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Comparison and Children's Categorization of Unfamiliar Objects

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An abstract of
A thesis submitted to the Faculty of Emory College of Arts and Sciences
of Emory University in partial fulfillment
of the requirements of the degree of
Bachelor of Arts with Honors

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Abstract

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Children's ability to categorize objects is an essential skill that has been heavily studied. Previous research indicates that children initially are drawn to a perceptual similarity such as similar shape as a basis for categorization, leading children to make such mistakes as classifying an apple and a balloon as belonging to the same category. However, further research found that encouraging children to compare two or more examples from a category reduces children's over-reliance on perceptual similarity as a basis for categorization. For example, comparing an apple and an orange encourages children to select a perceptually different looking banana over a perceptually similar balloon as a member of the category. These findings suggest that children begin to rely on deeper, less obvious characteristics of objects rather than only the perceptual ones when encouraged to compare objects within a category. The present study was designed to determine the effects of comparison on the categorization of unfamiliar objects, an important extension of the research on the role that comparison plays in children's categorization. Children saw either one (no compare condition) or two (compare condition) perceptually similar target objects from the same category (e.g., apple or apple and orange). They were then asked to select an object from the same category among a perceptually similar out-of-kind object (e.g., balloon) and a perceptually dissimilar novel member of the target category (e.g., kiwano). Results revealed no clear evidence that comparison facilitates categorization of novel objects in three-year-olds. However, this study is the first step in a series of experiments designed to investigate this acquisition process.

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CONTENTS

Children today are constantly exposed to new words and objects that must be recognized, sorted, and stored as a part of the learning process. Categorizing objects is one way in which children organize their worlds and tackle the immense array of objects and words in their vocabulary. By acknowledging and understanding overarching classifications (e.g., fruit, balls), they are able to recognize items more easily, figure out how they relate to each other, and use the knowledge they have acquired to guide their future actions with other items from the same categories. For example, learning to recognize examples of fruit will allow children to realize that other circular shaped objects with stems they encounter may also be sweet and edible.

The basic foundations of the categorization process in children have been a major topic of interest for researchers studying cognitive development. Specifically, the properties children rely on to correctly categorize these objects has been widely examined (Baldwin, 1992; Gentner & Namy, 1999; Landau, Smith, & Jones, 1988; Imai, Gentner, & Uchida, 1994; Klibanoff & Waxman, 2000). Markman and Hutchinson (1984) proposed that children have a default intuition that objects that have the same label tend to be taxonomically similar. Taxonomy can be defined as the classification of objects into hierarchies based on levels of inclusiveness. Therefore, taxonomic properties would be those characteristics of an object that classify it into its respective grouping. For example, a particular animal may be initially categorized as a mammal (most inclusive), a dog (more specific), and a poodle (most specialized) based on defining properties such as its reproductive habits, behavior, and type of fur, height, and head shape. However, it is not always the case that children will initially focus on the taxonomically relevant properties of an object when grouping the objects, or will even understand on what basis taxonomic categories are organized. Consequently, children may not always correctly categorize objects since they do not focus on the crucial features that unite the identities of objects of a like kind. There has been much debate regarding the properties children focus on and what processes enable them to ultimately categorize objects into their correct groupings. The findings from previous studies with children (Gelman & Coley, 1990; Gelman & Markman, 1986; Gelman & Wellman, 1991; Kalish & Gelman, 1992; Markman, 1989; Waxman, 1990) suggest that children understand that objects belong to different categories which are classified by their deeper characteristics beyond their perceptually similar traits

Although these studies and many others illustrate children's understanding of categorization, there are conflicting findings, which suggest that children categorize objects together or think of them as "like kinds" based on their perceptual similarities (Baldwin, 1989, 1992; Gentner, 1978; Gentner & Imai, 1995; Golinkoff, Shuff-Bailey, Olguin, & Ruan, 1995; Imai et al., 1994; Landau, Smith, & Jones, 1988; Smith, Jones, & Landau, 1992; Ward et al., 1989). Some researchers believe that early in development, children rely on shape to classify objects. Landau, Smith, and Jones (1988) illustrate in their study that although children rely on other aspects of objects such as the core properties (taxonomic), there is also a strong emphasis on the perceptual properties such as common shape. In this study, Landau, Smith, and Jones considered the possibility that children extend a noun to a specific object by determining which perceptual dimension is most important and then categorizing based on that dimension. Landau, et al.

experimented with shape, size and texture as a basis for categorization. They not only found a reliance on perceptual properties during the categorization process, but also found that children also do not rely equally on all perceptual dimensions, specifically prioritizing shape over other features (Baldwin, 1989, 1992; Landau, Smith, & Jones, 1988; Smith, Jones, & Landau, 1992).

In the previous research that tested whether children chose a thematic match or a taxonomic match, the taxonomic match was also similar in shape to the target object (Baldwin, 1992). Given the evidence suggesting reliance on shape during categorization, this brings up the question of whether children really were picking the taxonomic match because of its functional or taxonomic properties, or rather because of similarity in shape. Baldwin's studies tested this question. Overall, children had a preference for the shape match, which indicates that shape is a major quality that children rely on when categorizing objects. Therefore, although many studies reveal that children use taxonomic properties to properly categorize objects, it is also important to note that there are specific perceptual properties that play an important role in the process.

