 10 s in one continuous episode, the looking time variable has a value of 10 but the looking episodes variable has a value of 1. But one can also look at the object in several discontinuous episodes, say 10, separated by saccades directed elsewhere. In this second case, the looking time variable may still have a value approaching 10, but the looking episodes variable also has a value of 10.

What kind of differential information can the two variables provide? We propose the following account. An infant may look at an object for a long uninterrupted time because he or she is interested but also because the infant

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This shows that it is the nature of the categories to which the objects belong that is responsible for our results. This conclusion is also supported by the analysis of looking episodes for Experiments 5 and 6, which we present in the next section (''Further Analyses and Confirmation''). It is worth stressing that if we apply the same criterion of selection to the previous experiments, not a single result changes. In Experiment 1, 2 of the 16 10-month-olds did not comply with the stricter criterion of selection. We excluded them from analysis and ran other subjects under the same conditions. None of the reported results changed. In Experiment 2, no subject showed baseline preferences for one object. In Experiment 4, 2 of 12 subjects had a baseline preference for one object. We removed them and re-ran analyses. No result changed. We thus conclude that the baseline criterion of Experiments 5 and 6 improves the sensitivity of the method, better revealing infants' expectations by reducing baseline variability when necessary.

[8] The way looking time is computed varies according to authors and articles. In general, it is the full period in which the infant looks at the theater without turning his or her head away for more than a certain continuous value (also not constant from article to article) that is taken as a measure of analysis. This way of coding looking time includes the time in which the infant is not necessarily looking at the objects but is looking generically in the direction of the theater. We coded looking time in the following way. We considered only the actual time in which the infant's gaze was on the objects or in their immediate vicinities, and we did not include the time in which the infant was saccading away. In this way, looking time becomes the sum of all the inter-saccade intervals in which the infant is fixating the objects or their vicinities. Hence, the periods in which the infant was looking in a certain direction but not looking at the objects or their vicinities were not computed in the final value.

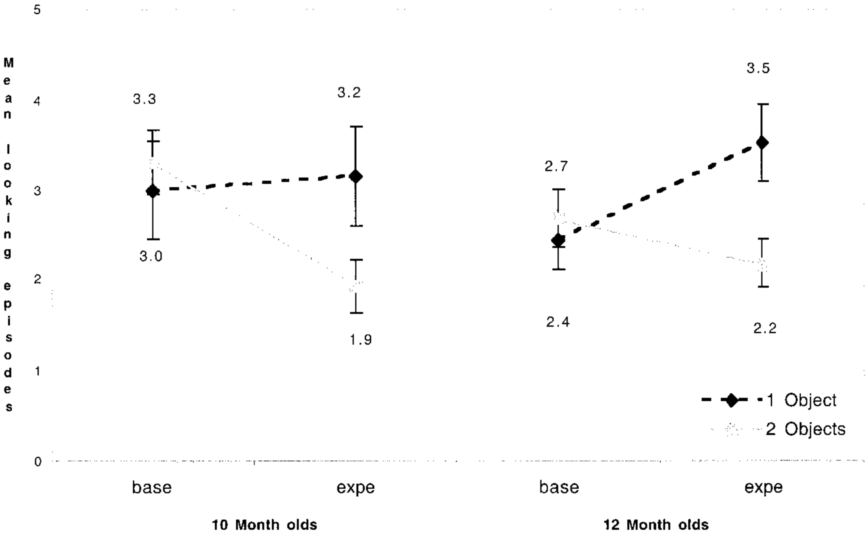

FIG. 8. Experiment 1 (head/object contrast). Mean looking episodes to one and two objects for 10-month-olds ($n = 16$) and 12-month-olds ($n = 16$), by experimental condition.

may need the time to encode its properties. Instead, a series of several ocular movements on and off the object, without any long displacement of attention (triggering a time-out), may be the sign of a search attitude. If the infant expects to find a certain number of objects on the stage and these expectations are violated, then he or she may tend to look around to see where the missing objects may be, thereby increasing the looking episode variable without necessarily increasing looking time. Thus, looking episodes may be at least as good a way, if not a better one, for detecting surprise as compared to the widely used looking time measurement. In a sense, this variable normalizes differences due to encoding speed and may reveal exploratory behavior more directly.

