Chapter 2

CLASSIFICATION AND CROSS-CLASSIFICATION IN CHILDREN

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ABSTRACT

A major cognitive challenge for children is to make sense of what William James described as the "blooming, buzzing confusion" of the world around them. The aim of this chapter is to examine children's conceptual development, particularly how children use classification, the ability to group items into categories, to structure the world into meaningful units. The history of cognitive development contains a number of theories of a developmental shift from simple conceptual structures to more abstract concepts. This chapter reviews the theoretical and empirical motivations for these theories. This chapter also reviews more recent proposals and evidence suggesting that children are capable of more complex concepts early on in development. In particular, this chapter discusses research on children's cross-classification. While classification involves categorizing a single item into just one category, cross-classification involves flexibly categorizing a single item into more than one category (e.g., a person is both a teacher and parent). These processes of classification and cross-classification reflect the degree to which children flexibly coordinate different categorization systems when considering the same items. It is essential to have this type of flexibility in order to have a rich understanding of the world, and to see items in the world from multiple perspectives.

Keywords: Classification, Cross-classification, Concepts, Script categories, Taxonomic categories

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A major cognitive challenge for children is to make sense of what William James described as the “blooming, buzzing confusion” of the world around them (James, 1890, p. 462). The aim of this chapter is to examine how children make sense of their everyday experiences through conceptual development. Concepts, which are mental representations, have been described as the “glue that holds our mental world together” (Murphy, 2002, p. 1). Concepts are effective in helping children process information because they allow children to parse the world into meaningful categories (classes of objects; Markman, 1989). When a child is riding a bike, for example, the child’s categorization ability allows him/her to separate the information in his/her visual field and to process it into a variety of meaningful categories such as people, animals, plants, buildings, vehicles, and so on.

The history of cognitive development contains a number of theories of a developmental shift from simple conceptual structures to more abstract concepts. This chapter reviews the theoretical and empirical motivations for these theories. This chapter also reviews contemporary proposals. We will argue that placing different kinds of categories in opposition may oversimplify the picture of children’s conceptual abilities and that children may be able to simultaneously form many kinds of category relations. As support for this argument we will describe recent studies on cross-classification. While classification involves categorizing a single item into just one category, cross-classification involves flexibly categorizing a single item into more than one category (e.g., a person is both a teacher and parent).

THE CLASSICAL VIEW

There are indeed a number of proposals describing a developmental shift from primitive or simpler conceptual structures to more sophisticated and abstract ones during the school age years (e.g., Inhelder and Piaget, 1964; Vygotsky, 1962). These proposals fall under the umbrella term of the classical view. The motivation for describing a shift in children’s conceptual development was both theoretical and empirical. Theoretically, the shift was thought to reflect children’s inability to identify and represent abstractions. The notion of a shift was mostly inspired by Piaget’s stage theory of cognitive development, which claimed that young children were incapable of logical operations. So the ability to form abstract concepts was considered just a piece of this more general development of logical thought. For example, being able to logically say that yellow and blue flowers are a part of the whole category of flowers involves thinking about the abstract properties, but not the concrete properties of flowers (e.g., color, shape). According to Piaget, “the ‘intension’ of a class is the set of properties common to the members of that class, together with the set of differences, which distinguish them from another class” (Inhelder and Piaget, 1964, p. 7). In other words, a class of items has a set of criteria or common properties that differ from those of another class of items. Dogs, for example, have four legs, fur, breathe, and bark whereas cars have four wheels, a steering wheel, doors, and an engine.

Empirically, the notion of a shift was also well supported. Many researchers found that until the age of 7 or 8 years, children find it very difficult to classify items into categories such as anima noncategorica sort task, you grouping a man an assorted set. For example, the table (Vyg (Inhelder and )

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such as animals, vehicles, or furniture. Instead, they often seemed to group items together by noncategorical relations. For example, when provided with an assortment of toys in a free-sort task, young children would arrange the toys into a visual scene or display such as grouping a man and a car together, saying that the man would drive the car. Also, when given an assorted set of blocks, young children would focus on the physical properties of the blocks. For example, children would separate the blocks based on where they were already lying on the table (Vygotsky, 1962) or children would place different size circles in an ascending order (Inhelder and Piaget, 1964).

