

REPORT

Infants' use of functional parts in basic-like categorization

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Abstract

An experiment with the sequential touching technique investigated the role of object parts on 1- to 2-year-old infants' ability to form basic-level categories (cows and cars) from two different superordinate domains. Using the novel task design developed by Rakison and Butterworth, infants were tested with normal category exemplars as well as modified versions that were made by removing or attaching object parts (legs and wheels). Results revealed a developmental trend whereby infants' use of object parts in categorization decreased with age. Analyses of infants' functional responses (e.g. jumping or rolling) suggested that they might initially associate different kinds of object movement with different kinds of parts.

Introduction

Of the three hierarchical category levels defined by Rosch and her colleagues – i.e. basic, superordinate and subordinate – it is the basic level (e.g. dogs, trucks) that is considered to be 'psychologically privileged' (e.g. Rosch, Mervis, Gray, Johnson & Boyes-Braem, 1976; Rosch, 1978; Mervis & Rosch, 1981).¹ This unique status results from, among other things, the fact that the basic level maximizes within-category perceptual similarity as well as between-category perceptual dissimilarity. Thus, exemplars from a single basic-level category often have similar shapes, similar functions, and many attributes in common, and at the same time they are very different from other basic-level category types (Rosch *et al.*, 1976; Tversky & Hemenway, 1984; Tversky, 1989). In comparison, instances from within a single super-

ordinate domain (e.g. animals, vehicles) are often quite perceptually dissimilar, and it has been assumed that categorization at this level must require information beyond that given in the perceptual array.

Recent work by Rakison and Butterworth (1998a, 1998b; see also Quinn & Eimas, 1996a) provided evidence that suggests that infants' categorization of superordinate domains – e.g. animals, vehicles and furniture – need not be based on information beyond external appearances. In one experiment, Rakison and Butterworth (1998a, Experiment 2) used the sequential touching procedure with 14-, 18- and 22-month-olds who were presented with a contrast of normal animals and vehicles as well as three contrasts with modified animals and vehicles that were created by removing or attaching legs and wheels. In one task with modified animals and vehicles, all the exemplars had legs and wheels; in another, all the exemplars had no legs or wheels; and in the last, half the exemplars of each category had legs and half had wheels. Results revealed that 14- to 22-month-old infants categorized animals and vehicles that were unmodified, but they failed to categorize in the conditions in which the stimuli had the same parts or had parts removed. The authors interpreted this behavior to mean that object parts are necessary, and in some cases sufficient, for infants'

¹The terms superordinate-like and basic-like are used here to denote that these groupings differ from adults' categories in the sense that they do not encapsulate, for example, hierarchical structure or appropriate category borders (see Mervis, 1987; Rakison, in press). Thus, although it is reasonable to refer to a task with, say, cats and dogs as a basic-level contrast, when infants form categories that include such objects it is probably more accurate to label them as basic-like.

superordinate-like categorization. This view was supported by the task in which infants had a 'choice' to categorize on the basis of object parts or category relations: the 14- and 18-month-olds classified by attending to legs and wheels rather than to the category membership of the object. However, the fact that members of a single superordinate domain have few properties in common suggests that object parts may play a singularly important role in categorization at that level. It remains to be seen, for instance, whether infants rely on object parts to group objects when between-category perceptual similarity is low but within-category perceptual similarity is high, as in the case of two basic-level classes from different superordinate domains.

In addition to evidence that shows that infants attend to object parts to categorize, there are also data to suggest, albeit tentatively, that infants in the second year develop expectations about the alignment of parts (Rakison & Butterworth, 1998b). In one task, for example, 14- to 22-month-old infants were presented with animals and vehicles whose parts (legs or wheels) were moved as a complete unit into the opposite orientation to that found normally; e.g. a cow had four legs on its back. The 22-month-olds, but less so younger infants, tended to arrange these stimuli so that legs or wheels were in a normal orientation despite the fact that the rest of the object was in a novel orientation. From these data, Rakison (in press; Rakison & Butterworth, 1998b) suggested that by the end of the second year infants may have developed expectations about the orientation, and possibly therefore the function, of certain object parts; e.g. wheels roll. More specifically, it was hypothesized that infants detect the relationship between different object parts and dynamic perceptible properties such as mode of locomotion.

