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Flexible Categorization in Preschool-Age Children: Comparing Color to Taxonomic Matching Strategies

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Abstract

The ability to categorize objects is essential to efficiently organizing the vast amounts of information and knowledge available in the world. Oftentimes, the same objects can be categorized into a variety of groups, and it is important to be able to flexibly perceive the different properties of objects and the multiple groups that they belong to. Preschool-age children have shown that they can perceive different categories of objects, such as concrete categories defined by perceptual characteristics and abstract categories defined by functional relationships. While the ability to utilize these modes of categorization is available early in development, it has been suggested that the ability to flexibly switch between these categories develops with age. The present study explores how preschool-age children spontaneously match images of objects, based on color or taxonomic relationship, and how flexible they are at switching their categorization strategy from one to the other to make a second match. Our results indicate that preschool-age children are biased to categorize objects by color to make the first match and that the ability to successfully switch between categorization strategies increases with age. A better understanding of how children flexibly categorize objects can be important for developing better educational tools that help children's cognitive flexibility and problem solving abilities.

Flexible Categorization in Preschool-Age Children: Comparing Color to Taxonomic Matching Strategies

The ability to categorize objects helps humans organize vast amounts of knowledge and allows for more efficient cognitive systems. The same objects can be categorized in a variety of ways, for example by concrete factors such as color, size, and shape or by more abstract concepts such as their functional relationship to other objects. Being able to flexibly categorize objects into different, appropriate domains is one measure of overall cognitive flexibility. Cognitive flexibility is essential for problem solving and learning, and seems to develop with age during childhood.

Numerous studies have explored how young children categorize objects. Smith (1984) showed that 3- and 4-year-old children had knowledge of object attributes and dimensions, such as color and size. In her experiment, a child was placed in a paradigm with two experimenters, where each person had three objects. Each experimenter would pick out an object and the child would have to pick one of their own objects after the experimenters' examples, based on an attribute such as color. The child had to abstract the common attribute from the experimenters' choices, form a mental representation of it, and apply it to their own object choice. Young children's success on this task suggested that they had a good understanding of object attributes and dimensions, such as color. An understanding of these perceptual characteristics is important in order to categorize objects.

However, color is not the only way that objects can be grouped together. Nguyen and Murphy (2003) showed that young children, from 3 to 7 years of age, had knowledge of multiple categories for objects, such as taxonomic and script categories. Taxonomic

categories are based on a common, shared property or similarity among category members; for example, “fruits” is a taxonomic category. Items that play the same role form script categories; for example, eggs and cereal are both in the script category of “foods eaten for breakfast”. Using a task where children had to match one of two pictures to a target picture, the experimenters found that 3-year-olds had knowledge of both taxonomic and script categories, and that as children got older, from 4 to 7 years of age, they developed knowledge of additional types of categories as well. The experimenters also discovered that starting at 4 years of age children could effectively cross-classify objects into both taxonomic and script categories, showing cognitive flexibility.

An earlier study by Waxman and Namy (1997) lends support to conclusions drawn by Nguyen and Murphy (2003). Waxman and Namy (1997) explored whether there was a preference by children 2 to 4 years of age to choose thematic categories over taxonomic categories when classifying objects during a forced choice paradigm. Thematic relationships arise between objects when they complement one another; for example, “dog” and “leash”. The experimenters found that these preschool aged children showed knowledge of both thematic and taxonomic category types, and that they did not show a preference for one over the other, but rather switched flexibly depending on the demands of the task.

There have been a number of studies, with varying results, that tested the flexibility of children to utilize different types of category knowledge. There are many different paradigms used to test this ability. One classic paradigm, utilized by Zelazo, Muller, Frye, Marcovitch, Argitis, Boseovski, Chiang, Hongwanishkul, Schuster, Sutherland and Carlson (2003) is the Dimensional Change Card Sort (DCCS) task. In this

task the child is given two target cards that vary along two dimensions; for example, by color and shape, such as a blue rabbit and a red boat. The child is then given a series of cards to sort and a rule such as "all the blue ones go with the blue rabbit and all the red ones go with the red boat". After sorting some of the cards the experimenter changes the rule such that the cards must be sorted by the other dimension; for example, "now all the boats go with the blue boat and all the rabbits go with the red rabbit." Zelazo et al. (2003) showed that 3- to 4-year-old children usually perseverate on the first rule given to them, regardless of whether the color or shape rule is presented first and regardless of having shown the ability to follow each type of rule previously. This seems to indicate a lack of categorization flexibility in children of that age. However, the experimenters found that 5-year-old children performed quite well on the task, and were able to successfully switch between sorting rules.

