Domain-General Categorization in 14- to 24-month-old Infants

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ABSTRACT

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The current experiments were concerned with the development of object categorization skills during the second year of life. Experiment 1 examined whether 18- and 24-month-old infants were capable of performing categorization at the domain-general level (i.e., very broad categories of animate and inanimate objects) using a sequential touching procedure. The 18-month-old infants categorized the objects at an above-chance level, but the 24-month-olds did not. However, the 24-month-olds demonstrated a higher percentage of cross-category touching (i.e., putting people on vehicles and furniture), which would make it difficult to demonstrate categorization using this particular procedure. In Experiment 2, 14-, 18-, and 24-month-old infants participated in a sequential touching task in which the part features of animate and inanimate objects were modified, allowing for a comparison of leg/wheel categorization (i.e., perceptually-based) and animate/inanimate categorization (i.e., conceptually based). None of the age groups performed either leg/wheel or animate/inanimate categorization at a level significantly greater than chance. Taken together, these results demonstrate that infants are capable of categorizing at a broad level during the middle of the second year of life, and that they do not use perceptual features as the sole basis for this categorization.

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Domain-General Categorization in 14- to 24-month-old Infants

Categorization involves the ability to classify distinctive objects into the same group according to some principle or rule (Oakes & Rakison, 2003). For example, we are able to categorize German Shepherds and Chihuahuas into the same category of ‘dogs,’ even though they look quite different from one another. The ability to categorize is important for a number of reasons. First, it places fewer demands on the limited human memory system (Oakes & Rakison, 2003). Instead of having to recall the features of every individual category member, we can remember the general properties of the entire group. Second, categorization allows us to make inferences about new category members based on what we already know about the characteristics of that category (Quinn, 2002). For example, if you learn that dogs bark and then you encounter a novel dog, you can infer that this dog will also bark even though you may never hear it do so.

Categorization skills develop, and are especially important, in the first few years of life (Oakes & Rakison, 2003). Without this ability, infants and young children would have to process and respond to each entity as entirely novel, an impossible feat given the infinite number of variations in the world around us. Also, studying categorization provides insight into other skills that are developing in early childhood, such as language and memory (Mareschal, Powell, & Volein, 2003). Examining how and when categorization skills develop has been an active field of study for investigators over the past several decades (Quinn, 2005).

Categorization abilities in infancy can be examined in a number of different ways. For very young infants (e.g., 3- to 4-month-olds), the familiarization/novelty-preference procedure is often used (Oakes & Rakison, 2003). Similar to any habituation paradigm, infants are first presented with numerous instances from one category (e.g., dogs) until they become habituated (i.e., looking time decreases significantly). In the test phase, the infants are presented with a novel instance from the familiar category (i.e., new dog) and a novel instance from an unfamiliar category (e.g., cat). If the infants look longer at the cat, it is assumed that the novel dog exemplar has been categorized with the dogs presented during familiarization.

When infants reach approximately 7 months of age, it is possible to switch from an image-based paradigm to a more hands-on, object-based paradigm (Oakes & Rakison, 2003). The object examination procedure is similar to the familiarization/novelty-preference procedure, except that objects are used instead of pictures. Habituation occurs when infants significantly decrease the time they spend visually and physically examining the objects. Categorization is also demonstrated in a comparable way to the familiarization/novelty-preference procedure (i.e., if the infants do not show an increase in examination time to a novel instance from the familiarized category).

Another paradigm used to study infant categorization with slightly older infants is the sequential touching procedure (Quinn, 2002). This technique involves presenting infants with an array of objects consisting of exemplars from two categories (e.g., animals and vehicles). The touching behaviour of the infants is examined in order to determine whether there is any systematic order to their touches. The infants are considered to have categorized the objects if they touch multiple objects from the same category at a level greater than chance (Mandler, Fivush, & Reznick, 1987).

A final test procedure, generalized imitation, examines the extent to which infants will generalize a modeled action (Mandler & McDonough, 1996). During the familiarization phase, the experimenter demonstrates an action with a test object (e.g., a dog drinking from a cup). In the test phase, infants are given a choice between a same-category exemplar (e.g., a horse) and an other-category exemplar (e.g., a car) to model the action. Categorization is inferred if the infants choose to generalize the action to the same-category exemplar at a level greater than chance. These test paradigms have been used to address a number of issues in the categorization literature, including the development of categories at variable levels of inclusiveness and the role of perceptual and conceptual processes in categorization.

Category Inclusiveness

Categories vary in their degree of inclusiveness. The category of 'dogs' is considered a basic-level category, which can be divided into less inclusive categories. These lower-level categories are known as subordinate-level categories, and in this instance would be made up of different types of dogs (e.g., terrier, dalmation, etc.). The basic-level 'dog' category can also be subsumed as part of a more inclusive category of 'animals,' which is termed a superordinate-level category. Finally, the 'dog' category is also part of an even broader category of 'animates.' This category would extend to include both humans and animals. At the highest level of inclusivity, animate and inanimate categories are termed domain-general categories. Categorization skills can be flexible such that the same entity (e.g., dog) can be categorized in different ways depending on the demands of the situation (Ellis & Oakes, 2006). For example, the dog may be regarded at a different level of category inclusiveness depending on whether it is surrounded by only other dogs or by a variety of other animals.

Researchers have debated over the level of categorization that is acquired earliest in infancy. Some researchers argue that the basic-level categories develop first because they have highly similar within-category features and highly dissimilar between-category features (e.g., Mervis & Rosch, 1981). These bottom-up theorists would argue that more inclusive categories are formed out of already acquired, lower-level categories (Mandler & Bauer, 1988). Others propose that children first acquire broader categories and learn to distinguish among the more specific categories as they get older (e.g., Mandler, 2003). This top-down hypothesis has received a great deal of research support.

Mandler and Bauer (1988) presented infants with superordinate- and basic-level categories in a sequential touching task. They found evidence of basic-level categorization at 16 and 20 months of age, but only when the basic-level categories came from differing superordinate categories. That is, the infants could categorize dogs vs. cars (different superordinate-level categories), but not cars vs. trucks (same superordinate-level category). The authors took this to suggest that sensitivity to superordinate-level categories develops before sensitivity to basic-level categories.

Similar results were also found by Mandler, Bauer, and McDonough (1991) with 18-month-old infants. Using a sequential touching task, the authors found that infants were able to differentiate superordinate-level categories (animals vs. vehicles) but not basic-level categories of low contrast (e.g., dogs vs. horses) or moderate contrast (e.g., cars vs. motorcycles). The only evidence of basic-level categorization was found using a high degree of contrast (e.g., dogs vs. fish). By 30 months of age the infants were capable of discriminating low and moderate degrees of contrast.

Another set of studies provided further evidence for the primacy of superordinate-level categories with even younger infants using an object examination task (Mandler & McDonough, 1993; 1998a). In the first study, both 9- and 11-month-old infants were found to categorize superordinate-level categories of animals and vehicles (Mandler & McDonough, 1993). They also discovered superordinate-level categorization with a group of 7-month-old infants, but at a slightly lower level of performance than the older children. In the second study the authors found further evidence of superordinate-level categorization in 7- to 11-month-old infants (Mandler & McDonough, 1998a). In line with other research (e.g., Mandler, et al., 1991), they also found that basic-level categorization developed after superordinate-level categorization, and tended to begin with basic-level categories with a high degree of contrast (e.g., dogs vs. birds).

This area of research was extended by Poulin-Dubois, Graham, and Sippola (1995) to include superordinate-, basic-, and subordinate-level categories. Using a sequential touching task, the authors examined the categorization skills of the same set of infants using a longitudinal design. They found evidence of superordinate-level categorization (e.g., animals vs. furniture) by 15 months of age, followed by basic-level categorization (e.g., cars vs. trucks) developing around 20 months of age. The infants did not display evidence of subordinate-level categorization (e.g., collies vs. German shepherds) even by 25 months of age.

A second longitudinal study also found evidence of superordinate-level categorization prior to basic-level categorization (Pauen, 2002). Using an object examination procedure, Pauen (2002) discovered that 8-month-old infants were capable of categorizing objects at the superordinate level, but not at the basic level. By 12 months of age, the same infants were able to demonstrate basic-level categorization.

Taken together these results support the hypothesis of a superordinate-to-basic-level progression of categorization in early infancy. One study demonstrated that subordinate-level distinctions may appear after basic-level distinctions (Poulin-Dubois et al., 1995), adding further support to the top-down hypothesis. There is also evidence that basic-level categories that do develop early tend to be high contrast comparisons (e.g., dogs vs. fish; Mandler, et al., 1991; Mandler & McDonough, 1998a). However, only one study has attempted to examine the development of categories even broader than the superordinate level.