This hypothesis is consistent with the finding that 18-month-olds, but not younger infants, attend to the relationship between form and function rather than to either property independently (Madole, Oakes & Cohen, 1993), and that they attend only to correlations that are compatible with those found in the real world, i.e. when the form of an object part predicts its function (Madole & Cohen, 1995). It is also compatible with Tversky's (1989; Tversky & Hemenway, 1984) claim that parts support inferences from surface appearance to function. Thus, object parts are 'simultaneously natural units of perception and natural units of function' (Tversky, 1989, p. 983). However, despite the considerable body of work on infants' and children's attention to the relationship between form and function, little is known about the specific form-function correlations among real-world objects to which infants attend.

The goals of the experiment presented here were twofold. First, it was designed to examine the role of parts in infants' categorization of basic-level classes from different superordinates, i.e. cows and cars. Rakison and Butterworth (1998a, 1998b) examined only infants' categorizing behavior with superordinate contrasts and, most notably, animals and vehicles. By comparison, cows and cars have a greater level of within-category perceptual similarity and presumably an equivalent level of between-category similarity (Mandler & Bauer, 1988). In the current study we used the same experimental design as that in Rakison and Butterworth (1998a, Experiment 2); however, we sought to examine how the same manipulations influence infants' categorization of objects from two basic-level categories drawn from distinct superordinate domains. It was predicted that infants in this study would categorize more easily than those tested previously with contrasts of animals and vehicles (Rakison & Butterworth, 1998a). It was also predicted that a single object part would be less likely to act as the basis for categorization in these tasks than in similar tasks with animals and vehicles because members of basic-level categories share a number of properties other than parts, e.g. shape and function.

Second, the study presented here was designed to examine infants' knowledge of certain form-function correlations. Following from Mandler (1992) who pointed out that infants often 'hopped' animals and 'rolled' vehicles in sequential touching tasks, in this experiment infants' functional responses – i.e. rolling and hopping/walking – were analyzed. Clearly, the movements made by infants with toy cows and toy cars will not match exactly the movements made by real-world objects. Moreover, 'jumping' and 'rolling' are not veridical functions of cows and cars. However, in performing these actions, it is likely that infants reproduce an approximation of the movement they have seen made by the toys' real-world counterparts. As such, functional responses to the stimuli can be viewed as some measure of infants' expectations, or knowledge, about the movement of objects or object parts.

Method

Participants

Forty-eight infants participated in the experiment, 16 with a mean age of 14 months 1 day (range 13 months 17 days to 14 months 13 days), 16 with a mean age of 17 months 24 days (range 17 months 16 days to 18 months 6 days) and 16 with a mean age of 22 months 0 days

(range 21 months 18 days to 22 months 14 days). Eight boys and eight girls were tested in each age group. The majority of infants were of white middle socioeconomic status. Seven further infants were tested but were not included in the study: four infants because of fussiness or crying, two infants for not engaging in the tasks (touching less than three objects) and one infant as a result of experimenter error. Infants' names were obtained through birth announcements published in the local newspaper. Parents were contacted by letter and later by telephone.

Stimuli

Four object-manipulation tasks were used in the study. Each task consisted of a contrast of cows and cars. The stimuli were three-dimensional realistic scale models and ranged in size from 4 cm to 6 cm in length and 2 cm to 4 cm in height. Every cow was a different breed and color (black, tan, black and white, and white), and every car was a different model and color (sedan, sports car, family, and estate car). The wheels of the cars were glued so that they could not move. One task, labeled hereafter the *control* task, was a straightforward contrast between four unmodified cow and four unmodified car exemplars. A second task, labeled the *matched-parts* task, was a contrast of cows with legs and wheels and cars with legs and wheels; i.e. stimuli were modified by adding legs to the cars and wheels to the cows. The legs were taken from scale model cows and the wheels were taken from scale model cars. A third task, the *no-parts* task, was a contrast of cows without legs and cars without wheels; i.e. stimuli were modified by removing these parts (see Table 1).