There was an assumption in early work on concepts that taxonomic categories were the only or the only “correct” forms of classification possible. Taxonomic categories are usually organized into hierarchies of increasingly abstract categories, such as terrier-dog-mammal-animal. The hierarchical relationship between the individual items is seen in people’s beliefs, for example, that all terriers are dogs and all dogs are animals. However, for the present purposes, the critical aspect of taxonomic categories is that they are based on common properties or similarity. Dogs, for example, are in the same category because they have four legs, fur, breathe, bark, and so on. These common features allow a hierarchical structure in which more specific categories have all the properties of more general categories, plus further, distinguishing properties (see Murphy, 2002). Most categories picked out by common nouns are taxonomic: chair, fish, telephone, cloud, and vehicle, for example, are all taxonomic categories whose members tend to share certain properties.

A number of researchers have found that young children group items based on other kinds of relations such as thematic and script rather than adult-like taxonomic categories. Objects in a thematic category share a complementary relationship and are often spatially and temporally contiguous. For example, a dog and its leash or cereal and a bowl form thematic pairs, because they relate in a meaningful way and they co-occur in time and space. The dog and leash are not similar; the cereal and bowl do not share many properties. Rather, the leash goes around the dog’s neck and restrains the dog when it is time to go for a walk. The bowl also contains the cereal on the table during breakfast time.

Because such relations are readily observed and have an associative basis, they might be easy for children to identify. For example, when Annett (1959) presented children, approximately 6 to 8 years of age, with drawings of animals (e.g., cow, butterfly), plants (e.g., tree, flower), vehicles (e.g., car, airplane), and furniture (e.g., chair, desk), and asked children to group the items that “go together,” they tended to organize the items into groups that shared a theme (e.g., butterfly and flower). Smiley and Brown (1979) found similar results with even younger children using a forced choice triad task. In this classic study, children were shown a set of fifteen triads. Each triad included a target item (e.g., bird), a taxonomic choice (e.g., robin), and a thematic choice (e.g., nest). For each triad, children were asked which of the two alternatives “goes best with” the target. Children were also tested approximately one week later with another set of fifteen similarly constructed triads. Results showed that preschoolers (4-year-olds) and first graders (6-year-olds) tended to select the thematic choice versus the taxonomic choice and that this preference was stable across the one week time period. Greenfield and Scott (1986) extended these findings to even 3-year-olds, who are also very good at explaining their thematic choices, using explanations that emphasize the complementary relationship between the two items (e.g., “The dog eats the bone”).
Other studies found that young children group items based on their role in scripts (Nelson, 1986, 1988). *Script* categories are formed when items play the same role (not complementary ones) in a script. A script is a schema for a routine event that tells us how and when things are supposed to happen. There are many familiar scripts that are common in childhood such as baking cookies, taking a bath, and going to a restaurant (Nelson, 1986). For example, children's going to a restaurant script might involve sitting down, looking over the menu, placing an order, receiving the food, and finally eating the food. Although there may be some variations between visits to different restaurants, the key pieces remain the same. The food, for instance, is received only after the order has been placed and is always paid for by the customer. Some researchers have suggested that children develop scripts categories by “opening a slot” in a script so that different items can fill the “slot” (e.g., Nelson, 1986). For example, a child may have a script for foods to eat for breakfast, in which different foods (e.g., eggs, cereal) can interchangeably or simultaneously fill a slot in the script. Thus, eggs and cereal both are in the script category of breakfast foods, not because they complement each other (like the leash and dog), but because they play the same part in the same event schema (what is eaten at breakfast).

