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in 3-Year-Olds

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An abstract of
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of Emory University in partial fulfillment
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Abstract

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In early development, children learn to organize their environment into categories, often using an object's shape as a basis for category membership (e.g., grouping an apple with other round objects). However, when children have the opportunity to compare similarly shaped objects from the same category (e.g., an apple and a pear), they are more likely to group objects based on function even when the function match is perceptually dissimilar (e.g., a banana). Even in the absence of comparison, children can extend category membership by function when functional information is highlighted. The current studies explore the unique and combined roles of comparison and function in the assimilation of *novel* instances (e.g., a kiwano) into familiar categories (e.g., fruit). In Experiment 1, 3-year-olds viewed one or two photographs of familiar exemplars drawn from the same familiar category and selected another category member between two objects: a perceptually similar, outside-of-category, familiar object (e.g., a balloon) and a perceptually dissimilar, within-category, novel object (e.g., a kiwano). Children, regardless of whether they viewed one or two objects, preferred the familiar perceptual match to the novel category match. In Experiment 2, when the perceptual and category matches were both novel, children displayed evidence of benefiting from comparison. Functional information, however, did not increase category responses, suggesting that highlighting function may fail to increase awareness of functionally relevant, perceptual properties. Together, these findings underscore the difficulty in assimilating novel objects into familiar categories but demonstrate that comparison may assist in this process.

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The Roles of Comparison and Function in the Categorization of Novel Objects in 3-Year-Olds

Children interact with thousands of objects every day. To efficiently and effectively process this information, it becomes useful to organize the world into systematic, meaningful categories. These categories may consist of common, stereotypical objects that share common features and functions, such as furniture (Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976), or they may represent objects haphazardly grouped together to form goal oriented, ad hoc groups, such as ways to escape being killed by the Mafia (Barsalou, 1983). It is with remarkable flexibility that children and adults rapidly create and use categories, either common or ad hoc. Yet, how do children learn to create categories, and, more specifically, how do they expand these categories to incorporate novel instances?

The ability to systematically organize the world into units capable of forming larger, conceptual categories is a developmental process that has interested scholars across multiple disciplines for centuries. In the nineteenth century, a debate emerged among philosophers, theologians, and psychologists over the nature of this process. Philosopher Alexander Bain, for example, claimed that the world, experienced through a plurality of sensations, is formed into a coherent image through repeated interactions (as cited in Martineau, 1866). Reverend James Martineau, however, suggested the alternative. The world, according to Martineau (1866), enters our perception as a uniform whole and it is through repeated interactions that individual sensations and specific qualities emerge. As such, a red ivory ball encountered for the first time will leave a mental representation of the entire object rather than its unique qualities. It is not until the ball is contrasted with another object, such as a white ball or an egg, that distinct sensations (e.g., color and shape) surface into our awareness. Influenced by these two contrasting theories proposed by Bain and Martineau, psychologist William James (1890) offered a compromise, suggesting that the world is initially perceived as a "great blooming, buzzing confusion" that becomes organized only after a variety of unique experiences.

With over a century of debate surrounding the nature of the organizational process, two competing, albeit related, theories have emerged among developmental cognitive psychologists. The first approach suggests that young children rely heavily on perceptual features as a basis for categorizing (Baldwin, 1989; Gentner, 1978; Graham & Diesendruck, 2010; Imai, Gentner, & Uchida, 1994; Landau, Smith, & Jones, 1988, 1998; Sheya & Smith, 2006). The second approach, however, suggests that children form categories based on a system of abstract, relational properties, focusing on the intended functions that are shared among instances rather than perceptual similarities (Christie & Gentner, 2010; Gentner & Namy, 1999; Namy & Gentner, 2002). Children who recognize the functions of objects would, therefore, rely more on the relational information to generalize category membership and group together objects that perform similar functions despite physical dissimilarities (Booth & Waxman, 2002; Kemler Nelson, 1999; Kemler Nelson, Frankenfield, Morris, & Blair, 2000a; Kemler Nelson, Russell, Duke, & Jones, 2000b). Although perceptual features are often reported as competing against functional properties, in reality function often correlates with, and is even causally related to, perceptual features (e.g., large eyes corresponds with seeing well at night) (McCarrell & Callanan, 1995; Ware & Booth, 2010).

The Defining Characteristics of Categories

Categories, regardless of whether they are formed on the basis of perceptual or relational commonalities, are often organized into taxonomic hierarchies with varying levels of inclusivity and specificity (Rosch et al., 1976). At the superordinate level, category membership is the most inclusive and least specific with objects such as lions, tigers, and bears within the general category of animals. At a less inclusive yet more specific so called “basic” category level, animals such as tigers form a distinct group separate from lions and bears. Within this basic level category, multiple subordinate level categories emerge to create the least inclusive and most specific groups, for example, by distinguishing male tigers from tigresses or by differentiating between Bengal tigers and Siberian tigers. Although the categorical hierarchies are culturally and linguistically dependent (Roberson, Davies, & Davidoff, 2000) as well as domain-knowledge specific (Johnson & Eilers, 1998), the superordinate, basic, and subordinate levels are organized into non-arbitrary categories common across classifications (Rosch et al., 1976).

Despite various degrees of inclusivity and specificity, categories formed at a given level often share characteristics with other categories organized along the same categorical level. Examining the primacy and characteristics of basic categories within the context of English nouns, Rosch and colleagues (1976) found that instances of basic level categories often share common perceptual features, such as shape. For example, every tiger, male or female, shares a common outline with comparable sized bodies, long tails, broad noses, and rounded ears. Given that category instances at the basic level have a stereotypical, uniform shape, objects are easily identifiable at this level of specificity and are most frequently labeled by children and adults through abstract figures, drawings, and even silhouettes (Rosch et al., 1976). As a reliable mechanism to parse the world into systematic groups, labels for basic level categories often constitute children’s earliest utterances, for example, learning the labels for “dogs” and “cats” before learning the labels for “animals” or “Dalmatians.”

The Role of Perceptual Features in Categorization

Early in development, children favor learning the labels for basic level objects before acquiring more general or specific terms. Gershkoff-Stowe and Smith (2004), examining the unique relationship between word learning and category structure, investigated whether children's first words tended to reflect a shape-based categorization strategy. Consistent with the notion that basic level category labels often constitute children's earliest words (Rosch et al., 1976), Gershkoff-Stowe and colleague report that an infant's first one hundred nouns often refer to categories well organized by shape, perhaps reflecting the fact that a child's environment is often predominated by categories with little shape variability (e.g., balls). They also note that children's awareness of the non-arbitrary relationship between shape and object as well as their propensity to rely on perceptual features as an indication of category membership increase as a function of learning new words, specifically nouns. Gershkoff-Stowe and Smith suggest that this increased attention to shape assists in the learning of new words, especially labels for basic objects, quickly and easily.

Given this strong correspondence between shape and category membership in young children's experiences, children often rely on shape as the strongest indicator of category membership despite having multiple perceptual features (e.g., texture, size, and color) available to serve as cues. To provide evidence supporting the importance of shape over other perceptual properties in early learning, Landau and colleagues (1988) presented two- and three-year-olds a novel object and provided a novel label (e.g., "dax"). After naming the object, the experimenters then showed children contrasting objects that each differed along several perceptual dimensions, matching the target solely in size, texture, or shape, and asked children to extend the novel label to one of the alternatives. Landau et al. discovered that shape was a stronger predictor of name generalization than either texture or size. In a similar study highlighting the importance of shape over other perceptual features, in this case color, Baldwin (1989) found that children often favor shape when extending object labels to unfamiliar instances despite frequent remarks and interest in color similarity. Not only did children show a preference towards shape matching, but they also showed a trend towards an increased reliance on shape as a function of development (Baldwin, 1989; Landau et al., 1988).

Although the shape bias often corresponds with and strengthens throughout language development (Baldwin, 1989; Gershkoff-Stowe & Smith, 2004; Landau et al., 1988), even infants show a propensity to generalize category membership on the basis of shape. A recent study by Graham and Diesendruck (2010) explored the strength of the shape bias in 15-month-olds by presenting infants with an unfamiliar target object possessing a non-obvious property such as rattling when shaken or squeaking when squeezed. When presented with three test objects differing in shape, color, or texture, infants inferred that objects sharing similar shapes to the target object would produce the target property rather than objects sharing similar colors or textures. Before developing an extensive vocabulary and even before recognizing the non-arbitrary relationship between shape and object, infants demonstrate a bias towards shape over other perceptual properties that is similar to the biases observed in young children.

To explain the importance of shape as a salient perceptual cue, Biederman (1987) proposes the recognition-by-components theory. Artifacts in particular, regardless of their categorical level, are composed of geometrical shapes such as blocks, cylinders and cones. These components, called geons (i.e., geometrical ions), are recognized by the perceptual system and, because the components are generally simple and relatively stable, allow occluded and degraded images to be easily identified. That is, by focusing on the inventory and relations among the geons that comprise the object one recognizes the object. Although Biederman specifically suggests that individuals rely on the parts to determine the whole, shape as a perceptual cue is essential in drawing concrete objects out of abstraction and obscurity.

Although shape is a strong predictor of category membership and a reliable strategy to identify objects, the primacy of shape declines over development with older children and adults placing an increased importance on function over perceptual features (Imai, Gentner, & Uchida, 1994). Gentner (1978) observed that the relationship between shape and age followed a pattern in which reliance on shape initially increased with development but subsequently decreased by school age. In a task where children were presented two novel objects (i.e., a "jiggy" and a "zimbo") with two novel functions (i.e., after pressing a lever the jiggy changed facial expressions, whereas the zimbo dispensed jellybeans), children were shown an object appearing as a jiggy but functioning as a zimbo. Asked to label the hybrid object, two- to five-year-olds reliably named the object by form, suggesting that the new machine was a jiggy, whereas older children, arguably understanding the centrality of function when categorizing, tended to generalize by function rather than shape. Landau, Smith, and Jones (1998) discovered similar developmental patterns. Whereas two- and three-year-old children consistently categorized by shape even when the functions of novel objects were demonstrated and verbally reinforced (e.g., "So rifs are made so you can mop up water with them"), older children and adults relied less on shape and more on function as a basis for novel object categorization. Although shape serves as a reliable strategy during initial language acquisition, children eventually develop a preference towards relational properties such as function as a basis for categorizing.