Deak, Ray and Pick (2004) claim that the classic DCCS paradigm as described above is not sufficient to test preschoolers' ability because the rules are usually too simple, for example using monochromatic colors and prototypical shapes. In a modification of the DCCS task Deak et al. (2004) tested the ability of 3- to 5-year-olds to sort real objects by either an easy rule (shape) or a hard rule (function). The experimenters found that many 3-year-olds failed to follow the function rule, but that 4- and 5-year-olds successfully switched between the shape and function sorting rules. This seemed to indicate, in contrast to Zelazo et al. (2003), that 4-year-olds did have the ability to flexibly switch between categorizing rules.

There are many factors that could potentially influence the ability of preschool age children to show categorization flexibility from task to task, which may account for

some of the conflicting data in the literature. Factors affecting this ability can be both external, such as the instructions given to the child, the way the child is trained on the task, cues during the experiment, and the nature of the task or stimuli (Ionescu, 2007). For example, perhaps the difference seen in the ability of 4-year-olds between Zelazo et al. (2003) and Deak et al. (2004) was due to the stimuli in one experiment being images and the stimuli in the other being real objects. There are also a number of internal factors of the child that can affect their performance, such as attention, memory, language ability, and ability to inhibit a previously correct answer (Ionescu, 2007). In addition, Deak et al. (2004) discovered that social support during the experiment, such as giving reminders about the rule before each trial, could significantly help a child's performance on the sorting task. It is clearly difficult to account for all of these varying factors when assessing measurements of flexibility, but it is important to consider the effects that these may have.

The goal of the present study was to further explore how children categorize objects, and how they flexibly switch between categories. Preschool children from ages 3 to 5 were tested on their ability to match two of three images on one dimension, and then to match two of the three images on a different dimension. The stimuli were designed so that one of the cards could be matched to either of the other two by either color or taxonomic category. The child was not prompted or told of a specific rule for categorizing by the experimenter, but rather tested to see how he or she would spontaneously group the cards. Over a series of trials the child would be presented with three cards and asked, "which two go together?" and "why"? After responding, the child would then be asked "do two others go together, but for a different reason?" and "why"?

Based on a study by Fisher (2011), which showed that processing of perceptual information is more robust than conceptual information in preschool aged children, we hypothesized that the participants would prefer to categorize the objects by color on the first match rather than by taxonomic category. Fisher (2011) also found that the ability to resolve conflicts between perceptual and conceptual information increases as children reach 5 years of age. We therefore predicted that the bias of choosing to group by color on the first match would decrease with age.

The children's ability to be cognitively flexible while categorizing, was tested by asking them to make a second match based on a different dimension. If the child could successfully switch between categorizing two objects based on color and categorizing two objects based on taxonomic category, or vice versa, it would show that the child could flexibly categorize objects in two different ways. We hypothesized that this ability would increase with age from 3 to 5 years.

Methods

Participants

A total of 20 preschool children from ages 3 to 5 participated in the experiment. Participants consisted of 11 male and 9 female children. Most of the children were Caucasian, with the exceptions of one Asian male and one African American male. Children attended one of three local preschools in Rochester, N.Y.: Twelve Corners Day Care Center, Kinderiffic Daycare or Browncroft Day Care Center. The parents of the children signed a consent form giving permission for their child to participate in the study. Parents were not compensated for the study, but children were given a sticker upon

completion of the experiment. The final data included responses from 19 out of the 20 participants, as one child's data had to be discarded due to confusion about the task instructions.

Materials

The stimuli used for each trial were different sets of three colored images of objects, each image cut and pasted onto its own plain, white index card. One example of a trial stimulus set was "sun, banana, apple" (see Figure 1). One of the images matched each of the other two in a different way, either by color or by a taxonomic concept. For example, "banana" matched "sun" because they were both yellow, and "banana" also matched "apple" because they were both considered fruits. However, there was not an overt reason to match the other two images, for example "sun" and "apple". There were 20 experimental trials and 1 example trial for each child, without repeating any of the stimulus sets during the trials. Roughly half of the children were exposed to one, fixed order of the trials and the other half of the children were exposed to the reverse order. A scoring sheet was used to record the child's responses (see Design/Procedure).

