Evidence for Knowledge-Based Category Discrimination in Infancy

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Two studies examined whether infants’ category discrimination in an object-examination task was based solely on an ad hoc analysis of perceptual similarities among the experimental stimuli. In Experiment 1A, 11-month-olds examined four different exemplars of one superordinate category (animals or furniture) twice, followed by a new exemplar of the familiar category and an exemplar of the contrasting category. Group A (N = 39) explored natural-looking toy replicas with low between-category similarity, whereas group B (N = 40) explored artificial-looking toy models with high between-category similarity. Experiment 1B (N = 40) tested a group of 10-month-olds with the same design. Experiment 1C (N = 20) reversed the order of test trials. For Experiment 2 (N = 20), the same artificial-looking toy animals as in Experiment 1 (group B) were used for familiarization, but no category change was introduced at the end of the session. Infants’ responses varied systematically only with the presence of a category change, and not with the degree of between-category similarity. This supports the hypothesis that performance was knowledge based.

INTRODUCTION

What kind of information is crucial for category formation at a preverbal age? Is it information about the appearance of objects, information about functional or causal relations, or both? These questions still provoke heated debates among psychologists interested in the origins of human cognition (see Goldstone & Barsalou, 1998; Madole & Oakes, 1999; Mandler, 2000a). One group of researchers suggests that the first categories of preverbal infants are purely perceptual in nature in the sense that they are exclusively based on attributes that can be perceived directly (e.g., Behl-Chadha, 1996; Quinn & Eimas, 1996; Roberts, 1988; Smith & Heise, 1992). This idea is consistent with traditional accounts of cognitive development in which conceptual thinking requires the ability to abstract from the immediate perception, and to rely on verbally encoded knowledge about defining characteristics (e.g., Bruner, Olver, & Greenfield, 1966; Inhelder & Piaget, 1964). Another group of researchers suggests that conceptual thinking may guide infants’ categorization, even at a preverbal age (Mandler, 2000a; Nelson, 1974; Premack, 1990). Following these authors, the earliest categories are based on core knowledge about causal, functional, or structural properties (e.g., Gelman, 1990; Keil, 1991). Such knowledge could either be innate (Fodor, 1975) or start to develop during the first year of life (Mandler, 1992). According to the conceptual view, the ability to perceive and learn causal patterns is a fundamental prerequisite for category formation at all ages (Carey & Spelke, 1994; Keil, Smith, Simons, & Levin, 1998; Pauen, 1999a).

Recently, the strong dichotomy between perception- and conception-based views has been questioned (e.g., Jones & Smith, 1993; Madole & Oakes, 1999; Quinn & Eimas, 1997; Quinn, Johnson, Mareschal, Rakison, & Younger, 2000). Among others, Madole and Oakes (1999) have argued that the focus of future investigations should shift toward a microanalytic consideration of the diverse sources from which children’s knowledge is derived. Despite such new developments, the general theoretical dissent regarding the nature of preverbal categories remains (see Mandler, 2000a; Quinn et al., 2000). One reason may be the diversity and inconclusiveness of empirical findings. As discussed below, this problem is closely related to the methods used for studying categorization in early childhood.

Categorization research with infants less than 1 year of age is dominated by two paradigms: visual-fixation tasks (either habituation/dishabituation or familiarization/preference for novelty) and the object-examination task. Both types of tasks employ the same general procedure and logic: Infants are first familiarized with a number of different exemplars from one category (e.g., dogs). Following familiarization, two new test stimuli are presented; one is a new exemplar of the familiar category (e.g., a new dog) and the other is a new exemplar of a contrasting category (e.g., a new fish). A clear preference for the latter is typically interpreted as evidence for category discrimination.

A general limitation of this procedure is that one can never be sure whether infants increase attention to the out-of-category exemplar because they recognize the category boundary or because of some other
reason. This ambiguity is reduced to some extent if a priori preferences for the out-of-category item can be ruled out as a possible explanation of the observed findings. Further evidence supporting the category-based explanation is provided by data indicating that infants generalize familiarization to the same-category test item. Whereas the first condition is typically met by studies using either visual-fixation tasks or the object-examination technique, this is not true for the second condition. Visual-fixation studies typically fail to report statistical comparisons of mean looking times for the last familiarization item and the within-category test item (e.g., Behl-Chadha, 1996; Eimas & Quinn, 1994; Quinn & Eimas, 1996). Therefore, these studies do not test whether infants actually generalize familiarization to the within-category test item. The corresponding analysis plays a crucial role in object-examination studies, however. If no increase in attention from the last familiarization item to the same-category test exemplar is observed, but an increase in attention to the contrasting-category test item is observed, then infants are assumed to have categorized the stimuli (Mandler & McDonough, 1993, 1998; Oakes, Coppage, & Dingel, 1997; Oakes, Madole, & Cohen, 1991). Mandler and McDonough (1993, 1998) have also found that occasionally, infants show a linear increase from the last familiarization trial over the same- to the contrasting-category test stimulus. They interpret this pattern as “advanced categorization.” This interpretation will be discussed further in the Results and Discussion section of Experiment 1A. For now, the important point is that in the examination paradigm too, generalization of familiarization to the within-category test item suggests that infants are distinguishing the test items on the basis of category membership rather than for some other reason.

Studies that have used the visual-fixation task and the object-examination task not only differ with respect to how they treat methodological problems, but also show considerable variation in experimental procedure. In a typical visual-fixation task, infants are presented, often in pairs, with a large set of pictures of different exemplars of a single category. During the test phase, infants see one or more pairings of a novel within-category exemplar and a novel out-of-category exemplar. The dependent measure in visual-fixation tasks is the total amount of time that infants spend visually fixating each stimulus. In a typical object-examination task, infants are presented with a sequence of three-dimensional (3-D) miniature models of real-world objects that they are allowed to both visually and manually explore one at a time. Following repeated exposure to only a small number of familiarization exemplars, one new same-category item and one new different-category item are presented. The dependent measure in these tasks is the amount of time that infants spend actively examining each object. Examination time is a subset of total looking time (Oakes & Tellinghuisen, 1994; Ruff, 1986). Some researchers (e.g., Mandler & McDonough, 1993) have argued that examination reflects conceptual processing to a greater degree than does looking time, which is highly influenced by perceptual features of the stimuli.