The Role of Relational Features in Categorization

Although research suggests that young children rely primarily on shape as a predictor of category membership, numerous studies have demonstrated that children readily categorize by relational features despite perceptual dissimilarities. As such, researchers have observed children generalizing on the basis of spatial relations (Christie & Gentner, 2010; Loewenstein & Gentner, 2001), functional similarities (Booth & Waxman, 2002; Kemler Nelson, 1999; Kemler Nelson et al., 2000a, 2000b), and abstract relational commonalities (Gentner & Namy, 1999; Namy & Gentner, 2002). For example, when preschoolers were presented novel artifacts with easily inferable functions, children who explored and discovered the functions subsequently extended novel labels to objects that preformed similar functions rather than objects that appeared perceptually similar (e.g., Kemler Nelson, 1999). Even engaging in a comparison process in which children were invited to discover commonalities between two or more category members without directly interacting with the objects also inhibited children's attention to shape and promoted conceptual, relational processing (e.g., Gelman, Raman, & Gentner, 2009). Unlike previous studies in which children extended novel labels on the basis of perceptual similarities, these studies, in general, emphasize the importance of two processes in acquiring conceptual categories: structural alignment and access to functional information.

Structural Alignment

As a mechanism to highlight common, relational structures shared across category members, Gentner (1983; Gentner & Markman, 1997; Markman & Gentner, 1993) proposed the structure-mapping theory. In an act of comparing two objects from the same category, common surface features that afford functional or relational information are aligned, drawing attention away from surface-level perceptual properties, such as shape, to increase awareness of the perceptual properties that afford function or relational structures. For example, when adults were shown two pictures (e.g., one in which a man was giving a bag of food to a woman and another where the same woman was instead giving food to a squirrel) and were asked to rate the similarities of the images through comparisons, they frequently matched objects by common, relational systems (Markman & Gentner, 1993). That is, following a similarity assessment, adults suggested that the woman receiving the food corresponded with the squirrel receiving the food. Despite one being human and the other an animal, participants privileged the common relation in their assessment, recognizing that the woman was relationally analogous to the squirrel. In contrast, those who were not asked to rate similarities tended to map the common objects between the two scenes (i.e., the woman). Gentner and Markman (1997) suggest that comparison elicits structural alignment and highlights relational commonalities that correspond with the surface-level similarities.

Under the assumption that structural alignment promotes attention to relational commonalities, young children extend novel labels to familiar objects based on conceptual rather than perceptual properties. Gentner and Namy (1999), investigating the role of comparison in the process of categorization, discovered that after comparing two similarly shaped, familiar objects (e.g., an apple and a pear) four-year-olds consistently overlooked perceptual dissimilarities and extended novel names (e.g., “blicket”) to objects sharing relational properties (e.g., a banana). However, when children were presented only one object (e.g., an apple), they selected matches based on overall perceptual similarities (e.g., a balloon), supporting previous research suggesting that young children often rely on shape when categorizing (Baldwin, 1989; Gentner, 1978; Landau et al., 1988, 1999). Although arguably counterintuitive, comparing two perceptually similar category members enabled children to ignore shape and evoked a process of structural alignment. By aligning salient structural features that afford function (e.g., the shiny peels and stems of apples and pears), subtle relational features are highlighted, including the function of the category members (e.g., apples and pears are fruits and therefore taste sweet, grow on trees, and are edible.). Given that form is often correlated with function (Ware & Booth, 2010), highlighting common perceptual features will often highlight common relational properties, therefore, assisting children in discovering non-salient conceptual commonalities (Gelman et al., 2009).

Extending the paradigm to novel objects, Graham et al., (2010) found that four-year-olds generalized categories to similarly shaped objects in the absence of comparison but with comparison tended to extend membership to structurally distinct objects sharing similar textures. In a task similar to Gentner and Namy (1999; Namy and Gentner, 2002), Graham and colleagues presented preschoolers with novel, geometric objects differing in shape and texture. Invited to compare two objects sharing similar textures, children generalized category membership on the basis of texture rather than shape. Whereas comparison elicited structural alignment and, thus, highlighted a less salient perceptual property (i.e., texture), children who were shown only one exemplar relied predominantly on a more salient, surface-level commonality (i.e., shape) to infer category membership. In addition to highlighting relational properties of familiar categories, comparison also facilitates in categorizing novel objects along subtle perceptual, yet non-relational, features. Important to note, however, is that despite highlighting a less salient perceptual feature, it is unclear whether comparison can facilitate in the discovery of relational structures of novel objects.

Although the previous studies demonstrate that children, through structural alignment, extend novel labels to the object as a whole, Gentner and colleagues (2007) found that comparison can also facilitate children's identification of novel object parts. In this task, three- to five-year-olds were presented drawings of unfamiliar objects and animals, each possessing a unique attribute or part (e.g., a wing), and were provided new names (e.g., "This one has a blick"). Asked to select an additional picture containing the novel label (e.g., "which one of these also has a blick?"), children reliably identified the item sharing the key part between two nearly identical alternatives that matched in shape. By increasing awareness of key perceptual features, structural alignment not only draws attention to relational properties of familiar categories (Gentner & Namy, 1999; Namy & Gentner, 2002) and to subtle perceptual features of novel objects (Graham et al., 2010), but also to key perceptual parts necessary for performing functions (e.g., to fly) and identifying roles (e.g., an animal).

Functional Information

Despite previous studies suggesting that young children primarily categorize on the basis of perceptual cues, such as shape, or attend to relational properties through structural alignment, toddlers can extend novel labels to functionally similar objects even in the presence of strong shape match competitors or in the absence of comparison. Investigating the relationship between function and shape, Kemler Nelson and colleagues (Kemler Nelson, 1999; Kemler Nelson et al., 2000a, 2000b) presented two-year-olds unfamiliar objects with functions that were causally related to specific perceptual features (e.g., a small basket attached to a handle dispensed balls into a nearby out-of-reach chute). With the opportunity to observe as well as to explore the functions, children were invited to generalize the target function to similar objects varying in perceptual similarity and functional affordance. Included in the set were objects that were highly perceptually similar to the target object but could not perform the function, and objects that were highly perceptually dissimilar but could perform the target function nonetheless. Kemler Nelson found that children who explored the objects generalized categories on the basis of similar functions rather than overall perceptual similarity, whereas children who had not interacted with the object tended to extend the novel label by shape (Kemler Nelson, 1999; Kemler Nelson et al., 2000b). By four years of age, this pattern of functional categorization has strengthened along three separate dimensions: when the functions are plausibly linked to the physical structure, when children respond slowly and thoughtfully, (Kemler Nelson et al., 2000a), and when the designers' intended functions are considered (Kemler Nelson et al., 2002). In these contexts, not only did toddlers and preschoolers primarily categorize by function rather than shape, but they also did so without the assistance of structural alignment and comparison.

McCarrell and Callanan (1995) reacted to the dichotomization of shape and function as bases for categorization by underscoring the critical relationship between form and function that exists in both natural objects and artifacts. However, they also note that overall perceptual similarity is an inadequate basis for children to form conceptual categories. Proposing that children draw inferences about function, including behavior, through perceptual information, McCarrell and Callanan explored the importance of relevant physical features when inferring corresponding functions. They presented two- and four-year-olds with drawings of novel animals in which there were clear correspondences between feature and behaviors (e.g., large eyes corresponded with "sees well at night"). They found that when asked to identify animals with matching functions (e.g., "which one sees well at night?") children frequently identified the creature whose form indicated the underlying behavior (e.g., the animal with large eyes). Even in conditions where children saw two nearly identical animals that differed only in key features, young children consistently selected the animal with the feature matching the target function, suggesting that categorizing by perceptual similarity, such as shape, may in fact depend on functional inferences of salient physical features.

Directly investigating the role of function in novel object categorization while indirectly observing the effect of comparison, Booth and Waxman (2002) presented 14- and 18-month-old infants unfamiliar objects and either demonstrated the novel functions or provided novel labels. The stimuli, constructed so that similarly functioning objects also physically resembled each other, were presented such that infants observed two objects from the same category and one contrasting object from a separate category before extending category membership to either one of two objects: one perceptually and functionally similar object or one perceptually and functionally dissimilar object. Booth and Waxman discovered a developmental effect with older infants reliably mapping the novel names onto functionally similar, novel objects. However, because the stimuli matched on function also matched on perceptual features, it remains uncertain whether children were primarily extending category membership on the basis of shape or function. Furthermore, as the study did not explicitly manipulate the opportunity to compare, it is unclear what role structural alignment played in children's use of functional information in this task. Despite these limitations, Booth and Waxman provide one of the first steps towards understanding the role of functional information in the context of comparison when categorizing novel objects.

The Current Study

A growing body of literature has focused almost exclusively on the unique roles that structural alignment or functional information contribute in shifting young children to categorizing on the basis of relational rather than perceptual features. However, given that children have an established ability to inhibit their strong propensity toward shape and to categorize along relational properties in some contexts, can comparison encourage children to focus on and use functionally relevant perceptual cues when categorizing novel objects? That is, does comparison highlight functional affordances of familiar categories and enable children to recognize these same affordances in novel instances? The current study was, therefore, designed to examine 1) the extent to which comparison fosters integration of novel objects into familiar categories and 2) whether comparison does so by highlighting perceptually subtle functional affordances shared among category members.

By examining the unique and combined roles of comparison and functional information in the categorization of *real*, *novel* objects, I propose to extend previous studies that limited analyses to the categorization of either real, familiar objects (Christie & Gentner, 2010; Gentner & Namy, 1999; Landau et al., 1988, 1998) or artificial, novel artifacts (Baldwin, 1989; Gentner, 1978; Gentner et al., 2007; Graham & Diesendruck, 2010; Kemler Nelson et al., 2000a, 2000b). More specifically, however, I plan to investigate the process of structural alignment by examining whether or not functionally relevant perceptual cues are highlighted through comparison. When encountering an unfamiliar object, do children primarily rely on perceptual similarities as a basis for categorizing and as such generalize category membership to similarly shaped objects? Or do children, through structural alignment, categorize by functional and relational properties?

The following two experiments investigated the process by which three-year-old children expand familiar categories to incorporate novel instances. Although prior research demonstrated that four-year-olds benefit from comparison when categorizing familiar objects, unpublished data revealed that when presented novel objects from familiar categories four-year-olds reliably selected relationally similar, yet perceptually dissimilar, category instances even in the absence of comparison. Three-year-olds, however, tended to rely on perceptual similarities of novel objects and use shape rather than function as a basis for categorizing. Given that younger children also benefited from comparison in familiar object categorization, the current studies examined the role in which comparison may assist in the assimilation of novel objects as shown in three-year-olds.

