

# **Children's acquisition of categories and the implications for research in the development of classification schemes**

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## **ABSTRACT**

Categorization ability has important implications for children's use of information retrieval (IR) systems. This paper critiques prior investigations in the field of child acquisition of categories and discusses some of the problems with prevailing approaches and methodologies. The theoretical framework based on essentialism adopted by many researchers is insufficient for explaining certain observations. This paper offers an alternative framework of expertise and linguistic relativity, which affords a perspective on child understanding of categories rooted in cultural values, especially as reflected in language. On this view, emergent understanding of categories is tightly bound to development of language expertise. For some researchers, an adult understanding of language has tainted their interpretation of children's understanding of categories. Finally, this paper suggests implications for future research toward the development of new classification schemes to accommodate children.

## **1. INTRODUCTION**

As digital information resources become more commonplace in children's lives, library and information science (LIS) researchers have shown increasing attention to children's information-seeking behavior in online environments. Many information retrieval (IR) systems designed for children are found to require categorical knowledge and skills beyond children's abilities. Children face particular challenges using bibliographic classification schemes employed in IR systems. However, systems designers have overlooked an extensive body of experimental literature on child categorization behavior. This paper offers a critical review of the cognitive development literature on categorization and highlights findings that are relevant to the development of classification schemes. At the same time, we believe that a lack of linguistic perspective too often leads to a perceived lack of understanding and identify limitations in prior research where the underlying framework has not taken linguistic relativity into account. From this review, we argue that classification researchers and systems designers must first attend to the experimental literature on child categorization and furthermore incorporate a broader view of child categorization as a socio-linguistic activity.

## **2. CATEGORIZATION ABILITY AND IR SYSTEMS**

In research on children's information seeking behavior, a few studies have detailed the difficulties that children of all ages have in using IR systems, especially due to bibliographic classification schemes. Neuman (1995) reports that one major hurdle to database use in high school library media centers is the mismatch between students' ideas of how information is

organized and the ways information is actually indexed. In research on children's Web searching, Bowler, Large and Rejskind (2001) note that middle-school students had little understanding of the hierarchical organization of knowledge. Several researchers have found that the quality of classification plays a major role in retrieval performance (Borgman, Hirsh, Walter, & Gallagher, 1995; Busey & Doerr, 1993; Solomon, 1993; 1994). In particular, Busey and Doerr (1993) observe that the ten main Dewey classes were not relevant to elementary school children's information needs. Borgman et al. (1995) found that intermediate school children had a particularly difficult time locating "fire trucks" in the Dewey hierarchy, which required navigating the hierarchy from "engineering" to "building for city services."

Similarly, a number of researchers have found that the terminology commonly employed by children in interactions with bibliographic classification schemes often does not match the subject headings used for indexing (Eaton, 1989; Moore, 1995; Poston-Anderson & Edwards, 1993; Solomon, 1994). For instance, Solomon (1994) notes that the everyday vernacular elementary school children use in their queries (e.g., "bikes" and "planes") often does not match the OPAC's subject headings (i.e., "bicycles" and "airplanes"). In a review of the literature, Eaton (1989) found that the vocabulary levels of subject headings meant for children are at a sixth-grade level or higher. Finally, Neuman (1993) and Agosto (2002) found that high school students wished that online databases and Web search engines categorized resources in ways that better suited their needs.

To address the difficulties that children have in using traditional IR systems, researchers and systems designers have developed several systems designed especially for children, such as Book House (Pejtersen, 1979; 1986; 1989), the Science Library Catalog (Borgman, Chignell, & Valdez, 1989; Borgman et al., 1995; Borgman, Krieger, Gallagher, & Bower, 1990), Kid's Catalog (now The Library Corporation's Kid's Catalog Web) (Busey & Doerr, 1993), Bücherschatz (Külper, Schulz, & Will, 1997), and the International Children's Digital Library (Druin, 2005; Druin et al., 2003). These tools introduce features meant to support children's developmental abilities, such as point-and-click interfaces, as well as simplified classification schemes. In each case, the design of these systems was informed largely by interviews and naturalistic observations of children's information-seeking behavior, though Borgman et al. (1989) asked children to complete exercises categorizing plant and animal terms. Work by Cooper (2000; 2002; 2004) also explores how children come to an understanding of library classification schemes.