Design/Procedure

Each child underwent 20 trials. The child was asked to perform two different matches on each trial. The child was given instructions and an example trial to teach them how to play the game. On each trial, three stimulus cards (see Materials) were laid out in front of the child in a row, the order of which was consistent throughout the study. The experimenter first asked the child which cards matched. After the child responded, the

experimenter asked why. After the child gave an explanation the experimenter asked if two of the cards also matched but for a different reason. After the child responded, the experimenter again asked the child to give an explanation as to why.

Each child was brought to a table at their preschool to do the experiment. The child sat on one side of the table and the two experimenters sat on the opposite side of the table facing the child. One experimenter administered the task while the other recorded responses and explanations of the child.

At the beginning of each child's testing session the first experimenter would say, "We're going to play a game ok? First I'm going to show you how to play." The experimenter then laid out the three example cards, namely with images of a red circle, a green circle and a red triangle. This example stimulus set was chosen to implicitly show the child the game of switching between categories, rather than to explicitly show the child the specific dimensions we wanted them to categorize by. The experimenter would ask, "Which two go together?" The child would respond by pointing or moving two of the cards; for example, by pointing to the red and green circles or by moving those cards together. The experimenter would then ask, "Why do those go together?" to which the child would respond with an explanation; for example, "they are both circles." This was considered the first matching response. To elicit the second match, the experimenter would ask, "Now, do two cards go together, but for a different reason?" The child would then respond in a similar way by pointing to or moving the cards; for example, pointing to the red circle and red triangle, and giving an explanation; such as, "They are both red." During this example trial, if the child struggled with the matches or the instructions, the experimenter would help them by showing them both matches and explaining why.

To begin the experimental trials the experimenter said, “Now we’re going to do that a few more times ok? Let me know if you don’t know what any of these pictures are.” The trials were then repeated in an identical fashion as above, without help from the experimenter if the child became confused or responded “I don’t know.” The children’s responses and explanations for both the first and second match questions on each trial were recorded by the second experimenter on the scoring sheets.

Results

The mean proportions of responses are shown in Figure 2. Children chose to categorize by color on 67.11% of the first matches, and 27.11% of the second matches. Children chose to categorize by taxonomic category on 30.00% of the first matches, and 53.95% of the second matches. Children responded with “I don’t know”, a wrong match, or no answer, collectively known as “other”, on 2.89% of the first matches and 18.68% of the second matches.

For our statistical analyses, data from the “other” category was factored out of the proportions of responses in order to analyze how children made color and taxonomic conceptual matches. Using a t-test we found that the participants chose to categorize by color on the first match significantly above the chance level of 50% (sample mean = 69.3674, $t(18) = 3.6611$, $p = .000719$). Conversely, using a t-test we found that the participants categorized by color on the second match significantly below chance (sample mean = 32.932, $t(18) = -5.9196$, $p = .000789$). Using a linear correlation and regression, we did not find that there was a significant correlation between age and choosing to categorize by color on the first match ($r = 0.3488$, $p = .07$).

Since the "other" category of responses was factored out of the analyses, the only two parameters that were counted in participants' responses were whether they categorized by color or taxonomic concept. If they did not categorize by color, they must have categorized by taxonomic concept and vice versa. Thus, to test the significance of the difference between categorizing by color more on the first match than the second match, and therefore categorizing by taxonomic category more on the second match than the first match, we used a correlated t-test and found that the change was significant ($t(18) = 4.11$, $p = .000657$). This showed that the participants tended to switch their categorization strategy from the first match to the second match (see Figure 3).

To test how the ability of the children to switch between categorization strategies is affected by age we used a linear correlation and regression. We found that there is a significant positive correlation between age and the ability to switch categorization strategies from the first to second matches ($r = 0.7069$, $p = .0007$) (see Figure 4).

Discussion

The ability to categorize objects, and to think flexibly to cross classify objects into multiple categories, helps humans organize the abundance of information and knowledge available to them about the world. Cross-classification of objects is only one measure of the larger phenomenon of cognitive flexibility, which applies to many domains and is critical for problem solving, learning and education.

It has been shown that preschool-age children have the ability to categorize objects on a variety of dimensions, including both concrete, perceptual characteristics like color, and abstract, functional or conceptual characteristics like taxonomic category

(Nguyen & Murphy, 2003; Smith, 1984, Waxman & Namy, 1997). It has also been shown that preschool-age children have the ability to flexibly switch between categories that an object may belong to, although the precise age at which this ability becomes available is unclear (Deak et al., 2004; Nguyen & Murphy, 2003; Smith, 1984; Waxman & Namy, 1997; Zelazo et al., 2003).