As discussed above, conflicting evidence suggests that preschoolers primarily categorize either by surface-level features (Baldwin, 1989; Gentner, 1978; Graham & Diesendruck, 20101; Landau et al., 1988, 1999) or by relational properties (Christie & Gentner, 2010; Gentner & Namy, 1999; Kemler Nelson, 1999; Kemler Nelson et al., 2000a, 2000b). As the first study examining how structural alignment assists in assimilating novel objects into familiar categories for which the functions are known, I first explored the role of comparison using a forced-choice task similar to those employed in previous studies (Christie & Gentner, 2010; Gentner et al., 2007; Gentner & Namy, 1999; Graham et al., 2010). The second experiment consisted of the same task with the exception that functional information was provided. Although the tasks varied slightly, both experiments attempted to explore how children deepen and expand their categories.

Experiment 1

In Experiment 1, I examined the role of comparison in children's ability to incorporate novel instances into familiar object categories. Children were presented either one or two pictures of familiar objects followed by two pictures of test objects: a perceptually similar, familiar match and a perceptually dissimilar, novel category match. Employing a forced-choice task, children extended the target category to one of the two test objects (Christie & Gentner, 2010; Gentner et al., 2007; Gentner & Namy, 1999; Graham et al., 2010). Under the assumption that structural alignment highlights existing knowledge about the functional relations in familiar categories, I predicted that comparison would facilitate the inclusion of novel items into these categories, even in the absence of strong shape commonalities.

If structural alignment serves to highlight existing knowledge about relational properties such that functionally relevant perceptual features (e.g., the handles on sports equipment and the stems on fruits) are emphasized, then children should extend category membership to novel items regardless of overall perceptual dissimilarities. That is, comparison should assist in shifting preschoolers away from a reliance on shape as a basis for categorizing. If, however, structural alignment by means of comparison does not assist in generalizing novel instances to familiar categories, children are expected to respond with either a preference towards perceptual features or with neither a preference towards perceptual nor relational features.

Method

Participants

Thirty-two 3-year-old children (*M* = 43.72 mos., *SD* = 4.11, range = 37.11 – 50.59), including 22 boys and 10 girls from the Atlanta metropolitan area, participated. Each family was contacted by phone or email after expressing interest in participating in developmental research. Participants were predominately from White or Black middle-class families. An additional 3 children were excluded from the analysis based on experimenter error (n = 1), fussiness and lack of cooperation (n = 1), or showing a side preference on at least nine of the ten trials (n = 1).

Materials

The stimuli consisted of 40 laminated photographs of real objects organized into 10 sets of four pictures each. Each set included two standards from the same object category and two choice alternatives including one perceptual match and one taxonomic match. The two standards were exemplars of the target category (e.g., fruits) that shared similar perceptual features and were selected to be familiar to young children (e.g., an apple and a pear). Among the two choice alternatives, the perceptual match (e.g., a balloon) physically resembled the standards but fell outside of the target category, whereas the taxonomic match (e.g., a kiwano) was perceptually distinct from the standards but within the target category. Unlike the perceptual matches, which were selected to be familiar to preschool children, the taxonomic matches were selected based on pilot data suggesting that the objects were likely to be novel instances of the target category. The possibility of color matching was eliminated by ensuring that none of the stimuli within each set matched in color. A complete list of the stimuli is presented in Table 1 along with a sample stimulus set displayed in Figure 1.

Procedures

In a quiet room, each child was seated at a table across from the experimenter. Parents either sat behind and to the side of the child or observed from an adjacent room via a one-way mirror. The session, which lasted approximately ten minutes, consisted of a forced-choice categorization task and a naming task.

Categorization Task.

Children were randomly assigned to one of two conditions: no compare or compare. In both conditions, the experimenter introduced the child to Lulu the Ladybug, a hand-puppet positioned on the table. After explaining that Lulu needed help identifying pictures, the experimenter invited each child to play a game with Lulu.

For children assigned to the no compare condition, the experimenter began each trial by presenting a single standard and drawing attention to the object by exclaiming, “Look at this one! Do you see this one?” The experimenter then placed the two choice alternatives directly below the picture, as shown in Figure 1A, and asked the child, “Which one of these is the same kind of thing as this one?” The standard presented in each set was counterbalanced across children, and the left-right placement of the perceptual and taxonomic matches was randomized across trials.

For those assigned to the compare condition, the experimenter presented both standards. As in the no compare condition, the first standard was shown with the experimenter saying, “Look at this one! Do you see this one?” The experimenter then placed the second standard directly beneath the first, drawing attention to the picture by exclaiming, “And now look at this one!” She then pointed back and forth between the two standards to prompt comparisons, saying “Do you see how these are the same kind of things?” The experimenter then placed the two choice alternatives below the standards, as depicted in Figure 1B, and asked the child, “Which one of these is the same kind of thing as these ones?” The presentation order of the two standards was counterbalanced across children, and the left-right placement of the choice alternatives was randomized across trials.

In both conditions, responses were recorded by the experimenter after each trial. If a child failed to respond or selected both the perceptual and taxonomic matches simultaneously, the experimenter responded by repeating the instructions and asking, “Can you pick *one*?” If the child, however, selected one alternative but later switched his or her response to the other, the experimenter recorded the child’s first response. Following the completion of one trial, the pictures were removed, and the next trial was administered until all ten trials were complete.

A second, independent coder analyzed the choices from video recordings for 5 children (31%) randomly selected in each condition. Inter-rater reliability was 100%.

Naming Task.

After administering all ten trials, the experimenter re-presented the stimulus cards one at a time and asked the child to tell Lulu the names for the pictures. To reduce potential discomfort with not knowing the names of the unfamiliar objects, the experimenter mentioned that some of the pictures were “really hard” and that he or she may not know the name of every picture. The experimenter then presented the picture cards individually and asked each child to name the objects in English. If the child failed to provide a label or indicated that he or she did not know the name, the experimenter encouraged him or her to provide a functional description by asking, "What do you think we do with it?" In the event that the child failed to respond after the prompt, the experimenter reassured the child and continued to the next picture until every object was attempted.

Naming responses were transcribed and scored by two independent raters as correct or incorrect. A third independent rater resolved all discrepancies. Correct responses were operationally defined as any response demonstrating the child's knowledge of the object's identity or function. These included responding with correct labels at a subordinate, basic, or superordinate category level (e.g., "Liberty coin," "penny," and "money" for the penny) or by responding with the name of different basic level object within the same superordinate category (e.g., "nickel" for the penny). Functional descriptions were also accepted as correct if the child provided enough information to sufficiently differentiate the target category from other potential categories (e.g., "You buy things with it" but not "You take it places" for the penny).

Results

Data are represented as the proportion of trials on which children selected the perceptual match. To assess response differences between conditions, I conducted a t-test indicating that performance in the no compare condition (M = .62, SD = .16) did not differ significantly from that in the compare condition (M = .57, SD = .15), by either subject, $t_{subject}(30) = .60$, p = .57, or item, $t_{item}(9) = 1.03$, p = .33. Regardless of condition or stimulus set, children tended to select the perceptual matches.

Comparisons to chance responding (i.e., .50) further confirmed children's propensity to respond perceptually. The proportion of individuals choosing the perceptual choice was significantly higher than predicted by chance in both the no compare, $t(15) = 2.95$, $p = .01$, and compare condition, $t(15) = 2.41$, $p = .03$.

Although the results suggest that conditions did not differ significantly, most stimulus sets elicited equal or greater perceptual responding in the no compare condition. The exception, however, was the "Things to Ride on" category (see Table 1), which elicited fewer perceptual responses in the no compare condition ($M = .19$) relative to the compare condition ($M = .25$) and lower overall perceptual responding across conditions ($M = .22$) in comparison to the other categories ($M = .65$, $SD = .18$). This outlying item is likely due to familiarity with the taxonomic match (i.e., the Segway). However, group analyses excluding this item did not yield patterns different than that described above.

Individual Patterns Analysis

According to the binomial formula, an individual child must select either the perceptual or taxonomic match on at least eight out of ten trials in order to exhibit reliably above chance performance. In the no compare condition, four out of 16 children displayed consistent perceptual responding, with the remaining 12 children exhibiting no consistent pattern. In the compare condition, two out of 16 children reliably selected the perceptual choices, whereas the remaining 14 children failed to display a consistent pattern.

To further explore these individual patterns, I employed a less stringent threshold, classifying children as selecting the perceptual match below, at, or above chance responding (i.e., .50). The number of children sorted into each category by condition is depicted in Table 2. Consistent with the results from the independent t-tests, a chi-square test of independence revealed that these patterns did not differ significantly across conditions, χ^2 (2, *N* = 32) = .34, *p* = .84. Thus, children, irrespective of condition, reliably selected the perceptual match more often than the taxonomic match.

Naming Analysis

To the extent that comparison highlights perceptually subtle, conceptually relevant features and assists in categorizing novel objects, I explored whether children's performance on naming differed as a function of comparison. Following the criteria described in the method section above, I calculated the proportion of correct responses separately for the standards and for each of the choice alternatives. Within the familiar standards, there was no difference in naming accuracy between children in the no compare (*M* = .86, *SD* = .08) and the compare condition (*M* = .89, *SD* = .09) by either subject, $t_{subject}(30) = -1.02$, $p = .31$, or item, $t_{item}(9) = -1.06$, $p = .32$. In contrast, children correctly labeled the familiar perceptual match marginally more often in the no compare condition (*M* = .93, *SD* = .11) relative to the compare condition (*M* = .84, *SD* = .16), $t_{subject}(30) = 1.96$, $p = .06$. An analysis of the novel taxonomic matches yielded similar effects with children in the no compare condition (*M* = .32, *SD* = .19) correctly labeling the unfamiliar object marginally more often than in the compare condition (*M* = .21, *SD* = .15), $t_{subject}(30) = 1.75$, $p = .09$. The effects were also statistically significant when analyzed by item for both the perceptual, $t_{item}(9) = 2.58$, $p = .03$, and taxonomic match, $t_{item}(9) = 2.83$, $p = .02$, suggesting that despite randomly assigning children to either condition those who viewed only one standard may have been more familiar with the items in general compared to those who viewed two standards, although it is possible that some aspects of the procedure (e.g., cognitive load) may have reduced children's naming performance in the compare condition relative to no compare.

Although all stimulus sets elicited lower naming accuracy of the perceptual match in the compare condition relative to the no compare condition, the “Things to Ride on” category (see Table 1) evoked the lowest accuracy (*M* = .56) in the compare condition compared to the other categories (*M* = .86, *SD* = .09). Naming accuracy for the taxonomic match in this set (*M* = .19), however, did not differ from naming accuracy for the other categories (*M* = .22, *SD* = .16) in the compare condition. These results, when examined in relation to the low rate of perceptual responses in the experiment proper, provide further evidence that the items included in the “Things to Ride on” category often failed to meet criteria standards.