However, by and large, the cognitive development research on children's categorization has yet to influence the design of IR systems for children. In her dissertation, Cooper (2000) observes, "While child-like thinking will eventually develop into adult-like thinking, approximately ten years of potential intellectual development are not supported by present information systems" (p. 32). Further understanding of children's category acquisition is necessary for the development of classification schemes and IR systems that support children's changing categorization ability.

### **3. ACCOUNTS OF CATEGORY ACQUISITION**

In the experimental literature on child categorization, it has been popular to investigate children's categorization skills and behavior by observing reactions to artificially constructed choice conditions. Generally the experimental tasks are constructed in an attempt to isolate a process of

induction or to assess a child's state of world knowledge. From these investigations, several accounts have emerged to explain children's ability to recognize or induce certain types of categories. In general, young children—usually under age seven—have been shown to perform differently on categorization tasks than older children and adults. Most frequently, *taxonomic* categorization abilities are contrasted against young children's propensity for categorization by common *perceptual* features and/or by *thematic* relationships. However, results have been inconsistent across a number of studies. We believe that there is a problem in the underlying framework generally being applied in categorization studies. Furthermore, we believe that categorization is inherently tied to expertise in the use of language in one's culture, and that such a view gives a far more parsimonious account of child development in categorization ability. First let us consider some of the past empirical work.

### 3.1. Empirical perspective

The work on categorization and cognitive development originates with Piaget and his categorization experiments, including especially his class inclusion problem (Inhelder & Piaget, 1969). Piaget found that children do not classify on a consistent basis until age four or five. Instead, according to Piaget, young children made spatial and thematic groupings without any unifying rationale. When children began to construct consistent categories, they overlooked salient, non-obvious features, attending instead to more striking perceptual features of objects. The Piagetian tradition continues in more recent work from Gentner and her colleagues (Gentner, 1988; Gentner & Namy, 1999; Namy & Gentner, 2002; Ratterman & Gentner, 1998), who propose that a "relational shift" occurs. The relational shift argument holds that, with development, children come to appreciate *relational* commonalities, such as function, causality, role relations, and progeneration. Four- and five-year-old children are shown to prefer metaphors that grew out of physical characteristics—"a snake is like a hose"—to those based on functional relations—"the moon is like a light bulb" (Gentner, 1988). Likewise, four-year-olds preferred perceptual matches to taxonomic matches, such as pairing an apple with a red balloon rather than a banana (Gentner & Namy, 1999). A similar claim has been made that children shift from syntagmatic to paradigmatic ways of categorizing things (Lucariello, Kyratzis, & Nelson, 1992; Nelson, 1977).

Another view offered by Keil (1989) is the "characteristic-to-defining shift," a process in which children develop the ability to recognize central or defining features in the face of other characteristics. In one study, Keil examined children's understanding of meal terms, asking them to listen to a description of a nonstandard meal and to name it (pp. 84-111). Kindergarten and second-grade children were unwilling to accept, for instance, a morning meal consisting of steak, potatoes, and apple pie at which the family dressed up to receive company as breakfast. These children based their judgment more on the type of food and/or the level of formality rather than the time of day. Older children did point out the *irregularity* of such meals, but consistently defined meals based on *time-of-day*, thus recognizing this as a "defining" characteristic for meals. In a series of related experiments, Keil examines the shifts in children's use of different characteristics to define various types of categories, including artifacts, natural kinds, and nominal kinds. On this view, children may be seen as universal novices, developing expertise at different rates within different domains.