Our results show that preschool-age children choose to categorize by color on the first match of the trials, which is consistent with our hypothesis. This supports the study by Smith (1984) who found that young children, starting around age 3, could easily abstract color similarities between objects. Our findings also parallel Fisher (2011), who found that the processing of perceptual information, like color, was more robust in 3- to 5-year olds than conceptual information, like taxonomic category. Contrary to our hypothesis we did not find a significant negative correlation between age and the bias to categorize by color on the first match. However, it could have been that children showed a bias toward color matches because they were unfamiliar with the taxonomic relationship presented in the task or because they were more familiar with color words, rather than because color is a more robust perceptual characteristic for preschoolers. Future studies should account for and balance factors such as object familiarity and word frequency in order to make sure that the children are actually biased towards color, rather than biased toward familiar items or certain language constructions.

Additionally, there may have been a practice effect that influenced children's tendency to choose the color match first. The children may have realized as the trials continued that color would always be a correct match, whereas the taxonomic categories differed in their transparency, thus providing more room for error on taxonomic matches.

It would be interesting to repeat the experiment by keeping all the taxonomic matches consistent and differing the perceptual matches, for example between colors, shape, size etc., to see if children switch to a taxonomic bias for the first match.

According to our data, the ability to flexibly categorize objects is positively correlated with increasing age. Older children in our experiment were better able to categorize by one dimension on the first match and then successfully switch to categorizing by the other dimension on the second match. This is consistent with our hypothesis and with the findings of the above-mentioned studies that found that cognitive flexibility developed with age (Deak et al., 2004; Nguyen & Murphy, 2003; Smith, 1984; Waxman & Namy, 1997; Zelazo et al., 2003). However, our results, like those of pervious studies, may have been affected by some of the factors detailed by Ionescu (2007). For example, there may have been subtle cues by the experimenter to the child to make the correct matches, as it was not feasible for this study to be double blind. Future studies should have both the experimenters be blind to the goals and hypotheses of the experiment to avoid cues or biases.

The present study found that preschool-age children show a bias to categorize based on color rather than taxonomic category when making a match, but that with increasing age these children can successfully categorize taxonomically on a second match, which shows cognitive flexibility. The mechanisms by which children become more cognitively flexible with increasing age, whether it is by brain development or formal education etc., are still unknown. Future research should focus on discovering how children develop these cognitive skills. Having an understanding of this kind of

development could lead to innovations in terms of education, such as teaching children to solve problems creatively and learn new strategies effectively.

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I would like to extend a special thank you to Twelve Corners Daycare Center, Kinderiffic Day Care and Browncroft Daycare Center for their cooperation and participation in this study. I would like to thank Alycia Pontello, Heather Alico and Emily Levine for helping to collect and analyze data for this project. I would also like to thank Dr. Richard Aslin for his support and guidance throughout this study.

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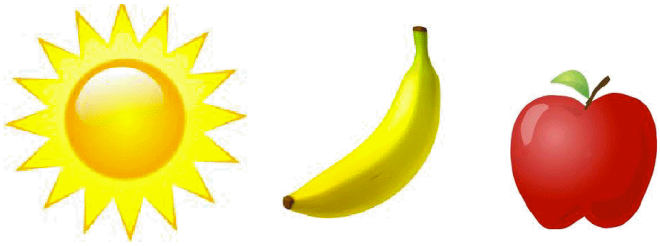
Figure Captions

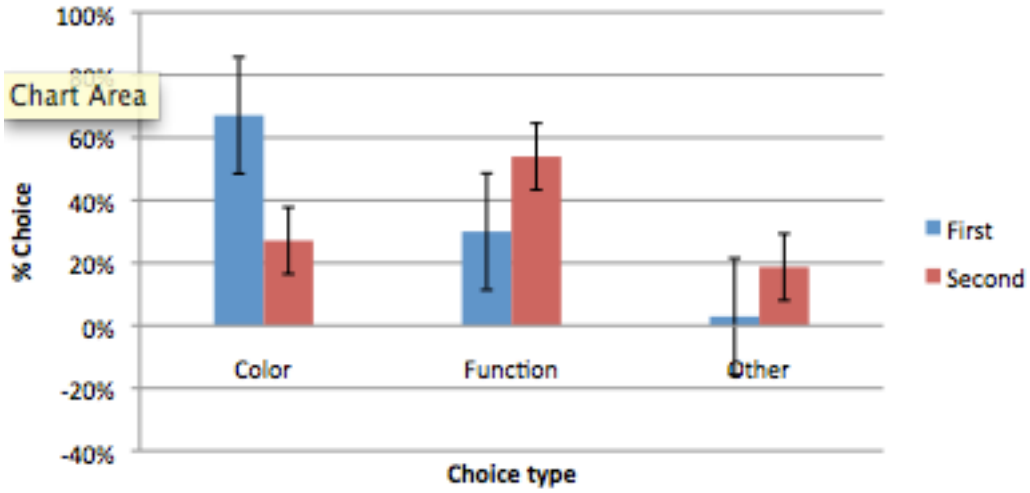
Figure 1: An example of stimulus set from one trial.