The fourth task, the *switched-parts confound*, was a contrast of cows and cars in which two exemplars of each category possessed legs but not wheels and two exemplars of each category possessed wheels but not legs. This task was designed to allow infants to classify on the basis of category membership (cows versus cars) or part relations (i.e. objects with wheels versus objects with legs). As in previous studies with similar designs (e.g. Rakison & Butterworth, 1998a, 1998b), each child participated in all four object-manipulation tasks. A Latin square, in which each task preceded and followed

each other task once, determined the order in which the tasks were presented. The rationale for this presentation order was to minimize, by averaging out the influence of one task on another task, the effect of using a within-subjects design. It is likely that the Latin square may have averaged out most task \times order interactions; however, it would not necessarily have eliminated all such effects (though see the Results section).

Procedure

Infants were tested individually in the laboratory. Each infant was seated on their parent's lap in front of a table of the appropriate height. For each object-manipulation task, the relevant eight objects were placed randomly on the table in front of the infant and the experimenter encouraged the infant to manipulate the objects with such statements as 'Here, these are for you to play with,' and 'Look at all these things.' The experimenter then left the room. Each task lasted 2 minutes, and the infant was allowed to manipulate the objects in any way. Parents were instructed that if an object was dropped from the table or put out of reach, they were to unobtrusively replace it within touching distance. Parents were also instructed to encourage the infant to play with the stimuli if no object manipulation occurred for 20 s or if the infant manipulated only one object for 20 s. There was no other feedback, labeling or pointing from the experimenter or from the parents. All four tasks were videotaped.

Coding and scoring

Coders scored every object contacted by an infant, either by hand or with another object, and the order in which the objects were touched. The idea behind this coding system is that, if sequential touches to objects within a category occur more often than would be expected by chance, this must be because infants apply some basis for categorization (Mandler, Fivush & Reznick, 1987). The rules used to code the infants' behavior were those defined by Poulin-Dubois, Graham and Sippola (1995; see also Rakison & Butterworth, 1998a, 1998b). In addition, coders noted the number of functional responses made by infants to the stimuli. The functional

Table 1 Object manipulation tasks and exemplars

Classification task	Stimuli	
Control	Four unmodified cows	Four unmodified cars
Matched-parts	Four cows with wheels and legs	Four cars with wheels and legs
No-parts	Four cows without legs	Four cars without wheels
Switched-parts confound task	Two cows with wheels and two cows with legs	Two cars with wheels and two cars with legs

behaviors coded were 'rolling' and 'jumping'. Rolling was defined as when an object in the appropriate orientation was moved horizontally in a smooth motion on the table surface. Jumping was defined as an action whereby an object in the appropriate orientation was moved horizontally and vertically in a 'hopping' motion. Infants could be coded as jumping or rolling both cars and cows.

Two judges coded independently 25% of the tasks (four infants from each age group). Inter-rater reliability was obtained by calculating Pearson correlation coefficients between the run lengths of the two judges, and by calculating a percentage agreement between the different objects scored as touched by the judges. Overall coder reliability for the run lengths made by the infants was $r = 0.92$, percentage reliability for objects touched by the infants was 91%, and coder reliability for the functional behaviors was $r = 0.92$. Once inter-rater reliability was established, each judge coded half of the tasks. The judges were not naïve to the rationale of the experiment; i.e. they were aware that the study was designed to test the effect of part manipulations on infants' categorization of cows and cars. However, because no specific predictions were made about any age groups' performance on any specific task, the lack of naïvety on the part of the judges to the rationale was not considered to have influenced overall coding.

Procedures for analyzing sequential touching were taken from those developed by Mandler *et al.* (1987) and used subsequently in a number of studies (e.g. Mandler & Bauer, 1988; Mandler, Bauer & McDonough, 1991; Rakison & Butterworth, 1998a, 1998b). The first analysis determined whether infants' sequential touching differed significantly from chance performance. The mean length of successive touches to the objects of each category was calculated for each infant on each task. This value was compared with the run length expected by chance if items from two sets of four objects were chosen at random (1.75). The second analysis, known as the Monte Carlo analysis, determined whether infants touched objects from one or from both of the available categories and whether touching runs of three or four objects from the same category occurred by chance. As in Rakison and Butterworth (1998a, 1998b), infants who touched systematically objects from one category were classified as *single* categorizers and infants who touched systematically objects from both categories were classified as *dual* categorizers. The categorizing run criterion was the same as that used in previous research (e.g. Mandler *et al.*, 1991). A Monte Carlo program matching that used by Mandler *et al.* (1987) was used to determine the probability of single and dual categorizing runs occur-