Script categories have been found to be especially important in memory and free association tasks. For example, Lucariello and Nelson (1985) found that 3- and 4-year-olds recalled items that were related by a script (e.g., pants, socks, shirt) better than a taxonomy (e.g., pants, coat, pajamas) and theme (e.g., pants-closet-hanger). Using a production task, Nelson and Nelson (1990) found that 5-year-olds produced more examples of script categories (e.g., outdoor clothing) than taxonomic categories (e.g., clothing). Yu and Nelson (1993) have subsequently extended the findings of these two studies to Korean-speaking children. Moreover, Lucariello, Kyratzis, and Nelson (1992) have provided further evidence for the earlier emergence of script categories than taxonomic categories. In Experiment 1, four- and 7-year-olds were asked to provide examples of animals, clothes, food, furniture, and tools. In Experiment 2, four- and 7-year-olds were asked to say words that come to mind after hearing a word (e.g., dog, ice cream). The results from Experiment 1 showed that younger children provided more examples from the script categories (e.g., zoo and farm animals). In addition, younger children in Experiment 2 provided more words that shared the same script as opposed to the same taxonomy with the target (e.g., dog-cat as house pets). Sell (1992) also used a word association task with preschool and elementary school children and found similar results.

Disputes regarding whether children form taxonomic categories have tended to create an exclusive approach to the study of categorization in which researchers attempt to discover which form of conceptual organization children use. Across the studies reviewed above, when taxonomic categories were pitted against other types of categories, the findings suggested that young children do not form taxonomic categories, but rather thematic or script categories. In other words, children do not shift to the adult form of classification, taxonomic categories, until around age 7 years.

However, proposals for a shift in the nature of children's classification have been criticized in three ways. First, a number of studies have found that children can form taxonomic categories. Clearly, they have no difficulty in learning basic-level categories such as dog, telephone, chair, tree, etc. even at very early ages. In one study, Rosch, Mervis, Gray, Johnson, and Boyes-Braem (1976, Experiment 8) presented a group of children with triads in which the target could be matched with a basic level choice or an unrelated choice (e.g., a cat:
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Another group of children were presented with triads in which the target could be matched with a superordinate choice or an unrelated choice (e.g., a cat: a fish, a car). Both groups of children were asked to point to "the two that are alike, that are the same kind of thing." Three-year-olds were extremely accurate at categorizing at the basic level (99%) relative to the superordinate level (55%). Children can even learn artificial basic level categories that map onto a taxonomic hierarchy (e.g., artificial animals that resemble squid and salamander; Horton and Markman, 1980).

In addition, children can even learn superordinate categories under certain conditions. Markman and Hutchison (1984) were able to increase superordinate categorization when they presented children with novel labels in a picture triad task. The rationale behind using novel labels was that nouns draw children's attention towards categorical relations since they do not encode information about thematic relations. Markman and Hutchison (1984, Experiment 2) presented 4-year-olds with picture triads that had a target (e.g., cow), a superordinate taxonomic choice (e.g., pig), and a thematic choice (e.g., milk). In the novel word condition, the experimenter pointed to the target and said, "See this? It's a kind of dax. Can you find another kind of dax?" In the no word condition, the experimenter pointed to the target and said, "See this? Can you find another one that is the same kind of thing as this one?" The results showed that children were more likely to select the taxonomic choice when a novel label was used in the task than when no label was used at all (69% versus 49%). Waxman and Gelman (1986) found parallel results with 3-year-olds when they used novel labels (actually Japane terms) in a free-sorting task as opposed to a triad task.

Markman, Cox, and Machida (1981) also found another way to increase superordinate categorization in young children. These researchers suggested that young children's tendency to categorize items thematically in object sorting tasks is due to the salience of spatial configurations. For example, when given an array of objects, children might be especially interested in how the items can be placed next to each other to form a meaningful, story-like scene. In this study, the researchers reduced the salience of spatial configuration by requiring 3-year-olds to sort small toys into bags as opposed to on a table. The results showed that sorting the toys into small bags helped children categorize superordinately (e.g., placing furniture in one bag and vehicles in another bag) more often than when sorting the toys on a table. Thus, it is clear that children can form taxonomic categories, both at the basic and superordinate levels.