Not surprising, diverging patterns of results have been obtained with these tasks, leading to different conclusions about the processes underlying infants’ performance: Visual-fixation studies have shown that infants as young as 3 to 4 months can distinguish between basic-level categories such as cats, dogs, fish, horses, zebras, and giraffes (Eimas & Quinn, 1994; Eimas, Quinn, & Cowan, 1994) or chairs, beds, sofas, and tables (Behl-Chadha, 1996). Apparently, infants at this age can also form superordinate-like classes, such as mammals and furniture (Behl-Chadha, 1996). Quinn and Johnson (2000) reported that 2-month-olds are better at distinguishing superordinate-like classes than basic-level categories. This suggests the existence of a global- to basic-level shift in early infancy. Quinn and Eimas (1996, p. 23) argued that “it is doubtful and most likely impossible that infants 3 to 4 months of age would have any conceptual knowledge about animals and instances of furniture at the basic level or higher.” To explain category discrimination, the authors assumed that categories are formed “on-line” in the course of the experimental session (see also Smith, 2000). This on-line process may be facilitated by the fact that visual-fixation tasks generally employ a pairwise presentation of multiple exemplars during familiarization.

More specifically, Quinn and Eimas (1996) assumed that young infants form a perceptually based representation during familiarization that generalizes to novel instances of the familiar category, but not to an out-of-category exemplar, resulting in a looking preference for the out-of-category exemplar during the test phase. This interpretation includes two related arguments: (1) categorization performance in infancy can be explained by on-line processes of visual abstraction, and (2) these on-line processes are based on perceptual information about the appearance of the presented stimuli. (It should be pointed out, however, that these data do not rule out the possibility that infants might apply previously acquired category knowledge.)

Referring to data obtained with object-examination techniques, Mandler and McDonough (1993, 1998) came to different conclusions. These authors
found that children failed to discriminate most basic-level categories, such as dogs and rabbits or dogs and fish, until the end of the first year of life. At the same time, global-level categories such as animals and vehicles were differentiated at 6 to 7 months of age (the earliest age at which the object-examination task can be employed, because younger infants are not yet able to handle objects effectively). Response patterns found for this type of contrast showed a shift from simple to advanced categorization between 7 and 11 months of age. To explain these findings, Mandler and McDonough (1993) suggested that the meanings developed before entering the experimental situation direct infants’ attention during the test phase. This conclusion rests partly on the argument that it should be more difficult for young infants to abstract a global-level category on-line than to abstract a basic-level category on-line after having been exposed to just a few familiarization exemplars. After all, within-category variability is much higher for global- than for basic-level categories (Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976). Mander and McDonough (1993) further speculated that the presentation of 3-D toy models may enhance the application of previously acquired knowledge more than do pictures, because only the toy models can be explored visually as well as manually. According to Mandler (1992, 2000b), infants start with the formation of rather broad conceptual distinctions, such as the global animate–inanimate distinction (see also Gelman & Spelke, 1981). This distinction could be based on the causal understanding of the difference between self-initiated and externally induced motion (e.g., Gelman, 1990; Mandler, 1992; Premack, 1990). In contrast to authors who use the visual-fixation task, Mandler and McDonough thus suggested that (1) pre-existing representations play a crucial role in explaining categorization performance in infants less than 1 year of age, and (2) these representations include conceptual (i.e., causal, structural, or functional) knowledge.

As this review of the current literature reveals, different models have been developed to explain categorization performance. These models typically combine claims about the role of perceptual and conceptual attributes in infants’ categorization with claims about the role of pre-existing representations that infants may (or may not) apply in categorization tasks. However, to enhance clarity in the theoretical debate, it may be useful to treat these aspects separately. First, it must be determined whether categorization performance in preverbal infants is ever based on pre-existing representations of the categories under investigation, or whether infants’ performance is always based on an ad hoc analysis of the perceptual features available in the experimental stimuli themselves. Only if it can be shown that pre-existing representations influence categorization performance at all would it make sense to speculate further about the role of perceptual and conceptual knowledge for category formation at a preverbal age. The series of experiments to be reported next focused on this issue.

In the present context, categorization was called on-line when infants relied only on their immediate perception of the given experimental stimuli to form a category within the familiarization period. In contrast, categorization was called knowledge based when infants referred to some already existing representation that was activated by the perception of the given stimuli but included properties other than those corresponding to the physical attributes of the experimental material. Such properties could be either perceptual or conceptual in nature. For example, a given toy animal without a specific smell (perceptual attribute) and without the ability to direct its own behavior (conceptual attribute) may nevertheless activate the memory of a real-world animal that has the corresponding perceptual and/or conceptual attributes. The crucial point is that infants’ performance was only called knowledge based if categorization responses were at least partly based on perceptual and/or conceptual properties belonging to a representation that had been formed prior to the start of the experimental session. Alternatively, performance was called on-line if categorization responses could be explained exclusively by an analysis of perceptual similarities and differences among the stimuli presented during the experimental session.

The current research investigated whether infants less than 1 year of age showed on-line-based or knowledge-based categorization as defined above, using the object-examination paradigm. This task was chosen because strong claims in favor of the knowledge-based view appeal to data obtained with this method. The experimental design was based on the following general logic: If infants showed on-line categorization, then their responses during the test phase should vary systematically with the degree of perceptual between-category similarity of the experimental material. More specifically, categorization responses should be stronger in a low between-category similarity condition than in a high between-category similarity condition. If infants showed knowledge-based categorization, however, a manipulation of perceptual between-category similarity should not greatly influence infants’ performance provided that the contrasted categories were familiar to the infants.

Following a similar line of reasoning, Oakes et al. (1997) tested 10- to 13-month-olds in an object-
examination task contrasting land and sea animals in a high and a low between-category similarity condition. They found that performance varied systematically with the degree of between-category similarity. As suggested by the on-line view, infants’ category discrimination was better in the low between-category similarity condition. However, because the authors used different basic-level exemplars in both similarity conditions, it is not possible to determine from the reported findings whether the activation of different knowledge or the manipulation of between-category similarity of the experimental stimuli was responsible for the observed differences in categorization performance. In an attempt to overcome this problem, the present experiments used identical basic-level exemplars in the high- and in the low-similarity condition, but varied the degree of perceptual between-category similarity among stimuli. Given the close relation between perceptual and conceptual attributes (Rosch et al., 1976), choosing appropriate stimuli for this purpose turned out to be difficult. To ensure that the stimuli designed for this purpose were appropriate, three preliminary experiments were conducted.

Preliminary Studies

Two different sets of stimuli were created, representing the same basic-level exemplars of animals and furniture items in both sets: the group of animals included a giraffe, a zebra, a crocodile, a hippo, and a turtle, and the group of furniture items consisted of a cupboard, a chair, a bed, an armchair, and a stool. These exemplars were represented by toys that differed systematically in their appearance between sets.