ring in 10 000 random draws. The program computed the number of categorizing runs of three or four items that would occur in a random draw repeated 10 000 times as a function of the number of touches (cf. Dixon, Woodard & Merry, 1998). Touches to the same object (i.e. repetitions) were allowed only if another object was manipulated between two touches to the same item and there were at least three or four unique items in the categorizing run. As with previous studies involving the Monte Carlo analysis, a cut-off point of $p < 0.10$ was used (e.g. Mandler & Bauer, 1988; Rakison & Butterworth, 1998a, 1998b).

Results

Run length analysis

One-tailed related t tests were used to compare the infants' mean run lengths to the run length expected by chance (1.75). Because there were two ways for infants to categorize on the switched-parts confound task (cows and cars or objects with wheels and objects with legs), the run lengths for each of the alternative groupings were also calculated. The mean run lengths for each task and their associated one-tailed t test values are shown in Table 2. To examine for effects of task order, a three-way mixed design analysis of variance (ANOVA) was performed, with Age (14, 18, 22 months) and Order (four levels) as

Table 2 Mean run lengths and associated t test values for five manipulation tasks

Classification task	14 months	18 months	22 months
<i>Control</i>			
Cows versus cars	2.63 (1.77)*	2.79 (3.53)***	3.27 (3.69)***
<i>Matched-parts</i>			
Cows with wheels and legs versus cars with wheels and legs	1.92 (0.63)	1.76 (0.96)	2.62 (3.95)***
<i>No-parts</i>			
Cows without legs versus cars without wheels	1.98 (0.84)	2.94 (2.20)**	3.34 (3.11)***
<i>Switched-parts confound</i>			
Cows (2 with wheels, 2 with legs) versus cars (2 with wheels, 2 with legs)	2.44 (2.12)*	2.81 (1.87)*	2.43 (3.07)***
Objects with wheels versus objects with legs	1.70 (0.50)	1.90 (0.52)	2.68 (1.08)

Notes: One-tailed t values are of comparison to run length (1.75), with 15 degrees of freedom.
* $p < 0.05$; ** $p < 0.025$; *** $p < 0.005$.

the between-subjects factors and Task (control, no-parts, matched-parts, switched-parts confound (cows and cars)) as a within-subjects factor. The ANOVA revealed no significant main or interaction effects, suggesting that the study's repeated measures design did not overly affect infants' categorizing behavior.

It can be seen from Table 2 that the mean run lengths of the three age groups on the control task were significantly greater than that expected by chance. In other words, infants at 14, 18 and 22 months behaved systematically to the cows and to the cars. In the matched-parts task, only 22-month-old infants formed mean run lengths significantly greater than chance, and in the no-parts task it was not until 18 months that infants generated mean run lengths significantly greater than chance. Thus, infants classified objects into groups more easily when there were fewer shared parts among the categories, i.e. when objects possessed neither legs nor wheels, than when there were more shared parts among the categories, i.e. when objects possessed legs and wheels. On the switched-parts confound task, the 14-, 18- and 22-month-olds generated run lengths that were significantly higher than chance to objects as cows and cars. Conversely, all three age groups made mean run lengths at chance level to stimuli in terms of objects with wheels and objects with legs.