We now show that using looking episodes as a dependent variable clarifies various aspects of infants' reactions in our experiments. Consider first Experiment 1. There was a major difference in looking times between 10- and 12-month-olds, but we argued that the difference does not lie in the ability to use the property strategy; what changes is the time needed to encode objects. Therefore, we predicted that if encoding time is factored out, group differences should disappear.

Figure 8 presents the main result of Experiment 1 with looking episodes as a dependent variable. The graph shows that the difference between the two groups disappears and that both groups clearly succeed in the task. A mixed design ANOVA with group (10-month-olds or 12-month-olds) as between-subjects factor, condition (baseline or experimental) and number of objects (one or two) as within-subjects factors, and subjects as random factor nested within groups confirmed both observations. While there was a significant effect of object number, $F(1, 30) = 6$, $p \leq .02$, there was no effect of group, $F(1, 30) = 0.14$, $p \geq .70$, or of condition, $F(1, 30) = 0.7$, $p \geq .37$. The interaction between object number and condition, which is the main indication of success in this task, was significant, $F(1, 30) = 9$, $p \leq .004$. However, there was no hint of a triple interaction among object number, condition, and group, $F(1, 30) = 0.003$, $p \geq .96$. A significant triple interaction would signal that the behavior of the two groups in the main comparison of interest is different. This is not the case.

Post hoc analyses conducted with the Scheffé method showed that while infants looked about as frequently at one object as at two objects in the baseline trials (overall, 2.7 vs 3.0 times, $p \geq .44$), they looked at one object more frequently than at two objects in the experimental trials (3.3 vs 2.0 times, $p \leq .0009$). Separate analyses of both groups yielded similar results.

Thus, whereas an analysis of looking time indicates a difference between 10- and 12-month-olds, if not in their ability to use the property method, then at least in the way the method is used, looking episodes showed that both groups, as we predicted, have exactly the same search behavior. This lends support to our hypothesis that the two groups differ in how they encode object properties and not in how they use them to identify objects. This informative result is lost if we limit our analysis to looking time.[9]

In other cases, looking episodes also showed aspects of infant behavior that cannot be detected by analyzing looking time alone. Consider Experiments 5 and 6. We argued that infants identify objects on the basis of property differences between the categories ''dog'' and ''human'' but fail to do so when the differences are within the human category. It may be argued that we overestimated the difference between the two experiments. After all, in Experiment 6, the interaction was not significant, but a clear tendency existed, $F(1, 11) = 3.63$, $p \leq .08$, and the shape of the graph, if not the strength of the effect, closely resembles that of Experiment 5.

Investigation of looking episodes shows that the difference between the two experiments is more marked than the analysis of looking time may lead

[9] In Experiments 3 and 4, where the contrast between humanlike and non-humanlike objects was removed, we found that infants failed to apply the property method. One may wonder whether an analysis of looking episodes also gives a negative result. It does. In Experiment 3, infants looked equally at one and two objects in both experimental conditions (1.8 and 2.2 times in the baseline condition and 2.4 and 2.2 times in the experimental condition for one and two objects, respectively). The interaction was not significant, $F(1, 11) = 1.5$, $p = .30$. Likewise, in Experiment 4, there was no sign that search behavior changed from the baseline to the experimental trials. Infants looked at one object an average of 3.1 times in the baseline trials and 4.0 times in the experimental trials, and they looked at two objects an average of 3.0 times in the baseline trials and 3.6 times in the experimental trials. There was not even a trend toward an interaction, $F(1, 11) = 0.3$, $p = .80$.