In Set A (see Figure 1, top), all items were toy replicas of real-world objects with realistic natural variation. Exemplars within each category varied greatly in shape, color, and surface pattern; systematic perceptual differences between categories concerned material aspects (animals in hard plastic, wooden furniture), characteristic parts (presence or absence of facelike features), and abstract form attributes (curvy borders, rounded contours, irregular colored and textured surfaces for animals; straight borders, sharp contours, and smooth, regularly colored surfaces for furniture). Hence, within- and between-category similarity were both rather low.

In Set B (see Figure 1, bottom), all toy models were made out of wood. Variation in their physical appearance was highly controlled. They were all marked with two black-and-white dots that could be interpreted as eyes in the case of animals, and as knobs or decoration in the case of furniture. Each item had curved as well as rectilinear parts, rounded as well as sharp edges, a smooth surface, and leglike appendages. The furniture items were designed such that each item had the same global shape as one animal, the same colors as another animal, and the same surface pattern as a third animal (see Table 1). Within each category (animals, furniture), all five exemplars displayed a different global shape, a different color combination, and a different surface pattern.

Preliminary Experiment 1. The first preliminary experiment tested whether the stimuli used in Sets A and B differed systematically with respect to the degree of perceptual within- as well as between-category similarity. A group of undergraduate students (age: M = 22.1, range = 19–29 years; 10 males, 10 females) were asked to rate similarity among pairs of objects on a 10-point rating scale (1 = minimal similarity, 10 = maximal similarity). The experiment consisted of two parts: In Part 1, all possible object combinations for one given set (either artificial- or natural-looking stimuli) were presented in random order, and in Part 2, the same was done with the remaining set. The order of presentation of the sets was counterbalanced across the sample. Participants were instructed to base their similarity estimates on information about the appearance of the stimuli only, and to disregard what they thought the objects might represent in the real world.

Mean scores for within-category similarity in each set were entered as dependent variables into an analysis of variance (ANOVA) with order of presentation for both sets (artificial first, natural first), and gender (male, female) as independent variables. This analysis revealed no significant effects, indicating that the two sets of stimuli were comparable with regard to perceptual within-category similarity. An ANOVA with between-category similarity for each set as the dependent variable revealed that similarity ratings were significantly higher for the artificial-looking stimuli than for the natural-looking stimuli, F(1, 16) = 33.17, p < .001. The intended manipulation of between-category similarity therefore was successful. Overall, similarity ratings were rather low for both sets of stimuli (see Table 2). It is important to note, however, that between-category similarity was rated slightly higher than within-category similarity for the artificial material, t(19) = −1.76, p = .09, whereas the reverse was true for the natural-looking stimuli, t(19) = 2.84, p < .05. In both analyses, neither gender nor order of presentation influenced the results.

Preliminary Experiment 2. This experiment tested whether between-category similarity among the artificial stimuli would be rated differently when adults applied previously acquired knowledge compared with
when they focused on the appearance of the given toys alone. The task closely resembled the object-examination task that infants received in later experiments. A group of undergraduate students (age: $M = 24$ years, range = 19–29 years; 20 males, 20 females) were given the same series of four exemplars of one category twice. Each object was presented for 20 s, during which the adult was allowed to freely explore the toy. Participants in the perceptual instruction condition ($N = 20$) were asked to focus exclusively on the appearance of the stimuli, whereas those in the knowledge-based instruction condition ($N = 20$) were asked to consider all they knew about the nature of the real-world objects represented by the given toys. Each object occurred equally often in each position.

Following familiarization, one new exemplar of the already familiar category and one exemplar of the contrasting category were presented, with order of test trials counterbalanced. Each object in both categories served as a test item equally often. Participants rated the similarity of each test item to the previously seen familiarization items on a 10-point rating scale (1 = minimal similarity, 10 = maximal similarity). Rating responses were entered into an ANOVA with instruction (perceptual, knowledge based) as the independent variable and rating response for the same-
category and the different-category test exemplar as the repeated-measurement variable. This ANOVA revealed a main effect for instruction, $F(1, 38) = 4.30, p < .05$, and a main effect for test trial, $F(1, 38) = 15.64, p < .01$, as well as a significant interaction between the two variables, $F(1, 38) = 57.00, p < .01$. As expected, the perceptual instruction group rated the same-category item as less similar to the previously seen familiarization items ($M = 3.80, SD = 2.12$) than the different-category item ($M = 5.05, SD = 1.82$), $t(19) = -2.80, p < .01$, whereas the reverse was true for the knowledge-based instruction group (same-category item: $M = 5.45, SD = 1.82$; different-category item: $M = 1.45, SD = 1.05$), $t(19) = 7.50, p < .01$. These results showed that between-category similarity was perceived as greater than within-category similarity for the artificial-looking material only when adults focused on the appearance of the stimuli. Between-category similarity was perceived as smaller than within-category similarity when real-world knowledge was applied.

Preliminary Experiment 3. Given that adults judged perceptual between-category similarity to be higher than within-category similarity for the artificial stimuli, one might ask whether young children would still be able to recognize the category membership of the artificial stimuli. An experiment with 2-year-olds (10 girls, 10 boys; age: $M = 2.5, range = 2.0–2.10$) investigated this issue. Children were given one item at a time and were asked: “Do you know what this is called?” In this task, 60% of the animals and 55% of the furniture items were labeled correctly at the basic level. When children were later asked to put all animals into a garden and all furniture into a house, the percentage of objects sorted correctly was 95% for the animals and 80% for the furniture items. These findings suggest that the artificial stimuli were still recognizable as animals or furniture, respectively.

Based on the results of all three preliminary experiments it was concluded that perceptual between-category similarity was higher for the artificial stimuli than for the natural stimuli (Preliminary Experiment 1). Also, perceptual between-category similarity was higher than within-category similarity for the artificial material (Preliminary Experiment 2), and this did not prevent young children from identifying the presented stimuli as exemplars of their respective superordinate category (Preliminary Experiment 3). Thus, a comparison of infants’ category performance in a study using both sets of stimuli should reveal whether pre-verbal infants’ performance in an object-examination task is more likely to be on-line based or knowledge based in the sense defined in the Introduction.