Other scholars suggest a developmental transition in children's reliance on different cues to category membership. They argue that as children mature and increase their knowledge about objects and categories, they begin to rely more on the taxonomic properties and less on perceptual properties (Imai, Gentner, & Uchida, 1994). Imai, Gentner and Uchida explored this theory in their study that clarified the particular mechanisms children initially use to group objects as being of "like kind." They found that early in development, children rely on shape to group objects, but as they begin to grow older and their knowledge about objects and categories expands, they begin to rely on the taxonomical properties. Imai, Gentner, and Uchida predicted that this shift during development would allow children to accurately categorize objects based on the taxonomical similarities. Imai et al. proposed that perhaps the initial shape bias helps children understand the basis for categories. This may then lead children to discover or shift their focus to the more defining taxonomic properties, which will allow them to ultimately group objects into their correct categories.

Gentner and Namy (1999; Namy & Gentner, 2002) proposed that one way to reconcile children's dependence on perceptual information with their emerging understanding of taxonomic categories is by invoking comparison as a mechanism. When children are told what an object is (e.g., "This is a balloon."), they must understand that an object is being talked about, what object the speaker is referring to, and they must understand what properties of that object are important to the object's classification as a category member (Gentner & Namy, 2006). Gentner and Namy (2006) propose that by comparing two or more objects that share both category membership and similar appearance, children begin to notice important characteristics about objects that will allow them to identify other members of a category that differ perceptually. For example, seeing an apple and an orange may help children notice properties in common beyond shape that would help them to also include a perceptually dissimilar banana in the category (e.g. edible, sweet, etc).

Although overreliance on shape could lead children to make classification errors, this shape reliance may help children to categorize objects correctly, since many objects from the same category are also similar in shape. For instance, an apple is circular just as an orange and plum are. However, this shape reliance may lead children astray when objects from the same category have differing shapes (e.g. a banana) or when objects from different categories have a similar shape (e.g. a beach ball). Since categories are defined by the taxonomic properties of the objects in them, children must eventually focus on functional properties (e.g. edible, sweet, grow on trees) instead of the perceptual traits (e.g. round) to categorize objects correctly. We must therefore understand the processes that help children concentrate on those taxonomic properties.

Gentner and Namy (1999) argue that as a result of the comparison process, the common structural characteristics may become more salient. Findings from Markman and Gentner's (1993, as cited in Gentner & Namy, 2006) revealed that comparison will make relational commonalities more salient to adults. When scenes are presented on their own, adults will focus on the objects in the scene rather than the relations among them, but by comparing two structurally similar scenes, one begins to notice the deeper functional or relational properties of an object that may not have been as apparent on first glance. For example, when viewing a scene of a truck towing a car and of a car towing a boat, people typically match the car in one scene to the car in the other. But after comparing the two scenes, adults will prioritize the towing relationship that they share, and will begin to match the truck in scene 1 with the car in scene 2 and the car in scene 1 with the boat in scene 2. The structural-mapping theory suggests that this happens because when comparing two objects people instinctively try to find relational commonalities between them, which is also known as structural alignment. A similar phenomenon was observed in business students who compared two training cases during Loewenstein, Thompson, and Gentner's (2003) study and consequently were able to recognize a common negotiation principle, illustrating how comparison facilitates insight into structure across a wide array of problem-solving domains.

The goal of Gentner and Namy's (1999) studies was to determine whether preschool-aged children begin to notice the conceptual structure of objects through the comparison of perceptually similar objects from the same taxonomic category. They hypothesized that comparison would facilitate the categorization process. They based this prediction on the notion that perceptual similarity elicits a deeper analysis which leads to the discovery of deeper, more category relevant taxonomic properties.

In Gentner and Namy's (1999) first experiment, they tested whether comparison facilitates categorization based on taxonomic properties in 4-year-olds. Forty-eight cards with colored line drawings of real objects were used (8 sets of 6 cards). Children were randomly assigned to either the *compare* or *no-compare* condition. The experimenter labeled the standards with a novel noun and then asked the children to help Jo-Jo, a stuffed dog, find another object with the same label. In the no-compare condition, the children saw only one standard from a target category (e.g. an apple from the fruit category). In the compare condition, the children saw four standards (e.g. an apple, a pear, a slice of watermelon, and a bunch of grapes). Children then selected between two alternatives as a match for the category. One alternative was perceptually similar but not of the same category (e.g. a balloon). The other alternative was a category match but perceptually different from the standards (e.g. banana).

Experiment one revealed that when given the opportunity to compare multiple objects of the same category, children were more likely to choose this category match, suggesting that comparison promotes structural alignment. However, this bias for the category match could be caused by the children making perceptual generalizations about the objects or because of the perceptual variability across the exemplars raised the possibility that the category match also overlapped perceptually with the standards. Experiment two was conducted to address this possibility. In this experiment, children were shown either one example of the category or two examples, both of which were established to be much more perceptually similar to the perceptual choice than the category choice. This ensured a clearer distinction between whether children were choosing on a perceptual basis or because the comparison enabled them to notice the deeper properties and therefore choose the category match. They found that even when both standards were more perceptually similar to the perceptual choice, giving children the opportunity to compare led them to choose the category match over the perceptual match. This supports the proposal that comparison promotes structural alignment and highlights the deeper relational bases for category membership.