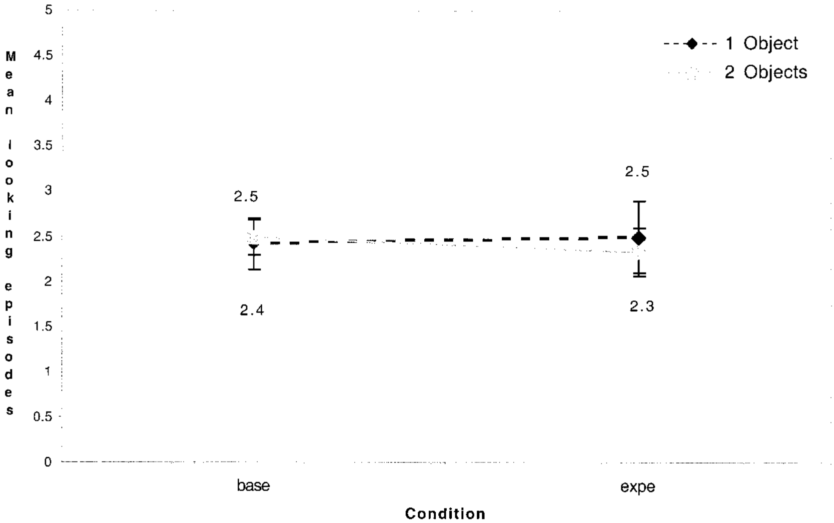

FIG. 9. Experiment 6 (head/head contrast, preselected subjects). Mean looking episodes to one and two objects for 10-month-olds ($n = 12$), by experimental condition. The reader may want to compare this graph to Fig. 7, which presents the results of the same experiment with looking time as a dependent variable.

one to think. Figure 9 presents the main result of Experiment 6 (head/head contrast) with looking episodes as a dependent variable. The graph shows that there was neither an effect nor a trend induced by the experimental manipulation, as confirmed by an appropriate ANOVA revealing the absence of any interaction, $F(1, 11) = 0.016$, $p \geq .70$.

By contrast, Fig. 10 presents the main result of Experiment 5 (head/dog contrast), again using looking episodes as a dependent variable. In this case, there was a clear ordinate interaction. While infants looked about the same number of times at one object as at two objects in the baseline trials, they looked one more time at one object in the experimental condition. An appropriate ANOVA confirmed that the interaction was significant, $F(1, 11) = 6.2$, $p \leq .03$.

Once looking episodes are analyzed, it appears that the contrast manipulated in the two experiments elicits very different behaviors, a fact that cannot be detected as clearly with an analysis of looking time. We can thus better ground our conclusion that infants identify objects as different when a humanlike face is contrasted with the face of another mammal but do not do so when both faces belong to the human category.

Methodological Conclusion

The problem of inferring mental states from nonlinguistic behavior is an old and difficult one. During the past 15 years, researchers in infant psychol-

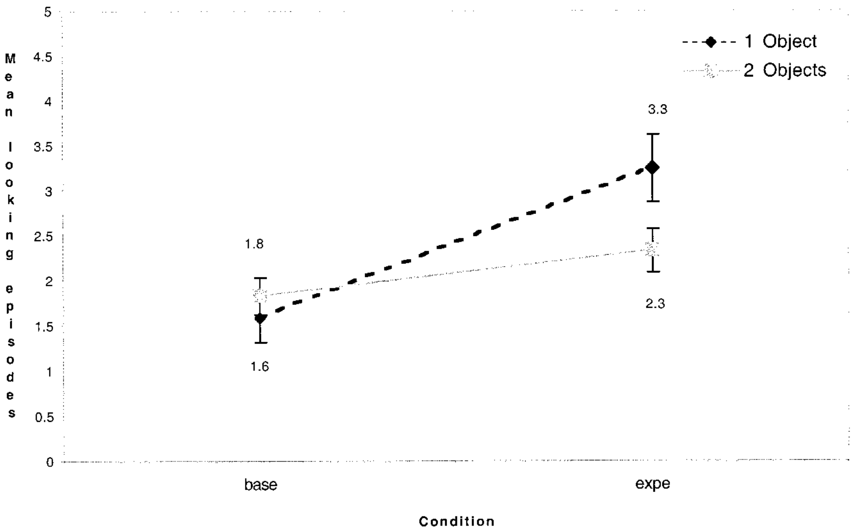

FIG. 10. Experiment 5 (head/dog contrast, preselected subjects). Mean looking episodes to one and two objects for 10-month-olds ($n = 12$), by experimental condition. The reader may want to compare this graph to Fig. 6, which presents the results of the same experiment with looking time as a dependent variable.

ogy have bridged this gap by widely using the violation of expectation method. This method assumes that when infants see their expectations violated, they will be surprised and their behavior will be affected accordingly. Surprise has nearly universally been measured using differences in looking times for certain scenes or objects, before and after experimental manipulation and/or habituation. This assumes that surprise results in longer looking time and, conversely, that longer looking times signal surprise.

The method has generated enormous progress in infant research. However, it has its limits. We do not know for sure whether longer looking times necessarily signal surprise. Conversely, we do not know for sure whether surprise necessarily produces longer looking times. As shown here, certain aspects of surprise may be revealed better by studying looking episodes, which constitute a rough measure of infants' exploratory behavior, rather than studying looking time. We think that analyzing different behavioral measures, and looking at how concordant or discordant they are, might allow researchers to better exploit the necessarily scant and noisy data that young infants provide us to explore the world of their beliefs.