Discussion

Inconsistent with my prediction, there is no indication that comparison assists in highlighting perceptually subtle, functionally relevant features when categorizing novel objects. Children who viewed one standard reliably selected the perceptual match as did children who viewed two standards. Although comparison enabled children to inhibit attention to salient perceptual cues, such as an object’s shape, when categorizing familiar items (Gentner & Namy, 1999), the current pattern with novel instances of known categories suggests that structural alignment may highlight familiar, conceptual properties, but it may not generate new, relational information.

Why would comparison encourage children to ignore the overall shape for familiar objects but not for novel objects? There are three possible explanations; the first being that the discrepancy observed between prior work and the current study may be a function of development. Previous literature documenting the benefits of comparison primarily examined the effects of structural alignment in four-year-olds (Gentner & Namy, 1999; Graham et al., 2010; Namy & Gentner, 2002; Namy et al., 2007). In contrast, I explored the relationship within three-year-olds when reliance on appearance may be at its highest. For instance, because many of the labels learned in early development tend to correspond to objects well organized by shape (Gershkoff-Stowe & Smith, 2004), children may learn that perceptual similarity serves as a reliable basis for categorizing. However, as children grow older and interact with objects of various shapes and sizes, they expand their knowledge about their environment, realizing that shape, although relatively stable across categories, is not always sufficient when categorizing. Given this account, older children may be more likely to generalize by common relational features, whereas younger children may be more likely to adhere to perceptual similarity. In other words, four-year-olds but not three-year-olds may benefit from comparison.

This account, however, cannot explain prior evidence that adults, under certain conditions, form categories on the basis of perceptual similarity when they encounter novel objects (e.g., Landau et al., 1988). To reconcile these differences, a second possible account concerning familiarity with specific categories may explain the inconsistent results between studies. Rather than shifting to conceptual responses as a function of development, children may shift to relational similarities as a function of their familiarity with individual categories. Imai and colleagues (1992), for example, suggest that knowledge about specific items reduces children’s bias towards overall appearances. In contrast to the developmental approach, this explanation proposes that the strength of the shape bias differs across time and categories. When children (and adults) encounter unfamiliar objects, they may initially rely on perceptually salient cues, such as an object’s shape, to infer category membership. However, as objects become familiar, structural alignment through comparison can highlight knowledge about common, relational properties and reduce children’s reliance on shallow, perceptual cues. Therefore, the discrepancy between previous research and the current study may reflect differences in category familiarity.

A third possibility is that relative familiarity with the perceptual choice, not perceptual similarity to the standards, is driving children towards the perceptual choice. Greater familiarity with the perceptual match relative to the taxonomic match may have shifted responses towards familiar objects over novel ones independent of perceptual similarity. However, the fact that familiarity and perceptual similarity were confounded in this experiment makes it difficult to infer the basis for children's preference for selecting predominantly the perceptual match.

The following experiment addresses this limitation by matching the perceptual and taxonomic choices on novelty. If children are driven by physical appearance, then they should reliably select a novel perceptual object relative to a novel taxonomic object when presented one standard. However, if children are driven by familiarity, then the proportion of perceptual responses should equal the proportion of taxonomic responses because neither object is more familiar than the other. By controlling for familiarity and, therefore, removing a confounding variable, I am able to more systematically investigate the role of comparison in novel object categorization.

As discussed above, evidence suggests that children can attend to perceptual functional affordances and extend novel labels to functionally similar objects when functional information is provided (Booth & Waxman, 2002; Kemler Nelson, 1999; Kemler Nelson et al., 2000a, 2000b). Given that preschoolers can use function as a basis for categorizing, will children shift their attention to functionally relevant features of known categories when functional information is highlighted? Because the current study did not incorporate function, it is unclear whether comparison can encourage children to focus on and use functionally relevant perceptual cues when categorizing novel objects. Experiment 2, therefore, explores the process of structural alignment by examining the role of comparison in tandem with function. In the following experiment, I manipulated whether functional information about the category was explicitly highlighted to ascertain whether this additional information will foster children's attention to perceptual cues relevant to function, thereby allowing them to identify the unique relational structures shared by the novel and familiar category instances. Of particular interest is how functional information interacts with the opportunity to compare.

Experiment 2

In Experiment 2, I examined the roles of comparison and function in the assimilation of novel instances into familiar categories. Three-year-olds viewed either one or two pictures of familiar objects and either were or were not given functional information about the target category. As in the previous experiment, children selected either a perceptual or a taxonomic match, but, unlike Experiment 1, both matches were novel. If comparison highlights functionally relevant knowledge of familiar objects and enables children to recognize the same affordances in novel instances, then children in the compare or function conditions should select the taxonomic match more often than those in the no compare or no function conditions. Children who receive both comparison and functional information should respond more taxonomic as a result of the variety of information at their disposal.

Method

Participants

Fifty-two 3-year-olds (*M* = 42.27 mos., *SD* = 3.64, range = 36.41 – 48.43) who had not previously participated in the earlier study completed the task. The sample included 26 boys and 26 girls who were recruited from the same population as Experiment 1. An additional 3 children participated but were excluded from the analysis for showing a side preference on nine or more of the ten trials.

Materials

Forty laminated photographs of real objects were organized into 10 sets of four. Each set consisted of two standard objects and two choice objects including one perceptual match and one taxonomic match (see Table 3). For each set, the two standards and the taxonomic matches were identical to those in Experiment 1 with the exception that two of the ten taxonomic matches were replaced. The foreign coin in the money set was replaced with a triangular coin due to its perceptual similarity to the standards, and the Segway was replaced with a hovercraft due to children's high accuracy in the naming task suggesting that the object, although selected to be novel, was in fact familiar to children of this age. All perceptual matches from Experiment 1 were also replaced with objects that perceptually resembled the standards but were identified as being unfamiliar to most three-year-olds. A sample stimulus set for each experimental condition is depicted in Figure 2.

Stimulus Ratings

Pictorial stimuli.

To confirm that the standards were reliably more perceptually similar to the perceptual match than the taxonomic match in each stimulus set, 33 Emory University undergraduates evaluated the perceptual similarity of each choice alternative to each standard. For each of the 10 sets the two standards were compared to the perceptual and taxonomic matches resulting in 4 pairings for each set, 40 pairings total. The presentation order of the pairs was random; however, the standard always appeared on the left in each pair with the choice alternative on the right. Pictures were resized such that no object differed drastically in size.

Students rated “how similar the pictures looked” in each pair based on overall physical appearance using a seven-point Likert scale, with 7 indicating “extremely similar” and 1 indicating “not at all similar.” As expected, the average perceived similarity of the two standards to the perceptual match was reliably higher than that to the taxonomic match for all ten sets (all *p*’s < .05). When comparing the ratings for each standard individually, greater similarity to the perceptual match than the taxonomic match was observed for all but two of the individual standards: the tricycle and the lollipop both for which the two alternatives did not differ significantly (*p*’s > .05) in their rated similarity to the standard (see Table 4).

Functional information.

To ensure that the functional descriptions selected to characterize each target category were ones that children reliably associated with the categories, I administered a function validation task with an additional 19 preschoolers (M_{age} = 43.53 mos., *SD* = 3.75, range = 36.71 – 48.09). On each trial, the experimenter presented two standards, drawn from separate sets (i.e., distinct categories), and asked the child to identify which object matched the functional information provided by the experimenter. For example, the child might see a pear and a baseball bat and hear, “Which one is juicy inside?” Functional descriptions were counterbalanced within pairings such that another child presented with the same object pairing was asked, “Which one do you play sport with?” The pairings were randomized with the exception that items classified within the superordinate category of food never occurred together. For example, a child was never asked whether the lollipop or the donut “tastes sweet.”

Children reliably selected the object matching the function with 95% to 100% accuracy for all ten target categories. One item was replaced early in testing after several children failed to select the dime in response to the question “Which one do you buy things with?” This description was later replaced with "Which one do you put in a piggybank?" which yielded 100% accuracy for subsequent participants. A complete list of the functional information is provided in Table 3.

Procedures

As in Experiment 1, each child completed the categorization task followed by the naming task.

Categorization Task.

Children were randomly assigned to one of four conditions: compare-function, compare-no function, no compare-function, or no compare-no function. In all conditions, the experimenter introduced the child to Lulu the Ladybug and invited him or her to play a game with Lulu as in Experiment 1.

For children assigned to the no function conditions, the experimental procedures were identical to those employed in Experiment 1, with the exception that both choice alternatives were novel (see Figures 2A and 2B).

For children in the function conditions, however, functional descriptions were provided each time a standard was presented. In the no compare-function condition, the experimenter displayed one standard (e.g., the apple from the fruit category) and drew attention to the picture by exclaiming, "Look at this one! Do you see this one?" The experimenter then provided the functional information while pointing to the object, for example, saying "This one is juicy inside" (see Figure 2C). In the compare-function condition, the experimenter presented both standards and stated identical function information for each (see Figure 2D). After introducing the first object, as in the no compare condition, the experimenter then placed the second standard (e.g., the pear) beneath the first saying, for example, "And now look at this one! This one is juicy inside!" As in the compare condition of Experiment 1 and the compare-no function condition of Experiment 2, the experimenter elicited comparisons by asking, "Do you see how these are the same kind of thing?" as she pointed back and forth between the two standards.

In all four conditions, after presenting the standard(s), the experimenter presented the two choice alternatives, as depicted in Figure 2, and asked children to select the one that was "the same kind of thing" as the standard(s).

As in Experiment 1, responses across all conditions were recorded by the experimenter after each trial. Following the completion of one trial, the pictures were removed and the next trial was administered until all ten trials were complete.

A second independent coder analyzed responses for 4 randomly selected children (31%) in each condition. Inter-rater reliability was 99%.

Naming Task.

The naming task and coding procedures were identical to that in Experiment 1 with one exception: children were not prompted to provide functional descriptions for the unfamiliar objects if they failed to provide a label or indicated that they "do not know." This change was implemented based on pilot testing indicating that with at least half of the stimuli selected to be novel, children often grew demoralized or disinterested in completing the naming task, especially if they were repeatedly questioned about the unfamiliar objects.

Results

The mean proportion of trials on which children selected the perceptual match is depicted in Figure 3. To compare the proportion of perceptual responses across conditions, I conducted a 2 (Compare vs. No Compare) x 2 (Function vs. No Function) Analysis of Variance (ANOVA). The results yielded no main effects of Comparison, $F(1,50) = 2.15$, $p = .15$, or Function, $F(1,50)$

< .01, p = .97, nor did it reveal a significant interaction between Comparison and Function $F(1,50)$ = .47, p = .50, indicating that children's responses did not vary reliably as a function of condition.