Poulin-Dubois, Frenkiel-Fishman, Nayer, and Johnson (2006) used a generalized imitation procedure to examine whether infants would extend motion and sensory properties between people and animal exemplars (i.e., within the animate domain-general category). Specifically, the researchers demonstrated actions using people exemplars, and infants were given the choice to imitate the action with either an animal or a vehicle exemplar. Both the 16- and 20-month-old infants tested were more likely to extend the actions to the animal exemplars than to the vehicle exemplars, providing some evidence for the presence of a broad domain-general category of animate objects.

As stated above, lower-level categories can be subsumed as part of higher-level, more inclusive categories. That is, superordinate-level categories are made up of a number of basic-level categories, and domain-general categories are made up of superordinate-level categories. While many studies have examined superordinate-level categories that combine to form domain-general categories of animates and inanimates, only one has attempted to investigate how and when infants begin to categorize at this broad, domain-general level (e.g., Poulin-Dubois et al., 2006). If the top-down hypothesis of category development is correct (i.e., broader categories appear first), it would be important to explore whether domain-general categorization can be detected as early as, or even earlier than, superordinate-level categorization.

Perceptual and Conceptual Processes in Categorization

Alongside category inclusiveness, a second area of debate in the categorization literature concerns the information that infants use to make category judgments (Poulin-Dubois et al., 2006). Some researchers argue that only perceptual features, such as visible object parts (e.g., legs, wheels), are used by infants to form categories below the age of 22 months (e.g., Rakison, 2003). Others maintain that infants use more conceptual representations about 'knowing' what something is to distinguish between categories (e.g., Mandler, 2003). Specifically, these researchers would argue that infants make conceptual categorical distinctions based on functional, causal, or structural properties (Poulin-Dubois et al., 2006).

In support of the perceptual approach, Quinn, Eimas, and Tarr (2001) demonstrated the importance of shape information in early categorization. Using a familiarization/novelty-preference procedure, they found that 3- to 4-month-old infants were able to discriminate dog and cat shapes. The infants were only presented with silhouettes, and they were able to discriminate between members of different categories when they were given silhouettes solely of the head region. This supports the notion that perceptual features, such as object shape, are an important part of early categorization.

A study by Oakes, Coppage, and Dingel (1997) illustrated the importance of perceptual variability when 10- and 13-month-old infants are forming categories. The infants were familiarized with category exemplars that had either highly similar features or highly variable features. Overall, the infants were more likely to display a novelty-preference when they had been familiarized with exemplars that were perceptually similar. That is, the infants more easily formed categories when the category members looked alike. There was a trend for the older infants to form categories even with exemplars with highly variable features. The results of this study highlight the role of perceptual factors when forming categories.

Rakison and Butterworth (1998) were specifically interested in whether perceptual features, such as object parts, would influence categorization. Using a sequential touching procedure, they found that 14-, 18-, and 22-month-old infants readily made the distinction between objects with legs and objects with wheels. However, the two younger age groups had difficulty distinguishing within the legged objects. That is, they were capable of distinguishing categories with different part features (e.g., cars with wheels vs. animals with legs), but were unable to distinguish categories with similar part features (e.g., animals with legs vs. furniture with legs). The researchers concluded that the infants were categorizing primarily based on part features.

In a second experiment, Rakison and Butterworth (1998) manipulated the part features of a number of animal and vehicle exemplars. Again using a sequential touching paradigm, the authors tested 14-, 18-, and 22-month-old infants. In a control task with normal objects (i.e., animals with legs, vehicles with wheels), all of the age groups were able to successfully distinguish the categories. In the experimental conditions, the objects had either matched-parts (i.e., animals with wheels and legs, vehicles with wheels and legs), no matched-parts (i.e., animals with no wheels or legs, vehicles with no wheels or legs), or switched-parts (i.e., animals with wheels, vehicles with legs).

In the matched-parts and no matched-parts conditions, none of the age groups were able to differentiate between the categories (Rakison & Butterworth, 1998). That is, when the exemplars possessed the same part features (i.e., legs and wheels) or shared no salient part features (i.e., no legs or wheels), the infants did not distinguish between the animal and vehicle category members. In the switched-parts condition, both the 14- and 18-month-olds categorized the exemplars according to part features (i.e., legs or wheels) and not according to their ontological categories (i.e., animals or vehicles). By 22 months of age, the infants were not categorizing the objects based on part features. The authors argue that these results strongly support the prominence of perceptual information in categorization, even among infants up to 18 months of age.

Opposing the perceptual interpretation of early categorization are the conceptual theorists. They would argue that excessive reliance on perceptual features is a disadvantage, and can actually be misleading (Madole & Oakes, 1999). For example, when forming a category of animals, perceptual input would indicate that most animals have legs. However, would this lead to the conclusion that legged tables belong in the animal category, but legless fish do not (Mandler, 2003)? A greater reliance on conceptual features would be advantageous, because the nonobvious properties of category members are more stable (Madole & Oakes, 1999). Fish would be grouped in the category of animals if one of the inclusion criteria was self-initiated motion, a nonobvious but stable property of animals, and this would also serve to exclude tables.

Mandler (e.g., 1992; 1997; 1999; 2003) has been one of the most prominent supporters of the conceptual approach to early categorization. Mandler argues that there are two different processes for obtaining perceptual and conceptual information, and that they are developing simultaneously almost from birth (Mandler, 2000). Mandler emphasizes the importance of concepts because they are what allow infants to notice the important perceptual associations (Mandler, 2003). This idea is in sharp contrast to the perceptual theorists who argue that perceptual associations are what eventually lead to concepts (Rakison, 2003).

Mandler has proposed a process of perceptual analysis through which perceptual information 'becomes' conceptual (Mandler, 1992). Theoretically, the infant actively recodes perceptual input into a meaning that is accessible through an image schema. The earliest image schemas are believed to be related to motion, something that infants are especially attracted to. According to Mandler, infants first code motion cues, such as animacy, which are later associated with perceptual cues, such as what animate things look like. Importantly, she believes that the infants are not simply perceiving motion cues, but they are actively interpreting and recoding them (Mandler, 2000).

Conceptual theorists often attempt to demonstrate that categories can be formed among exemplars despite a lack of perceptual similarity. If categories can be formed among dissimilar looking exemplars, there must be some basis for the categorization that is not readily observable. That is, the infants must be using nonobvious or conceptual information as the basis for grouping the exemplars.

Mandler and McDonough (1996) used the generalized imitation technique to determine the extent to which 14-month-old infants would generalize a demonstrated action. Experimenters demonstrated either animal properties (e.g., drinking from a cup) or vehicle properties (e.g., giving a ride) with the appropriate exemplars. When the infants were given the opportunity to imitate the actions, they were significantly more likely to use a same-category exemplar. For example, if the infants viewed a dog drinking from a cup and were given a rabbit or a truck to imitate with, they were more likely to use the rabbit to demonstrate the action. These results provide some support for the conceptual theory of categorization because the infants were overriding a certain level of perceptual dissimilarity (i.e., rabbits do not look exactly like dogs).

In their second experiment, Mandler and McDonough (1996) found the same pattern of results even when atypical exemplars such as anteaters were used, which would have increased the perceptual variability of the category members. In a third experiment, the experimenters modeled the original action on both appropriate and inappropriate exemplars. For example, drinking from a cup was demonstrated with both a dog and a car. However, the infants chose to generalize the action only to the appropriate category exemplars. Even after seeing an animal and a vehicle drinking from a cup, the 14-month-olds would only demonstrate the action with the animal exemplars, thus displaying some conceptual knowledge of the kinds of things that drink from cups. However, this technique has been criticized because the infants could be using perceptual matching to determine which exemplar is more appropriate for modeling (Rakison, 2003). That is, the matching of part features may actually be the basis for generalization (i.e., infants choose the object with the most perceptual features in common with the object that the experimenter used to demonstrate).

A second study by Mandler and McDonough (1998b) was conducted to refute this claim. A distinction was made between domain-neutral actions and domain-specific actions. Domain-neutral actions were considered to be equally appropriate for both animals and vehicles (e.g., going into a building), but domain-specific actions were appropriate for only one category (e.g., drinking from a cup is only appropriate for animals). The 14-month-old infants in this study generalized the domain-specific actions to the appropriate categories, as was found in Mandler and McDonough (1996). However, they were equally likely to generalize the domain-neutral actions to both categories (Mandler & McDonough, 1998b). For example, even after seeing a dog go into a building, the infants were equally likely to later demonstrate the action with either a cat or a car. If the infants had simply been attempting to perceptually match their object to the exemplar used by the experimenter, this pattern of results would not have been found. The authors also argued that this provides evidence that the infants possess some conceptual knowledge of what animals and vehicles can do (i.e., both vehicles and animals can go into buildings, but only animals drink from cups).