GENERAL DISCUSSION

This article has investigated Xu and Carey's (1996) startling result that infants under 1 year of age are unable to identify objects on the basis of their (non-spatiotemporal) properties. In partial contrast to this result, we argued that properties of conspecifics must be available for object identification early in development. In Experiments 1 and 2, where we contrasted humanlike objects and artifacts, our prediction was borne out with both 10- and 12-month-olds. However, when humanlike objects were replaced by other artifacts (Experiments 3 and 4), 10-month-olds failed to apply the property method. Instead, once humanlike objects were contrasted with doglike objects (Experiment 5), infants succeeded in applying it, whereas they again failed to do so when all of the objects were humanlike (Experiment 6). Thus, a contrast within the mammal superordinate category can be used to apply the property method, but one involving subordinates of the human category cannot be used as successfully. These results suggest that, under conditions of relatively short acquaintance with entities in the world, infants can use properties common to all and only humans for object individuation. Overall, our results support our HFH proposal. They also require a revision of various accounts of Xu and Carey's results.

Current Accounts of Xu and Carey's Results and the Current Findings

There are currently two (possibly three) major accounts of why infants fail to exploit even radical property changes for the purpose of object identification. First, Xu and Carey's OFH claims that 10-month-old infants fail because they possess only the most general sortal ''physical object.'' But we have shown that 10-month-olds have a more extensive knowledge of sortals. Whether or not this amounts to a refutation of the OFH depends on how the hypothesis is formulated. A strong version, which seems to have been endorsed by Xu (1998, 1999), holds that infants at 10 months lack representation of object kinds and can thus use only spatiotemporal cues for object individuation. This version argues for a developmental change between 10 and 12 months as radical as Piaget's stage transitions. Our results challenge this version of the hypothesis. Other formulations may be compatible with our findings, for example, one that allows contrasts other than those used by Xu and Carey (1996), including the human/nonhuman contrast, as a basis for object individuation. However, by granting infants the ability to use the property strategy for some natural classes such as humans, the OFH loses predictive power in favor of independently motivated hypotheses such as the HFH, which can make specific predictions about what concepts are used as sortals.

The object indexing theory proposed by Leslie, Xu, Tremoulet, and Scholl (1998) and Scholl and Leslie (1999) as a variation and expansion of Trick and Pylyshyn's (1993, 1994) FINST theory could be considered as a second explanation of Xu and Carey's (1996) results. This theory maintains that 10-month-old infants cannot use the property method as a direct consequence of how object indexing takes place. Indexes are assigned independently and before feature binding occurs, and once assigned, they ''stick'' to objects even when they disappear behind occluders. Because indexes point to objects regardless of object features, it is possible that when object A disappears behind an occluder and object B reappears from behind it, both are tracked by the same index. By contrast, if A and B appear simultaneously in different locations, two different indexes are automatically assigned to them and A and B are tracked separately. Thus, 10-month-olds may succeed at individuating objects on the basis of spatial cues but fail to apply the property method.

The account may differ from the OFH,[10] but we do not see how it can make different predictions for the current results. Object indexing cannot explain why, in the presence of the humanlike/non-humanlike contrast, 10-month-olds assign two separate indexes even when they are not given spatio-temporal information. To explain this, the object indexing theory would need to be modified to allow for routes connecting humanlike features stored in the feature map directly to indexes. But this means that the theory must make special provisions for systems that treat conspecifics as special objects. So, just as with the OFH, the object indexing theory needs to assume the HFH in order to explain our results.