Gentner and Namy's (1999) study illustrated the importance of comparison in categorization. Their results were the main motivating factor behind this present study and the details of their procedure are significant as they provide the basis for this present study's procedure. However, many other researchers have demonstrated that comparison facilitates children's ability to categorize objects by helping them to focus on deeper, more category relevant properties as a basis for categorizing. Oakes and Ribar (2005), for example, also showed how comparison facilitates the categorization process by making less apparent properties more perceptible to infants. They tested 4-and 6-month olds to see whether these infants could distinguish between cats and dogs, as determined by adults. Previous research has revealed that infants have limited memory for visual arrays (Oakes & Ribar, 2005). Therefore, Oakes and Ribar used two different familiarization processes: a "paired presentation format" during which the infants saw pairs of pictures of either cats or dogs, and giving them a chance to compare the images, and a "successive presentation task" where pictures of cats or dogs were flashed one at a time. Therefore, during the successive presentation task the infants would not be able to compare the items because they would not be able to remember the objects as easily, whereas when the items were presented at the same time right next to each other, the 4-month-olds could easily compare them. Once infants were familiarized to one category, they were then shown novel objects that were either of the same, familiarized category, the other contrasting category (e.g., those familiarized to cats saw dogs) or of a completely distinct control category (a truck). Oakes and Ribar reasoned that after being familiarized with one category infants would have longer looking times at the new category if they could distinguish the two. If the infants were to look longer at the contrasting category than the familiar category, then it can be inferred that infants can distinguish between the two categories. The truck stimulus served as a baseline measure of category novelty.

Oakes and Ribar found that in the "paired presentation format" where infants were able to compare the pictures, infants looked longer at the contrasting, rather than the familiarized category. However, 4-month-olds in the “successive presentation task” did not have higher looking times for the contrasting category. Therefore, there is no evidence that 4-month-old infants can form exclusive categorical representation when the items are presented one at a time. One of the key variations between the two familiarization formats was that during the paired presentation, infants were able to compare the two items. This illustrates how comparison is a tool that facilitates the categorization process by making less apparent properties more perceptible.

Klibanoff and Waxman (2000) studied the effects of comparison on 3-year-olds’ ability to categorize objects on the basis of individual properties (e.g., striped or bumpy). They found that comparing objects form the same category that shared the target property facilitated children’s ability to generalize a label for that property to other, unrelated objects with the same property. Therefore, when given the opportunity to compare objects children notice specific properties essential to categorizing. Many other researchers studied how the comparison process allows for the deeper core properties of objects to become more salient. Kotovsky and Gentner (1996) observed how preschoolers who compared two pictures noticed the similarities across two pictures that other control children did not. This exemplifies how comparison will enable children to focus on properties of objects that would have otherwise been overlooked. In a study with 18-month olds, Namy, Smith, and Gershkoff-Stowe (1997) found that those infants who compared two objects during a sorting task were able to later sort the objects into two categories better than the infants who did not go through the comparison process. Finally, Loewenstein and Gentner (2001) tested whether 3-year-old children could find a hidden object in a room after they were shown where it was hidden in a smaller model room. They found that children who compared two similarly arranged model rooms were better at this mapping task. Loewenstein and Gentner therefore concluded that comparison of the model rooms enabled the children to notice common properties in the room that they would have otherwise overlooked, making the mapping task easier. All of these studies illustrate the importance of comparison in regards to categorization, since the comparison of perceptually similar objects clearly enables children to focus on the structural properties.

The Present Study

Although the research previously discussed supports the idea that comparison facilitates categorization by highlighting the category-relevant features, it does not actually demonstrate that children gain *new* insights into categories through comparison. This is because the items used in the previous categorization studies were all familiar to children. As a result, the research has not addressed the question of whether comparison serves a knowledge generating function as well as a knowledge highlighting function. The goal of the present study is to test whether comparison enables children to acquire new category knowledge. Learning the processes that enable children to correctly categorize *unfamiliar* objects is the next most logical and important step in understanding the role of comparison in conceptual development. Every day children are exposed to objects they have never seen before. It is important to understand how they sort and store all of the new information they encounter.

Overall there have been many findings that illustrate how comparison of objects leads children to understand the deeper relational aspects of objects. This structural alignment allows them to learn objects and the relation between them as well as the deeper functional properties. The research on how comparison facilitates the categorization process is the main motivation behind my study. I am expanding upon this research by looking at how the comparison process plays a role in categorizing novel objects. The data will have many applications to real world settings, since children are often presented with new objects with which they are unfamiliar. There must be some processes that help them learn the objects and ultimately categorize them correctly, and our study will examine if comparison is one of those properties.

This present study will focus on children's ability to categorize unfamiliar instances of a familiar category (e.g. a Kiwano from the fruit category). I will test to see if comparison influences the categorization process with unfamiliar objects in the same way that it does with familiar ones. The procedure used in Experiment 2 of Gentner and Namy's (1999) study was replicated with a novel category match in place of the familiar category match. At the end of the procedure children named all the objects they had seen during the experiment, and this naming data was used as a supplementary measure of learning in addition to their category choices.

The goal of this project is to test whether comparison enables children to acquire new category knowledge. If comparison serves a knowledge generating function, then children should classify the new object as a member of the target category in the compare condition more often than in the no compare condition. I predicted that comparison would enable children to focus on the deeper core properties of an unfamiliar object that would then allow them to learn and organize the novel object into a specific category. If comparison does not serve as a knowledge generating function, children should respond randomly or systematically select the perceptual match regardless of condition. This outcome would suggest that comparison's ability to facilitate categorization is primarily useful when reasoning about familiar objects and may not be a useful tool for learning novel objects.

Method

Participants

In this experiment twenty-eight 3-year-olds (M = 40.64, range = 9.73) were tested in the Language and Learning Lab on the Emory University Campus. Participants were both male (15) and female (13) and predominantly White or Black from middle class families living in the Atlanta area (35% Black, 65% White). Participants were drawn from a database of families recruited through direct mailings and online advertisements who have volunteered to participate in child development research. They received a small gift for their participation. Five additional children were excluded from the analysis due to their failure to accurately label or describe the functions of at least 85% of stimulus items selected to be familiar to children of this age (see below).