More recently, researchers have reframed the debate about acquisition of categories, arguing against any clear-cut developmental shifts and recalling Rosch et al.'s (1976) observation, "It would not appear to be a fruitful approach to ask whether children classify on the basis of form *or* function *or* attributes *or* category names *or* 'similarity' or any other single criterion" (p. 422). Recent research has established that children have access to a variety of categorization modes, depending on task (Deák, Ray, & Pick, 2002; Kalish & Gelman, 1992; Nguyen & Murphy, 2003). In studies, children exhibit flexibility in their categorization behavior, attending to different information under different circumstances. For instance, three-year-old children correctly inferred that a wooden pillow would be hard, basing their judgment on the object's material properties rather than its taxonomic category (Kalish & Gelman, 1992). Likewise, four- and seven-year-olds were able to cross-classify foods into different types of categories, matching sausage links taxonomically with steak (as meats) on the one hand and thematically with pancakes (as breakfast foods) on the other (Nguyen & Murphy, 2003). Blending the perspectives presented above, these researchers have posited that development occurs along with experience in the world and what develops is the child's ability to select the appropriate mode of categorization for the task at hand.

Finally, one of the most promising perspectives on category acquisition grows out of research on expertise. In work on categorization with *adult* novices and experts, a number of researchers have found results that recall the findings of Piaget and Gentner. In work with students and professors with differing levels of experience in physics, novices relied on surface features when categorizing physics problems, whereas experts used abstract principles (Chi, Feltovich, & Glaser, 1981). Similarly, in work with experienced commercial fishermen and novices with little knowledge of fish, novices favored appearance when classifying fish, while experts relied on specific environmental and behavioral factors (Shafto & Coley, 2003). As with the children at different ages in Piaget's class inclusion experiments, adults perform qualitatively differently on categorization tasks depending on their level of domain expertise. Like young children, adult novices seem to be preoccupied with perceptual features, whereas experts attend to non-obvious features and reason about abstract concepts. Studies such as these suggest that the differences Piaget observed in children's categorization abilities may be a function of expertise rather than a result of developmental change.

Indeed, research on expertise in children has challenged prevailing notions of children's performance with regard to categorization. For instance, young children with domain expertise are able to look beyond perceptual features to organize their knowledge according to abstract features. Chi and her colleagues (Chi & Koeske, 1983; Gobbo & Chi, 1986) found that four- to seven-year-old children with dinosaur expertise used the non-obvious feature of diet to organize dinosaur categories. Children with domain expertise also use their knowledge to draw inferences. Chi and colleagues (Chi, Hutchinson, & Robin, 1989) further found that seven-year-olds with dinosaur expertise could successfully categorize unfamiliar and novel dinosaurs by making domain-related inferences, whereas novices were less successful because they were limited to their less useful general world knowledge. Novice children sorted dinosaurs based on visual similarity, but the expert children sorted dinosaurs into families on the basis of implicit features. Finally, children and adults can perform more or less equally in well-known domains. Adults and five- to nine-year-old children, both with dinosaur expertise, performed equally in dinosaur sorting tasks (Johnson & Eilers, 1998). When asked to group pictures of dinosaurs,

adult and child experts alike attended to subtle physical features and behavioral characteristics while adult and child novices focused on surface features alone.

However, recent research has revealed the limitations of expertise. Several studies have shown that children's expert knowledge is locally confined and isolated from other systems of related knowledge. For instance, Johnson and colleagues (Johnson & Eilers, 1998; Johnson, Scott & Mervis, 2004) found that adults who were experts on dinosaurs could transfer their ability to other related biological domains with which they were unfamiliar, such as birds and fish, while child experts could not. When asked to sort the fish and birds into categories, adult dinosaur experts made decisions based on non-obvious characteristics such as diet, whereas the child dinosaur experts performed at the same level as novices, attending only to surface features. These findings signal a significant gap in the prevailing paradigm under which child categorization is usually investigated and require a more detailed theoretical framework.