A second criticism of the proposal of a shift was that a number of studies have found that children are not as strongly interested in thematic relations early on in development, contrary to the traditional claim. In one study, Dunham and Dunham (1995) presented children with a match to sample task where there was a target (e.g., police car), a taxonomic choice (e.g., car), a thematic choice (e.g., policeman), and an irrelevant choice (e.g., lamp). Children saw the target and then were asked, "Can you find another one the same as this one?" These researchers found that there was a general preference among 3-year-olds for the taxonomic choices. In a follow-up study, the researchers provided a more stringent test of children's taxonomic categorization by reducing the perceptual similarity between the targets and taxonomic choices. For example, when the police car was the target, the taxonomic choice was a Volkswagen Beetle, not a sedan, because a police car and Beetle are perceptually less similar. Even when perceptually similarity was minimized, 3-year-olds still had a preference for the taxonomic choices and this preference was stable across a two week time period. Indeed some research has even suggested that there may be a reversal of the shift from basic
level taxonomic categories to thematic relations and finally to superordinate level taxonomic categories (see Blanchett, Dunham, and Dunham, 2009; Gelman, Coley, Rosengren, Hartman, and Pappas, 1998).

Questioning the conclusion that children have stable conceptual preferences, Waxman and Namy (1997) tried to discover the contexts or circumstances under which children may display different conceptual preferences. In this study, children were presented with small objects arranged in triads. Each triad included a target (e.g., carrot) and a taxonomic choice (e.g., tomato) pitted against a thematic choice (e.g., rabbit). The researchers found that 4-year-olds had a preference for the thematic choice when asked to select an alternative that “goes best” with the target. Yet, 4-year-olds had a preference for the taxonomic choice when asked to find “another one” of the target (similar to the findings of Dunham and Dunham, 1995). Waxman and Namy (1997) explained that phrases such as “find another one” emphasize taxonomic categories for children whereas phrases such as “goes best” emphasize thematic relations. The researchers concluded that children do not have an overarching, stable conceptual preference, but rather children rely on different concepts depending upon the demands of the situation. A number of studies have found corroborating evidence that the specific wording of instructions influences children’s preference for different types of categories by emphasizing some, but not other, relations (e.g., Deak and Bauer, 1995, 1996; Tarc and Gelman, 2010). Other studies have also found that different aspects of the testing stimuli influence children’s tendency to use one kind of category relation as opposed to another (e.g., Cimpian and Markman, 2005; Golinkoff, Shuff-Bailey, Olguin, and Ruan, 1995; Sheuner, Bonthoux, Cannard, and Biaye, 2004; Ware, Gelman and Kleinberg, 2013).

The third criticism of the shift was that studies have found that adults use thematic and script categories when the relations are sufficiently strong. Past studies found that elderly adults in the United States (e.g., Annett, 1959; Smiley and Brown, 1979) and adults without Western education (e.g., Luria, 1976) prefer thematic relations. Studies have also found thematic categorization among college-age adults. For example, Murphy (2001, Experiment 1) used a free sorting task that included stimuli that were equally conducive to thematic and taxonomic categorization. In the neutral condition, adults heard directions that were unbiased; the adults were told to arrange 9 pictures into “groups that seem best or most natural to you.” In the enhanced condition, adults heard directions that were designed to highlight taxonomic categorization. In this condition, adults were given the definition of a category, which is “a set of things that share some commonalities...” Murphy (2001) reasoned that if adults grouped the stimuli thematically even after hearing directions that pulled for taxonomic responding, then this would be strong evidence for a thematic preference. The results showed that adults created thematic categories across the two conditions and that there was not a significant difference between the two conditions.