### Table 1 Form, Color, and Surface Pattern of Artificial-Looking Stimuli

<table>
<thead>
<tr>
<th>Objects</th>
<th>Form</th>
<th>Color</th>
<th>Surface Pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animals</td>
<td>Giraffe</td>
<td>Yellow and brown</td>
<td>Net shaped</td>
</tr>
<tr>
<td>Zebra</td>
<td>Zebra</td>
<td>Black and white</td>
<td>Striped</td>
</tr>
<tr>
<td>Crocodile</td>
<td>Crocodile</td>
<td>Dark and light green</td>
<td>Dotted</td>
</tr>
<tr>
<td>Hippo</td>
<td>Hippo</td>
<td>Gray and pink</td>
<td>Plain</td>
</tr>
<tr>
<td>Turtle</td>
<td>Turtle</td>
<td>Red and brown</td>
<td>Checked</td>
</tr>
<tr>
<td>Furniture</td>
<td>Cupboard Similar to giraffe</td>
<td>Red and brown (turtle)</td>
<td>Plain (hippo)</td>
</tr>
<tr>
<td>Chair</td>
<td>Similar to zebra</td>
<td>Dark and light green (crocodile)</td>
<td>Net shaped (giraffe)</td>
</tr>
<tr>
<td>Bed</td>
<td>Similar to crocodile</td>
<td>Gray and pink (hippo)</td>
<td>Checked (turtle)</td>
</tr>
<tr>
<td>Armchair</td>
<td>Similar to hippo</td>
<td>Yellow and brown (giraffe)</td>
<td>Striped (zebra)</td>
</tr>
<tr>
<td>Stool</td>
<td>Similar to turtle</td>
<td>Black and white (zebra)</td>
<td>Dotted (crocodile)</td>
</tr>
</tbody>
</table>

### Table 2 Within-Category Similarity and Between-Category Similarity among Natural-Looking Stimuli, and Artificial-Looking Stimuli: Adult Ratings

<table>
<thead>
<tr>
<th></th>
<th>Within-Category Similarity</th>
<th>Between-Category Similarity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
</tr>
<tr>
<td>Natural-looking stimuli</td>
<td>3.12</td>
<td>.98</td>
</tr>
<tr>
<td>Artificial-looking stimuli</td>
<td>3.14</td>
<td>1.02</td>
</tr>
</tbody>
</table>

Note: Minimal similarity = 0; maximal similarity = 10.
EXPERIMENT 1A

Group A received realistic toy replicas of real-world objects in which both within- and between-category perceptual similarity were rather low (see Figure 1, top). Group B received toy models of the same real-world exemplars, with the only difference being that perceptual between-category similarity was high (see Figure 1, bottom). If 11-month-olds did not categorize the given stimuli at all, or if the on-line view were correct, Group A (low between-category similarity) should show an increase in examination time from a new exemplar of the already-familiar category to a new out-of-category exemplar. Group B (high between-category similarity), in contrast, should show a decrease from a new exemplar of the already-familiar category to a new exemplar from the contrasting category, because the out-of-category test item has more perceptual features in common with the familiarization stimuli than the same-category test item. On the knowledge-based account, in contrast, no substantial differences in infants’ responding across conditions should occur. One would expect an increase in mean examination time from the familiar-category item to the contrasting-category item.

Method

Participants. A total of 79 infants (age: $M = 11$ months, 13 days, range = 11 months–11 months, 30 days) participated. Infants’ names were drawn from birth announcements in a local newspaper. Their families were contacted via letters and phone calls. Half of the infants were randomly assigned to Group A ($n = 40$, 20 girls, 20 boys), and the other half were assigned to Group B ($n = 39$, 21 girls, 18 boys). Four additional infants were originally tested but started to cry and did not complete the session. All infants remaining in the final sample came from a White, middle-class socioeconomic background.

Procedure. Infants were seated in a high chair. After a short warm-up period, the experimenter placed the first object within reach in front of the children. For 20 s, the infants could do with the toy whatever they wanted (e.g., play, explore, ignore). If a given toy fell off the table, the experimenter quickly picked it up and placed it back on the table. A small light fixed on the wall behind the high chair indicated the duration of each trial. Half of the children in each condition were familiarized with animals; the others were familiarized with furniture. The order of presentation for all stimuli was varied systematically across infants in each group such that each object occurred equally often in each position. Items were presented in the same order to Groups A and B. During familiarization, a series of four different exemplars from one category was presented twice ($2 \times 4$ familiarization trials), followed by one new exemplar from the familiar category (first test item = Trial 9), and one new exemplar from the contrasting category (second test item = Trial 10). The experimenter did not label any of the objects, and parents were asked to not interact with the children during the session.

Scoring. For the purpose of later scoring, three different copies of these videotapes were made. Either Trial 9 or Trial 10 (random choice) of a given session was copied onto a first tape. The remaining test trial of the same session was copied onto a second tape.
The third tape contained all familiarization trials (Trials 1–8). Two independent coders who had not been involved in the process of data collection and were blind to the hypothesis first measured examination times on the two test trials (first and second tape). Observers were unaware of which of the two test trials they were viewing. The third tape was scored only after the other two tapes. This procedure sought to rule out the possibility that knowledge about the hypothesis could influence the results. Both observers recorded examining time, defined as the time during which a given child was concentrating on and inspecting the object (Oakes et al., 1991; Oakes & Tellinghuisen, 1994). This state of focused attention involves active intake of information about the object as opposed to activity for its own sake, which may include the object (Ruff, 1986).

Results and Discussion

Mean intercoder reliability for examination was $r = .95$, with a range of $r = .92$ to $r = .96$. For each trial, the mean score of both coders provided the raw data for further analysis.

Familiarization trials. To test whether infants habituated to the presented material and/or category, two separate scores were calculated: (1) mean examination time during the first presentation of all four different familiarization stimuli, and (2) mean examination time during the second presentation. These two scores were entered into a 2 x 2 x 2 (Group x Familiarization Condition x Presentation) mixed-design ANOVA. The analysis revealed a significant main effect for presentation, $F(1, 75) = 11.86, p < .01$. All other main effects and interactions were nonsignificant. Infants examined the material longer during the first presentation ($M = 6.19$ s, $SD = 2.68$ s) than during the second presentation ($M = 5.11$ s, $SD = 2.69$ s). Neither group (artificial-looking or natural-looking material) nor familiarization condition (animals or furniture) affected infants’ performance. Hence, no a priori preferences for any given set of stimuli were observed.