Materials

Stimuli for this experiment consisted of laminated prints of 40 color photographs of objects (e.g., apple, balloon). The pictures were organized into 10 sets of 4 pictures each, including two perceptually similar exemplars from a target category such as vegetables (e.g. carrot and corn), and two choice objects including an out-of-kind object that was perceptually highly similar to both exemplars (e.g., space shuttle, see Figure 1), and a category match selected to be *unfamiliar* to children of this age, based on pilot testing, and perceptually dissimilar from the two target exemplars (e.g., an artichoke). A complete list of stimuli appears in Table 1. The two target category exemplars as well as the perceptually similar out-of-kind choice object were selected to be familiar to children of this age based on previous research.

Ten novel labels were selected to refer to each of the ten target categories to clarify that all the objects in the set were a part of the same category. Labels, assigned to sets in two different random orders, included the following: toma, blicket, ziven, riffle, daxen, seebow, kern, pilk, tillen, and wint.

A ladybug puppet named Lulu was used as a prop to help justify the use of novel words to the 3-year-olds. Participants were told that they would be learning Lulu's special ladybug language.

Procedure

The child took a seat at a table across from the experimenter. A video camera was in the corner of the room, and Lulu the ladybug was positioned on the table for the child to play with. Parents either observed through a one-way mirror or unobtrusively sat behind the child. The experimenter instructed the parents to avoid interacting with the children during the test sessions.

Participants were assigned to either a compare or no compare condition. In both conditions, the experimenter first introduced the child to Lulu the ladybug and explained to them that Lulu had her own special ladybug language. The child was then invited to play a game with the experimenter where he/she would be able to learn some of Lulu's special ladybug words.

For each of the 10 stimulus sets, the experimenter administered a category introduction phase followed by a test phase. Only the category introduction phase varied by condition. In the compare condition, for each set, the experimenter placed one of the two category exemplars on the table and labeled it using a novel "ladybug word". For example, the experimenter would say, "Lulu calls this one a Blicket!" The experimenter then placed the second perceptually similar exemplar from the same target category directly underneath the first object and again labeled the object with the same novel word, saying, for example, "She also calls this one a Blicket! Can you see how these are both Blickets?" Order of presentation of the two exemplars for each set was counterbalanced across children. The experimenter than asked the child to repeat the novel word, saying for example, "Can you say 'blicket'?" Eliciting confirmation from the children that they understood the objects were from the same labeled category, encouraged comparison of the two exemplars and ensured engagement with the task.

In the no compare condition, the child saw only one of the exemplars. The selection of exemplar used was counterbalanced across children. As in the compare condition, the experimenter labeled the exemplar using a novel label and asked the child to repeat the label. For example, the experimenter might say, "Lulu calls this one a Blicket! Can you say 'Blicket'?"

Following the category introduction phase, the experimenter administered the test phase. This phase of the experiment was consistent across both conditions. While the category exemplar(s) were still on the table, the experimenter simultaneously presented the two choice objects, including the perceptually similar out of kind match and the perceptually *dissimilar* category match. The two photographs were placed next to each other on the table underneath the exemplar(s) as shown in Figure 1. The experimenter then asked the child to choose which one had the same label as the object(s) viewed during the label introduction phase. For example, the experimenter would say “Can you tell Lulu which one of these is a Blicket?” Once the child chose an object, the experimenter recorded his/her choice and moved on to the next set.

Assessment of stimulus familiarity

After completing the forced-choice categorization task for each of the ten sets of stimuli, the children were asked to tell Lulu the English names of the objects. The experimenter presented each of the pictures to the child and asked, “Can you tell Lulu what *we* call this?” This final step of the experiment was employed to confirm that objects which had been previously shown in pilot testing as familiar to 3-year-olds, were in fact famil iar. However, I was also interested in determining whether the naming responses for the unfamiliar objects varied as a function of condition, as a second dependent measure. Of interest is whether children in the compare condition regarded the novel objects as members of the familiar target categories more often than those in the no compare condition.

The children's naming responses were transcribed from video recordings of the session. Two independent raters classified children's responses for each object as either familiar or unfamiliar. Children were considered familiar with the object if they provided the correct basic level label (e.g., "apple"), superordinate label (e.g., "fruit"), different basic level within the same superordinate (e.g., "broccoli" for an artichoke) or accurate functional description (e.g., "I eat it"). If the child provided an incorrect label or functional description or responded "I don't know" when asked to identify the object, the object was considered unfamiliar. A third independent rater resolved any coding discrepancies.

Results

To assess the effect of comparison, I calculated mean proportion taxonomic choices in each of the two conditions (compare and no compare). Children in the compare condition selected the taxonomic item on .44 proportion of trials (SD = .19). Those in the no compare condition selected the taxonomic items on .46 proportion of trials (SD = .19). I first compared conditions by conducting t-tests using both subjects and items as random variables. I then compared the responses in each condition to chance responding (.50) to assess reliability of children's responses. To assess the consistency of trends observed across children, I also conducted an individual pattern analysis using a Pearson chi-square test. Finally, I conducted an analysis of children's naming data for the novel objects as an alternative measure of the effect of comparison on categorization.

Condition Comparison

I conducted both a between subjects (subject analysis) and within subject (object analysis) t-test to compare the mean proportion of taxonomic responses in each condition. Inconsistent with Gentner and Namy's (1999) work with familiar objects, I found no evidence that comparison facilitates categorization of novel objects within familiar categories. Neither the subject nor item analysis revealed differences between the compare condition and the no compare condition, $t(26) = -.196$ and $t(9) = -.346$ for subject and item analyses respectively, both p's $> .10$. This finding suggests that comparison did not significantly alter children's categorization of novel objects in this task.

