

Commentary: Where Do Categories Come From?

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One cannot avoid being impressed by the importance of the study of the development of categorization to large areas of developmental psychology, perceptual psychology, psycholinguistics, linguistics, and philosophy. This topic means a great deal to many disciplines, and the requirements that have been placed on the nature of what constitutes a good explanation of development are more intense than in any other area that I have ever studied. Because of this centrality, students of child categorization must deal with fundamental problems in the theories of reference, semantics, information processing, memory, and even psychobiology. They must conduct their work within the edifice of a theory of semantics that not only has holes in its roof, but often seems to be missing some major walls and supporting pillars. Despite a great deal of current interest in the description of semantic structures, we still have only a few bits and pieces of formal analyses of a few semantic spaces. As a result, it is often difficult to know how to control and properly select experimental stimuli. While they are dealing with these theoretical problems, researchers must also deal with practical problems involved in working with subjects whose verbal abilities are either nonexistent or incomplete in the particular areas under investigation. They must often utilize tasks that provide only weak evidence that stimuli are being categorized in more than just a peripheral way. Whether gathering experimental or observational data, investigators must concern themselves deeply with the social milieu within which children learn and within which they demonstrate the state of their knowledge.

Given the problems confronting progress in this area, we must admire all the more deeply the accomplishments of our three contributors—Bornstein, Mervis, and Markman. Each of their chapters constitutes a significant contribution toward furthering our understanding of the development of categorization. Together, they show us that, despite the difficulties inherent in this area, we can expect to encounter progressively more intelligent answers to the basic question about the development of categorization: "Where do categories come from?" Even more importantly, they show us that the really interesting issues in this area arise exactly at those points at which their ideas intersect.

The reader may have noted that Bornstein's focus has been on the period of infancy, that Mervis' has been on the period of the first words, and that Markman's has been on the preschool period. Each of these three researchers has been working within a somewhat different set of theoretical assumptions. It is my impression that these differences in approach are not at all accidental, but that they are direct reflections of changes in the fundamental nature of categories as children mature. I am not imagining that the core mechanisms of the categorization process change with age; rather it seems to me that change focuses on the modification of the shape of the semantic spaces upon which the

categorization process operates. Also, as Markman suggests, children seem to acquire a number of additional procedures that supplement the basic categorization process. If we look at a 10-year-old schoolchild, we find a vast array of categories and subcategories, organized according to a variety of principles. In a sense, this child represents the end state of the process of categorization development that we are studying. Somewhat unrealistically, let us imagine that we can get a reasonably accurate mapping of the category system of this 10-year-old. We may then ask ourselves the basic question in this area: Where did these categories come from? How did this particular 10-year-old develop exactly this set of categories and not those of some other 10-year-old in some other culture? There are a number of answers to these questions. Each of these answers focuses on a particular period of human development. There are four sources of categories that I would like to consider: biological substrates, attribute clustering, social interaction, and language. These are the four major forces that are generally discussed in the literature and they are also the four that are examined by our three participants. Let us begin with the question:

IN WHAT WAYS DO CATEGORIES ARISE FROM BIOLOGICAL SUBSTRATES?

All of us realize that there must be a certain neurological substrate upon which categorization depends. However, opinion is sharply divided regarding the exact ways in which innate biological substrates determine higher levels of categorization. Addressing this issue, Bornstein advances an ontogenetic typology of categorization processes that posits a loose linkage between children's age or developmental levels and their use of the four possible categorization processes. It seems to me that Bornstein's most important contribution here is the articulation of a typology of categorization processes. This typology, which is much like that we find in Kant, is now articulated with new data from infancy research. However, I believe that there is still some room for further differentiation of this typology. The importance of identity equivalence as separate from referent equivalence is unclear, as Bornstein himself notes. Referent equivalence needs to be differentiated into equivalence processes across various types of transformations. The overlap between acquired perceptual equivalence and conceptual equivalence needs to be clarified. With further modifications and elaborations of this type, a typology of categorization processes would become increasingly useful.

The degree to which this typology of categorization processes can also serve as a guide to sequence in ontogenesis is unclear. As Bornstein himself notes, the evidence currently available indicates that the three most primitive categorization processes—categorization by identity, categorization by referent equivalence, and categorization by perceptual similarity—can all be demonstrated either at birth or within the first 2 months. On the other hand, children cannot demonstrate evidence of categorization by conceptual/linguistic equivalence until the end of the first year. Thus, rather than motivating a four-stage progression, the data on levels of categorization only seem to motivate a distinction between categorization that can be achieved at the onset of infancy and categorization that occurs during the period preceding the onset of language. One could argue that children's abilities to use the first three categorization processes in the first months of life simply reflect the ease with which categorization processes of this type are learned. Al-

ternatively, one could argue that children's command over categorization in these first few months is given to them as a part of their biological inheritances. It seems to me most unlikely that abilities that emerge so uniformly across children in the first 2 months could have anything less than a major biological component. If we are to believe that learning plays any major role in the acquisition of the most fundamental categorization processes, we will need to see something in the way of a plausible account of how the various types of referent equivalence might be learned. This would be an extremely interesting line of research for infancy researchers.