This research has demonstrated that very young infants are able to categorize objects despite perceptual dissimilarities, therefore seemingly based on more conceptual reasoning (Mandler & McDonough, 1996; 1998b). However, the Rakison and Butterworth (1998) study found almost a complete lack of conceptual categorization, even up to 22 months of age. In the switched-parts condition, the 14- and 18-month-olds tended to group animals with legs with vehicles with legs, or animals with wheels with vehicles with wheels, with no obvious conceptual basis for grouping them in such a way. Given these striking findings, it would be important to carry out a second study with switched-part objects to determine whether the results can be replicated. Also, it would be pertinent to examine the relative role of perceptual and conceptual factors within the different levels of categorization. Perceptual features may be most important for lower-level category distinctions; different types of dogs have many perceptual features in common. However, conceptual factors may be more important for higher-level category distinctions; vehicles and furniture, as part of the inanimate domain-general category, have very few perceptual features in common.

The goal of the current studies was to examine the development of domain-general categories in infancy. Experiment 1 attempted to examine the age at which infants are capable of domain-general categorization. Experiment 2 was designed to explore the potential role of perceptual and conceptual processes in categorizing at the domain-general level. Taken together, these studies address both of the outlined areas of debate in the categorization literature.

Experiment 1

Surprisingly, to date, only one study has examined whether infants can form categories at a higher level of inclusiveness than animals, people, vehicles, and furniture (Poulin-Dubois et al., 2006). If infants have a broad animate category, they should group people and animals together in one category. Similarly, if they possess a broad inanimate category, they should group vehicles and furniture together. Research has shown that superordinate-level categories seem to develop prior to basic-level categories (e.g., Mandler & Bauer, 1988; Mandler et al., 1991, Mandler & McDonough, 1993; 1998a). Assuming that categorization progresses in a top-down fashion, infants should be capable of domain-general categorization at the same age as, or earlier than, superordinate-level categorization. Experiment 1 assessed whether 18- and 24-month-old infants were capable of categorizing at the domain-general level.

Method

Participants.

Thirty-one 18-month-old infants (*M* age = 18.61 months, *SD* = 0.65, *range* = 17.41 to 19.67 months) and 37 24-month-old infants (*M* age = 24.21, *SD* = 0.85, *range* = 22.72 to 25.87 months) participated in Experiment 1. Two additional 18-month-olds participated but were excluded due to parental interference (*N* = 1) and fussiness (*N* = 1). Two additional 24-month-olds participated but were excluded because of fussiness (*N* = 1) and experimenter error (*N* = 1). The 18-month-old sample consisted of 19 males and 12 females, and the 24-month-old sample consisted of 18 males and 19 females.

Families were recruited through birth lists provided by a governmental health office (see Appendix A for recruitment letter). All infants were born full-term and had no visual or auditory difficulties as reported by parents. Children were from families who spoke either English or French at home, although many also had exposure to second (*N* = 22) and third languages (*N* = 6). They were tested in their dominant language and, given the non-linguistic nature of the task, language exposure was not expected to impact performance.

Materials.

Small, plastic three-dimensional objects were used. The animate domain exemplars consisted of eight people (African American man, African American woman, African American boy, African American girl, Caucasian man, Caucasian woman, Caucasian boy, Caucasian girl) and four animals (dog, cow, dolphin, eagle). The inanimate domain exemplars consisted of four vehicles (truck, car, boat, airplane) and four pieces of furniture (chair, desk, bed, bathtub; see Figure 1 for a photograph of all exemplars). The objects ranged in size from 1.90 x 4.20 x 6.50 cm to 13.10 x 3.50 x 7.80 cm, and were presented to the infant on a 44.80 x 34.60 cm tray. A brown cloth was used to cover the objects, and a Thermor stopwatch was used to monitor trial length. The testing session was recorded through a Sony video camera on a Hi-8 video cassette tape.

Procedure and Design.

When families arrived for their session appointment they were greeted by two experimenters and were escorted to a reception room where one parent was asked to complete an informed consent form and a demographics questionnaire (see Appendices B and C). During this time, one experimenter explained the testing procedure to the parent while the other experimenter played with the infant. Parents were informed of the nature of the task, and were asked not to interfere with the procedure or to label any of the objects. After these instructions, the parent and child were led into an adjacent testing room. The infant was seated either on his or her parent's lap or in a clip-on chair attached to the table, with the parent sitting directly behind. The experimenter was seated directly across the table from the infant.

Prior to the testing session, the objects were selected from one of six testing arrays (see Appendix D). Each array consisted of eight objects, four from the animate domain and four from the inanimate domain. These objects were arranged on the tray in a random fashion, and then covered with the brown cloth. The tray was kept on a table next to the experimenter, and was out of the infant's view. After the infant was seated, the tray was placed on the table in front of the experimenter, but out of the infant's reach. The experimenter removed the cloth and made a sweeping hand motion over the tray while saying "Look at all of these toys. These are all for you." They tray was then pushed towards the child, and he or she was given 2 min to freely manipulate the objects. No further prompting was given unless the child did not touch any new object (or touched no objects) for more than 30 s, in which case the sweeping hand motion and original statement were repeated. If an object fell off the table, the parent or experimenter picked it up and inconspicuously placed it back on the tray.

Coding.

The sequence of touches to the objects was coded. The interpretation of the sequential touching procedure is that if infants are manipulating objects from a given category in a sequence greater than that expected by chance, they must be doing so based on object relatedness or category membership (Mandler et al., 1987). In order to be considered a touch, the infant needed to make physical contact using a finger, hand or another object, and the contact needed to be accompanied by eye gaze. Accidental touches or brushes against objects were not considered intentional and were not counted.

In order to determine whether categorization had occurred, a mean run length (MRL) score was calculated for each infant. MRL is determined by dividing the total number of touches by the total number of runs. A run occurs when a sequence of touches are from within the same category (e.g., a touch sequence of car-boat-bathtub would be considered an inanimate run). A run of only one touch would indicate that the infant touched one object from one of the domain-general categories, followed by a touch to the other domain-general category.

If an interval of more than 10 s occurred between the end of one touch and the beginning of the next touch, a break in the sequence was recorded (Poulin-Dubois et al., 1995). The 10 s break criterion is used in sequential touching coding because if a significant length of time has passed between two touches, the infant may not make any conceptual link between them. That is, a touch to the desk exemplar followed 25 s later by a touch to the truck exemplar may not be evidence of inanimate categorization. However, a short time interval between touches can be interpreted as more likely that the child has associated the two objects. If a break was recorded, it would interrupt any ongoing run.

Whenever the same object was touched twice or more in succession, only 1 touch was recorded (Starkey, 1981). If 10 s elapsed between touches to the same object, both touches were recorded but with a break between them. When two objects were deemed to be touched simultaneously, they were recorded as one touch (Poulin-Dubois et al., 1995). If these objects were from the same domain-general category (e.g., car and desk), they were considered part of any ongoing run. If these objects were from different domain-general categories (e.g., cow and bathtub), the simultaneous touch would break any ongoing run. Whenever a dropped object was replaced by the parent or experimenter and was immediately touched by the infant, this touch was not counted and did not break any ongoing run. A blank coding sheet for the animate/inanimate trials can be found in Appendix E, along with an example of a completed coding sheet, including MRL calculation, in Appendix F.

One MRL was calculated for overall animate/inanimate categorization. Once calculated, the infant MRLs were compared to a MRL expected by chance if the objects were touched randomly. This chance value (1.75) is calculated based on the number of categories and the number of exemplars within each category (Mandler et al., 1987). The formula derives from the fact that once an item has been touched, there are $n-1$ objects left from that category that could be touched, and n items from the other category:

$$\text{MRL} = \frac{n}{n-1} \times \frac{\dfrac{n-1}{2n-1}}{1-\left(\dfrac{n-1}{2n-1}\right)^2}$$

A second coder, an undergraduate-level student naïve to the experimental hypotheses, independently coded 25% of the infants (at least one infant from each testing array). Interrater reliability was obtained by calculating a percentage of agreement for the order in which the items were touched. Average agreement was 88.29% for the 18-month-olds and 94.78% for the 24-month-olds.

Results and Discussion

One-sample t-tests were used to compare infant MRLs to the MRL expected by chance (1.75). Preliminary analyses revealed no significant gender differences in MRL for either age group, and therefore all further analyses were collapsed across gender.