Comparisons to chance

To assess how systematically children were categorizing the novel objects, I compared children's mean proportion of taxonomic responses to chance performance (.50, given 2 alternatives). Children's taxonomic scores in both the no compare condition ($t(13) = -.840$, $p > .10$), and the compare condition ($t(13) = -1.096$, $p > .10$) did not differ reliably from chance performance. Therefore, there is no evidence that 3-year-olds were consistently including the taxonomic match in the category even after comparing objects.

Individual pattern analysis

Individual pattern analyses can often reveal trends within the data not explained by the tests of means. The number of children with taxonomic scores above, below and equal to chance levels (i.e. 50%) is illustrated for each condition in Table 2. With ten trials, children had to make a taxonomic choice five times to be at chance performance and less than or greater than five to be below or above chance respectively. I summed the number of children who scored within these response patterns for each condition. As Table 1 reflects, the distribution of individual children's taxonomic responses in the co compare condition did not differ significantly from the distribution in the compare condition. In fact, although more children performed below chance than above chance in both conditions, there were a number of children in both conditions who were responding at above chance rates, suggesting that some children were successfully including the novel object in the target category. A chi-squared test was conducted, confirming that the distribution between the scores of children in the no compare condition and those in the compare condition do not differ, $\chi^2 = .311$, $p > .10$.

Naming Analysis

I also investigated children's post-experiment naming accuracy on the novel items to be categorized as an alternative measure of comparison's effect on categorization. To the extent that comparison facilitates categorization, children should be able to generate an appropriate label or functional description for these objects more often in the compare than no compare condition. Mean proportions of correct naming was calculated and compared between conditions. The means revealed no evidence that comparison was affecting children's ability to identify novel objects ($M_{Compare} = .18$, $SD_{Compare} = .17$, $M_{NoCompare} = .21$, $SD_{NoCompare} = .12$, $t\ (26) = .68$, $p > .10$). Analysis of individual items, illustrated in Table 3, reveals higher naming accuracy for the compare over the no compare condition for five items, a decrease for four, and one that remained about equal between the two conditions. Therefore, the comparison task did not seem to aid children in naming unfamiliar items.

Additionally, given that the individual patterns showed that some children were succeeding, I calculated the correlation between the children's mean proportion taxonomic scores in the forced-choice task and their proportion of correct naming. For the both the No Compare ($r(12) = -.132$, $p > .10$) and Compare ($r(12) = -.086$, $p > .10$) conditions. I found no correlation between children's taxonomic scores and the proportion of correct naming.

Discussion

Inconsistent with my hypothesis, the results of this study reveal no evidence supporting the claim that comparison facilitates categorization of novel objects in three-year-olds. There was no consistent pattern towards either perceptual or taxonomic responding. Instead both perceptual and taxonomic responding were at chance level in both conditions. In an unreported pilot study prior to conducting the main experiment, I replicated Namy and Gentner's finding that comparison allows children to focus on the deeper taxonomic properties of *familiar* objects, which ultimately helps them to categorize objects correctly using these same stimuli. Although comparison facilitates categorization with familiar objects, however, it does not appear to facilitate categorization of novel objects. Children in the no compare condition, who saw a single exemplar, did not differ significantly in their responses from children in the compare condition, who compared two exemplars. Neither condition differed significantly from chance. This result was unexpected both because children in the no compare condition failed to show evidence of perceptual bias and because the Compare condition did not yield higher taxonomic responding. There is no clear evidence that comparison facilitates categorization of novel objects.

Why did comparison fail to facilitate categorization of novel objects in the same way that it did with familiar objects? When initially attempting to replicate Namy and Gentner's findings, I tested 4-year-olds just as they did in their original study; however, I failed to find evidence of perceptual biases in the no compare conditions with this age group. After failing to replicate this finding, I predicted that since the original study was done nearly ten years earlier, perhaps 4-year-olds today were more sophisticated. Four-year-olds may have been more aware of the objects around them and were, as a result, correctly categorizing the objects during the task even in the no compare condition. I then attempted to replicate Namy and Gentner's findings with 3-year-old children to determine whether our explanation of the non-replication was correct. I successfully replicated the benefits of comparison on categorization with the younger children using familiar objects, so we opted to focus on 3-year-olds to test children's ability to categorize novel objects in the experiment reported here.

This change in age may have influenced the results for several reasons. One possibility is that the task may have been too confusing for this age of children, leading to random responding across conditions. In future studies we would need to ensure clarity of the task with 3-year-olds and show expected shape bias in the No Compare condition before attempting to investigate how comparison may influence categorization. Another possibility is that the 3-year old children did not verbally express themselves as well as the 4-year-olds in terms of the naming data and therefore did not consistently provide object labels even when their behavior during the experiment proper suggested that they actually knew them. Therefore, an accurate representation of the subjects' knowledge of the objects may not have been collected since it was based on an oral response. Another important reason that 3-year-olds may not have been as readily able to capitalize on the comparison information was due to more limited attention at this age. Children may not have focused long enough on the objects or appropriately distribute attention between the two exemplars for the effect of comparison to take place. As a result, comparison may not have helped children categorize unfamiliar objects.