### **3.2. Theoretical perspective**

The traditional empirical perspective on child categorization has been to assume children's categorization ability undergoes a qualitative change over time and that the changes in categorization ability are universal and occur with maturation. Investigations of expert performance seriously challenge this perspective, emphasizing the *domain dependency* of knowledge. Thus categorization ability is highly domain dependent. We argue that there is a further socio-linguistic component in child categorization that is often overlooked—that expertise in categorization must be seen as a relative difference in culture-specific language expertise. Many studies of children's categorization behavior look for lines delineating what the children “understand” about “real world” categories. Some, such as Gentner, look for differences in understanding caused by changes in visual and auditory cues. Others, Keil for example, look for shifts in behavior over time. However, many of these studies employ paradigms that may be obscuring the child's true understanding. Moreover, the experimental tasks cannot be fully separated from the social task of verbal communication. The language of describing a meal, for example, is not inseparable from the social function of meals. Our language often privileges social and cultural relationships over other types of relationships. Researchers investigating the boundary between linguistics and epistemology must take into account the influence that language has on their own understanding. Otherwise, differences in linguistic perspective can lead to conclusions of differences in understanding—differences that may not actually exist.

Whorf suggested that the principle of relativity applies to linguistics in much the same way that it applies to physics. He argued that we cannot make observations of other cultures and languages without being affected by our own language in the process. “We are thus introduced to a new principle of relativity, which holds that all observers are not led by the same physical evidence to the same picture of the universe, unless their linguistic backgrounds are similar, or can be calibrated” (Whorf, 1956, p. 214). If we grant that child language is not exactly the same as adult language, then some sort of “calibration” must be factored into experimental analysis of child categorization behavior. The limitations of an essentialist perspective may have caused some researchers to miss a bigger picture. Categorization choices are not made by children in a social void; they are made during interactions with more “knowledgeable” adults. It is not sufficient to focus on the aspects of *things* which children use to “identify” categories. Important

aspects of *language* use in categorization must also be carefully considered. Choice of categorical terms is dependent on knowledge of cultural values—knowledge that is encoded in whatever language is being used to describe the categorical relationships. When assessing experimental results, it is important to ask whether an observed effect is due to changes in the subjects' ability to understand the world or a change in subjects' linguistic perspective. On this view, domain knowledge and socialization are at the heart of differences in children's categorization. Expertise in categorization might not be separable from expertise in a culture's language.

In an interesting study of language use, Bowerman and Choi (reported in Bowerman, 1996 and described by Hays, 2000) find important differences in the way spatial categories are understood by English and Korean children. They point out that notions of “in” and “on” are encoded quite differently in English locative prepositions and Korean motion verbs. As a result, children in these cultures acquire categories of placement and containment relations in different ways depending on their native language. For English speaking children, putting a cup on a table and putting a lid on a container involve the same spatial relationship between two objects, and can be described with interchangeable verbs and prepositions. For Korean children, placing a lid on a container also involves fitting two shapes together, and requires a different motion verb (“kkita”) to describe the action. This difference is not emphasized in English and is not expressed by English speaking children. Bowerman and Choi's results are important. An essentialist view of categories, based only on the physical world, has no power to explain their observations. But, if we take the view that children are learning to perceive their world *through their language*, observations such as Bowerman and Choi's make a great deal of sense. On this view, English and Korean speaking children are simply being guided by their language to focus on different relationships between things. As they achieve greater expertise in their language they will, by extension, achieve greater expertise in attending to those features and relations that are privileged in their language.

Like implicit rules in a complicated game, the rules of one's language limit the ways one can speak about things. When developing a methodology for evaluating children's categorization behavior, it is important to consider whether elicited responses are pure expressions of knowledge or complex turns in a game of language. In *Philosophical Investigations*, Wittgenstein (1997) gives a detailed discussion of the role that language plays in our developing understanding of the world around us. Use of language, for Wittgenstein, is very much like playing at a game. In the context of child learning, language games “are informal but ritualized interactions between a child and an adult by means of which a child is trained in certain features of his native language” (Pitkin, 1972). For Wittgenstein, language games are a kind of drastically simplified model of how language works. Within his simplified model, the child plays at language while discovering the implicit rules that govern language use. Language games involve not just speech but other activities linked with speech, including categorization. Taylor (2003) gives the example of a child's acquisition and use of the word “kitty.” The child might first apply the term “kitty” to the family pet and later extend its meaning to apply to other animals or soft things in general. At some point, the child will have learned to apply the term to all cats, but not to dogs or other soft things. As Taylor points out, the child is learning how the term “kitty” can be used in communication while simultaneously building a new category of KITTY-like things. Extending this to a consideration of children's intellectual access to classification schemes, it is easy to see that a child will understand components of the scheme

long before she puts them to use. Whether reacting to an experimental stimulus or browsing a library catalog, any expression a child makes regarding categories must be taken in the context of a sophisticated social game—one in which the child is learning to play with language.