The average MRL for each age group is presented in Table 1. The 18-month-old infants had an average MRL ($M = 2.02$, $SD = 0.73$) that was significantly greater than chance, $t(30) = 2.07$, $p = .047$, whereas the average MRL for the 24-month-olds ($M = 1.72$, $SD = 0.42$) was not above chance, $t(36) = -.43$, $p = .67$. An independent-samples t-test revealed that the average MRL of the 18-month-olds was significantly higher than the average MRL of the 24-month-olds, $t(66) = 2.13$, $p = .04$. Fifty-eight percent of the 18-month-old infants ($N = 18$) had a MRL greater than the chance MRL value of 1.75, whereas only 32% of the 24-month-olds ($N = 12$) had a MRL above the chance value. An independent-samples t-test demonstrated that the 18-month-olds had a significantly higher percentage of MRLs above chance than the 24-month-olds, $t(66) = 2.16$, $p = .03$.

It would be expected that once infants are capable of categorizing at a certain level of abstraction (e.g., superordinate-level categorization), this ability should be maintained as the infant matures (i.e., the ability to categorize at the superordinate-level should not be 'lost'). The 18-month-olds in this study were successfully categorizing at the domain-general level but the 24-month-olds were not, which shows an unexpected age-related decline. However, it is first important to determine that this is not due to some systematic difference in the touching behaviours of the different age groups. The average number of touches for the 18- and 24-month-old infants were compared using an independent-samples t-test. No significant age difference was found in average number of touches (18-month-olds: $M = 15.81$, $SD = 5.67$, 24-month-olds: $M = 16.32$, $SD = 4.81$), $t(66) = -.41$, $p = .69$. These results indicate that the 24-month-olds did not simply touch fewer objects than the 18-month-olds.

As specified in the coding criteria, when infants touched one object with another object, this was counted as a touch. These touches may be of particular interest in this study given that people replicas were included as exemplars from the animate domain. One other sequential touching study included people exemplars, but they were only ever presented alongside animal exemplars (Oakes, Plumert, Lansink, & Merryman, 1996). In the current study the people exemplars were also presented with inanimate exemplars such as vehicles and furniture, which may have promoted more object-to-object touching with the people exemplars (e.g., touching a people exemplar on a bed).

An independent-samples t-test was conducted to compare the percentage of object-to-object touches with people exemplars, out of the total number of touches, across the two age groups. The 24-month-olds had a significantly greater percentage of object-to-object touches involving people exemplars ($M = 11.42$, $SD = 11.25$) than the 18-month-olds ($M = 5.77$, $SD = 8.65$), $t(66) = -2.29$, $p = .03$. Importantly, the object-to-object touches involving the people exemplars were far more likely to involve inanimate exemplars than animate exemplars. That is, the infants in both age groups were touching the people exemplars to the vehicles and furniture (inanimates), rather than to the animals or other people exemplars (animates). A breakdown of the percentage of object-to-object touches using people exemplars for each age group can be found in Table 2. Using independent-samples t-tests, no significant age differences were found when comparing the types of exemplars involved in object-to-object touches with people exemplars.

Given that the vast majority of object-to-object touches with people exemplars were to inanimate domain exemplars (i.e., across domain-general categories), this would suffice to lower the MRL of the 24-month-olds. For example, if an infant picked up a people exemplar and then touched it to a furniture exemplar, the animate run which began with the people object would be broken by the touch to the inanimate object. Therefore, a high frequency of animate-inanimate sequential touches, specifically people-inanimate sequential touches in this instance, would increase the number of breaks in the infant's sequence of touches, thereby lowering his or her MRL. In the 24-month-old sample, a significant negative correlation was found between MRL and percentage of object-to-object touches with people exemplars, $r(37) = -.38$, $p = .02$. That is, infants who had a lower percentage of object-to-object touches with people exemplars had a higher MRL. This correlation was not significant for the 18-month-old sample, $r(31) = -.17$, $p = .39$.

In order to further explore the effect of object-to-object touches with people exemplars on MRL, the sequence of touches for each infant was re-coded, and all of those touches were removed. For example, if the people exemplar was touched to the vehicle exemplar in the sequence man-car-dog-chair, the sequence would become man-dog-chair. All other coding criteria remained the same. For example, if 10 s had elapsed between the man touch and the dog touch, a break would have been recorded between those touches in the new sequence. Also, any object-to-object touch that was followed by a hand-touch to that same object (e.g., the infant touched the man to the car, then touched the car with his or her hand), still remained a touch in the new sequence. After the sequences of touches were re-coded, new MRLs were calculated and these values were compared to the MRLs from the original sequence using paired-sample t-tests. The average MRL for the 18-month-olds increased slightly from 2.02 to 2.04, and this increase was not significant, $t(30) = -.52$, $p = .61$. The average MRL for the 24-month-olds had a greater increase from 1.72 to 1.79, but this increase was also not significant, $t(36) = -1.59$, $p = .12$.

The 18-month-old infants in this study were found to perform domain-general categorization at an above-chance level. This suggests that at least by 18 months of age, infants have an understanding of the broad animate/inanimate distinction. The 24-month-olds did not successfully categorize the domain-general objects, which was unexpected given the performance of the 18-month-olds. This age difference was not due to the older age group touching fewer objects. However, age differences were found in the object-to-object touches with the people exemplars. Specifically, the 24-month-old infants had a higher percentage of object-to-object touches with people exemplars, and the majority of those touches involved inanimate exemplars. These cross-category object-to-object touches would increase the number of breaks, thereby decreasing the average MRL for the 24-month-olds. The inclusion of people exemplars seemed to promote symbolic play in the older age group, making it difficult for them to demonstrate categorization using a sequential touching procedure.

Experiment 1 examined the development of domain-general categories in 18- to 24-month-old infants. Given that successful domain-general categorization was discovered, at least within one of the age groups, it becomes important to examine how infants group these broad category items. That is, we can examine the role of perceptual and/or conceptual input in the development of this category level. Experiment 2 was designed to examine the role that part features might play in the categorization of domain-general objects.

Experiment 2

A second area of controversy in the categorization literature revolves around a perceptual vs. conceptual basis for categorization. The noteworthy results demonstrated by Rakison and Butterworth (1998) using switched-part exemplars provided a strong endorsement in favour of perceptually-based categorization. However, it first seems important to determine whether the results in that study can be replicated. Experiment 2 investigated the extent to which 14-, 18-, and 24-month-old infants use object parts when categorizing objects. Similar to Rakison and Butterworth (1998), the part features of certain objects were modified to examine categorization, this time at the animate/inanimate level. The modified objects allowed for an examination of categorization from two different perspectives. That is, would categorization be based on category membership (i.e., grouping animals and people together despite differences in parts), or based on part characteristics (i.e., grouping animals and vehicles together because they both have legs)?

Method

Participants.

Thirty-nine 14-month-old infants (*M* age = 13.73 months, *SD* = 0.81, *range* = 12.26 to 14.79 months), 32 18-month-old infants (*M* age = 18.51 months, *SD* = 0.59, *range* = 17.41 to 19.67 months), and 37 24-month old infants (*M* age = 24.16, *SD* = 0.99, *range* = 22.72 to 27.70 months) participated in Experiment 2. Two additional 14-month-old infants participated but were excluded because they did not touch any objects from one of the categories (either animate/inanimate or leg/wheel). Two additional 18-month-olds were tested but excluded due to fussiness (*N* = 1) and experimenter error (*N* = 1). Finally, three additional 24-month-olds participated but were excluded because of experimenter error. The 14-month-old sample consisted of 19 males and 20 females, the 18-month-old sample consisted of 21 males and 11 females, and the 24-month-old sample consisted of 19 males and 18 females. Participants were recruited in the same way as described in Experiment 1. Children were from families who spoke either English or French at home, although many also had exposure to second (*N* = 43) and third languages (*N* = 14).

Materials.

Small, plastic three-dimensional objects, similar to those in Experiment 1, were used. The animate domain exemplars consisted of four people with wheels (Caucasian man, Caucasian woman, Caucasian boy, Caucasian girl) and four animals with legs (dog, cow, dolphin, eagle). The inanimate domain exemplars consisted of four vehicles with legs (truck, car, boat, airplane) and four pieces of furniture with wheels (chair, vanity, bed, bathtub; see Figure 2 for a photograph of all exemplars). The objects ranged in size from 7.10 x 3.20 x 4.30 cm to 14.10 x 8.30 x 6.10 cm, and were presented to the infant on the same tray used in Experiment 1. The same cloth, stopwatch, and recording equipment were also used.

Procedure and Design.

The objects were combined to create six testing arrays (see Appendix G). Each array was made up of eight objects, and could be broken down by category membership in two ways. Four of the objects were from the animate domain-general category, and four were from the inanimate domain-general category. Also, four of the objects had leg features and four of the objects had wheel features. These part features were systematically altered such that each domain-general category consisted of half leg-objects and half wheel-objects. That is, in each array, two animate exemplars had wheels, two animate exemplars had legs, two inanimate exemplars had wheels, and two inanimate exemplars had legs.