Lin and Murphy (2001, Experiment 1) also found thematic responding among college-age adults using a forced-choice triad task. In this study college-aged adults were presented with conflict triads with a target (e.g., cat), a taxonomic choice (e.g., lion), and a thematic choice (e.g., litter box). The results revealed that 62% of adults selected the thematic choice when asked to decide which item “goes best” with the target. Even when the directions were modified to be less biased towards thematic categorization, adults still showed some thematic responding. When Lin and Murphy (2001, Experiment 2) asked adults to select the two items that “best form a category” approximately half of the adults selected the thematic choice (49%). Although there was less thematic responding when the directions were modified, the
researchers pointed out that the important finding was that taxonomic categorization was not the only form of categorization that was used. Rather, thematic relations were still important, even for the college-age adults. This overall body of results on adults makes it difficult to argue that thematic categories are primitive.

In summary, the notion of a shift has fallen out of favor for three reasons. First, research has demonstrated that children form taxonomic categories (e.g., Rosch et al., 1976; Horton and Markman, 1980; Markman et al., 1981; Markman and Hutchinson, 1984). Second, children are not as interested in thematic relations (e.g., Dunham and Dunham, 1995; Waxman and Namy, 1997). Third, research has found that even college-age adults form thematic categories (e.g., Lin and Murphy, 2001; Murphy, 2001). Thus, it is unlikely that there is a developmental shift from thematic or script categorization to taxonomic categorization. It is also unlikely that these other types of categories are replaced with taxonomic categories, suggesting that children’s categorization abilities are more complex than the shift had predicted.

Although taxonomic categories are useful, other modes of categorization can also be useful in everyday life. For example, Markman (1989) points out that children must learn thematic and script categories such as things that are found at a birthday party, things you bring to school, breakfast foods, and so on, as part of their learning about the activities in their culture. Rather than outgrowing such categories, we may continue to use thematic and script categories alongside taxonomic categories in adulthood (Murphy, 2001).

**CONTEMPORARY VIEWS**

While the classical view has fallen out of favor, a contemporary version of it still exists in the field of cognitive development. As mentioned earlier, the ‘classical view’ depicts children’s dependence on perceptual similarities, on concrete associations and on atheoretical strategies for learning (Smith, Jones and Landau, 1996; Sloutsky and Fisher, 2004). Indeed, some researchers continue to assert that children use ‘dumb attentional mechanisms’ (DAM) to notice superficial, perceptual similarities or to make simple associations of and among objects (Smith et al., 1996). It is from these external associations that children form what appear to be complex categories (Smith et al., 1996). From this view, children lack both knowledge and the logic structure to form adult-like concepts and therefore rely on salient features on which to base their concepts (Sloutsky, 2003; Piaget, 1929). Children use these simple mechanisms until reaching school age, whereupon they are taught to reason about their world, thereby building their knowledge as their concepts become more adult-like (Smith et al., 1996; Sloutsky and Fisher, 2004; Sloutsky, 2003). This view is based on Piaget’s (1929) proposal that young children are incapable of creating richly structured, cohesive concepts based on a deeper meaning of how objects, people and animals interact with each other and the world around them.

In contrast, different approaches to the study of children’s classification have also emerged and garnered favor within the field of cognitive development (see Murphy, 2002 for review). Many of these approaches base children’s categorization abilities on a deeper, more active processing of their world rather than merely making perceptual associations or tracking statistical information. Contrary to the ‘classical view’ are researchers who believe in an
one such view is the naive theory or theory-theory approach to the study of children’s concepts. According to the naive theory approach, children are “little scientists” who are cognitively predisposed to learn about their world by organizing information into theories (e.g., Carey and Spelke, 1994; Gelman and Kalish, 2008). These theories are intuitive or lay theories that children continue to update based on their everyday experiences and interactions with others. While the naive theory approach does not discount children’s use of perceptual association or tracking statistical information to categorize, children are able to form categories that are beyond the concrete information available to them (Gelman, 2003; Gelman and Kalish, 2008). Children may use perceptual similarities and track statistical information in such a way that aids in the building of their naive theories (Gelman and Meyer, 2011).