The second source of categories that we should consider is children's cognitive processing of direct perceptual interactions with the world. Thus, the next question we try to address is:

IN WHAT WAYS DO CATEGORIES ARISE FROM CHILDREN'S DETECTIONS OF PERCEPTUAL REGULARITIES?

Mervis advances a series of interesting and clear-headed claims regarding the origins of the categories underlying children's first words. The most crucial assumption is stated in this way:

“As with adult-basic-level categories, child-basic categories are characterized by gradients of goodness-of-example. . . . Thus, the most representative exemplars are those that share large numbers of attributes with many other exemplars of the category, while at the same time sharing few attributes with exemplars of related categories.”

Mervis' formulation of category membership is essentially correct. Following this formulation, we can think of categories as areas of local density in a multidimensional semantic space. For example, things that are round can also be rolled, bounced, and thrown. This correlation of the attributes of roundness, reliability, bounceability, and throwability defines a nexus of properties in semantic space. As Mervis clearly notes, the child's idea of what this space looks like may differ in very reasonable ways from the adult's. For the child, a round bank may be categorized as a ball simply because of the strength of *roundness* as a feature in the computation of *ballness*.

If we could view all child-basic categories as local maxima in the density of correlation of attributes, we could construct a rather straightforward account of the development of categorization prior to acquisition of words. Following Bornstein, we could imagine that the child categorizes experiences into objects by using categorization by identity, reference equivalence, and perceptual equivalence. Each object that is categorized in this way is then stored in the child's memory along with its attributes. When a large number of objects begin to occupy points in semantic space that are extremely close to each other, a local maximum arises that then constitutes a child-basic category.

There are three qualifications that must be made on this analysis. The first, and most important, is that it is not at all clear that we can think of semantic space as a tabula rasa upon which experience writes at will. As both Eleanor Rosch and Mervis herself have pointed out, there may be certain universal natural prototypes in domains such as

color and shape. Thus, although the Dani distinguish only two basic colors (*mili* and *mola*), when exposed to a series of red color chips they tend to remember best those colors that are closest to what Americans judge to be "good" reds. Although we would not imagine that there is a biological basis for the prototypical chair, we might well imagine that among the class of *balls* the nonprototypicality of the rugby ball might be at least in part a consequence of the importance of a universal natural type for "complete sphericity." In general, it is clear that once experience begins to write on semantic space it becomes highly nonuniform. However, it also seems to be the case that semantic space may not be uniform even at birth.

The second qualification we must make is that the notion of local maxima may become difficult to apply when there is extreme category overlap or embedding. Stated somewhat more abstractly, we can say that the prelinguistic child's semantic space may well contain dense, narrow maxima embedded within larger, broader maxima. For example, within the broad local maximum for *ball*, there may also be narrower local maxima for *balloon* and *marble*. When the parent gives the name *balloon* to an object, it may be that the child judges it to be actually a *balloon*. This should occur if the current exemplar of a balloon is a good example for the local maximum for the concept *balloon*. However, if the current exemplar is not a good balloon, will it be judged to be a ball, thereby leading the child to believe that the name for balls is *balloon*? In other words, if a referent fits within two child-basic category levels, one of which is embedded within the other, how does the child decide which level relates to the verbal label? Mervis and Roth (1981) have considered issues like this in the context of adult color categorization, but they have not yet considered the impact of these considerations on child categorization.

The third qualification on the role of correlated attributes in the emergence of the categories underlying words is that many words do not demonstrate the intense correlation of attributes that we see in common nouns. In particular, as Huttenlocher and others have argued, the actions underlying verbs involve great variance in the identity of the positions in which they occur, the instruments they utilize, the agents that conduct them, and the objects upon which they are performed. However, it is not at all clear that we cannot categorize actions. Rather, it appears that the basis of that categorization is fundamentally different from the basis for categorization of objects.

These problems with the use of correlated attributes to explain the ontogenesis of categories are not fatal flaws. Rather, they are qualifications that need to be made in our application of the notion of correlated attributes.

