Labeling effects on cognitive development

In the first years of life, children acquire a rich repertoire of conceptual categories. They learn that things with feathers tend to fly, that animals possessing certain features are dogs, that foods of a certain color and shape are edible, that objects made of certain materials bounce when they fall. Simultaneously, they learn names for these categories, e.g. they learn that flying things with feathers are called "birds," that the sound dogs make is called "barking" and that a certain class of motions is called "bouncing." A key question is whether and how learning and using verbal labels affects cognitive development. For example, in English paintings hang "on" walls and plates rest "on" tables despite obvious differences between the two kinds of support. Does having a common label for these two different relations change how children learn the conceptual category? More broadly, what aspects of cognitive development depend on or are augmented by learning and using language? Here, we summarize key findings implicating the role of verbal labels in category learning, numerical concepts, and relational reasoning.

Labels and categorization

The learning of conceptual categories is, in principle, separable from the learning of verbal labels. A child can have a conceptual category of "dog"—such that dogs are reliably classified as being the same kinds of things—without having a name for it. Indeed, a classical view, sometimes called the cognitive priority hypothesis, holds that for a child to learn a label, the child must already possess some conceptual category onto which the label is mapped. On this view, the role of words is strictly communicative. Adults may use words to direct a child's attention, for instance, telling the child not to pet the dog because it may bite, but on this view, the words "pet" and "dog" do not play a role in the child's learning of these concepts. An alternative position is that labels play an active role in the process of constructing concepts. On this view, the experience associating a common label with different category exemplars (different dogs, different instances of petting), helps the child to form the category in the first place. There is now a considerable body of research supporting the hypothesis that labels play an important role in category learning, and indeed, continue to play a role in adult categorization. The idea that word-learning can shape the conceptual space is closely linked to the idea of linguistic relativity (the so-called Sapir-Whorf hypothesis). Languages vary substantially in how they divide up the world. For instance, in English the word "on" is used both for a cup being on a table and a handle being on a door, but not for a apple *in* a bowl. In Finnish, the apple in a bowl and handle on a door are described by the same term using the inessive case *–ssa*, whereas the cup on a table is descibed using the adessive case *–lla*. Dutch uses separate terms for all three relations and Spanish uses the same term for all three. If labels play a role in structuring conceptual categories, then cross-linguistic differences in patterns of lexicalization may produce concomitant differences in conceptual structure in people speaking different languages.

Labels have been argued to facilitate categorization in infants as young as 3-months. For example, Sandy Waxman and colleagues have found that when objects such as toy dinosaurs paired with novel words ("this is a toma"), infants are more likely to form a category, dishabituating to an out-of-category object such as a fish, but not an in-category object such as a new dinosaur. Results such as these led these researchers to argue that labels are invitations to form categories. Studies examining the learning of more abstract categories such as spatial relations like "on" have also found evidence of facilitative effects by labels. Marianella Casasola found that 18-month old infants could form an abstract spatial category only when accompanied by a label. The claim that labels facilitate category learning in infancy is controversial. Vladimir Sloutsky and his colleagues have reported multiple studies in which young children learn categories best in silence and in which labels and other concurrently delivered auditory information can attenuate learning of categories that are based on visual similarity. These researchers argue that labels may indeed aid categorization and related processes such as induction later in development, but may overwhelm young infants through a process of auditory overshadowing.

Studies have shown labels to impact category learning in adulthood. Gary Lupyan and colleagues have found, adults show an advantage for categorizing objects with a label versus with visual information only. In particular, participants learned to distinguish two categories of "aliens" about twice as fast when they learned the names of the two different kinds of aliens compared to when they categorized them without learning the names.

An important question is what, if anything is special about verbal labels. One possibility is that infants are naturally attuned to word-like stimuli and use them as a cue to compare and contrast the labeled entities. Another possibility is that there is nothing special about verbal labels *per se*, but that it is how people use them—as discrete, categorical cues to category membership—that, over time, leads children to treat them as privileged category markers. Linda Smith and colleagues have argued that as children learn words, the frequent redundancy between labels and other cues (visual information, syntactic information) and category organization helps them use labels to facilitate their learning. For example, in English, most early-learned nouns name object categories organized by similarity in shape, (e.g., ball, spoon). As children learn the structure of these individual categories (e.g. balls have a similar shape, spoons have a similar shape, etc.), they also form a more general association between nouns words and shape-similarity. This higher-order association—known as the shape bias—leads children to selectively attend to similarity in shape when learning new words and subsequently learn new words more quickly. As children learn even more words, they can flexibly shift their attention to category-relevant dimensions other than shape depending on context, e.g., material in the context of nonsolid substances, or color in the context of adjectival frames. Smith has described word learning as on-the-job training for attention in the service of future word learning.