This approach suggests that children have theories or abstract representations of how the world works, and then fill in the specific details as they learn more from others (Gelman, 2003; Diesendruck, 2003). For example, 4-year-olds, and to a lesser extent 3-year-olds, while they are not knowledgeable about exactly what the internal parts of natural kinds and artifacts are, do know that the insides are different and can accurately perform a sorting task based on their internal parts (Gelman and Wellman, 1991; Simon and Keil, 1995).

Indeed, in a landmark study by Gelman and Markman (1986), it has been found that children use non-obvious, hidden properties as criteria for category membership. These researchers tested whether children could categorize animals based on category membership and not on perceptual similarities. Children were presented two objects, e.g., a dolphin and a shark (labeled fish), and were told a novel property of each (e.g., ‘this dolphin pops above the water to breathe’ and ‘this fish stays underwater to breathe’, respectively). A third picture of a tropical fish is presented, which is perceptually similar to the dolphin, but is labeled as a fish. The child is asked how this fish would breathe. Children as young as 4-years-old were able to categorize based on category membership (e.g., selecting the shark that breathes under water) even when the choice was perceptually dissimilar to the target. These results were also obtained when the test object was labeled with a synonym of the target category member rather than the identical label (Gelman and Markman, 1987). This ability to categorize based on category membership rather than perceptual similarity has been extended to infants younger than two-and-a-half (Jaswal and Markman, 2002). (For a more extensive review of how children use labels as cues to rich, cohesive categories please see Gelman, 2003; Jaswal, 2004; Noles and Gelman, 2012).

This section provides evidence that children have a much more active and interactive role processing the items in their world, including early sensitivity to the internal features of items in a category.

**Cross-Classification**

A challenge to research examining young children’s categorization abilities is developing methods sensitive enough to determine these abilities. Past research stemming from the classical view of concepts has tended to pit different forms of categories against each other, assuming that taxonomic categorization was the single, most accurate form of categorization. This research has tended to underestimate children’s conceptual abilities. New perspectives
on concepts, including the naive theory approach, however, have led to the recognition that children may form and use different kinds of categories. This research has recently opened the door to exploring cross-classification. While classification involves categorizing a single item into just one category, cross-classification involves flexibly categorizing a single item into more than one category (e.g., a person is both a teacher and parent). Cross-classification is an important developmental ability. As children acquire more knowledge of the world, they come to recognize that the same entity can be perceived in many ways, and differing in the particular perspective they bring to bear on it. For example, thinking of someone as a parent, a teacher, a soccer player, an extravert, and so on, may be important to understanding the complex behavior of a single person. Thus, it is essential to children’s full understanding of the world that they be able to cross-classify items.

Although a number of key studies described in the previous sections have shown that children can form different kinds of categories, few studies have shown that children can cross-classify a single object into these categories. For example, studies have typically used a between-participants design, demonstrating that different groups of children can form different categories under varying circumstances (e.g., Waxman and Namy, 1997). Some studies have also shown that children can categorize an item into different categories at different times.

True cross-classification, however, entails the same child categorizing a single object into more than one type of category. In order to fully understand an item that potentially belongs to many categories and to interact with it appropriately, it is essential for children to be able to cross-classify. There is indeed emerging evidence for cross-classification in children. In one study by Blaye and Bonthoux (2001), children were allowed to spontaneously categorize a target item taxonomically or thematically. For example, children were asked if an axe goes best with a shovel and hammer (taxonomic pair) or log and stump (thematic pair). One week later, children were presented with a drawing of a scene that primed children to use a different form of categorization than before. For example, if children had originally selected the shovel and hammer (the taxonomic pair), then they would have been shown a forest, a thematic scene. If children had originally selected the log and stump (the thematic pair), then they would have been shown a tool shed, a taxonomic scene. Blaye and Bonthoux (2001) found that by age 5 years, children changed their initial form of categorization of an item from taxonomic to thematic or vice versa when provided with a contextual cue. Blaye and Jacques (2009) also found similar evidence for children’s ability to switch in succession between two category representations of an item the researcher has made simultaneously available to children.