Figure 2: A bar graph of the raw data from the experiment.

Figure 3: A bar graph of the experiment data after "other" answers were factored out.

Figure 4: A linear regression showing the relationship between age and flexible categorization ability.

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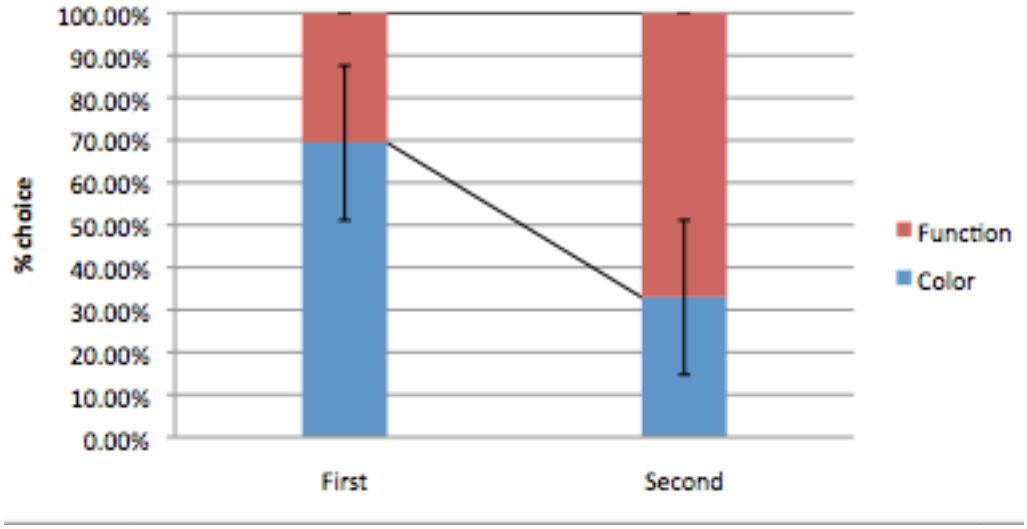
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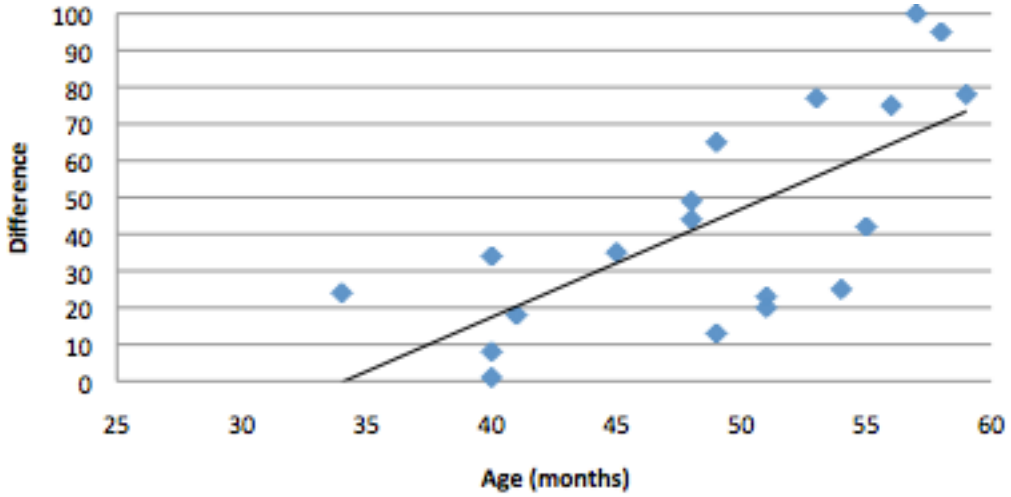
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