An item analysis, however, revealed a significant main effect of Comparison, $F(1,8)$ = 6.40, p = .03, indicating lower perceptual responding in the compare conditions (M = .59, SD = .19) relative to the no compare conditions (M = .67, SD = .19). There was no main effect of Function, $F(1,8) < .01$, p = .94, and no interaction, $F(1,8)$ = .93, p = .36. This constitutes tentative evidence that comparison decreased children's reliance on salient perceptual cues as a basis for categorizing.

Comparisons to chance responding (i.e., .50) were consistent with the item analysis suggesting that children in the no compare conditions tended to select the perceptual match more often than those in the compare conditions. In the no compare conditions, children selected the perceptual match significantly more often than predicted by chance in both the function, $t(13)$ = 2.77, p = .02, and no function, $t(12)$ = 3.86, $p < .01$, conditions. The proportion of perceptual responses in the compare conditions did not reliably differ from chance in either the function or no function conditions, p's > .10.

Individual Patterns Analysis

Based on the binomial formula, a child must select the perceptual or taxonomic matches on eight out of the ten trials to be reliably above chance. Following this criterion, four out of 13 children in the no compare-no function condition consistently selected the perceptual choice, whereas two out of 13 in the compare-no function group showed the pattern. For individuals assigned to the function conditions, four out of 14 in the no compare condition reliably selected the perceptual match, whereas two of the 12 children who were provided with functional information in the compare condition exhibited the perceptual pattern.

Table 5A shows the number of children in each condition whose responses were below, at, or above chance performance using the less conservative measure. A chi-square test of independence revealed that, collapsed across function conditions, the proportion of children who selected the perceptual match on less than 50% of the trials was marginally higher in the compare than the no compare conditions, χ^2 (2, N = 52) = 4.97, $p = .08$ (see Table 5B). An analysis of function collapsed across comparison yielded no reliable effects χ^2 (2, N = 52) = 3.03, $p = .22$.

Naming Analysis

Table 6 depicts the mean proportion of correct responses organized by stimulus items for each condition. As in Experiment 1, children's accuracy in identifying the familiar standards did not differ across conditions and neither comparison nor function resulted in significant differences in naming by either subject or item analysis, *p*'s > .10, indicating that familiarity of the target category exemplars did not differ among conditions.

An analysis of the choice alternatives, however, revealed slight differences in children's naming performance. For the novel perceptual matches, a 2 (Compare vs. No Compare) x 2 (Function vs. No Function) ANOVA yielded no main effects of comparison or function, *p*'s > .10, but instead showed a marginal interaction between comparison and function by subjects, $F(1,50) = 3.55$, $p = .07$. Post-hoc analyses examining the mean proportions of naming accuracy (see Table 6) suggest that although there is no additive benefit of function in compare conditions, function increased accuracy when labeling the perceptual match in the no compare condition. This interaction, however, was non-significant when analyzed by items, *p*'s > .10.

In contrast, children's accuracy in labeling the novel taxonomic matches revealed no main effect of function nor did it yield a significant interaction between comparison and function when analyzed by subject and item, *p*'s > .10. However, an item analysis, showed a main effect of comparison, $F(1,8) = 4.99$, $p = .05$, suggesting that the opportunity to view two standards may assist in generating accurate descriptions and labels for unfamiliar category members. When analyzed by subject, this effect was non-significant, $p > .10$.

Given that children in the compare conditions were more likely to correctly label the novel objects, I analyzed whether children who accurately named or described the category match also tended to select this item during the experiment proper. Although the relationships were non-significant, there was a trend towards higher accuracy in naming predicting higher rates of taxonomic responses (i.e., a lower proportion of perceptual response) for all conditions, $r_{no\ compare\text{-}no\ function}(24) = -.37$, $r_{compare\text{-}\mathrm{no\ function}}(24) = -.06$, $r_{compare\text{-}\mathrm{function}}(24) = -.43$, except No Compare-Function, $r(24) = .20$. However, these correlations, even when collapsed across comparison and/or function, were not statistically significant, all *p*'s > .10.

Individual Items Analysis

As indicated by the adult ratings, two standards from a given target category were not always perfectly matched in their perceptual similarity to the perceptual and taxonomic matches (see Table 4). In particular, for seven sets (i.e., fruits, hats, musical instruments, things to ride on, vegetables, sweets, and sports equipment), adult raters indicated that the intended perceptual similarity relations (i.e., standards being more perceptually similar to the perceptual match than the category match) were stronger for one standard than the other. Assuming that children are driven by overall appearance, children in the no compare conditions who saw standards that share more salient perceptual similarities with the perceptual matches should exhibit higher perceptual responding than children who saw standards that share less salient perceptual similarities with the perceptual matches. It may also be the case that those in the compare conditions may have varied their response as a function of which standard they saw first.

To assess how variability in perceptual similarity influenced responses within individual sets, I examined the correlation between the adult ratings measuring perceptual similarities of the standard to choice alternatives and the proportion of perceptual responses selected in the presence of each standard within the no compare and compare conditions when collapsed across function conditions. The proportion of perceptual selections was identified for each standard in the no compare conditions. In the compare conditions, response rates were based on presentation order of the two standards.

Correlations reveal that adult ratings of the standards' perceptual similarity to the taxonomic match failed to predict the proportion of perceptual responses in both the no compare and compare conditions, p's > .10. Perceived similarity between the standards and the perceptual matches, however, was significantly correlated with children's responses in the no compare, $r(18) = .46$, $p = .04$, but not in the compare conditions, $p = .47$. That is, in the absence of comparison, children behaved in predictable patterns by varying their responses as a function of the perceptual similarity of the choice objects to the standards. In contrast, the same standards evoked a non-consistent pattern when a second standard was presented, providing further support for the benefits of comparison in novel object categorization. More specifically, when standards within a category vary significantly in perceptual similarity, creating situations where an object becomes a strong perceptual competitor, children are less likely to incorporate novel instances into familiar categories without opportunities for comparison.

As discussed in the method section above, the average perceived similarity of the standards to the perceptual match was consistently higher than that to the taxonomic match for all but two items. For neither the tricycle nor the lollipop did the adult similarity ratings for the perceptual match reliably exceed their ratings for the category match. As such, I could not affirm that the perceptual match was indeed perceptually similar to the standard relative to the taxonomic match for those sets. Despite being perceptually dissimilar to the choice alternatives (as indicated by the mean ratings in Table 4), the tricycle elicited the predicted response pattern as more children selected the perceptual match than the taxonomic match in the no compare conditions ($M = .69$).

The lollipop, however, revealed the opposite pattern. When presented the lollipop independently, children tended to select the taxonomic match ($M = .31$). Even when viewing the lollipop in conjunction with the ice cream cone, children responded categorically at a rate comparable to those in the no compare conditions when the lollipop was presented first ($M = .29$) or second ($M = .33$). Viewed in relation with the adult similarity ratings, this unexpected result may reflect typical response patterns when children encounter novel objects without a strong perceptual competitor present. In general, however, children's response patterns are consistent with the adult ratings and confirm that perceptual similarity heavily influences children's categorization of novel objects within stimulus sets.

Discussion

Consistent with Experiment 1, children in the no compare conditions consistently selected the perceptual match, indicating that in the absence of comparison children rely on shape to categorize novel objects. Children in the compare conditions, although not reliably choosing the category match, were less likely to select the perceptual match than those in the no compare conditions. Although this trend was non-significant in the subject analysis, the item analysis and comparisons to chance suggest that comparison encourages children to focus less on overall shape and more on subtle perceptual features that afford function when categorizing novel objects. Contrary to expectations, however, the addition of functional information did not assist in increasing category responses in either the compare or no compare conditions.

These findings are consistent with my prediction that comparing similarly shaped objects from the same familiar category may help to highlight non-obvious properties by increasing attention to functionally relevant, perceptual properties when assimilating novel objects into established categories. The results, however, failed to support my hypothesis that providing functional information would increase category responses.

In contrast to previous research indicating that children can categorize by function when functional information is highlighted (Booth & Waxman, 2002; Kemler Nelson, 1999; Kemler Nelson et al., 2000a, 2000b), children in the function conditions did not differ reliably from those in the no function conditions. One possible explanation for this inconsistency is in the manner of presenting functional information. Whereas Kemler Nelson and colleagues (Kemler Nelson, 1999; Kemler Nelson et al., 2000a, 2000b) invited preschoolers to explore novel artifacts and discover its functions, I provided less obvious, verbal descriptions of familiar objects, potentially adding opportunities for tangential discourse and distractions. Alternatively, for children to categorize primarily by function, it may be necessary for the function to correspond to easily inferable, perceptual cues (e.g., a long, rigid object with an attached basket to deposit balls into an out-of-reach chute, Kemler Nelson, 1999) rather than subtle perceptual features that are more distantly connected to causal properties (e.g., a peel to indicate that fruits are “juicy inside”).

Despite the inconclusive results with respect to function information, the current patterns support the hypothesis that comparison may assist in integrating novel objects into familiar categories.

General Discussion

These two experiments constitute the first in a series of studies examining the process by which children learn to incorporate photographs of real, novel objects into familiar categories. Consistent with previous research employing schematic or constructed stimuli (Baldwin, 1989; Gentner, 1978; Graham & Diesendruck, 2010; Landau, Smith, & Jones, 1988, 1998), the results indicate that children often rely on salient perceptual features, such as shape, to categorize unfamiliar objects. When children are presented a familiar object and are asked to generalize the category to one of two items, they reliably select either the familiar perceptual match as in Experiment 1 or the novel perceptual match as demonstrated in Experiment 2. However, when they are provided the opportunity to compare two perceptually similar standards from the same category, children's shape driven responses were attenuated by the process of comparison. Although comparison failed to reliably elicit category responses, the results indicate that engaging in a comparison process assisted in reducing perceptual biases. Contrary to my expectations, explicitly highlighting functional information about the category did not lead to increased category responding, which may suggest that children are limited in the ways in which functional information helps to elicit functional responses.

The Role of Structural Alignment

Both Experiments 1 and 2 examined the role of structural alignment in novel object categorization; however, only Experiment 2 demonstrated that children can benefit directly from comparison. In Experiment 1, three-year-olds viewed one or two objects from a known category and selected either a perceptual or a category match as belonging to the target category.

Children, regardless of whether they viewed one or two items, preferred the familiar perceptual match relative to the novel category match. However, when the choice alternatives were matched on novelty, the results from Experiment 2 revealed an alternative response pattern. Preschoolers who viewed two standards were less likely to generalize to novel perceptual matches than those who viewed either standard alone. In other words, children's behaviors were consistent with the structure-mapping theory, which proposes that structural alignment renders less obvious, relational structures more salient thus inducing a shift towards a categorical rather than a perceptual response. Although comparison, as demonstrated in Experiment 2, clearly facilitated in the assimilation of novel objects into known categories, the results from Experiment 1 revealed a contradictory pattern.