The run length analysis indicates whether infants responded systematically or otherwise to the object sets, but it does not analyze infants' performances across tasks and age groups. Accordingly, the run lengths were investigated further using a two-way mixed design ANOVA with a multivariate approach for within-subject effects (Pillai's trace). The main analysis had three levels of Age (14, 18, 22 months) as a between-subjects factor and five types of Task (control, no-parts, matched-parts, switched-parts confound (cows and cars), switched-parts confound (objects with wheels and objects with legs)) as a within-subjects factor. The analysis revealed a significant main effect for Age, $F(2, 45) = 4.42$, $p < 0.025$. Pairwise comparisons ($p < 0.05$) among the means indicated that the 22-month-olds ($M = 2.87$) generated significantly higher run lengths than the 14-month-olds ($M = 2.13$). There were no other significant differences among the run lengths of the age groups. The main effect for Task was also significant, $F(4, 42) = 3.52$, $p < 0.025$. Related t tests revealed that significantly longer mean run lengths were made in the control task ($M = 2.90$) than in the matched-parts task ($M = 2.10$), $t(47) = 2.86$, $p < 0.01$, and the switched-parts confound task (legs and wheels) ($M = 2.10$), $t(47) = 2.35$, $p < 0.025$. Infants also made significantly longer run lengths in the no-parts task ($M = 2.75$) than in the matched-parts task ($M = 2.10$),

$t(47) = 2.47$, $p < 0.025$. There were no further significant effects. The Task \times Age interaction was not statistically significant.

Monte Carlo analysis

Table 3 shows the percentage of infants classified as single or dual categorizers and the mean lengths of any categorizing runs made. The data indicate that 14-month-olds tended to be single categorizers (single $M = 45\%$, dual $M = 10\%$), i.e. they made categorizing runs to only one of the two available categories. On the other hand, approximately half of the 18- and the 22-month-olds were classified as single categorizers and half were classified as dual categorizers. The exception to this behavior was the high number of 18-month-olds on the matched-parts task classified as single categorizers (56%) in comparison with the number classified as dual categorizers (12%). This difference is reflected in the run length analysis that showed that the 18-month-olds failed to categorize successfully on the matched-parts task.

Table 3 Percentage of categorizers and mean categorizing run lengths

Classification task	14 months		18 months		22 months	
	%	<i>M</i>	%	<i>M</i>	%	<i>M</i>
<i>Cows versus cars</i>						
Single	50	5.5	31	5.5	44	5.3
Dual	6	4.0	44	4.5	50	5.4
Total	56		75		94	
<i>Cows with legs and wheels versus cars with legs and wheels</i>						
Single	44	4.6	56	4.1	44	5.0
Dual	0	0	13	3.8	50	4.1
Total	44		69		94	
<i>Cows without legs versus cars without wheels</i>						
Single	56	4.0	31	7.1	38	7.2
Dual	13	4.9	44	3.6	56	5.3
Total	69		75		94	
<i>Cows (2 with legs, 2 with wheels) versus cars (2 with legs, 2 with wheels)</i>						
Single	38	4.2	50	5.4	44	3.6
Dual	31	5.1	31	4.2	50	4.8
Total	69		81		94	
<i>Objects with legs versus objects with wheels</i>						
Single	38	5.2	12	5.5	31	3.2
Dual	0	0	25	3.8	25	3.6
Total	38		37		56	

The mean run lengths of those infants classified as categorizers appear to be equally predictive of categorization. The 14-month-olds, for instance, made relatively low mean run lengths ($M=4.5$) on the two tasks in which they failed to categorize (according to the run length analysis). The mean run lengths of the 18-month-olds were comparable to this score on the task in which they failed to categorize (matched-parts: $M=4.0$) but higher on the task in which they categorized successfully (no-parts: $M=5.4$).

Analysis of functional behavior

Because tests of infants' functional responses have not been previously performed in sequential-touching studies, three analyses were devised to examine different aspects of this behavior – i.e. rolling and jumping – to the stimuli. As a first analysis, a χ^2 goodness of fit test was used to examine the number of infants across the three age groups who made at least one appropriate functional response to the stimuli on the control task. The rationale for this test was to determine (a) that infants made functional responses, and (b) which kinds of functional responses were made. The test was significant, $\chi^2(2)=25.17$, $p<0.001$, indicating that the functional responses made by the infants were not equally distributed across the stimuli. Examination of the data revealed that the number of infants ($N=26$) who 'rolled' cars was considerably higher than the number of infants who 'jumped' cows or who made both responses (three and seven respectively).