One limitation of this study is that the forced choice task may have been an underestimation of the children's rich understanding of the objects. A study that compensates for this would use an alternative measure of the children's' knowledge of the object that did not involve an oral response. The measure of object knowledge collected at the end of our experiment, during which children are asked to label the objects, would be used as a measure of learning. If comparison facilitates children's understanding of novel objects, the preschoolers would be able to display their knowledge of the novel objects without an oral response. For example, when confronted with a child who is not very verbally expressive, I might offer the child an alternative way to express his knowledge, such as drawing or acting out what they believe the object is or does. These illustrative or physical representations of the object could be a new way to measure the child's understanding of the object. During this study, many 3-year-olds offered a physical representation of the object's actions, providing evidence that this age group would be comfortable explaining an object by physically acting out its functional properties. By allowing children to express their understanding of the unfamiliar objects in a different way, we may collect a more accurate measure of comparison's ability to facilitate understanding of novel objects.

To address the possibility that they may not be able to focus during the task, we may alter the experiment to include a more strict confirmation of the child's acknowledgement of comparison. For example, after the comparison task we may ask the children not only if they understand that the two exemplars have the same label (e.g. "do you see how these are both blickets?"), but also ask them why they think the two objects are the same thing. This additional question would elicit greater processing and ensure that they sufficiently compared the two objects.

An additional explanation for why comparison did not facilitate categorization of novel objects is that novel objects may be too distracting for three-year-olds. Perhaps children's attention is diverted to this foreign object and they are unable to notice or apply the deeper core properties essential for proper categorization. The new object steals their focus away from the effects of the comparison task and disrupts their mental processes concerning categorization. In other words, during the comparison task, the children may have been noticing the overlapping taxonomic properties of the two objects; however, when the novel object came into sight, the child's thought process completely shifted to thinking about, and attempting to analyze, this new object they had never seen before. Consequently, during the forced choice task, children may not have chosen the taxonomic match because they had ceased to focus on the core properties of the target category by the time a choice was made.

A possible follow-up study would test children with the same procedure but with an additional period prior to the experimental task during which the children could inspect the novel objects. By allowing children to examine the novel objects before presenting the bases from the target category, the amount of distraction caused by the objects during the actual forced choice task would be greatly diminished. If children were to then choose the taxonomic match over the perceptual match, we could hypothesize that upon initial interaction, novel objects are too distracting to 3-year-olds, but after examining these unfamiliar objects, children are able to understand their deeper core properties. This would illustrate how comparison may be a helpful tactic in facilitating categorization of novel objects in 3-year-olds as long as they have had the opportunity to inspect the objects prior to categorizing.

In another follow-up study to address the possibility of novel objects being too distracting, we could use the same procedure and compare two familiar objects just as done in previous studies as well as this one, but give the children an option of a novel taxonomic or *novel* perceptual match. By making both of the choices unfamiliar, perhaps the distractions caused by the novel object could be balanced between the two choices. Also, children may be forced to focus on the deeper properties of the objects rather than the unfamiliar aspects when making their choice since they would be unfamiliar with both objects. If children were to choose the novel taxonomic category match significantly more often than the novel perceptual out of category match, we could say that, again, comparison facilitates categorization of novel objects, when attentional distribution between the two choices is equated.

A final potential explanation for why comparison did not facilitate categorization of novel objects is that since the objects are unfamiliar, children simply do not recognize that they share deeper core properties with the exemplars. Even if children knew they were supposed to be looking for an object with similar taxonomic properties, for these novel objects they would have had to recognize perceptual correlates of the core properties since they did not already know anything specific about the core properties of the novel object. If this level of analysis is too complex, they would not choose the taxonomic match during the forced choice task. In this case, comparison may only serve as a knowledge highlighting factor and not a knowledge generating role. Therefore, comparison would be a useful tactic to highlight already existing knowledge of familiar objects but would not help children learn the properties of an unfamiliar object. Process of elimination may have them choose the novel object because they knew the familiar perceptual match did not have those same properties, but perhaps that was not a convincing enough thought to sway children to chose the novel taxonomic match.

One approach to addressing this issue of comparison failing to generate new knowledge would be to use objects as opposed to pictures. Perhaps the use of photographs limited children's ability to recognize perceptual cues that are relevant to core category properties. Graham et al. (2010) used objects in their study with preschoolers, testing the effects of comparison on categorization of novel objects with varying shapes and textures. Similar to our experiment, the researchers tested 4-year-olds by showing them a set of objects, which consisted of either one or two exemplars depending on condition and two test objects. The test objects in this experiment, however, were either a shape match or texture match. Researchers used this setup to test whether comparison would lead children to focus on the subtler perceptual property, texture, over shape. Graham et al. found that comparison does in fact cause children to categorize based on texture as opposed to shape, illustrating that comparison may enable 4-year-olds to use novel properties as a basis for categorizing objects. Since preschoolers in Graham et al.'s study began to categorize based on texture after the comparison task was employed, perhaps the 3-year-olds in our study, who also compared objects, would begin to notice the subtler perceptual properties associated with deeper core properties if shown actual objects as opposed to pictures. The objects may allow the children to focus on properties beyond shape (e.g. a beach ball is not only round but made of resilient material which will allow it to bounce). By seeing a three-dimensional figure, children would look beyond shape and truly understand the taxonomic properties of the new object. A follow-up study using objects as opposed to pictures would reveal whether a picture of an object restricts a child from understanding the deeper core properties of a novel object.

The most crucial question underlying this research is how children acquire new category knowledge. We know at what age and developmental point in their lives children begin to categorize objects, but we do not fully understand what sources of information and strategies they use to construct categories or incorporate new instances into existing categories. The results from this study reveal that we cannot say that comparison facilitates categorization of novel objects. Therefore, comparison may not be the best way to highlight the deeper core properties of unfamiliar objects. There may be other learning techniques to help children understand the characteristics of novel objects necessary to categorize them correctly.