Test trials. Infants’ mean examination times for the last familiarization trial and both test trials (Trials 8, 9, and 10) were entered in a 2 x 2 x 3 (Group x Familiarization Condition x Trial) mixed-design ANOVA, which revealed a significant main effect for trial, $F(2, 150) = 30.58, p < .001$, as well as a significant three-way interaction between group, familiarization condition, and trial, $F(2, 150) = 3.54, p < .05$. No other main effects and interactions were significant. To explore further the nature of the observed three-way interaction, post hoc tests (Student-Newman-Keuls) compared mean examination times for both groups (A, B) in both familiarization conditions (animals, furniture) on Trials 8, 9, and 10, respectively. When Trial 8 served as the dependent variable, Group A differed significantly from Group B for those infants who had been familiarized with furniture, $p < .05$. Infants who were familiarized with the natural-looking furniture items examined the last familiarization stimulus for a shorter time than did those who had been familiarized with the artificial-looking furniture items. When Trials 9 or 10 served as the dependent measures, no two subgroups differed significantly. Accordingly, the observed three-way interaction could be attributed primarily to differences in mean examination times on the last familiarization trial (see Figure 2). The corresponding difference on this specific trial was not replicated in later studies, and was therefore likely a result of chance variation across groups.

Because examination times for the critical two test trials (Trials 9 and 10) did not differ substantially...
Experiment 1A

Experiment 1B

Experiment 1C

Method

A total of 40 infants (age: \( M = 10 \) months, \( 12 \) days, \( range = 10 \) months, \( 1 \) day–10 months, \( 3 \) days) participated. Infants were recruited in the same way as in Experiment 1A. Half of the infants were randomly assigned to Group A (12 girls, 8 boys), and the other half were assigned to Group B (7 girls, 13 boys). Five additional infants were originally tested but started to cry and did not complete the session. All infants remaining in the final sample came from a White, middle-class socioeconomic background. The experimental procedure, stimuli, and scoring technique were identical to that in Experiment 1A.
Results and Discussion

Mean intercoder reliability on all trials was \( r = .92 \), with a range from \( r = .81 \) to \( r = .99 \). Mean examination time decreased significantly from the first part of the familiarization period (\( M = 6.73 \) s, \( SD = 2.67 \) s) to the second part of the familiarization period (\( M = 5.28 \) s, \( SD = 2.81 \) s), \( t(39) = 3.19, p < .01 \).

To test infants’ performance during the test phase, mean examination times for the last three trials were entered in a \( 2 \times 2 \times 3 \) (Group x Familiarization Condition x Trial) mixed-design ANOVA. This analysis revealed a significant main effect for trial, \( F(2, 76) = 6.41, p < .01 \). No other main effects or interactions were significant. Mean examination times were \( M = 5.17 \) s (\( SD = 4.25 \) s) for the last familiarization trial, \( M = 6.10 \) s (\( SD = 4.92 \) s) for the same-category item, and \( M = 7.63 \) s (\( SD = 4.59 \) s) for the out-of-category item. Post hoc comparisons revealed no significant increase in mean examination time from Trial 8 to Trial 9, but a significant increase from both Trials 8 and 9 to Trial 10 (see Table 3).

Infants generalized familiarization to the first test item (new exemplar of familiar category) but not to the out-of-category item. This was consistent with the pattern of “simple categorization” observed in previous studies with infants younger than 11 months of age (Mandler & McDonough, 1993, 1998). As in Experiment 1A, no differences between the two experimental conditions were observed during the test phase, and infants in both experimental groups responded only with an increase in mean examination time to the category change. The general finding that perceptual between-category similarity did not affect responses during the test phase could thus be replicated with an independent sample of 10-month-olds.

**EXPERIMENT 1C**

Another methodological problem associated with the classical version of the object-examination task concerns the fixed sequence of the test trials. Because the out-of-category exemplar is always presented after the within-category exemplar, one could argue that the significant increase from the first to the second test trial reflects natural changes in attention throughout the experimental session. To test whether the order of presentation of test stimuli accounted for the observed findings, Experiment 1C was conducted.

**Method**

A total of 20 infants (age: \( M = 11 \) months, 13 days, \( range = 11 \) months–11 months, 30 days) participated. Children were recruited in the same way as in Experiment 1A. Half of the children were randomly assigned to Group A (4 girls, 6 boys), and the other half were assigned to Group B (6 girls, 4 boys). Two additional children were originally tested but started to cry and did not complete the session. All children came from a White, middle-class socioeconomic background. The experimental procedure and the stimuli were identical to that in Experiment 1A, except that all children examined the out-of-category item first rather than second during the test phase.

Results and Discussion

Mean intercoder reliability was \( r = .96 \) with a range from \( r = .91 \) to \( r = .99 \). Mean examination time decreased significantly from the first half of the familiarization phase (\( M = 6.95 \) s, \( SD = 2.38 \) s) to the second half (\( M = 5.06 \) s, \( SD = 2.89 \) s), \( t(19) = 2.93, p < .01 \). To test infants’ performance during the test phase, mean examination times for the last three trials were entered in a \( 2 \times 2 \times 3 \) (Group x Familiarization Condition x Trial) mixed-design ANOVA. This analysis revealed a significant main effect for trial, \( F(2, 32) = 13.59, p < .001 \). No other main effect or interaction reached significance. Mean examination times were \( M = 5.19 \) s (\( SD = 3.83 \) s) for the last familiarization trial, \( M = 8.58 \) s (\( SD = 3.89 \) s) for the out-of-category item presented on Trial 9, and \( M = 6.58 \) s (\( SD = 4.04 \) s) for the perceptually new same-category item, presented on Trial 10. Post hoc comparisons revealed a significant increase in mean examination time from the last familiarization trial to each of the two perceptually new test stimuli, as well as a significant decline from the out-of-category item to the new within-category item (see Table 3). This replicates the results obtained in Experiment 1A.

The major findings of Experiment 1 can be summarized as follows: (1) infants aged 10 to 11 months showed a decrease in attention during the familiarization period; (2) following familiarization with four different 3-D toy models of the same global category, 10- as well as 11-month-olds preferred to examine an out-of-category item over a new within-category exemplar, irrespective of order of presentation; and (3) infants’ responses did not vary systematically with the degree of perceptual between-category similarity.

If infants either compared individual exemplars or formed some type of categorical representation only on the basis of perceptual information available during the familiarization phase, a systematic manipulation of between-category similarity should have influenced changes in mean examination time during the test phase. Three independent studies provided
evidence against this idea, suggesting that some type of pre-existing categorical representation may be guiding infants’ attention in the object-examination task presented here. If this pre-existing representation refers to the categorical distinction between animals and furniture, infants should only show an increase in mean examination time from the first to the second test trial if the second item belongs to a new real-world category. However, it is also possible that infants in Experiment 1, Group B were responding to the fact that the exemplar from the novel category presented a novel combination of familiar features rather than to its membership in a different real-world category. On this account, a same-category item showing a new combination of already-familiar features should not elicit an orientation response. Experiment 2 tested this hypothesis.