Recently, Lynn Perry argued that word learning trains attention to dimensional similarity more generally. While even 2-year-old children are skilled at selectively attending to one dimension of similarity (e.g., shape) to the exclusion of others (e.g., color) in generalizing the novel names to novel objects, it is not until closer to 8-years-of-age that they can do so in non-naming similarity classification. In particular, younger children prefer to classify objects based on overall or holistic similarity relationships while older children and adults prefer to classify objects based on identity or dimensional similarity relationships. Perry found that labels not only facilitate young children's categorization along a single dimension of similarity but also lead to subsequent increases in dimensional attention in similarity classification. This builds on neural network modeling by Linda Smith and colleagues demonstrating that it is the process of labeling the attributes of objects that drives the learner to selectively isolate dimension and attend to dimensional rather than holistic similarity. This developmental shift in similarity classification may therefore be driven, at least in part, by labeling. Together, this body of work shows that learning and using verbal labels may be important for selectively focusing on category-relevant information. Thus, labels not only facilitate the learning of individual categories by making continuous information more categorical, but also create smart category-learners who can readily focus on category-relevant dimensions and acquire new category information more quickly.

Further evidence for this claim comes from studies of adults under conditions of verbal interference and individuals with acquired language deficits (stroke-related aphasia). In both cases, linguistic impairments (especially naming impairments) have been shown to adversely affect the categorization process, particularly when it requires focusing on a few specific dimensions while abstracting over others.

Labels and Numerical Concepts

A very interesting case of effects of labels on cognitive development concerns the learning of number concepts. There is broad agreement that non-human animals and young children can apprehend (subitize) the quantity of small sets (1 to 3 or 4) and approximate the numerosity of larger sets. In addition, older children and adults can entertain concepts of large exact numerosities, e.g., 15 as being categorically distinct from 16. Recent cross-cultural studies suggest that this ability derives from the use of number words combined with a learned counting routine. Further evidence of the importance of linguistic training in this domain comes from work by Elizabet Spaepen and colleagues showing that Nicaraguan home-signing adults—deaf individuals living in a numerate culture without a conventional sign language, fail in conceptualizing exact numerosities. Number concepts require massive abstraction over perceptual details (consider that a group of 10 people and 10 fish are both members of the category 10 despite massive perceptual differences). Exact number concepts beyond about 4 may require linguistic support.

Labels and Relational Thinking

In comparison to other animals, humans have a knack for forming relational categories and making inferences on the basis of relations. For example, although many animals can be trained to respond one way to large circles and a different way to small circles, it is extremely difficult to train non-human animals to respond on the basis of relations such as sameness (e.g., press the left button if two shapes are the same, and press a different button if two shapes are different) while abstracting over perceptual features of the input. Such relational tasks are also difficult for young children, particularly because they require the learner to consider abstract relations that objects might have in common while ignoring the specific properties of the objects themselves.

Performance improves, however, when these abstract relations are labeled. In particular, Dedre Gentner and colleagues have argued that labels help children identify relations and use them in analogical reasoning. Consider a task in which children need to map by analogy the relationship between small doll and a large doll to a perceptually dissimilar display showing a set of boxes. Gentner and colleagues have shown that labeling profoundly affects children's ability to perform analogical mappings. Labeling the small doll "baby" and the large doll "daddy" enabled 3 and 4-year-old children to map the size relation onto differently-sized boxes. Critically, performance is even facilitated by labeling the relation using a novel label. For example, when 3-5-year-old children are presented with a card portraying a bird and nest and told, "the nest is the dax for the bird," better able to identify a relation like "home for" and generalize it to a card portraying a horse and barn. The benefit of labeling the relations occurs on multiple timescales: The presence of a label helps children in-the-moment to direct their attention to task-relevant dimensions. But even days later, when children are presented with the same relational reasoning task without labels, children who had initially been given a label are better able to solve it than children who were never given labels in the first place. Thus, learning the names of abstract relations may play a critical role in allowing people to flexibly represent relational categories.

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See Also: Category based induction; Interrelationship between language and cognition; Numerical cognition and language development; Shape bias in word learning; Spatial cognition and language development.

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