Given that comparison reduces children's reliance on perceptual similarity, why did children reliably select the familiar perceptual match relative to the novel taxonomic match in Experiment 1? As discussed above, object familiarity, not perceptual similarity, appeared to drive responses. In the first experiment, perceptual matches—in addition to physically resembling category standards—were intended to be familiar to children, whereas taxonomic matches were selected to be novel. Response patterns, when analyzed in correlation with Experiment 2, indicate that, rather than selecting objects on the basis of perceptual or relational similarities, children shifted their responses as a function of familiar items. In other words, children who, after engaging in comparisons, reliably selected the perceptual match had often selected based on familiarity, grouping the familiar items with the familiar standards.

One may argue, of course, that children tended to respond on the basis of perceptual similarity, garnering support from previous evidence suggesting that children exhibit a strong shape bias. However, the second experimental series confirmed that, although young children often rely on shape as an indicator of category membership, the patterns exhibited in Experiment 1 was heavily influenced by object familiarity. After matching the choice alternatives on familiarity by replacing familiar perceptual matches with novel perceptual matches, children who were invited to compare were more likely to generalize to novel taxonomic matches than children who viewed only one category member. That is, in the absence of a familiar perceptual match as a competitor, children benefited from comparison. Thus, these results indicate that the discrepancy between experiments is a function of differences in object familiarity rather than differences in the process of structural alignment.

The response patterns from Experiment 2 corroborated previous research demonstrating the benefits of comparison in object categorization. Consistent with prior accounts examining the process of alignment in word learning (Gentner & Namy, 1999; Namy & Gentner, 2002), spatial relations (Christie & Gentner, 2010; Loewenstein & Gentner, 2001), and novel object classification (Graham et al., 2010), children reliably selected the perceptual match despite its functional dissimilarities to the category exemplars when presented either of the standards individually. In other words, in the absence of comparison, salient perceptual properties such as shape overshadowed subtle relational features, such as functional affordances. As discussed by Gershkoff-Stowe and Smith (2004), reliance on shape is often a reliable strategy in early development that is reinforced by the environment because many of the categories initially learned tend to be well organized by shape.

Although this pattern confirms children's propensity to generalize on the basis of shape, when additional information, such as a second, perceptually similar standard is provided, responses are consistent with the structure-mapping theory proposed by Gentner (1983; Gentner & Markman, 1997; Markman & Gentner, 1993). More specifically, children who were provided with opportunities to compare highly similar category members reduced their reliance on salient perceptual properties, focusing instead on subtle relational commonalities of familiar objects and recognizing similar functional affordances in novel instances. Important to note and, perhaps, counterintuitive is that despite the physical similarity between the two standards, children who viewed both exemplars were more likely to ignore shape and attend to perceptually dissimilar, yet functionally similar, category instances than those who viewed only one exemplar. That is, aligning common surface structures that afford function led to an alignment of common relational structures. By eliciting structural alignment, comparison allows children to detect relational commonalities that are not easily discoverable without additional information in novel objects.

The finding that comparison reduces children's reliance on shape similarity emphasizes two key characteristics about the nature of structural alignment in the assimilation of novel objects into familiar categories: 1) alignment serves to *highlight* existing knowledge and 2) alignment serves to *generate* new knowledge.

The account that comparison enables children to ignore salient perceptual features and attend to subtle relational properties suggests that structural alignment highlights existing knowledge about known categories. When presented with two highly similar objects drawn from the same basic category, children tended to generalize to the perceptually dissimilar taxonomic match more often than those who were presented with one category exemplar. Rather than employing a strategy based on salient surface appearances—as would be expected if children relied exclusively on shape to draw inferences—children engaged in a process of structural alignment and extracted deeper, non-obvious commonalities shared among category members. However, in order to incorporate novel instances into known categories children must first identify the relational structures that define the categories, a process assisted by through the comparison of familiar category members. Because the categories as well as the standards employed in the current study are familiar objects to preschoolers, structural alignment must, therefore, serve to highlight existing knowledge about deeper, conceptual commonalities that link the category members together.

In addition to highlighting existing knowledge, structural alignment also enables children to generate new knowledge about novel objects, as demonstrated in the present study. In order to reduce reliance on perceptual similarity and effectively incorporate unfamiliar items into established categories, children must infer functionally relevant information about novel items to which they had no prior knowledge through subtle perceptual cues. That is, to determine whether a perceptually dissimilar object belongs in a category, children must recognize the functional affordances in the novel instance. For example, to infer that the hovercraft is in fact a thing to ride on, children may be attending to functionally relevant features, such as handlebars, which indicate that the item is primarily a mode of transportation. The fact that comparison decreases perceptual responses, or alternatively increases taxonomic responses, indicates that structural alignment also assists in generating knowledge about relevant, functional properties of unfamiliar objects, thereby facilitating the categorization of novel objects.

As the first in a series of studies investigating the nature of structural alignment in novel object categorization, the current experiments provide evidence that comparing familiar objects facilitates the discovery of functional properties in novel objects. How children acquire new categories by incorporating *novel* objects with *novel* functions has yet to be tested. However, these preliminary results suggest that structural alignment aids in both highlighting existing knowledge and generating new information about the relational properties of novel instances in ways that extend beyond basic perceptual similarity.

The Role of Functional Information

Contrary to my prediction, the data failed to support my hypothesis that functional information increases children's awareness of perceptually subtle, yet functionally relevant, features when categorizing novel objects. If functional information directed attention to relational properties, then children who heard the functional descriptions, regardless of whether they viewed one or two category members, should have more readily incorporated the novel category match into the target category than those who did not hear the descriptions. However, those who received functional information responded comparably to those who did not receive the functional information in both the compare and no compare conditions, indicating that function, at least when presented verbally and when corresponding to subtle perceptual properties, does not reliably facilitate the categorization of novel objects.

Although the current study suggests that functional descriptions neither increased awareness of subtle relational properties nor decreased attention to salient perceptual features, several researchers have argued that children can use function as a basis when categorizing novel objects. Kemler Nelson (1999; Kemler Nelson et al., 2000a, 2000b), for example, found that toddlers extended novel labels to objects that performed similar functions following a brief period of exploration and discovery of the artifacts' intended functions. Meanwhile, Booth and Waxman (2002) reported that infants reliably mapped novel names onto functionally similar objects, whereas McCarrell and Callanan (1995) as well as Ware and Booth (2010) emphasized the non-arbitrary relationship between form and function, noting that children draw inferences and form categories by attuning to salient perceptual features that afford function. Given that function serves as a reliable basis for categorizing and that preschoolers can benefit from functional information when they encounter unfamiliar objects, why does function facilitate the categorization of novel objects in some studies but not in others?

One possibility is that despite evidence suggesting that children favor function over form, functional information may genuinely fail to facilitate children's categorization under certain conditions. Landau et al. (1998), for example, explored the strength of the shape bias in early word learning by testing children's propensity to generalize novel labels on the basis of perceptual features when presented with competing functional information. Although earlier reports demonstrated that children can favor function over form, Landau and colleagues reported that children continued to generalize by shape, even when conflicting functional information was provided. That is, the addition of functional information failed to reliably shift children to functionally similar matches. However, it is more likely that methodological differences between previous studies and my own can account for the discrepancy in the findings across studies. There are at least three differences: the type of stimuli employed, the relationship between form and function, and the presentation of the functional information.

First, the studies demonstrating that children can categorize by function differed from the current study in the primary question driving the research, thereby differing in not only the procedures but also the interpretations. Whereas previous research examined whether children *can* ignore salient perceptual features and categorize by function, the current study investigates whether explicitly highlighting functional information *facilitates* the assimilation of novel objects into familiar categories. Although both approaches explore conceptual development by studying the unique role of function, the two differ in the purpose of the research and, therefore, differ in the methodological procedures. For example, to create conditions in which toddlers would reliably categorize by functional properties, Kemler Nelson (1999) constructed novel objects (e.g., a long, rigid object with an attached basket) to perform novel functions (e.g., to deposit balls into an out-of-reach chute). Others have designed similar artifacts to perform easily inferable functions based on salient perceptual cues (Booth & Waxman, 2002; Ware & Booth, 2010). In contrast, the current study involved not only novel objects but also familiar ones. To provide the assurance that the categories were familiar to young children, real objects were used, and to minimize distractions, pictorial stimuli were employed. The differences between two- and three-dimensional objects, however, may have contributed to differences in children's abilities to draw inferences about those perceptual properties that were functionally relevant. Whereas three-dimensional objects easily convey subtle, perceptually available features, such as weight, texture, and movement, two-dimensional photos are limited strictly to perceptual cues when conveying information. It is possible that children who interacted with novel artifacts generated additional knowledge about function beyond that available perceptually and, as such, had a variety of functionally relevant cues at their disposal in comparison to children who viewed pictorial stimuli.

Second, the discrepancy between those objects designed and constructed for specific studies and real objects selected from the surrounding environment may also evoke differences in the salience of an object's intended function. Although children often rely heavily on overall perceptual similarity to categorize (e.g., Baldwin, 1989; Graham & Diesendruck, 2010; Landau et al., 1988), evidence suggests that children favor function when that function is causally related to structural features in simple, easily inferable ways (Kemler Nelson, 1999; Kemler Nelson et al., 2000a, 2000b; McCarrell & Callanan, 1995; Ware & Booth, 2010). In other words, children reliably categorize by function when there is a clear form-function correspondence between the structure and the intended function. The current study, however, employed a variety of functions that highlighted both external (e.g., "you ride around on it") and internal properties (e.g., "it's yummy and chewy"). Consequently, some functions had obvious form-function correspondences, whereas others were more subtle. For categories with subtle perceptual cues or cues that indirectly related to internal functional properties, children may have encountered difficulty discovering category matches that shared common functions and, therefore, reverted to overall appearance when categorizing novel objects.

A third possible account is that the method by which children discovered the functionally relevant properties influenced children's use of functional information. Unlike prior studies in which children were presented three-dimensional, novel objects and were invited to not only explore but to also discover the intended functions (Booth & Waxman, 2002; Kemler Nelson, 1999; Kemler Nelson et al., 2000a, 2000b, 2002; Ware & Booth, 2010), children in the present study were provided verbal descriptions of two-dimensional, familiar objects. However, for children to generalize new labels to new object by function, prior experience interacting with the object appears to play a fundamental role (Kemler Nelson, 1999). One may argue, of course, that descriptions of familiar objects evoke knowledge generated from previous encounters, rendering short descriptions of known categories as potent as brief interactions with novel objects. It is also possible, however, that verbal descriptions produced the adverse effects of overloading children with verbal information and inviting opportunities for distractions. Thus, in the current study the descriptions may have negated, or at least reduced, the potential benefits of both function and comparison. In order for function to facilitate novel object categorization, it may be necessary to increase the salience of the functional information by devising procedures to encourage direct interactions with three-dimensional objects.