#### **4. IMPLICATIONS**

Differences in experimental technique have led to different and often conflicting observations in child categorization studies. To our knowledge, no single theory of category acquisition can account for all the observations. All too often, the social and linguistic components of categorization tasks are overlooked in analysis. For example, the standard procedure in many studies has been to present the child with certain visual stimuli—objects that stand in certain relations to one another—and ask the child to choose an object that stands in some relation to a target object. The research focus has been on the object that the child chooses and the categorical relation(s) between the chosen object and the target object. Rather than focusing on different *objects* and *labels*, the research should explore how the child reacts to different *scenarios*. The responses children give should be analyzed as *linguistic expressions* in response to contextual cues rather than snapshots of their knowledge and understanding of *categories of things*. Children’s responses reveal what they understand about language interaction. The focus of research into child categorization behavior should be re-oriented to include assessments of language expertise. We believe that two areas in particular—child understanding of hierarchies and attention to salient characteristics—hold significant opportunities for improvement in research. Classification schemes and IR systems for children will benefit from the findings of future research in these areas.

##### **4.1. Hierarchical organization**

When researchers compare children’s categorization behavior with adults or discuss the ways in which children develop toward “adult-like” ways of categorizing, they are generally thinking of taxonomically-related, hierarchically-arranged categories. Clearly, part of category acquisition is a progression toward an understanding of the ways in which a culture hierarchically organizes concepts. Markman (1989) notes that “a heightening of interest in categorical relations ... takes place with development” (p. 24). We would further emphasize that this development goes hand in hand with acculturation and language development.

As they come to understand hierarchical organization, children face particular issues related to superordinate categories and mutual exclusivity. Early on, Rosch et al.’s (1976) groundbreaking work established that three-year-old children experienced difficulty sorting objects that are taxonomically related (e.g., cars and motorcycles) because they were unable to recognize superordinate categories (e.g., vehicles). In contrast to objects at Rosch’s basic level, individuals do not interact with superordinate level objects; they cannot form images of superordinate level objects; nor are superordinate level objects explicitly differentiable. Sorting objects at the basic level is easy for even very young children, but sorting objects at the superordinate level poses greater challenges as it requires greater understanding of semantic categories. Even nine- to twelve-year-old children have been shown to struggle with superordinate categories in the Dewey hierarchy to locate categories of interest (Borgman et al., 1995). Lacking facility with semantically organized superordinate categories necessarily limits children’s ability to make use of hierarchically-arranged information.

Children also struggle with the overlapping nature of hierarchical class-inclusion relationships. For example, in a study by Callanan & Markman (1982), two- and three-year-old children insisted that a doll cannot also be a toy and that a hammer cannot also be a tool. Linguistic perspective is important here too. Markman (1989) suggests that children assume that category terms are mutually exclusive as part of an efficient strategy of language acquisition: novel words must imply some sort of contrast in order to be maximally communicative. However, this view falls short for real-world scenarios. Deák (2000) points out that while mutual exclusivity may be a useful *base* assumption for acquisition of some concepts, when multiple relations are apparent to the child, mutual exclusivity is less likely to be the default assumption. Language provides implicit cues about the utility of alternative interpretations in different scenarios. New research should explore the role of language in how children come to understand hierarchical relationships.

#### 4.2. Salient characteristics

The availability of different kinds of information leads children to make different categorization decisions. Differences in stimulus have been shown to have significant influence (Daehler, Lonardo, & Bukatko, 1979; Deák & Bauer, 1996). In one study, four-year-olds paired a drawing of a panther with a drawing of a black stallion, but paired a black panther figurine with a Tabby house cat figurine (Deák & Bauer, 1996). With exposure to richer information, children will adjust their preferences for perceptual similarity, becoming better able to discern taxonomic relations.