This criticism also extends to the neuropsychological explanation of the change between 10 and 12 months of age proposed by object indexing theorists. Studies in humans and primates suggest that information about objects (the ‘‘what’’ system) and information about location (the ‘‘where’’ system) are processed in separate (ventral and dorsal) pathways (Haxby et al., 1991; Ungerleider & Miskin, 1982). Xu (1999) and Leslie et al. (1998) argued that the difference between 10- and 12-month-olds’ ability to use the property method may be due to the development of the connection between the ‘‘what’’ neural system and mechanisms of object indexing. The 10-month-olds, unlike 12-month-olds, would lack a fully developed connection between these systems and for this reason are unable to use property information for object identification. Our results show that 10-month-olds use property information about faces to individuate objects. Indeed, most studies of the functional organization of the ventral pathway in both humans and monkeys precisely use faces as stimuli for objects (Haxby et al., 1991; Wang,

[10] It is difficult to argue on the basis of theories that have yet to be developed, but we may see some areas that could distinguish the two accounts. Differences could be seen when the current investigations are tied to systems for counting small quantities. The object indexing theory is also meant to be an explanation for subitizing (see Trick & Pylyshyn, 1994), whereas the OFH is indifferent as to what mechanism could be at the basis of infants’ numerical expectations. As such, object indexing seems to be committed to more constrained predictions about what happens when infants fail to apply the property method. The OFH is indifferent as to whether infants think that objects A and B are one and the same object or else suspend any numerical judgment. The object indexing theory, instead, seems to be committed to the view that infants do count one object. This is because for the object indexing theory, infants’ failure is caused by the fact that a single index is attributed to both objects. It could be thus possible, in principle, to test the object indexing theory against the OFH.

Tanaka, & Tanifuji, 1996; Wang et al., 1998; for a review, see Ungerleider & Haxby, 1994). The fact that such information is available at 10 months for object identification shows that the change between 10 and 12 months is not captured by a simple explanation in terms of activation of the connection between the ''what'' (ventral) system and the object indexing system. Xu's (1999) and Leslie et al.'s (1998) proposal needs to be refined and must at least postulate a separate treatment for humanlike objects, as held by the HFH.

A further account for the change from 10 to 12 months of age has been offered by Wilcox and Baillargeon (1998). In a nutshell, the authors argued that 10-month-olds fail to use the property method not because they have some conceptual deficit but rather because any task using the property method is too complex. To succeed, infants must store a representation of the event occurring when the occluder is in place and compare it to the representation of the state of the world when the occluder is removed. They argued that this costly comparison between events, and not any lack of sortals, is at the root of infants' failure to apply the property method. With a less demanding task that requires them to monitor only one single continuous event (a task that Wilcox & Baillargeon called ''event monitoring'' as opposed to the ''event mapping'' required in the property task), infants might use sortals in the proper way. There is no question that the property method, as used in Xu and Carey's (1996) experiments as well as in ours, is demanding. However, an account based merely on complexity cannot explain our results. Why do infants succeed in mapping events when complex property information about conspecifics is provided, as shown in Experiments 1 and 2, and fail with simple differences between objects, as shown in Experiment 4? This question cannot be answered by a simple analysis of task demands. Reference to an independently motivated hypothesis, such as the HFH, would be needed.

In conclusion, all current explanations of Xu and Carey's (1996) results fail to account for those presented here unless a special place is made for the HFH. The reason is that, we think, they share a common strategy. They all ignore the nature of the specific objects involved in the tasks. By contrast, the HFH is a theory about what specific objects in the world are special for the infant and hence about the properties that are available early on for the purpose of object identification. It is the fact that there are such special objects that shows that the accounts proposed so far are unsatisfactory.

Alternative Accounts of the Current Results: Similarity, Discriminability, Attention, and Relevance

The HFH makes a strong claim about why infants succeeded on the property task. It is therefore important to examine alternative explanations that do not refer to the humanlike nature of the objects involved. There are at least four plausible accounts for our results that do not make explicit use of the HFH. One assumes that the perceptual similarity between stimuli can explain all results. The second (possibly a variant of the first) argues that our results arise because of differences in discriminability of the properties involved. The third assumes that the results depend on the different attentional resources allocated by infants to the stimuli. Finally, the fourth (possibly a variant of the third) claims that infants' patterns of successes and failures depend on calculations of relevance. We find them all unconvincing.

A similarity-based explanation argues that infants' successes are due to the degree of similarity between objects rather than to the nature of the categories to which they belong. Support for this explanation may come from the fact that infants succeed when humanlike objects are pitted against artifactual objects but fail when two humanlike objects are pitted against each other; hence, they succeed when objects are maximally dissimilar and fail when they are maximally similar. The results of Experiments 3 and 5 make this account implausible. Arguably, the human faces and dogs' faces used in Experiment 5 were more similar than the artifacts used in Experiment 3. But infants succeeded with the former contrast and not with the latter one. If success depends on a general calculation of perceptual similarity, one would expect the opposite pattern of results. The same argument applies to the discriminability-based explanation.[11] In Experiment 4, we used very apparent contrasts that are known to be discriminated early on in development and in visual processing (e.g., the contrast between a ball and a cube), but infants did not use the property method to identify the corresponding objects. By contrast, a human face and a dog's face should be more difficult to discriminate than a ball and a cube, but in Experiment 5 infants succeeded. If anything, a discriminability account should predict opposite outcomes.