Despite the methodological limitations, the current findings provide evidence that children may employ certain strategies, such as comparison, to help facilitate the assimilation of novel objects into familiar categories. Although functional information failed to increase category responses, I cannot assert from this null finding that children fail to benefit from function. It may be that the functional information explicitly highlighted differed from the functional information emphasized through structural alignment. It is also possible that comparison fails to increase attention to functionally relevant perceptual cues and instead highlights correlated properties that, although are neither causally nor functionally related, often co-occur across category members. The methodological explanations, however, do suggest the potential limitations in children's ability to utilize function as a basis for categorizing, specifically in the nature and presentation of functional information.

Limitations and Future Directions

In addition to the methodological issues of presenting salient functional information, the present experiment does not account for individual differences in children's familiarity with the objects employed in the study. Although pilot data initially confirmed that familiar objects, on average, were highly familiar and novel objects, on average, were not, children differ in their interactions with their environment and, therefore, likely differ in their knowledge about specific objects. That is, what is familiar to one child may be novel to another. In order to gain a clear insight into how children incorporate *novel* instances into *familiar* categories, it will be necessary in the future to identify and exclude children who fail to meet the object familiarity criteria, specifically those who indicate novelty of the category standards or familiarity of the choice alternatives. Employing similar procedures as those used by Gentner and Namy (1999; Namy & Gentner, 2002), follow-up studies should view the naming data as an indication of familiarity and use the proportion of accurate labels and descriptions as a basis for exclusion rather than (or perhaps in addition to) a separate dependent measure.

Although naming data provide a window into object familiarity, the fact that the naming task was performed directly after completing the forced-choice task may have impacted children’s naming responses, in which case post-experiment naming may not be an entirely objective measure as it may overestimate or, conversely, underestimate a child’s knowledge and understanding about the objects. For naming responses to be coded as correct, children were required to provide either an accurate label or an accurate description with enough information to sufficiently distinguish the target category from other potential categories. For example, a child who described the tambourine as “you shake it to make music” provided adequate information to differentiate the musical instrument from other, more general descriptions such as “you shake it.” As such, the former description is coded as correct, whereas the latter is considered incorrect. A child who described the tambourine in general terms, however, may know that the object produces noise and is often used in conjunction with musical instruments but lacks a sufficient verbal description. Despite a child potentially knowing that the tambourine creates music, my data would indicate that the object is unfamiliar thus underestimating his true knowledge. Although the naming data may suggest that familiar objects are in fact novel and, consequently, exclude participants from the analysis, this relatively conservative measure provides the assurance that for children who *do* meet the inclusion criteria the categories are truly familiar.

In addition to measuring category familiarity, the naming data may also be extended to assess object novelty. Instead of determining whether children provided sufficient information to suggest knowledge of familiar standards, the naming data determine whether children provided insufficient information to verify object novelty. It is possible, however, that viewing the choice alternatives simultaneously with the category standards may prime children to respond in the naming task with a general categorical label. For example, viewing the thumb harp in relation to the tambourine may have compelled a child to label the taxonomic match as “music” despite his likely inexperience with the object. Coded as correct, the data would, in this case, overestimate a child’s knowledge by suggesting familiarity of objects—specifically the taxonomic matches—that are in fact novel. Following the assumption that the categorization task primes naming responses, the naming data may be a function of objects co-occurring, indicating learning rather than object novelty. However, because the perceptual match arises from a distinct category separate from that of the standards, it is unlikely that the naming data overestimates familiarity of the perceptual match and thus is more likely to have provided an accurate measure of object novelty for the perceptual alternative. This may explain, in part, why children’s accuracy was overall higher for the novel taxonomic matches than the novel perceptual matches.

Throughout this thesis, I have argued that structural alignment assists in assimilating novel objects into familiar categories by highlighting existing knowledge and generating new information about perceptually dissimilar, novel category matches. Assimilation, however, examines the process by which novel objects become incorporated into established categories. How comparison may or may not facilitate accommodation or, more importantly, the acquisition of new categories has yet to be tested. In future work, it will be important to examine the extent to which structural alignment generates knowledge about novel categories in order to fully explore the role of comparison in the development of categories.

Another point of interest to expound upon is the evidence suggesting that function does not reliably facilitate novel object categorization. To what extent does the current study replicate prior work demonstrating that young children favor form over function (e.g., Landau et al., 1998) and to what extent does it reflect methodological differences (e.g., Booth & Waxman, 2002; Kemler Nelson, 1999; McCarrell & Callanan, 1995)?

Conclusion

Before children learn to reliably categorize objects on common conceptual and relational properties, they first show evidence of favoring shallow, perceptual cues, such as shape similarity, when categorizing. Evidence suggests, however, that young children *can* ignore salient perceptual features and focus instead on subtle relational properties when provided opportunities for either object comparison or functional exploration. The current studies constitute the first step towards understanding how children acquire novel categories by examining the process by which comparison and functional information may or may not assist in the assimilation of novel instances into established categories. The results reveal that comparison may highlight perceptually subtle functional affordances, indicating that structural alignment facilitates the discovery of functionally relevant properties when learning novel objects, although salient perceptual properties such as shape continue to play a prevalent role in children's classification of novel objects. Verbal descriptions of function failed to facilitate in novel object categorization.

Contributing to the literature, the current findings suggest that comparison highlights common relational structures by shifting attention to subtle perceptual features that afford function and generates new knowledge by enabling children to recognize similar affordances in novel objects. Although it is clear that alignment facilitates learning across a range of domains (e.g., language acquisition, analogies, and spatial relations), tasks (e.g., word learning, categorizing, and labeling parts), and ages (i.e., infants, children, and adults), it is unclear how the alignment process would assist or fail to assist in the accommodation of novel instances as well as the acquisition of new categories. Future research may help to discover the process by which categories are acquired, expanded, and modified by exploring the extent to which structural alignment facilitates the discovery of and attention to relevant, functional features in novel object categorization.

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Table 1. Stimulus items listed by category set from Experiment 1

			Choice Alternatives	
Category Set	**Standard 1**	**Standard 2**	**Perceptual**	**Taxonomic**
Pastries	Bagel	Donut	Tire	Funnel Cake
Money	Penny	Dime	Cookie	Foreign Coin
Balls	Baseball	Beach Ball	Orange	Koosh Ball
Fruits	Pear	Apple	Balloon	Kiwano
Hats	Bowler Hat	Top Hat	Bucket	African Hat
Musical Instruments	Drum	Tambourine	Cake	Thumb Piano
Things to Ride on	Bicycle	Tricycle	Eyeglasses	Segway
Vegetables	Corn	Carrot	Rocket Ship	Artichoke
Sweets	Lollipop	Ice Cream Cone	Rose	Gobstopper
Sports Equipment	Golf Club	Baseball Bat	Pencil	Curling Stick

Table 2. Number of children who selected the perceptual match below, at, and above chance performance organized by condition in Experiment 1 (N = 32)

Proportion of Perceptual Choices	**Condition**		**Total**
	No Compare	**Compare**	
< .50	4	3	7
.50	2	3	5
> .50	10	10	20
Total	16	16	32

Table 3. Stimulus items listed by category set from Experiment 2

				Choice Alternatives	
Category Set	**Functional Information**	**Standard 1**	**Standard 2**	**Perceptual**	**Taxonomic**
Pastries	*"It's chewy and yummy."*	Bagel	Donut	Washer	Funnel Cake
Money	*"You buy things with it."* or *"You put it in a piggybank."*	Penny	Dime	Compass	Triangle Coin
Balls	*"You throw it."*	Baseball	Beach Ball	Death Star	Koosh Ball
Fruits	*"It's juicy inside."*	Pear	Apple	Punching Ball	Kiwano
Hats	*"You put it on your head."*	Bowler Hat	Top Hat	Thimble	African Hat
Musical Instruments	*"You play music with it."*	Drum	Tambourine	Air Filter	Thumb Piano
Things to Ride on	*"You ride around on it."*	Bicycle	Tricycle	Cassette Tape	Hovercraft
Vegetables	*"It helps you to grow big and strong."*	Corn	Carrot	Torch	Artichoke
Sweets	*"It tastes sweet."*	Lollipop	Ice Cream Cone	Shekere	Gobstopper
Sports Equipment	*"You play sports with it."*	Golf Club	Baseball Bat	Fireplace Poker	Curling Stick

Table 4. Mean adult ratings of physical similarity between the standards and choice alternatives in Experiment 2

	Choice Alternatives	
Category Sets and Standards	**Perceptual**	**Taxonomic**
Pastries		
Bagel*	5.27	3.00
Donut*	5.15	3.18
Money		
Penny*	4.88	3.27
Dime*	4.82	2.30
Balls		
Baseball*	5.15	4.24
Beach ball*	5.64	4.09
Fruits		
Pear*	5.73	2.78
Apple*	3.67	2.21
Hats		
Bowler hat*	2.88	1.85
Top hat*	4.73	1.79
Musical Instruments		
Drum*	3.66	1.36
Tambourine*	5.73	1.45
Things to Ride on		
Bicycle*	2.82	1.58
Tricycle	1.97	1.91
Vegetables		
Corn*	3.27	1.58
Carrot*	5.30	1.45
Sweets		
Lollipop	2.73	2.28
Ice cream cone*	3.73	1.58
Sports Equipment		
Golf club*	5.85	2.97
Baseball bat*	4.85	3.00

Note: * $p < .05$; similarity ratings are significantly higher for the perceptual match than the taxonomic match; a higher ranking implies greater similarity.

Table 5A. Number of children who selected the perceptual match below, at, and above chance performance organized by condition in Experiment 2 (N = 52)

Proportion of Perceptual Choices	**No Compare**		**Compare**		**Total**
	No Function	**Function**	**No Function**	**Function**	
<.50	0	2	3	4	9
.50	4	2	2	0	8
>.50	9	10	8	8	35
Total	13	14	13	12	52

Table 5B. Number of children who selected the perceptual match below, at, and above chance performance organized across compare and function conditions in Experiment 2 (N = 52)

Proportion of Perceptual Choices	**Collapsed across Function**		**Collapsed across Compare**	
	No Compare	**Compare**	**No Function**	**Function**
<.50	2	7	3	6
.50	6	2	6	2
>.50	19	16	17	18
Total	27	25	26	26

Table 6. Mean proportion of naming accuracy organized by condition in Experiment 2

Stimulus Items	**No Compare**		**Compare**	
	No Function	**Function**	**No Function**	**Function**
Standards	.84 (.13)	.87 (.18)	.89 (.10)	.88 (.09)
Perceptual Match	.01 (.03)	.06 (.08)	.03 (.05)	.03 (.05)
Taxonomic Match	.26 (.17)	.16 (.15)	.26 (.24)	.28 (.19)

Note: standard deviations are reported in parentheses

Figure Captions

Figure 1. Sample stimulus set from Experiment 1 in the no compare (1A) and compare (1B) conditions.