One idea pertaining to this topic is that children need experiences with objects in the real world in order to categorize them correctly. For example, children may need to observe the object in action to get the full sense of the object's deeper properties and the contexts in which it routinely appears. This "top down" approach: understanding the functions and contexts for objects before understanding the perceptual features that correspond to them, is rivaled by the "bottom up" idea that children must first understand the basics of the features that comprise category instances before sorting different objects into the overarching groups. It is crucial that we understand the ways in which children learn to categorize objects so that we can improve the teaching techniques used to help children learn the new objects that they are exposed to every day.

Conclusions

Early in development, young children often rely on perceptual similarities to group objects as being of like kind. However, many object categories are not organized by shape but rather by the non-obvious core properties of the objects (such as function, internal structures, and relations to other objects). Gentner and Namy (1999) found that comparison of objects leads preschool-aged children to focus on these deeper core properties and ultimately categorize objects correctly. This study examines the role of comparison in the categorization of novel instances of familiar object categories, and more specifically whether comparison helps children to categorize novel object in the same way that it did with familiar objects. Although comparison facilitates the categorization of familiar objects (Gentner & Namy, 1999), we cannot conclude from the findings of this study that comparison helps 3-year-old children to categorize novel objects. This study contributes to the field of cognitive development because it expands upon research regarding the thought processes children use to learn new objects. Not only did we discover a new age during which these cognitive processes occur, but we also generated a preliminary exploration of whether children generate new knowledge about novel objects through comparison. The ability to correctly categorize novel objects, which depends largely on the understanding of an object's core properties, is an essential skill during the early stages of word learning, and this study is the first step in a program of studies to investigate this acquisition process.

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Table 1

Stimulus Items listed by Set

		Item		
Set	Target 1	Target 2	Perceptual	Taxonomic
Sweets	Bagel	Donut	Tire	Funnel Cake
Money	Penny	Dime	Cookie	Foreign Coin
Balls	Baseball	Beach Ball	Orange	Koosh Ball
Fruits	Pear	Apple	Balloon	Kiwano
Hats	Top Hat	Hat	Bucket	African Hat
Instruments	Drum	Tamboreen	Cake	Thumb Harp
Vehicles	Bicycle	Tricycle	Glasses	Segway
Vegetables	Corn	Carrot	Rocket Ship	Artichoke
Candy	Lollipop	Ice Cream	Rose	Gobstopper
Sports	Baseball Bat	Golf Club	Pencil	Curling Poll

Table 2

Number of children with taxonomic responses above, equal to, or below 50% in the No Compare and Compare Conditions

Taxonomic Score	No Compare	Compare
>.50	5	4
= .50	2	3
< .50	7	7

Table 3

Proportion of children who correctly named each novel item

Object	No Compare	Compare
Funnel Cake	.06	.20
Foreign Coin	.06	.40
Koosh Ball	.19	.33
Kiwano	.06	.07
African Hat	.06	.13
Thumb Harp	.25	.20
Segway	.56	.40
Artichoke	.25	.13
Gobstopper	.25	.13
Curling Poll	.00	.13
Mean	**.18**	**.21**

Figure Captions

Figure 1. Stimulus presentation procedure by condition
Figure 2. Proportion of taxonomic and perceptual responses by condition (chance responding = .50)

Figure 1.