EXPERIMENT 2

In this experiment, infants received the same object-examination task as in Experiment 1A (Group B: artificial material). The only difference was that the second test item did not represent an exemplar from the contrasting category, but rather was a true hybrid of the perceptual features of three of the four familiarization exemplars. Accordingly, Experiment 2 provided no change in category at the end of the experimental session, but provided a similar variation in perceptual similarity between the test items and the familiarization stimuli. If infants applied knowledge about category membership, no increase in attention from the first to the second test item should be perceived. Alternatively, infants may be more interested in toys that provide a new combination of already-familiar perceptual features than in toys that look completely different. In this case, infants who participated in Experiment 2 should show a pattern of responses similar to those infants who participated in Experiment 1A.

Method

Participants. A total of 20 infants, 11 months of age (age: M = 11 months, 18 days, range = 11 months, 2 days–11 months, 29 days) participated. The sample consisted of 8 girls and 12 boys. Infants were recruited in the same way as in Experiment 1A. Three additional infants were originally tested but started to cry and did not complete the session. All infants came from a White, middle-class socioeconomic background.

Stimuli and procedure. The stimuli consisted of artificial-looking animals only. Infants received the same toys as in Experiment 1A (Group B; see Figure 1, bottom). They were presented in the same order and manner as in Experiment 1A with the sole exception of the second test item (Trial 10). Instead of a furniture item, a hybrid of three familiarization stimuli (animals) was presented. This hybrid had the same surface pattern as one of the familiarization exemplars, the same shape as a second one, and the same colors as a third one (see Figure 3).

It was expected that whereas infants who participated in Experiment 1A (Group B/familiarization with animals) showed a linear increase from Trial 9 to Trial 10, no such increase would be found in Experiment 2 (due to the lack of a category change). Perceptually, there were very few differences between the stimuli that served as second test items in each experiment: These differences concerned only the specific outlines and arrangement of parts. Therefore, if infants only relied on an ad hoc analysis of overall similarities and differences in the appearance of the given test stimulus to previously seen familiarization exemplars, responses to the second test item should not differ substantially between Experiment 1A (Group B, familiarization with animals) and Experiment 2.

Results and Discussion

Mean intercoder reliability for Experiment 2 was $r = .95$, with a range from $r = .91$ to $r = .98$. For each trial,
the mean score of examination time between both coders provided the raw data for all further analyses. Infants examined the given animals for a significantly longer time during their first presentation \((M = 5.44 \, \text{s}, \, SD = 2.38 \, \text{s})\) than during their second presentation \((M = 4.23 \, \text{s}, \, SD = 1.55 \, \text{s})\) in the familiarization phase, \(t(19) = 2.48, p < .05\).

During the test phase, infants who participated in Experiment 2 showed an increase in mean examination time from Trial 8 \((M = 4.90 \, \text{s}, \, SD = 2.88 \, \text{s})\) to Trial 9 \((M = 6.34 \, \text{s}, \, SD = 3.01 \, \text{s})\), and a slight decrease from Trial 9 to Trial 10 \((M = 4.95 \, \text{s}, \, SD = 3.59 \, \text{s})\). None of these mean differences were significant, however (see Table 3). To test whether infants’ performance differed systematically between Experiment 1A and Experiment 2 for Trial 10 only, a \(2 \times 3\) (Study \(\times\) Trial) mixed-design ANOVA was conducted that compared performance of those infants who participated in Experiment 1A/Group B (familiarization with artificial-looking animals) with the performance of those infants who participated in Experiment 2. This analysis revealed a significant main effect for trial, \(F(2, 76) = 5.04, p < .01\), as well as a significant interaction between study and trial, \(F(2, 76) = 5.49, p < .01\) (see Figure 4).

Subsequent analyses revealed no significant differences between the means in the two studies observed, either for the last familiarization trial, \(F(1, 39) = .24, p > .05\), or for the first test trial, \(F(1, 39) = .41, p > .05\). Up to this point, infants who participated in both experiments had received identical stimuli. After combining both datasets \((N = 40)\), infants showed a significant increase from the last familiarization trial \((M = 5.21 \, \text{s}, \, SD = 3.94 \, \text{s})\) to the first test trial \((M = 6.76 \, \text{s}, \, SD = 4.14 \, \text{s})\), \(t(39) = -2.64, p < .05\), suggesting that they increased their attention to a perceptually different-looking exemplar of the already-familiar animal category.

As hypothesized, means in the two studies differed significantly only for the last test trial, \(F(1, 39) = 11.67, p < .01\). In Experiment 1, an increase in mean examination time was observed between Trial 9 and Trial 10, \(t(19) = 2.32, p < .05\). In Experiment 2, examination times tended to decrease (see Figure 4), but this decrease failed to reach the level of significance (see Table 3). An analysis of individual response patterns was consistent with this finding: Whereas 75% of all infants who participated in Experiment 1A (Group B, familiarization with animals) showed an increase in examination time from Trial 9 to Trial 10, this was true for only 30% of the infants who participated in Experiment 2. The remaining 25% (Experiment 1A) and 70% (Experiment 2) showed a decrease in examination time. This difference between the studies was significant, \(\chi^2(1, N = 40) = 8.12, p < .01\).

Four related object-examination studies tested whether infants’ categorization performance could be attributed to on-line processes of category formation during familiarization, or to the application of previously acquired knowledge. Experiment 1 contrasted animals with furniture, using natural-looking toy models (Group A) as well as toy replicas with artificially increased between-category similarity (Group B). Both 11-month-olds (Experiment 1A) and 10-month-olds (Experiment 1B) noticed the category change equally well for both sets of stimuli. This pattern of findings
did not depend on the order of test trials (Experiment 1C). Experiment 2 used only artificial-looking stimuli and compared infants’ responses during the test phase with and without introducing a category change at the end of the experimental session. In both cases, the critical test item had the same global shape, coloring, and surface pattern as did the exemplars from the familiarization category. An increase in mean examination time occurred only after a change of category.

As is argued below, results of both experiments seem to support the knowledge-based account. This conclusion rests on the assumption that performance in the object-examination task reflected infants’ ability to discriminate animals and furniture in categorical terms. Whether this was actually the case must be addressed before further implications of the reported findings can be examined.

Does the Object-Examination Task Assess Categorization Skills?