Figure 2. Sample stimulus set from Experiment 2 in the no compare-no function (2A), compare-no function (2B), no compare-function (2C), and compare-function (2D) conditions.

Figure 3. Mean proportion of perceptual responses for each condition in Experiment 2 with standard error bars.

Figure 1

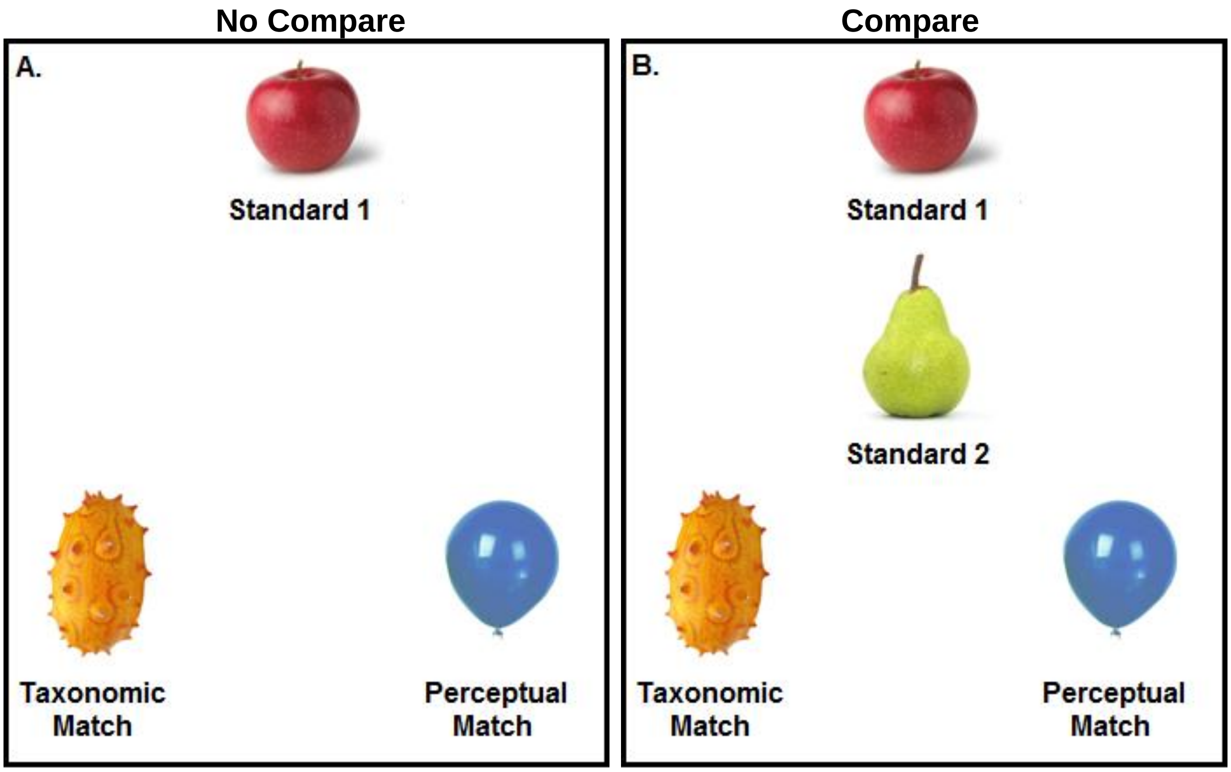

No Compare
Compare
A.
Standard 1
Taxonomic Match
Perceptual Match
B.
Standard 1
Standard 2
Taxonomic Match
Perceptual Match

Figure 2

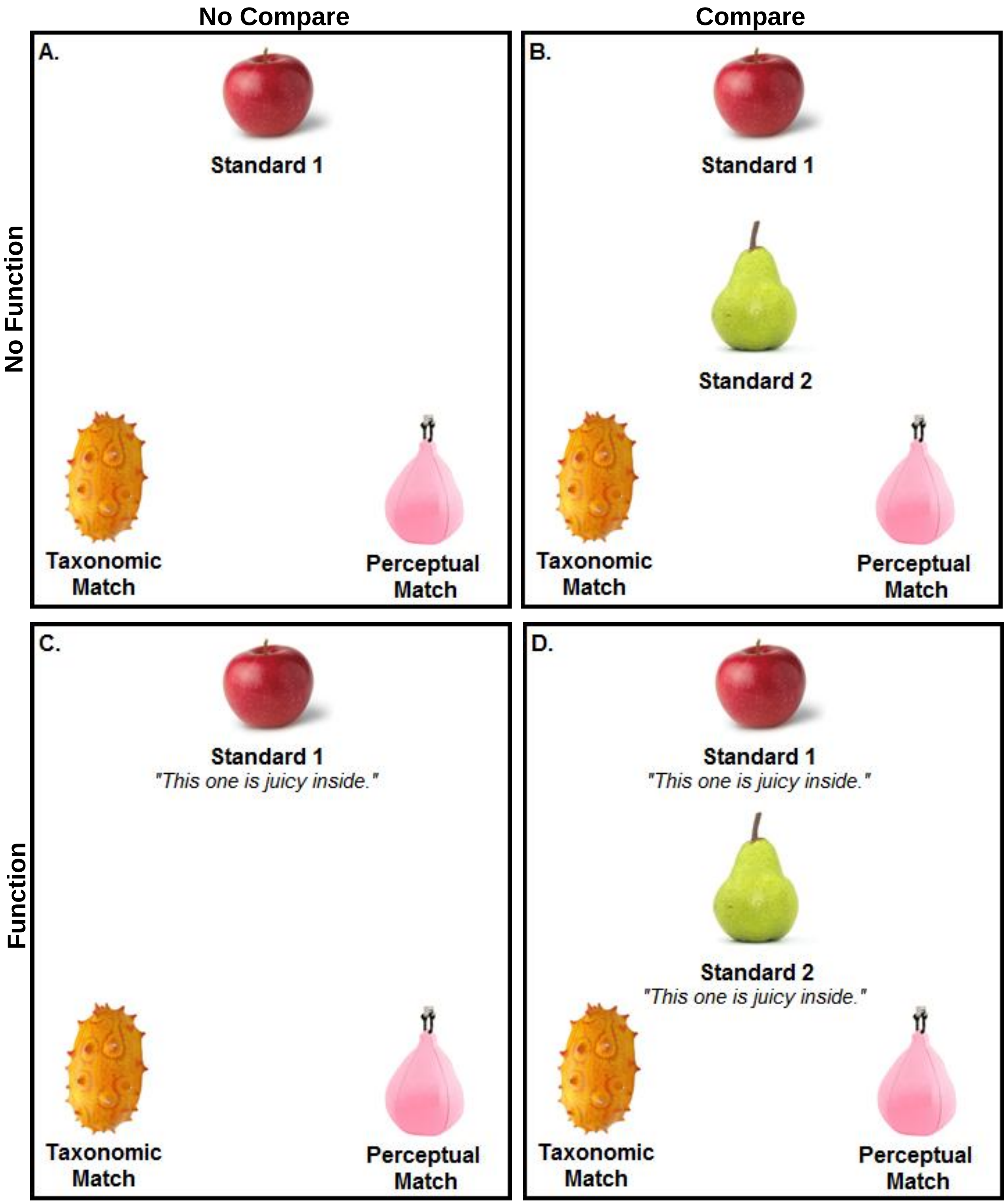
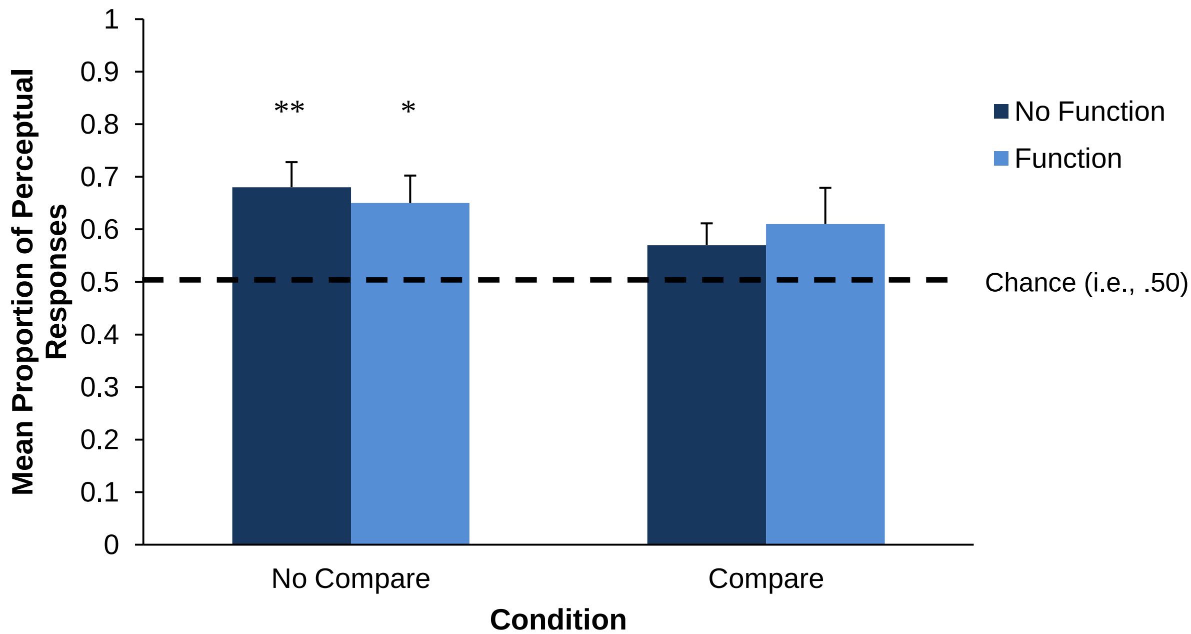

No Compare
Compare
No Function
Function
A.
Standard 1
Taxonomic Match
Perceptual Match
B.
Standard 1
Standard 2
Taxonomic Match
Perceptual Match
C.
Standard 1
"This one is juicy inside."
Taxonomic Match
Perceptual Match
D.
Standard 1
"This one is juicy inside."
Standard 2
"This one is juicy inside."
Taxonomic Match
Perceptual Match

Figure 3



Note: * *p* < .05, ** *p* < .01