When a variety of relations are available to a child, how are salient features chosen? Zaki, Nosofsky, Stanton and Cohen (2003) found that during categorization tasks, individuals will pay most of their attention to exactly those characteristics that an item has in common with some family of other items and that are *uncommon* in other groups. The best fit to observed behavior comes from a model of family resemblance that gives greatest weight to the attributes that carry most discerning power. From an information theoretic point of view, this reduces entropy when deciding between two categories. They argue that the account which satisfies Ockham's razor is one in which categories are formed simply by paying different levels of attention to certain facets of the things being categorized. On this view, children who have not yet learned to focus on certain categorical aspects of items should select categories based on the more obvious features (such as physical attributes).

As noted above, early work on children's categorization capabilities from Piaget and others emphasized the primacy of perceptual features in young children's categorization tasks (Gentner, 1988; Ratterman & Gentner, 1998). Although recent studies have shown that under certain circumstances, children can attend to taxonomic relationships in categorization tasks, researchers have continued to assert that children often *prefer* to categorize based on perceptual features (Markman, 1989; Nguyen & Murphy, 2003; Tversky, 1985). Clearly, children find perceptual features highly salient for categorization. However the account offered by Zaki et al. does not require us to believe that the child does not *understand* taxonomies, only that recognizing taxonomic *features* has something to do with features that are marked in a language.

In summarizing the Whorfian perspective, Lee (2000) argues that language is an inseparable part of how we select what we attend to. "[L]anguage plays a significant role in mediating culturally

specific selections and interpretations of essentially *non-culture-specific*, universally available phenomena, elaborating them into the systems of knowledge and patterns of understanding that constitute and structure the particular social realities of particular speech communities” (Lee, 2000, p. 51). Children acquire from their language a sense of which phenomena are important and the relations by which phenomena should be grouped. Nelson (1977) reaches a similar conclusion: “[T]he present proposal is that the child has many layers of relations, properties, and functions available for any concept at any stage in development. What will be elicited in [the experimental task] will depend upon the salience of particular relationships for a particular word concept” (Nelson, 1977, p. 112). The way a child perceives the evidence for any particular type of category will have everything to do with the culture in which the child was raised and the language of that culture. Future research must be sensitive to the socio-linguistic influences on attention to salient characteristics of categories.

## 5. CONCLUSION

Children face a number of challenges in using IR systems designed for adults. The research into children’s acquisition of categories offers a backdrop to understanding the impediments in children’s use of traditional classification schemes. Attention to this literature offers LIS researchers a richer understanding of children’s cognitive and developmental needs, which may in turn influence the design of classification schemes and IR systems to better accommodate children’s information needs and abilities.

This paper reviews much of the empirical evidence on child category acquisition. Although the research indicates that children pay attention to a variety of relationships among categories, including script, thematic, causal, and spatial relations, most bibliographic classification schemes adhere to strict class-inclusion, hierarchical relationships. Categorization schemes have an opportunity to offer children additional meaningful modes of access by representing additional relationships that model the child’s language. While Cooper (2000; 2002; 2004) has shown how cognitive development plays a role in children’s acquisition of library terms and concepts, much more work is necessary to understand the cognitive component of bibliographic classification schemes. This work must take a more linguistic approach. Specifically, we argue that linguistic relativity has lead many experimental researchers to mistake a difference in child *language use* as a difference in ability to *understand categories*. Taking a different view, we see the child as fluent in a less structured language but disfluent in adult language and, as a result, less likely to apply adult-like categories. Children are certainly capable of applying more structure when highly salient cues indicate some usefulness. We see the progress of acquiring taxonomic categories as inseparable from the socio-linguistic process of acculturation and language acquisition. As a result, future research must be careful to include linguistic factors as part of any performance analysis.

In conclusion, we consider categorization an inherently social and linguistic activity; categorization is an act of linguistic expression that never happens outside of a social context. The child who expresses a preference for one type of category over another is demonstrating something about her knowledge of her own language and culture. As she acquires expertise in her language and culture, she will acquire expertise in new ways of categorizing the world. Seen in this light, understanding the development of socio-linguistic expertise is central to an understanding of the acquisition of categories.

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