As a second analysis, a two-way mixed design ANOVA with a multivariate approach was used to compare the number of functional responses to unmodified objects with the number of functional responses to objects without parts. The test was performed to ascertain whether infants' functional responses were affected by the presence or absence of parts. Because the likelihood of a functional response is not orthogonal to the total number of touches made, for each infant the total number of appropriate functional responses (rolling objects with wheels (cars) or jumping objects with legs (cows)) was divided by the total number of touches made. Thus, the reported means are the proportion of touches in which a functional response was made by the infants. The main analysis had three levels of Age (14, 18, 22 months) as a between-subjects factor and two types of Task (control, no-parts) as a within-subjects factor. The analysis revealed a main effect for Age, $F(2, 45)=3.54$, $p<0.0001$, and a significant Task \times Age interaction, $F(2, 45)=5.10$, $p<0.01$. Related t tests revealed that the 14-month-olds (control $M=0.23$; no-parts $M=0.05$; $t(15)=2.28$,

$p<0.025$) and the 18-month-olds (control $M=0.33$; no-parts $M=0.20$; $t(15)=2.57$, $p<0.025$) performed significantly more functional responses on the control task than on the no-parts task. No reliable differences were found in the number of functional responses made by the 22-month-olds on the two tasks. It should also be noted that the 18-month-olds ($M=0.20$) and 22-month-olds ($M=0.22$) made an equivalent number of functional responses to objects without parts.

As a third analysis, a two-way mixed design ANOVA was used to examine infants' pattern of functional responses in the switched-parts confound. On this task, infants could respond functionally to object parts, e.g. jumping a car with legs, or to category, e.g. rolling a car with legs. Because of the two different potential responses, the total number of part-appropriate responses and the total number of category-appropriate responses were coded for each infant on the switched-parts confound task. It was not necessary to calculate a ratio score, as in the previous analysis, because the scores were coded from the same sequential touching runs. The main analysis had three levels of Age (14, 18, 22 months) as a between-subjects factor and two types of Response (parts, category) as a within-subjects factor. The analysis revealed a main effect for Response, $F(1, 45)=18.89$, $p<0.0001$. Examination of the data revealed that infants made significantly more responses to objects on the basis of parts ($M=0.98$) than on the basis of category membership ($M=0.27$). There were no other statistically significant effects.

Analyses of object salience

Following the guidelines developed by Mandler and her associates (Mandler *et al.*, 1987), the most salient category was defined as (a) the object set most often categorized by single categorizers, or (b) the object set touched first by dual categorizers. In a first analysis of salience, it was found that, across all three age groups, more infants made categorizing runs to cows than to cars on the control task, $\chi^2(1)=4.90$, $p<0.01$. There were no significant preferences for either category in any of the tasks. In a second test of salience, it was found that 18-month-olds made significantly more touches to the cars than to the cows on the control task (car $M=7.7$, cow $M=4.8$, $t(16)=2.86$, $p<0.025$) and on the switched-parts confound (car $M=6.8$, cow $M=4.3$, $t(16)=2.38$, $p<0.05$). In addition, 22-month-olds made significantly more touches to cars ($M=8.4$) than to cows ($M=5.5$) on the control task, $t(16)=2.24$, $p<0.05$. There were no other significant effects on any task or at any age level. A third test of salience revealed that the number of touches to the different exemplars

was not uniformly distributed, $F(3, 141) = 2.97$, $p < 0.05$. Pairwise comparisons ($p < 0.05$) on the number of touches showed that significantly fewer touches were made to the family car ($M = 1.43$) than the sedan car ($M = 1.79$), the estate car ($M = 1.83$) and the sports car ($M = 1.91$). There were no other significant effects among the car or the cow stimuli.

Discussion

The results of this experiment suggest that 14- to 22-month-old infants' categorization at the basic-like level varies as a function of the presence or absence of critical functional parts. The results also suggest, however, that there is a developmental trend whereby infants attend to other, as yet unknown, properties as the basis for categorization in the absence of functional part distinctions. Consistent with Mandler *et al.* (1987), infants in all three age groups categorized unmodified objects as cows (legs) and cars (wheels). However, 14-month-old infants failed to categorize when objects had parts removed (no-parts task) and when objects had the same parts (matched-parts task). In other words, 14-month-olds found no basis for categorization in the absence of functional part differences. This suggests that object parts such as legs and wheels may to some extent define category membership for infants at this age.