In order to achieve this counterbalancing, the people objects were altered to have wheels instead of legs, while the animal objects remained intact (i.e., had leg features). The vehicle objects were altered to have legs instead of wheels, and the furniture objects were given wheels instead of legs. This mix of part features within domain-general categories allows for a contrast of animate/inanimate categorization and leg/wheel categorization. If the infants were found to perform animate/inanimate categorization at an above-chance level, they would be doing so despite differences in object parts (i.e., categorizing legged-animals with wheeled-people). However, if the infants were found to perform leg/wheel categorization (i.e., categorizing animals with legs with vehicles with legs) it would demonstrate a relatively unsophisticated knowledge of animate and inanimate categories.

The same testing procedure was used as in Experiment 1.

Coding.

The same coding procedure was used as in Experiment 1, with the addition of leg/wheel categorization. After coding was completed for the animate and inanimate objects, the sequence of touches was re-coded onto a leg/wheel coding sheet (see Appendix H). That is, a touch to an animal object would be coded as an animate touch, and then recoded as a leg touch. A touch to a people object would be coded as an animate touch, and then recoded as a wheel touch. MRLs were calculated for overall animate/inanimate categorization and for overall leg/wheel categorization. The same chance value (1.75) was used to determine whether categorization was occurring at a level greater than chance.

As in Experiment 1, an undergraduate-level student, naïve to the experimental hypotheses, completed the reliability coding. Interrater reliability was determined using the animate/inanimate coding sequence, and was calculated based on 25% of the infants in each age group (at least one infant from each testing array). Average agreement was

89.86% for the 14-month-olds, 93.08% for the 18-month-olds, and 92.06% for the 24-month-olds.

Results and Discussion

One-sample t-tests were used to compare infant MRLs to the MRL expected by chance (1.75). Preliminary analyses revealed no significant gender differences in MRL for any of the three age groups, and therefore all further analyses were collapsed across gender.

The average animate/inanimate MRL and leg/wheel MRL for each age group are presented in Table 3. The 14-month-old infants had an animate/inanimate MRL (M = 1.59, SD = 0.49) that was below chance, $t(38) = -2.03$, p = .05. Their leg/wheel MRL (M = 1.83, SD = 0.67) was also not significantly greater than chance, $t(38) = 0.76$, $p = .45$. The animate/inanimate MRL for the 18-month-old infants (M = 1.65, SD = 0.35) did not exceed chance, $t(31) = -1.63$, $p = .11$, and their leg/wheel MRL (M = 1.80, SD = 0.60) was not significantly above chance, $t(31) = .52$, $p = .61$. The animate/inanimate MRL for the 24-month-olds (M = 1.68, SD = 0.38) was not above chance, $t(36) = -1.13$, $p = .27$, and their leg/wheel MRL (M = 1.78, SD = 0.42) was not significantly greater than chance, $t(36) = .44$, $p = .67$.

A 2 x 3 (Type of MRL x Age Group) mixed analysis of variance was conducted to examine the two types of MRL across the three age groups. There was no significant main effect of age group, $F(2, 105) = .03$, $p = .97$, and no significant interaction between age and type of MRL, $F(2, 105) = .36$, $p = .70$. There was a significant main effect of type of MRL, $F(1, 105) = 5.65$, $p = .02$, such that the leg/wheel MRL collapsed across the three age groups ($M = 1.81$, $SD = 0.57$) was significantly higher than the animate/inanimate MRL collapsed across the three age groups ($M = 1.64$, $SD = 0.41$)

In terms of animate/inanimate categorization, 26% of the 14-month-olds ($N = 10$), 38% of the 18-month-old infants ($N = 12$), and 38% of the 24-month-olds ($N = 14$) had a MRL greater than the chance MRL value of 1.75. In regard to leg/wheel categorization, 41% of the 14-month-olds ($N = 16$), 44% of the 18-month-old infants ($N = 14$), and 38% of the 24-month-olds ($N = 14$) had a MRL greater than chance value. A 2 x 3 (Percentage of MRLs Above Chance for Each Type of MRL x Age Group) mixed analysis of variance examined the percentage of MRLs above chance for each type of MRL across the three age groups. No significant main effect was found for either percentage of MRLs above chance for each type of MRL, $F(1, 105) = 1.30$, $p = .26$, or age group, $F(2, 105) = 0.38$, $p = .69$. There was also no significant interaction between the two variables, $F(2, 105) = 0.53$, $p = .59$.

In order to calculate leg/wheel MRLs, all of the legged exemplars (i.e., animals and vehicles) were considered as part of the 'leg' group. However, the dolphin exemplar did not have leg features per se, but two fins. It could therefore be argued that this was not a fair comparison of part features because the dolphin was missing the feature of interest. Previous research with switched-part objects utilized a walrus exemplar in the leg category (Rakison & Butterworth, 1998). Also, the fin features on the dolphin exemplar were noticeable and could be considered 'leg-like.' Of the six testing arrays, three included the dolphin exemplar and three did not. The results from these orders were collapsed to create two groups: those including the dolphin and those not including the dolphin. A 2 x 3 (Dolphin Testing Array x Age Group) between-subjects analysis of variance was conducted to examine whether the dolphin exemplar influenced leg/wheel categorization. No significant main effect was found for either age group, $F(2, 102) = .19$, $p = .82$, or dolphin testing array, $F(1, 102) = 1.15$, $p = .29$. There was also no significant interaction between age group and dolphin testing array, $F(2, 102) = 1.95$, $p = .15$. These results suggest that the inclusion of the dolphin exemplar in the leg category did not influence leg/wheel categorization for any of the three age groups.

The 14-, 18-, and 24-month-old infants in this study did not perform either animate/inanimate categorization or leg/wheel categorization at a level significantly greater than chance. There was no significant difference in the percentage of infants who achieved a MRL above chance for either type of categorization. Overall, there was a trend for higher leg/wheel MRLs than animate/inanimate MRLs. The results from Experiment 2 do not demonstrate evidence of either perceptual or conceptual categorization. That is, none of the age groups categorized the conceptual animate and inanimate categories. The same was true for perceptual categorization, in that no age group categorized the perceptual leg and wheel categories. Conceptual categorization would have been especially challenging in this instance, because the same-category exemplars had differing part features. However, it is noteworthy that the infants did not resort to part-based categorization using the leg and wheel features.

General Discussion

Studying categorization allows us to answer fundamental questions about how infants begin to see the objects in the world around them. By examining the domain-general level of categorization, we are exploring the important distinction between living and non-living things. Learning about how typically developing children see the world also allows us to examine differences in populations of children who are experiencing developmental difficulties. For example, some researchers have examined whether typically developing children categorize differently from children with Autism Spectrum Disorder (ASD). A recent study found that children with ASD began categorizing lower-level categories before higher-level categories (Frenkiel-Fishman, Poulin-Dubois, & Rostad, in preparation), supporting other findings that children with ASD often focus on narrower parts of the environment (Klinger & Dawson, 1995).

Categorization research can also be applied to other areas of child development, such as language. For instance, it has been documented that children often overextend labels (e.g., calling all furry things "dog;" Samuelson & Smith, 2000). This can reflect categorization skills along with language abilities. These knowledge foundations formed early in life become the building blocks for all later learning (Mandler & McDonough, 1998a), and therefore examining how information comes to be organized in infancy is a worthwhile pursuit. The current experiments addressed two main areas of contention in the categorization literature.

First, researchers have attempted to determine the level of categorization that infants initially acquire. Bottom-up theorists argue that children learn lower-level categories first (i.e., basic- and subordinate-level) because they have a high degree of within-category similarity (Mervis & Rosch, 1981). Top-down supporters believe that children first acquire broad categories, and learn to distinguish among the narrower, lower-level categories as their age increases (Mandler, 2003). A number of research studies have demonstrated that children can distinguish superordinate-level categories before basic-level categories (e.g., Mandler & Bauer, 1998; Mandler et al., 1991;

Mandler & McDonough, 1993; 1998a). However, only one study has examined categories at a greater level of inclusiveness than the superordinate level (Poulin-Dubois et al., 2006).

The first experiment examined whether 18- and 24-month-old infants were capable of categorizing objects at the domain-general level using a sequential touching procedure. Infants were presented with objects from the animate domain (i.e., people and animals) and from the inanimate domain (i.e., vehicles and furniture), and their touching behaviour was analyzed. The results showed that the 18-month-olds were categorizing at a level significantly greater than chance, but the 24-month-olds were not. These results were not due to the 24-month-olds simply touching fewer objects than the 18-month-olds. Further analyses revealed that the older infants were engaging in a high degree of object-to-object touching, specifically touching the people exemplars to the inanimate objects. This led to a high number of cross-category touches (i.e., people-vehicle or people-furniture), which would break any ongoing runs and lower average MRL. For the 24-month-old sample, a significant negative correlation was found between MRL and percentage of object-to-object touches with people exemplars, such that a high percentage of those touches was related to lower MRLs. This correlation was not significant in the 18-month-old sample, suggesting that the relationship between these variables did not impact the MRLs of the 18-month-olds as strongly.