Nguyen and Murphy (2003) also examined cross-classification in 4-year-olds, 7-year-olds, and adults by focusing on taxonomic (e.g., vegetables, meats) and script (e.g., breakfast foods, dessert) relations within the domain of food. Nguyen and Murphy (2003) found that by age 4 years, children spontaneously cross-classify foods into both taxonomic and script categories, classifying ice cream, for example, as a dairy product and as a dessert on different occasions. Another example is Nguyen (2007) who examined the use of both taxonomic and script systems of categorization for thinking about the same items from different domains in addition to food, including animals, clothing, and furniture. This research replicated the findings of Nguyen and Murphy (2003) with food and extended these findings to other domains. The results showed that by age 2 to 3 years, and with improvements around age 4 years, children have knowledge of both taxonomic and script organization and use these two
very different systems of organization for cross-classification. These results suggest that cross-classification involving taxonomic and script organization is not domain specific. Rather, in this case, cross-classification is potentially applicable to any domain in which it is possible for the same items to be organized based on both taxonomic and script relations.

Nguyen and Gelman (2011) recently compared the effect of generic versus specific noun phrases on children’s cross-classification of items that belong to a taxonomic and script category. In these experiments, children were given the opportunity to classify an item into a familiar category (taxonomic or script), and then to cross-classify the item into an alternative, novel category (script or taxonomic) with the help of clues expressed in generic or specific language. The prediction was that if generics have a facilitative effect on children’s cross-classification, then children should tend to cross-classify more when they hear clues expressed in generic (e.g., “Animals are sols”) than specific language (“These animals are sols.”). As predicted, generics helped 5-year-olds and adults make the connection between an item and its multiple category memberships to cross-classify items more than specific noun phrases. Generics may have this facilitative effect by referring to categories as a whole as opposed to referring to individual items in the categories, thereby highlighting for children the different groups that a single item belongs to simultaneously.

There is also growing evidence that children are able to reason about the different category memberships of a cross-classified item in order to make appropriate inductive inferences about novel items. This ability is called *inductive selectivity*. For example, Kalish and Gelman (1992) found when reasoning about items with overlapping object and material categories (e.g., wooden pillow belongs to the object category of pillow and material category of wood), that by age 4 years, preschoolers consider material composition as a crucial category for inferences about the properties of fragility and texture. For instance, when asked if a wooden pillow was hard or soft, children focused on the material category of wood as opposed to the object category of pillow, and answered that it was hard.

Nguyen (2012) also found that by age 4 years, children have the ability to appropriately make different types of inferences about a single cross-classifiable item based on its taxonomic and script category membership. Children use taxonomic categories for biochemical inferences that are based on the common properties of items whereas they use script categories for situational inferences that are based on the role that items play in a routine or event. For example, when children were told that a target item had novel stuff inside and were asked to select another item that also had the same stuff (e.g., “Mip is special stuff inside of a cat. Do you think a kitten or pumpkin also has the same special stuff inside?”), children tended to select the taxonomic choice (e.g., kitten) as opposed to the script choice (e.g., pumpkin). In contrast, when children were told that an item is for novel special time and were asked to select another item that was also for the same special time (e.g., “A cat goes with a special time called Mip. Do you think a kitten or pumpkin also goes with the same special time?”), children tended to select the script choice (e.g., pumpkin) as opposed to the taxonomic choice (e.g., kitten).