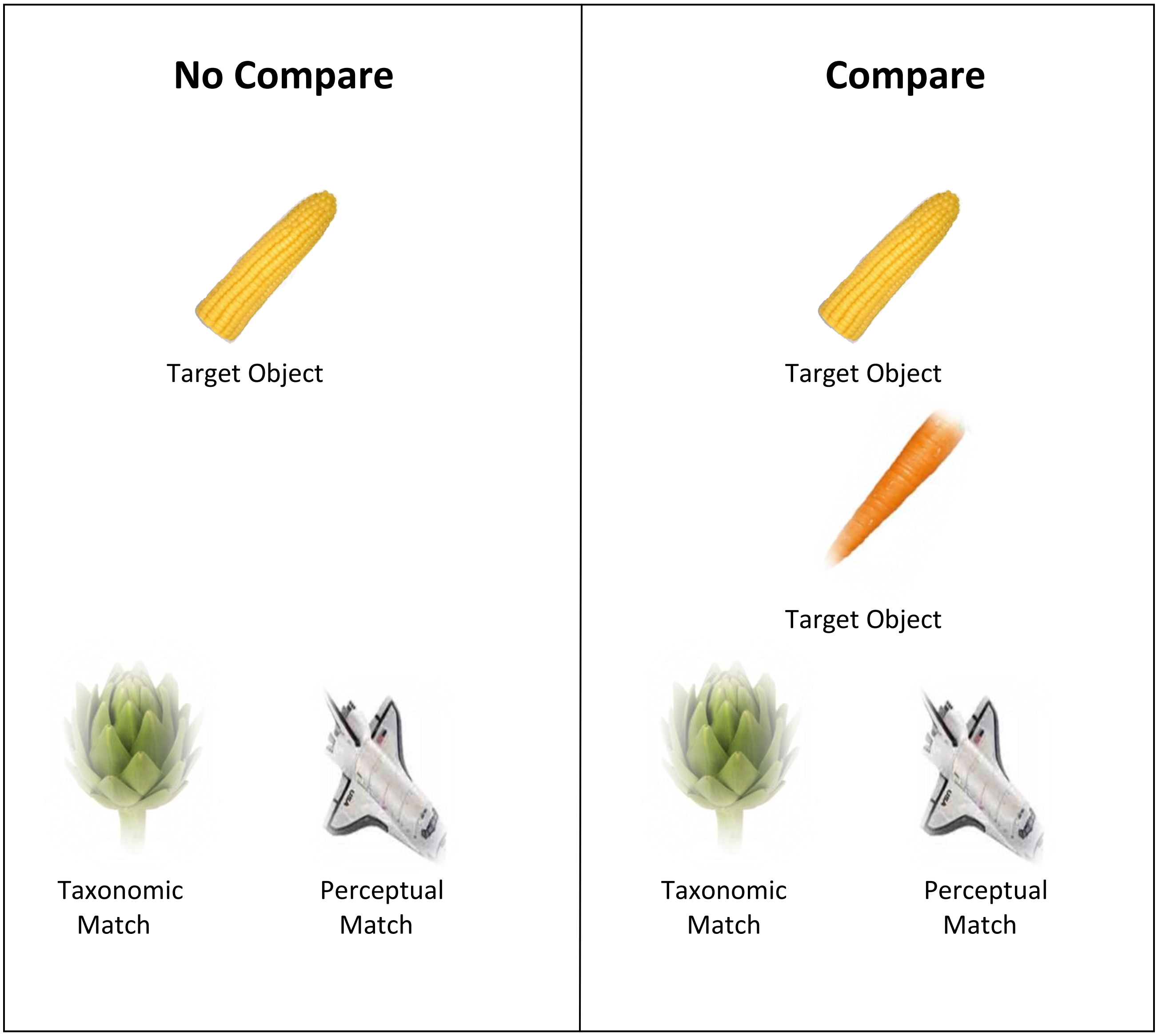
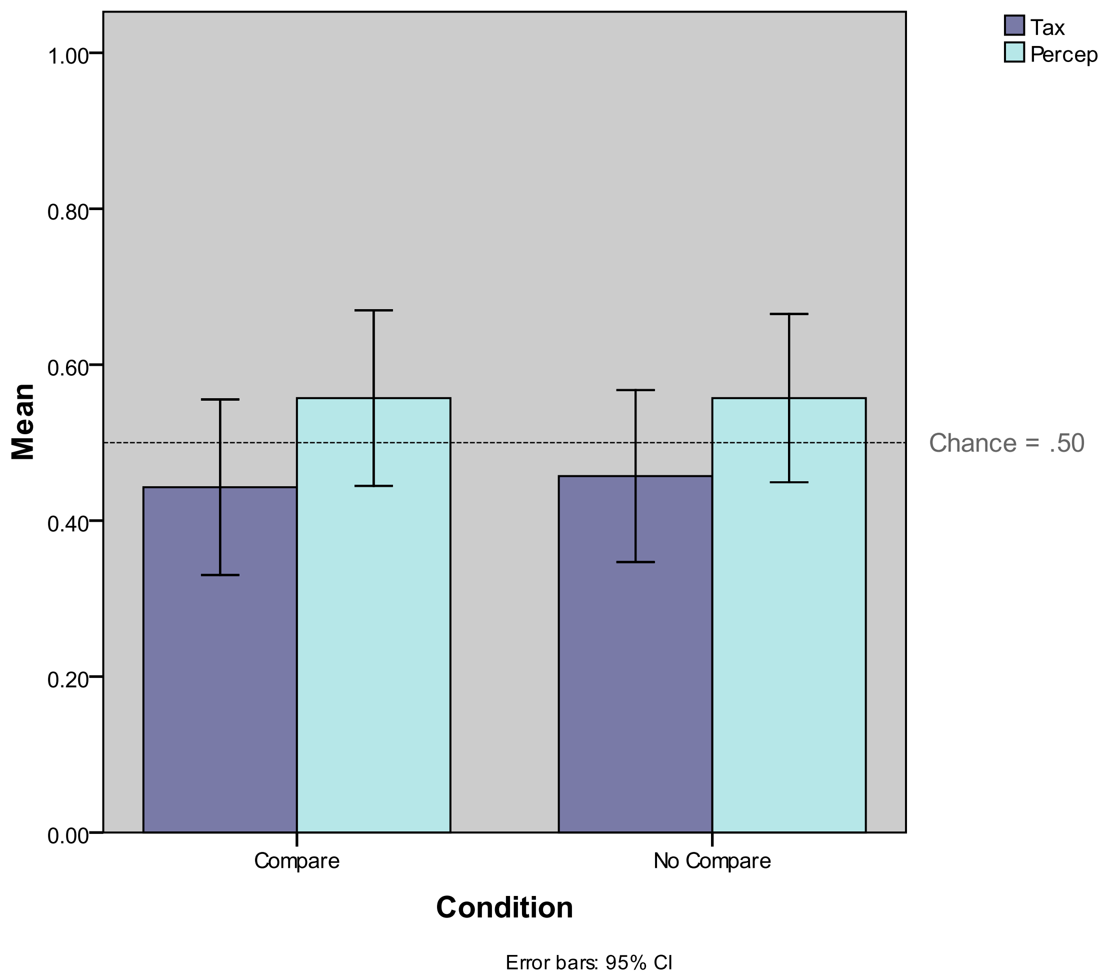

No Compare
Compare
Target Object
Target Object
Target Object
Taxonomic Match
Perceptual Match
Taxonomic Match
Perceptual Match

Figure 2.



Tax
Percep
1.00
0.80
0.60
0.40
0.20
0.00
Mean
Chance = .50
Compare
No Compare
Condition
Error bars: 95% CI