In classification tasks that use either visual-fixation tasks or the object-examination technique, category discrimination is typically inferred if infants generalize familiarization to a new member of the already-familiar category, and increase attention to a new member of a different category (see Introduction). In Experiment 1A, 11-month-olds showed a different pattern of responses, however. Mean examination times increased from the last familiarization item to the new within-category exemplar, and they increased still more from the within-category exemplar to the out-of-category exemplar. This raises the question of whether infants categorized the given stimuli at all.

It is possible that infants simply compared the perceptual similarity between individual familiarization stimuli on the one hand and both test stimuli on the other hand. In this case, the out-of-category exemplar may be examined for a longer time than the same-category test item because it shares fewer perceptual attributes with each of the previously seen familiarization items. Several arguments can be raised against this interpretation. First, if changes in mean examination time were based on a comparison of perceptual similarity between individual stimuli, infants should respond differently in the high and in the low between-category similarity condition. More specifically, infants in the low between-category similarity condition should examine the out-of-category item for a comparably longer time than the same-category test item. Infants in the high between-category condition should show the reverse pattern of preference; that is, they should prefer the within-category test stimulus, because it differs in shape, texture, and color from the familiarization stimuli, whereas the out-of-category stimulus is similar to the familiarization stimuli on these dimensions. Three independent studies (Experiments 1A, 1B, and 1C) provided evidence against this hypothesis. Second, in Experiment 1B, 10-month-olds produced a pattern of responding consistent with the idea that they categorized the given stimuli (i.e., they generalized familiarization to the first test item despite the fact that this item was perceptually new as compared with the familiarization stimuli). It seems rather unlikely that infants who are only 4 weeks older no longer categorize the given items when tested with the same material and the same type of task. Finally, Pauen (1997) tested 11-month-olds’ categorical distinction between animals and furniture with a slightly modified version of the target task. In this study, 10 exemplars from the same global domain were presented during the familiarization phase, followed by one out-of-category exemplar. Despite the fact that no item was shown twice and highly different-looking exemplars from each category were presented, 11-month-olds decreased examination time throughout the familiarization period (Trial 1 to Trial 10). They only increased attention when a new exemplar of the contrasting category was presented on Trial 11 (see also Pauen, 2000a). The general finding that infants treat different-looking members of the same category equivalently while treating an out-of-category exemplar differently could thus be demonstrated with 11-month-olds who participated in an object-examination task with the same categories employed in the current research. In sum, these findings suggest that the object-examination task provides a suitable tool to measure categorization performance in infants of the tested age range. This raises the question of whether infants form a category on-line or whether they apply previously acquired knowledge.

Is Categorization Performance On-Line Based or Knowledge Based?

The on-line-based account assumes that infants base their responses in the object-examination task on similarity comparisons of the appearance of the given experimental stimuli. These comparisons could either refer to (1) overall similarity, (2) a single critical feature, or (3) a specific configuration of attributes. Each of these alternatives will be discussed in turn.

Preliminary Experiments 1 and 2 revealed that, overall, perceptual similarity between categories is low for stimulus set A, but high for stimulus set B. If infants had formed a category on-line and responded to the test exemplars in terms of their degree of mis-
match with that categorical representation, systematic differences between the two conditions should have occurred. In the high between-category similarity condition, the increase in attention should have been stronger when the same-category item was presented than when the out-of-category item was presented. In the low between-category similarity condition, the reverse pattern should have been found. The fact that infants showed similar responses in both experimental groups thus argues against the idea that comparisons related to overall similarity can account for the observed pattern of responding.

Alternatively, infants may have focused attention on a single perceptual attribute to form a category online. Potentially relevant attributes that would allow for category discrimination can easily be identified for the natural-looking toys, but not for the artificial-looking toys: The artificial-looking items from both categories had the same material consistency, were painted with similar colors, and had the same type of surface pattern, but the natural-looking stimuli varied substantially across categories with respect to these features (see Figure 1). Therefore, none of these features can explain the reported findings. On this account, then, categorization performance in the low between-category similarity condition should have been better than in the high between-category-similarity condition. However, performance in the two conditions was comparable.

At a more abstract level, certain perceptual features varied systematically between animals and furniture items in both experimental conditions. The proportion of rectilinear outlines provides an example (Van de Walle, Spelke, & Carey, 1997). This proportion appeared to be somewhat higher for furniture items than for animals even in the high between-category similarity condition. To test whether infants’ discriminated artificial-looking animals and furniture items based on this type of information, Pauen (2000b) recently replicated Experiment 1 with the same objects, except that the objects were painted in one homogeneous color, thereby removing all information about surface patterns and eyeline markings that allowed for an identification of individual exemplars as animal or furniture items, respectively. Only information about the specific outlines of each given object remained the same. This set of stimuli was presented to a group of twenty 11-month-olds. No significant changes in mean examination time were observed across the three critical test trials, suggesting that the proportion of rectilinear outlines alone cannot account for the positive categorization response observed in Experiment 1.

Other single features that might vary systematically between animals and furniture items could be the presence or absence of specific parts. A look into the developmental literature reveals that parts are considered to play a special role in young children’s perceptual categorization (Tversky, 1989). Using a sequential touching task, Rakison and Butterworth (1998a, 1998b) found that 14- and 18-month-olds behaved systematically toward categories with different parts (i.e., animals with legs versus vehicles with wheels), but did not do so toward objects with similar parts (animals with legs versus furniture items with legs). In the present series of studies, 10- and 11-month-olds clearly differentiated between animals and furniture, despite the fact that items from both categories had legs (see also Mandler & McDonough, 1998; Pauen, 1997). The same was true for eyes in the high between-category similarity condition. In the low between-category condition, however, both animal and furniture items had eyeline markings. Because infants performed equally well in the two conditions, the presence or absence of eyes cannot account for the observed findings either.

Finally, rather than focusing on the presence or absence of specific features, infants may respond to a different configuration of attributes. Part configuration is known to be highly relevant for object identification and categorization in adults as well as in children (Biederman, 1993; Hummel & Biederman, 1992; Madole & Cohen, 1995; Saiki & Hummel, 1996; Tversky & Hemenway, 1984; Younger, 1990; Younger & Cohen, 1986). Experiments conducted by Rakison and Butterworth (1998a) revealed that a confounded spatial configuration of body parts could impair categorization performance in 14- to 18-month-old children. The authors displaced legs of animals and furniture items by either changing their orientation but maintaining the configuration (e.g., placing four legs on the back of an animal), or by destroying the natural configuration (e.g., placing each leg at a different side and angle of the main body). Infants’ performance was only impaired in the latter case. In Experiments 1 and 2 of the present research, however, none of the animals or furniture items had misplaced legs. All items were presented as standing on their legs.