After removing the object-to-object touches with people exemplars, both age groups had an increase in their average MRL, with the 24-month-olds having the greatest increase. This provides some evidence that a high percentage of object-to-object touches with people exemplars does lower MRL. Compared to the 18-month-olds, the 24-month-olds in the current study had gained an additional six months of experience with people. This experience could have served to improve their appreciation of the people exemplars, thus increasing their saliency. Research has demonstrated that symbolic play is only beginning to develop at 18 months of age (Tomasello, Striano, & Rochat, 1999), and therefore the 24-month-olds in the current study likely had a more advanced understanding of symbolic play (i.e., that people toys go on furniture and vehicle toys) than the 18-month-olds.

In order to examine the animate category at the domain-general level, it was necessary to include people exemplars along with animal exemplars. However, at least for the older infants, this allowed for the possibility of symbolic play with the objects. Though the object-to-object touching was certainly appropriate, with a sequential touching procedure it would serve to lower the MRLs of the 24-month-olds, making it difficult for their average MRLs to exceed chance. One previous study included people exemplars in a sequential touching procedure (Oakes et al., 1996). In that study the people exemplars were only ever presented alongside animal exemplars, which likely minimized any cross-category touches.

If this study were to be repeated, it would be worthwhile to consider the types of inanimate items presented alongside the people exemplars. The furniture items in the current study (e.g., bed, bathtub, chair) may have been especially likely to promote symbolic play. This is supported by the finding that the furniture items were the most frequent partners in the object-to-object touches with the people exemplars (see Table 2). Other furniture items such as a lamp, television set, or bookcase may be less attractive for symbolic play. If this change led to a decrease in symbolic play and an increase MRLs, it would support the interpretation that the older infants in the current study may have been approaching the objects in a symbolic way more than a categorical way. If that was the case in the current study, it would explain why removing their symbolic play touches did significantly increase their MRLs.

It should not be concluded from these results that 24-month-old infants are incapable of domain-general categorization. It may be that a sequential touching procedure which includes people exemplars along with inanimate items may not be appropriate for this age group. A technique which presents objects consecutively rather than simultaneously, such as an object examination procedure, would eliminate the possibility of object-to-object touching. A generalized imitation procedure, where infants are given a prop and two objects from different categories, is also often used with older infants. Future research in domain-general categorization should be extended to use these alternative procedures with older age groups, as well as to examine whether domain-general categorization can be found in infants younger than 18 months of age.

Previous research using a sequential touching task has found that infants from 12 to 30 months of age will sequentially touch items from the same basic- and superordinate-level categories (e.g., Mandler & Bauer, 1988; Mandler et al., 1991; Oakes et al., 1996). The 18-month-olds in the current study also sequentially touched items from the same domain-general categories of animates and inanimates. However, it has been argued that sequential touches are not the only way to demonstrate categorization. Alternate touching may also be a demonstration of successful categorization (Oakes & Plumert, 2002). That is, a touch pattern of animate-inanimate-animate-inanimate-animate-inanimate could indeed be a categorization strategy, only in a dividing pattern rather than a connecting pattern.

It would be impossible to attempt to interpret an infant's touching pattern in terms of both sequential touching and alternate touching. That is, one could not conclude that an infant was demonstrating categorization with both an animate-inanimate alternate touch and an animate-animate sequential touch, otherwise all back-to-back touches would be evidence of categorization. However, it may be possible to observe a change in touching patterns over time as infants become familiar with the task and switch to more sophisticated categorization strategies (Oakes & Plumert, 2002). It remains unclear though how to determine whether the 24-month-olds in this study could have been displaying both sequential and alternate categorization strategies.

In addition, some authors argue that the initial response to the objects in a sequential touching task is not what should be taken as evidence of categorization (Oakes & Madole, 2000). For instance, Oakes et al. (1996) found that 13-month-old infants did engage in successive touching after 2 min with the objects, but not before. Therefore, it may be that infants come to notice or discover the category distinctions after having time to engage with and explore the objects, a unique opportunity in a sequential touching task. Future research using a sequential touching procedure may benefit from a familiarization phase in which the infants are presented with the objects prior to the task, or simply a longer sequential touching period (Oakes & Plumert, 2002).

Some researchers believe that studies using toy objects are not representative of how infants function in the real world, arguing that infants do not appreciate toy objects as representations of their real world counterparts (Johnson, Younger, & Furrer, 2005). If infants and young children are unable to appreciate that toys are symbols for real things, examining their categorization skills using toys would seem to be an unworthy pursuit if the goal is to understand how they categorize in everyday life. Research using scale models as representations has found that children younger than 2½ years of age have some difficulty representing the 'dual' nature of the symbols as both things in and of themselves and as representations of other things (e.g., DeLoache, 1989; DeLoache & Marzolf, 1992). More recent research has also shown that 18- to 20-month-old infants can be relatively poor at understanding objects as symbols (e.g., Tomasello et al., 1999; Younger & Johnson, 2006).

However, other research has shown that even young infants are capable of seeing links between symbolic representations and real-world counterparts. DeLoache, Pierroutsakos, Uttal, Rosengren, and Gottlieb (1998) found that 9-month-old infants would investigate and touch pictures as if they were the real objects. Younger and Johnson (2004) found an understanding of symbolic relations between toys and real-world counterparts by 14 months of age. While testing infants in the current experiments, appropriate vocalizations were common (e.g., saying "woof" when touching the dog). Also, the cross-category touching that occurred with the people exemplars and the inanimate items in Experiment 1 seems to demonstrate knowledge of how the objects would interact in the real world. It seems fair to argue then that even young infants have some understanding of objects as symbolic representations of real things, and that the results from the current studies could be applied to real-world functioning.

The second experiment was designed to address a different area of debate in the categorization literature, specifically, the degree to which infants use perceptual vs.

conceptual information when making category distinctions. Perceptual theorists make the argument that perceptual features, such as visible object parts, are the basis for categorization, especially in early infancy (e.g., Rakison, 2003). Conceptual theorists believe that even young infants are capable of using more conceptual, nonobvious information when making category judgments, such as functional, causal, or structural properties (e.g., Mandler, 2003).

In Experiment 2, 14-, 18-, and 24-month old infants were presented with objects from animate and inanimate domain-general categories. However, as opposed to the unmodified objects used in Experiment 1, the part features of certain objects were modified in Experiment 2. The animal exemplars remained intact (i.e., had leg features), the people exemplars had wheels, the vehicle exemplars had legs, and the furniture exemplars had wheels. These modifications allowed for a direct comparison of category-based categorization (i.e., animate and inanimate exemplars) and part-based categorization (i.e., leg and wheel exemplars). None of the age groups displayed either category-based or part-based categorization at a level significantly above chance.

The lack of significant leg/wheel categorization, especially in the younger age group, is noteworthy. Previous research using switched-part objects in a sequential touching procedure found that 14-month-old infants performed part-based categorization to a very high degree for superordinate-level categories such as animals and vehicles (Rakison & Butterworth, 1998). In fact, the average leg/wheel MRL for the 14-month-olds in that study ($M = 4.88$) is higher than any MRL found in any other study at any level of categorization, using either unmodified or switched-part objects.

It could be that part-based categorization is less suitable for domain-general category exemplars than for superordinate-level exemplars, given that domain-general categories are broader and contain more within-category variability. At a low level of categorization (e.g., basic-level category of 'dog'), using parts as the basis for categorization may be less likely to lead to inaccurate categorization decisions. That is, members of the same basic-level category do indeed have many similar part features (i.e., all dogs have many part features in common, despite other perceptual differences such as size or color). As you move up the levels of categorization, part-based categorization becomes less appropriate. Even at the superordinate-level, category members still have some common part features. Dogs and birds both have legs and cars and bicycles both have wheels, even though they differ in number.

However, once you reach the domain-general level of categorization the number of part-based features in common decreases even further. Especially in the inanimate domain, the part features that could be used to group vehicles and furniture together are almost nonexistent. Therefore, this wider amount of variability found at the domain-general level of categorization could make part-based categorization an inappropriate strategy, more so than it would have been at the superordinate level in the Rakison and Butterworth (1998) study.