To begin investigating how children learn inductive selectivity, Hayes and Lim (2013) have recently uncovered the role that awareness of context cues plays in children’s selective induction. Using a training protocol, these researchers found that children and adults could not learn to make selective inferences in the absence of conscious awareness of the relationship between the context and the appropriate dimension for responding (e.g., color, shape).
Shafto, Coley, and Vitkin (2007) have also found that older, school-aged children will use their knowledge of a living thing's taxonomic relations when reasoning about its internal properties, but will use their knowledge of a living thing's ecological relations based on its habitat or predation when reasoning about the impact it may have on an ecosystem. Coley (2012) has also revealed that school-aged children's ability to selectively draw upon ecological versus taxonomic relations is influenced by children's environment and experiences with nature such that there is earlier selectivity among children residing in rural areas than suburban ones.

**FUTURE DIRECTIONS**

Given that the classical view on concepts does not take into account children's cross-classification, a future direction for conceptual development research is to develop a model for how children mentally organize different types of categories that are used for classification and cross-classification. One such model may be a nonhierarchical network that captures the shared similarity among items in a taxonomic category as well as the roles that items play in a script category (cf., Lakoff, 1986; Ross and Murphy, 1999). Because items can be cross-classified into taxonomic and script categories, children might organize these category relations in a type of nonhierarchical network that does not have the organizational structure of a hierarchical or taxonomic network.

Although aspects of the nonhierarchical network may be organized hierarchically, items in this network are connected to many coexisting and noncompeting categories. Consider the case of ice cream that could be connected to the taxonomic category of dairy products and the script category of birthday party items. Individual items within the network are then connected to each other through shared category membership. So cheese and ice cream may be related because they are both dairy products. In addition, a gift and ice cream may be related because they are both birthday party items.

A child's decision to categorize ice cream as a dairy product or birthday party item may be influenced by the context of the situation. For instance, if the category of birthday party items is not deeply entrenched, then this category may only be activated in certain contexts such as when ice cream and gift are seen together at a party. Otherwise, if ice cream and cheese are seen together at the grocery store, then the category of dairy products may be activated. A child's decision to categorize ice cream as a dairy product or birthday party item may also be goal directed (see also Barsalou, 1982, 1983, 1985, 1991). For example, if a child is helping to plan a birthday party, then ice cream and gifts may instantly come to mind. Of course being able to activate more than one connection at a time could be extremely useful and is possible in a nonhierarchical network so long as a child is able to coordinate the different category relations simultaneously. For example, knowing that ice cream is both a dairy product and birthday party item is especially helpful when organizing a birthday party for a friend who is lactose intolerant.

In addition, it will be important for future research to examine the underlying mechanism that helps facilitate children's navigation through such a nonhierarchical model. There are now a number of studies that have examined children's cognitive flexibility or ability to switch between different strategies or responses as a result of changing context cues or task
demands (e.g., see Best, Miller, and Jones, 2009; Deák, 2003; Jacques and Zelazo, 2005; Miller, Chatley, Marcovitch, McConnell Rogers, 2014). As related to categorization, cognitive flexibility may allow children to consider different types of categories that an item may belong to, depending upon the situational context. Cognitive flexibility may be highly relevant to children's cross-classified concepts because it involves flexibly considering different categories that a single item belongs to, as opposed to allowing one category to dominate children's representation of an item. Future research should examine the relation between cognitive flexibility and children's sensitivity to different kinds of category relations.

**CONCLUSION**

Throughout the history of the study of cognitive development there have been many theories that describe how children undergo a marked shift in the formation of simple to more complex concepts during the school age years (e.g., Inhelder and Piaget, 1964; Vygotsky, 1962). In this chapter we have argued that pitting different kinds of categories oversimplifies children's conceptual abilities and that children are able to simultaneously form a variety of category relations and use them for classification and cross-classification. As we continue to move away from the classical view of concepts, and gain a better understanding of children's classification and cross-classification, further research will be needed to develop and test new models, including a nonhierarchical network.

**REFERENCES**


Classification and Cross-Classification in Children