Considering other body parts and their spatial arrangement, one could argue that the location of a headlike part containing facial features might allow infants to discriminate animals from furniture items. Quinn and Eimas (1996) reported that information about the head region seems crucial for 3- to 4-month-olds’ ability to categorize animals. Based on the same kind of information, 7- to 11-month-olds were able to discriminate between animals and humans in an
object-examination task conducted by Pauen (1999b). Furthermore, it is known that infants can discriminate faces with two eyes located above a mouth from other stimuli that contain the same elements but are presented in a nonbiological configuration (Johnson & Morton, 1991). In the light of such findings, one might speculate that infants in the current research recognized animals by the presence of two eyes above a mouth painted on some kind of headlike part. Facial features were barely visible in several animals, however (natural- as well as artificial-looking stimuli). Furthermore, infants who were familiarized with animals and who therefore were provided with more facial information did not perform any better than infants who were familiarized with furniture items. These observations provide evidence against the idea that infants learned to distinguish the two categories on-line by focusing exclusively on head and face information.

In sum, although many perceptual attributes known to be relevant for object categorization varied substantially between categories in the natural-looking set of stimuli, these attributes were shared by exemplars from both categories in the artificial-looking set of stimuli and did not, therefore, provide a basis for distinguishing these stimuli. Despite substantial differences in overall similarity between familiarization and test stimuli, infants performed equally well in both conditions (see Experiments 1A, 1B, and 1C). Furthermore, neither a single perceptual feature, nor a specific configuration of attributes could be identified that varied systematically between categories in both conditions that would have allowed infants to form a category on-line during familiarization, and to discriminate animals from furniture items even in the high between-category similarity condition. Taken together, these analyses point to the conclusion that the on-line view cannot explain the reported findings.

According to the knowledge-based account, the toy models used in each condition may activate the same type of categorical representation—a representation that infants formed prior to the start of the experimental session and that contained more information than was displayed in the given stimuli. In this case, the appearance of individual items still played an important role, but rather than providing the sole basis for on-line processes of category formation during the familiarization period, it may have helped to determine membership of each individual exemplar in the same category. Perceptual cues that allow infants to identify category membership of toy models may vary substantially between stimuli, thus leading to a flexible and adaptive strategy for determining class membership of each item presented (Jones & Smith, 1993; Thelen & Smith, 1994).

According to Mandler and McDonough (1993, 1998), infants may identify each given object as a toy replica of some real-world category (e.g., the global category “animals”). When different exemplars of the same category are presented in series during the familiarization period, the same type of pre-existing knowledge may be activated on each trial. If a given out-of-category exemplar activates some other type of pre-existing representation than all exemplars examined before, infants should show a significant increase in mean examination time from the first to the second test item. The reported findings of both experiments in the present research are consistent with this interpretation. Infants’ responses varied systematically with the presence or absence of a category change (see Experiment 2), but not with the degree of perceptual between-category similarity (see Experiment 1).

Similar findings have been obtained with preschoolers in studies using a quite different paradigm. For example, Gelman and Coley (1990) reported that 4- to 5-year-olds preferred to project a hidden property of a particular animal (e.g., an internal organ) to a different-looking animal that belonged to the same category than to an animal that was highly perceptually similar to the target but belonged to a different category. Inductive judgments did not cross ontological boundaries; that is, structural and causal attributes of living entities were not projected onto nonliving entities and vice versa (see also Carey, 1985; Keil, 1989). This general pattern of results also has been documented for 14-month-olds (Mandler & McDonough, 1996). Studies on inductive reasoning thus suggest that knowledge about category membership has a comparatively stronger impact on children’s responses than does perceived similarities in the appearance of the presented experimental stimuli. The studies reported in this article reveal similar responses in an object-examination task conducted with 10- and 11-month-olds.

When thinking about the type of attributes that might be relevant for infants’ category formation, it seems important to keep in mind that perceptual and conceptual attributes are closely linked in many cases. For example, Tversky and Hemenway (1984) showed that different parts suggest distinct functions, whereas similar parts tend to have comparable functions (see also Madole & Cohen, 1995). If one assumes that infants are able to perceive and learn causal patterns early in life, they should also learn quickly to pay attention to the part configuration of a given exemplar to predict its causal and functional properties. Mandler and McDonough (1993, 1998) proposed that
infants may be specifically interested in whether an object is able to perform self-initiated movement (see also Pauen, 2001; Premack, 1990; Spelke, Phillips, & Woodward, 1995). This may motivate them to pay special attention to the form and location of leglike appendages. Furthermore, infants seem highly interested in whether an object can interact socially with others (Carey & Spelke, 1994; Johnson, Booth, & O’Hearn, 1998; Meltzoff, 1995). This may lead them to pay special attention to the head region and to facial features (Pauen, 1999b; Quinn & Eimas, 1996). Causal knowledge about the distinction between self-starters and non–self-starters, as well as causal knowledge about social versus nonsocial beings could provide the first basis for a conceptual distinction between animates and inanimates, which may in turn guide infants’ search for specific perceptual attributes in the given set of experimental stimuli.

As already pointed out, results obtained with an object-examination task do not allow for conclusions with regard to the nature of those properties underlying knowledge-based category discrimination. Pre-existing representations activated in the given task context could include perceptual as well as conceptual information about objects other than those presented during the experimental session. The reported findings suggest that infants went beyond the perceptual information provided by the given stimuli, but leave open the question of the nature of the activated knowledge.

Categorization tasks that test infants’ performance must address the fact that both pre-existing representations and an ad hoc analysis of perceptual attributes related to any given stimuli may simultaneously influence infants’ responses (e.g., Smith, 2000). For that reason, the specific relation between both aspects needs to be explored in more detail. Studies that focus on this question may not only contribute to a better understanding of category formation in preverbal infants, but also could be useful for the development of theoretical models that describe general principles of human category formation and object identification.

ACKNOWLEDGMENT

The reported studies were conducted at the University of Tübingen and at the University of Magdeburg as part of a larger project (Object Categorization in Preverbal Children), funded by the German Research Foundation. Part of this work was presented at the 1997 biennial meeting of the Society for Research in Child Development in Washington, DC, as well as at the 1998 meeting of experimental psychologists in Marburg, Germany. The author would like to thank Birgit Träuble, Nicola Zauner, Andrea Schreier, Michael Schmidt (Tübingen), Diana Sodtke, Annika Falkner, and Denis Krappe (Magdeburg) for their assistance with data collection and video coding. Special thanks also go to Gretchen Van de Walle for helpful comments on earlier drafts of this manuscript.

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