It may also be that modifying the people exemplars to have wheels could have been too peculiar for the infants in the current study, such that no categorization strategy seemed appropriate. However, animals with wheels and vehicles with legs are also out of the ordinary, and the 14- and 18-month-old infants presented with these configurations in the Rakison and Butterworth (1998) study reverted to part-based categorization. The 22-

month-old infants in that study were actually able to overcome the modified part features and begin to categorize based on animal and vehicle category membership. Therefore, an explanation that the objects in the current study were too unusual seems insufficient to explain the lack of significant categorization.

The differing results may potentially be due to differences in the way that the part features were modified. As can be seen in Figure 2, the objects in the current study were modified with the intent to change only the requisite leg and wheel part features. However, Rakison and Butterworth (1998) modified their objects to be more like animal/vehicle hybrids. For the animal exemplars, the top half of animal objects were attached to the bottom half of vehicle objects, which included platforms along with the wheels (i.e., not simply attaching the wheels to the side of the animals where the legs were removed). For the vehicle exemplars, the top half of vehicle objects were attached to the bottom half of animal objects, which included stomach/midsection areas along with the legs (i.e., not simply attaching the legs to the bottom of the vehicles where the wheels used to be).

There may have been extra focus placed on the part features in Rakison and Butterworth (1998) because of the inclusion of additional body parts, which would not be the case in the current study. If it is true that a difference in object modification influenced categorization, it would demonstrate that perceptually-based categorization can be quite fragile. This argument would favour the conceptual theorists, who believe that conceptually based categorization is more consistent and less likely to lead to inaccurate conclusions about which objects belong together (Mandler, 2003).

Another methodological difference from the Rakison and Butterworth (1998) study is the breakdown of the objects that were modified. In Rakison and Butterworth (1998), two animals had legs, two animals had wheels, two vehicles had legs and two vehicles had wheels. However, in the current study, the people had wheels, the animals had legs, the furniture had wheels, and the vehicles had legs. Therefore, both of the items from the same superordinate-level category had the same part feature. In future studies, the features could be modified such that one exemplar from each superordinate-level category had legs and the other had wheels (i.e., one people with legs, one people with wheels, one animal with legs, one animal with wheels, etc.). With the current design, the infants may have been looking at the objects as four sets of two category members, rather than two sets of four category members.

The results from Experiment 1 indicate that 18-month-old infants are capable of domain-general categorization with unmodified objects. It would therefore be expected that at some point infants should be able to perform domain-general categorization even with switched-part objects, as did the 22-month-old infants in the Rakison and Butterworth (1998) study with superordinate-level exemplars. It could be that this ability develops after 24 months of age. It could also be that the modifications in the current study (i.e., solely part features rather than hybrid objects) created objects that did not fit into any recognizable structure. Although the modifications in Rakison and Butterworth (1998) can be criticized for drawing extra attention to part features, the objects in their study may have been more comprehensible. For example, including some of the animal body allowed the vehicles in that study to have a smoother transition from top to bottom. Were these to be real entities, they might actually look like they could move and function. In the current study, the vehicle objects ended abruptly where the legs were attached. The people objects ended at the waist where the wheels were attached. These modifications may have made the objects somehow unrecognizable, and therefore incomparable to any category scheme.

These experiments were among the first to examine a level of categorization above the superordinate level. The animate and inanimate domain-general categories have hardly been explored, despite some researchers arguing that the animate-inanimate distinction is learned relatively early in infancy (Rakison, 2003; Rakison & Poulin-Dubois, 2001). The results from Experiment 1 demonstrate that during the middle of the second year of life, infants are capable of distinguishing these domain-general categories. Experiment 2 found a lack of either category-based or part-based categorization with modified objects. Further research will be required to clarify the basis for early infant categories (i.e., perceptual or conceptual categorization), but we now know more about the progression of category acquisition in terms of category inclusiveness.

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Appendix A

Recruitment Letter

Dear parents,

The Child Development Laboratory at Concordia University is involved in a series of studies looking at infants' understanding of animacy. This research is funded by the Natural Sciences and Engineering Research Council of Canada. The Commission d'Accès à l'Information du Québec has kindly given us permission to consult birthlists provided by the Régie Régionale de la Santé et des Services Sociaux de la Région de Montréal-Centre. Your name appears on the birthlist of _______, which indicates that you have a child of an age appropriate for our study.

In the present study, we are examining infants' understanding of living beings and inanimate objects. Your child will be presented with a selection of toys to play with for two minutes to assess his or her categorization skills. During this task, your child will be sitting in a child seat and you will be seated directly behind. A video camera will be used to record the tasks, so that we can measure how long your child plays with the toys.

Participation involves one visit to our research centre on the Loyola Campus of Concordia University, located at 7141 Sherbrooke Street West. Appointments can be scheduled at a time which is convenient for you and your child, including weekends. Free parking is available on the campus for our participants, and we will gladly reimburse any other transportation expenses at the time of your visit. Upon completion of the study, a Certificate of Merit will be given to your child, and a report of the results of the study will be mailed to you as soon as it is completed

For the purposes of this study, we are looking for infants who are ___ months of age, who hear English or French spoken at home, and who do not have any visual or hearing difficulties. If you are interested in having your child participate in this study, or would like any further information, please contact Kristin Rostad at 514-848-2424, ext. 2279 or Dr. Diane Poulin-Dubois at 514-848-2424, ext. 2219. We will try to contact you by telephone within a few days of your receipt of this letter.

Thank you for your interest and collaboration.

____

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____

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Appendix B

Informed Consent Form

This is to state that I agree to allow my child to participate in a research project being conducted by Dr. Diane Poulin-Dubois and Kristin Rostad of Concordia University.

A. PURPOSE
I have been informed that the purpose of the research is to examine how infants understand living beings and inanimate objects.

B. PROCEDURES
The present investigation involves examining how infants categorize objects in the world around them, and the strategies they are most likely to use. Your child will be presented with a series of small toys from different categories of objects and we will measure how long he/she touches each of them. During this task, your child will be sitting in a child seat and you will be seated directly behind. We will videotape your child's responses and all tapes will be treated in the strictest of confidentiality. That means that the researcher will not reveal your child's identity in any written or oral reports about this study. Your child will be assigned a coded number, and that number will be used on all data collected in this study.

C. RISKS AND BENEFITS
Your child will be given a certificate of merit at the end of the session as a thank-you for his/her participation.

There is one condition which may result in the researchers being required to break the confidentiality of your child's participation. There are no procedures in this investigation that inquire about child maltreatment directly. However, by the laws of Québec and Canada, if the researchers discover information that indicates the possibility of child maltreatment, or that your child is at risk for imminent harm, they are required to disclose this information to the appropriate agencies. If this concern emerges, the lead researcher, Dr. Diane Poulin-Dubois, will discuss the reasons for this concern with you and will advise you of what steps will have to be taken.

D. CONDITIONS OF PARTICIPATION
- I understand that I am free to withdraw my consent and discontinue my participation at any time without negative consequences, and that the experimenter will gladly answer any questions that might arise during the course of the research.
- I understand that my participation in this study is confidential (i.e., the researchers will know, but will not disclose my identity).
- I understand that the data from this study may be published, though no individual scores will be reported.

I HAVE CAREFULLY STUDIED THE ABOVE AND UNDERSTAND THIS AGREEMENT. I FREELY CONSENT AND VOUNTARILY AGREE TO HAVE MY CHILD PARTICIPATE IN THIS STUDY.

MY CHILD'S NAME (please print) ____________________________________

MY NAME (please print) ____

SIGNATURE ___________________________ DATE ____________________

WITNESSED BY ________________________ DATE ____________________

If at any time you have questions about your rights as a research participant, you are free to contact Adela Reid, Research Ethics and Compliance Officer, Concordia University, at (514) 848-2424 ext 7481 or by email at areid@alcor.concordia.ca

____

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Appendix C

Demographics Questionnaire

Infant's first name: ______________________ Date of Birth: ________________

Infant's last name: ______________________ Gender: _______________

Language(s) spoken at home: ____

Mother's name: _____________________ Father's name: ______________________

Address: _____________________________ Telephone #: _____________ home

_____________________________ _____________ work

Mother's occupation: __________________ Father's occupation: ________________

Mother's education (highest level attained): ___________________________________

Father's education (highest level attained): ___________________________________

Mother's marital status: ______________ Father's marital status: ______________

Please answer the following general information questions about your child:

Birth weight: ___________________ Length of pregnancy: ______ weeks

Birth order: ___________ (e.g., 1 = 1st child) Number of children in family:_________

Were there any complications during the pregnancy? ____________________________

Has your child had any major medical problems? _______________________________

Does your child have any hearing or vision problems? ___________________________

Please answer the following general information questions about your family:

Does your family have a pet (or pets)? (yes/no)

If you answered yes, please list your pet(s) indicating the kind of pet(s) (e.g., dog, cat, fish) and the number of pets:

____

Appendix D

Testing Arrays for Experiment 1

Order 1	Caucasian man Caucasian woman	Eagle Dolphin	Car Boat	Desk Chair
Order 2	African American man Caucasian girl	Dog Cow	Car Airplane	Desk Bathtub
Order 3	African American woman African American girl	Eagle Cow	Truck Boat	Chair Bathtub
Order 4	Caucasian girl Caucasian boy	Dolphin Dog	Truck Airplane	Desk Bed
Order 5	African American man African American boy	Dolphin Cow	Boat Airplane	Bathtub Bed
Order 6	African American woman Caucasian boy	Eagle Dog	Car Truck	Chair Bed

Appendix E

Blank Animate/Inanimate Coding Sheet

Subject Number:_______ Sex: F M Tested by:______________ Order:______

Birth date:_________ Test date:_________ Coder:__________ Coding date:_________

Lap Baby: Y N Parental Interference: ______________________________

Start:_______________ Stop:_________________

Comments:____

____

	1	2	3	4	5
Animate					
Inanimate					

6	7	8	9	10	11

12	13	14	**Touches**	**Runs**	**MRL**

Total Touches: **Total Runs:** **Total MRL:**

Appendix F

Example of Completed Animate/Inanimate Coding

	1	2	3	4	5
Animate	woman		dolphin	eagle	man
Inanimate		car			

10 *s* elapsed between touches – this breaks the ongoing run

6	7	8	9	10	11
				man	eagle
boat	desk	car chair	boat		

Simultaneous touch to same-category exemplars – does not break run

12	13	14	**Touches**	**Runs**	**MRL**
			6	4	1.50
car	boat	chair	8	3	2.67

(man)

Total Touches = 14 **Total Runs** = 7

Highlight indicates that car was touched using another object (man)

Total MRL = $\frac{\text{Touches}}{\text{Runs}} = \frac{14}{7} = 2.00$

Appendix G

Testing Arrays for Experiment 2

Order 1	Caucasian man Caucasian woman	Eagle Cow	Car Boat	Bathtub Chair
Order 2	Caucasian man Caucasian girl	Dolphin Cow	Boat Airplane	Vanity Bathtub
Order 3	Caucasian woman Caucasian girl	Eagle Dog	Truck Car	Chair Vanity
Order 4	Caucasian girl Caucasian boy	Cow Dog	Truck Airplane	Bathtub Bed
Order 5	Caucasian man Caucasian boy	Dolphin Dog	Car Airplane	Vanity Bed
Order 6	Caucasian woman Caucasian boy	Eagle Dolphin	Boat Truck	Chair Bed

Appendix H

Example of Re-Coding Animate/Inanimate Coding into Leg/Wheel Coding

	1	2	3	4	5	6	**Touches**	**Runs**	**MRL**
Animate	girl	dog	boy	cow			4	1	4.00
Inanimate					bath	bed	2	1	2.00

Total Touches = 6 **Total Runs** = 2

Total Animate/Inanimate MRL $= \frac{6}{2} = 3.00$

	1	2	3	4	5	6	**Touches**	**Runs**	**MRL**
Leg		dog		cow			2	2	1.00
Wheel	girl		boy		bath	bed	4	3	1.33

Total Touches = 6 **Total Runs** = 5

Total Leg/Wheel MRL $= \frac{6}{5} = 1.20$

Table 1

Mean Run Lengths, Standard Deviations, and Associated t-Test Values in Experiment 1

18-month-olds			24-month-olds		
M	*SD*	*t*(30)	*M*	*SD*	*t*(36)
2.02*	0.73	2.07	1.72	0.42	-.43

Note. Values enclosed in parentheses represent degrees of freedom.

* Indicates significantly above chance MRL (1.75), $p < .05$ (one-tailed)

Table 2

Percentage of Animal, People, Vehicle, and Furniture Objects Touched Using People Exemplars in Experiment 1

	Animal		People		Vehicle		Furniture	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
18-month-olds	10.26	28.50	0.00	0.00	16.35	37.29	73.40	42.88
24-month-olds	4.47	10.36	0.00	0.00	10.64	21.34	84.89	23.84

Table 3

Mean Run Lengths, Standard Deviations, and Associated t-Test Values in Experiment 2

	14-month-olds			18-month-olds			24-month-olds		
Type of MRL	*M*	*SD*	*t*(38)	*M*	*SD*	*t*(31)	*M*	*SD*	*t*(36)
Animate/Inanimate	1.59	0.49	-2.03	1.65	0.35	-1.63	1.68	0.38	-1.13
Leg/Wheel	1.83	0.67	0.76	1.80	0.60	0.52	1.78	0.42	0.44

Note. Values enclosed in parentheses represent degrees of freedom.

* Indicates significantly above chance MRL (1.75), $p < .05$ (one-tailed)

Figure 1. Experiment 1 Stimuli

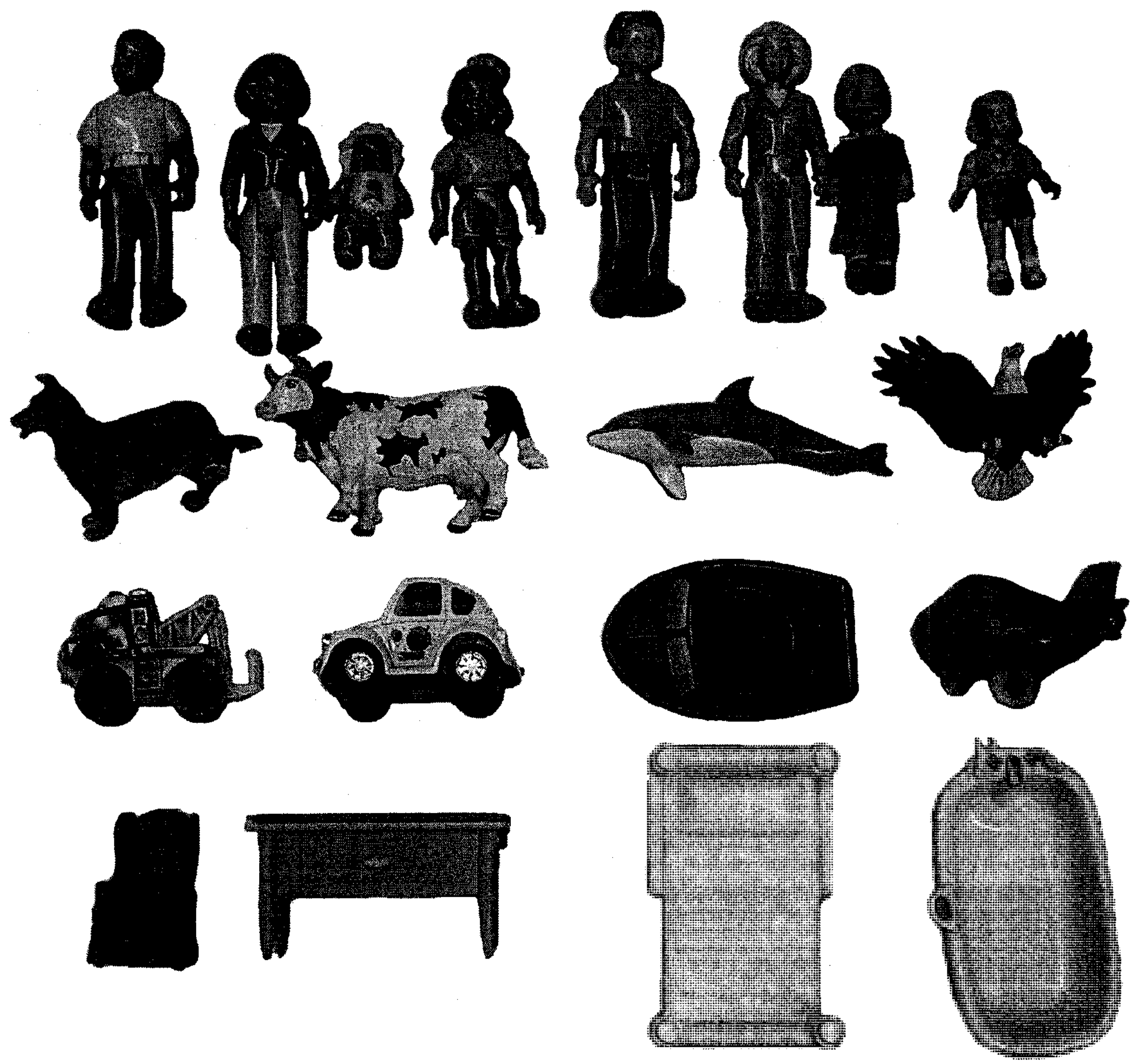

Figure 2. Experiment 2 Stimuli