A third account points at attentional factors. Infants may succeed not by virtue of some module dedicated to the recognition of conspecifics but rather because they allocate enough attentional resources to the stimuli presented to them. We are not in a position to exclude the intervention of subtle attentional phenomena in our tasks. However, we also find this explanation unconvincing. If either looking time or looking episodes are an indication of attention, then infants allocated comparable attentional resources to the objects presented in Experiments 1 and 4, or in Experiments 5 and 6, as shown by baseline looking times. But they succeeded in Experiments 1 and 5 and failed in Experiments 4 and 6. No generic attentional-based explanation can easily account for such differences.

A fourth possible account appeals to the notion of relevance.[12] Like adults, infants may preferentially attend to information that is relevant to them (Sperber & Wilson, 1995). More specifically, infants may be endowed with only some skeletal principles guiding the distinction between different

[11] We are indebted to an anonymous referee for suggesting this possible account.
[12] We are indebted to Rochel Gelman for suggesting this possible account.

classes of objects, such as animate/inanimate, and may then build their knowledge base by attending to properties relevant to this distinction (Gelman, Durgin, & Kaufman, 1995). In this sense, humans are highly relevant objects, and thus 10-month-olds may be willing to give special attention to faces and use the available information processing resources to track objects with human traits separately. By the same token, when they are shown two objects that differ only in properties they find irrelevant (such as in Xu and Carey's [1996] experiments or in our Experiments 3 and 4), they do not invest in the extra cognitive cost of setting up separate representations for them. Such an account has the advantage of explaining most of the successes and failures in Xu and Carey's experiments, as well as in ours, with 10-month-olds. However, we think it is unlikely that it can account for the full pattern of our results. First, there are well-known difficulties in specifying a relevance metric for adults, and we are not aware of any completed attempt at providing one for infants. Second, if we take the current formulation of relevance theory, there is a sense in which the HFH and a relevance-based account do not differ. According to relevance theory, relevance increases by either reducing cognitive effort or increasing cognitive effect (Sperber, Cara, & Girotto, 1995; Sperber & Wilson, 1995). If infants possess special mechanisms to treat properties of congenerics, then processing information about humans is likely to be less costly than processing information about objects belonging to other categories. Therefore, information about humans becomes more relevant by definition. In this sense, a relevance-based explanation does not differ from the HFH, but it has to be dependent on the HFH to explain why 10-month-olds find treating humanlike objects more relevant than treating arbitrary artifactual objects. Third, if infants succeed at using the property method when confronted with the humanlike/non-humanlike contrast because humanlike objects are relevant and artifactual objects are not, then presumably they should succeed—and even more so—when they see two humanlike objects that both are relevant. However, Experiment 6 did not confirm this prediction. The result seems to suggest that infants attend to special kinds of properties in order to individuate objects. While it is possible to modify a relevance-based explanation to account for such results, this requires substantial elaboration of the proposal.

In conclusion, the HFH is currently the most complete explanation consistent with our results. We also hold that it is a productive explanation. It has a rich set of consequences, to which we now briefly turn.

Human Faces, Humans, and the Architecture of the System

Is it by chance that infants identify and distinguish objects with a human face from other objects, or is it a feature of the architecture of the system? We favor the latter hypothesis. In our experiments, we have used objects with human faces, but the HFH is not just about face recognition. We hold that information about faces is integrated into a more complex system, whose role is to identify conspecifics conceptually and predispose us to apply the right psychological assumptions to members of our species (Mehler et al., 1994). Thus, we think that face recognition systems are subordinate to a more general human identification system that can be triggered by different input channels. There are other properties that may activate the conspecific module, such as hearing a natural language and seeing a certain body schema. All such properties could, in principle, be used to solve the problem of identifying conspecifics and telling them apart from other kinds. If we are right, we would expect infants to exploit them to succeed in using the property method. These theses yield a wide set of predictions that deserve further research.

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