By 18 months, infants categorized cars from cows in the absence of parts, but they did not categorize cars from cows when objects shared parts. Thus, when object sets do not possess different distinctive parts such as legs and wheels, 18-month-olds attend to other properties as the basis for categorization.² Nevertheless, they continue to treat objects with the same parts – in this case, legs and wheels – as equivalent. This suggests that shared object parts are sufficient to interfere with 18-month-old infants' ability to attend to other bases for categorization. By 22 months, infants categorize not only objects without parts, i.e. cars without wheels from cows without legs, but also objects that share the same parts, i.e. cars with legs and wheels from cows with legs and wheels. In conjunction, these data suggest that object parts such as legs and wheels may define category membership at 14 months, and may act as characteristic features by 18 or 22 months.

This series of results is somewhat compatible with those found by Rakison and Butterworth (1998a). That

is, 14- to 22-month-olds' categorization of object sets from two superordinate domains – which is to some extent what a contrast of cows and cars comprises (Mandler & Bauer, 1988) – is affected by object parts. The present data extend the findings of earlier work, however, in that they reveal the role of within-category similarity in infants' ability to find a basis for categorization. In other words, infants categorize more readily when objects within a category share many attributes – as they do in the case of basic-level classes – than when objects within a category share relatively few attributes (i.e. superordinate domains).

At first sight, infants' performance on the switched-parts confound appears to contradict the findings of Rakison and Butterworth (1998a). That is, in the present study infants categorized objects as cars and cows rather than as objects with wheels and objects with legs. This can be taken as further evidence, however, that the level of within-category similarity affects infants' attention to object parts in categorization. More specifically, it suggests that object parts play a greater role in categorization when within-category similarity is low than when it is high. It remains to be seen, however, to what extent functional object parts play a role in categorization when between-category similarity is high, as in the case of two basic-level classes from a single superordinate.

The functional analysis suggests that infants may develop knowledge about objects' type of movement by attending to parts. At 14 and 18 months, for example, infants are more likely to emulate real-world objects' mode of locomotion with category exemplars that possess parts than with those without parts, and they are more likely to perform such responses on the basis of object parts (e.g. things with wheels 'roll') rather than category membership (e.g. cars 'roll'). Overall, the results of the analyses suggest that at 14 months infants may associate certain functional parts with certain kinds of movement. Possibly by 18 months, but most likely by 22 months, infants associate certain objects – independently of parts – with certain kinds of movement. Hence, as proposed by Rakison (in press; Rakison & Butterworth, 1998b), infants may acquire knowledge – initially in the form of expectations (Haith, Wentworth & Canfield, 1993) – about properties that are commonly thought of as conceptual (e.g. animate versus inanimate motion) through the correlation of parts and dynamic object properties given in the perceptual input.³ For instance, in the case of different types of locomotion,

²There are a number of candidates other than object parts that could act as the basis for perceptual categorization; e.g. facial features (Quinn & Eimas, 1996b), overall shape (Landau, Smith & Jones, 1992) or form–function correlations (Madole *et al.*, 1993).

³See Roberts (1998) for a similar functional correlational account of early word–object learning.

infants may notice the relationship between kind of movement – smooth versus gaited motion, for example – and the object parts that concurrently are in motion.⁴ Note, however, that these conclusions are based on infants' behavior toward scale model toys, and it remains to be seen whether infants responded to the function of the object themselves, i.e. actions exhibited by cars and cows in the real world, or to function from their own egocentric viewpoint, i.e. what an infant can do with a toy cow or car.

In conclusion, the experiment presented here provides evidence that, just as with superordinate domains, object parts play a role in infants' categorization of two basic-level classes from different superordinates. The data indicate that parts such as legs and wheels may act more like defining features than characteristic features at 14 months, and they may act more like characteristic than defining features for older infants. The data also suggest that infants in the second year may develop knowledge – possibly as a result of their attention to the correlation between parts and motion – about the different kinds of locomotion of certain land-based objects.

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⁴ It is true that parts other than the ones necessary for movement may also be in motion during locomotion; e.g. the tail of a cow or the arms of a human. However, the movement of these parts would not be highly correlated with the locomotion of the object to which they are attached; i.e. tails and arms move at times other than during locomotion.

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