We can turn now to a consideration of the third major source of category structure in young children: social interaction with their parents and peers. Here the question we wish to address is:

IN WHAT WAYS DO CATEGORIES ARISE FROM SOCIAL INTERACTION?

Although the role of the adult in focusing the child's attention on attributes of objects may be relatively slight in the first year, it grows in importance with time. Mervis has been instrumental in drawing our attention to the importance of social interaction as a

source of category development. Her work has also underlined the complexity of the relation between parent-child interaction and the child's underlying category structure.

In the current chapter, Mervis has focused her attention on a very particular type of social interaction: one in which the mother and child are expected to repeatedly name a small set of objects under the watchful eye of the experimenter. It is my impression that the unique demand characteristics of this situation have led to results that may not be representative of other interactions between the mother and the child. Because the emphasis here is on producing play and entertainment, it may be that mothers tend to relax the precision of their naming behavior in this situation. The fact that mothers of Down Syndrome children do not show such relaxation may be a consequence of particular social pressures placed upon these parents by medical counselors who encourage them not to use "baby talk." I should note that I have no hard evidence to back up these claims. They derive simply from my own impressions obtained while playing with children and watching others play with children.

Another rather subtle aspect of this experimental situation may be the lessening of the importance of episodic encoding of particular exemplars as a source of category information. In Mervis' experimental situation, all objects appear as toys, rather than as objects serving their normal functions. For example, if a round wax candle is perceived in the middle of a formal table setting, I would imagine that even a toddler would be less likely to think of it as a *ball*. In normal word learning, a child is presented with highly distinct exemplars embedded in a rich and distinctive context. Researchers such as Anglin (1977), Macnamara (1982), and myself have argued that much of early lexical acquisition involves the acquisition of highly undergeneralized terms. Macnamara relates this process to the acquisition of proper nouns—that is, words that refer to particular episodic encodings for objects. Nelson, Rescorla, Gruendel, and Benedict (1978) report that some 30% of children's early words are overgeneralized. However, both Macnamara and I have found levels of overgeneralization closer to 5%. Of course, both of us admit to being a bit pedantic in terms of the way we named objects for the children. But the point is that calling a tiger a *kitty* is neither a universal of parental speech nor a particularly efficacious teaching strategy. The use of this strategy in the context of Mervis' experiment may arise more from boredom and the limitation of options than from the mother's normal teaching practice. As Mervis and Pani (1980) have argued, presentation of good exemplars is the best form of instruction and the one that the mother would no doubt prefer. ,

I believe that Mervis is correct in holding that children come to the word-learning task with certain preconceptions regarding the shapes of categories for which they would like to learn names (MacWhinney, 1978). However, unlike Mervis, I believe that at least some children are extremely sensitive to the shapes of the categories presented to them by adults. If adults present such children with consistent category labels, they will be willing to

abandon their own hypotheses and acquire the labels sanctioned by the adult language. That at least some children show very low levels of overgeneralization sets important limits on Mervis' claims regarding the pervasiveness of child-basic categories and indicates that the process of social interaction with adults may be an equally powerful source of the acquisition of categories.

I return to the issue of the acquisition of undergeneralized terms in a moment. Here, I should simply note that there are, of course, many other issues to be considered in the area of social interaction and its influence on categorization.

Topics such as adults' reactions to overgeneralization and undergeneralization and the role of monitoring in the children and the adults should be considered. But our time is short and we must move on to examining the last major source for categories: language.

IN WHAT WAYS DO CATEGORIES ARISE FROM LANGUAGE?

Markman maps out two major areas in which language seems to influence the acquisition and organization of categories. She rightly considers the first area as relevant to a resolution of Quine's classic induction problem. She argues that children assume that the referents of new words are simple objects rather than complex thematic relations. Markman looks at this strategy in terms of a universal constraint on what children do not consider. I believe that it is more profitable to look at language-specific influences on the shape of what children do consider as possible referents for words. Evidence for a general class of semantic-induction strategies has been offered by Braine, Carey, Macnamara, MacWhinney, Maratsos, Pinker, and many others. An example of a strategy of this type is encoding of the verbal material that occurs between the auxiliary verb *is* and the progressive suffix *-ing* as referring to a process, as in *Bill is nibbing* where *nib* is judged to refer to a process. If the nonce word is followed by a noun, the child infers that the word is an action, as in *Bill is nibbing the table*. There are, of course, as many strategies of this type as there are syntactic frames in the language the child is learning. In the novel-word condition in Markman's experiment, the context is the indefinite article *a*. This context forces induction of the attribute or semantic feature (+object) into the lexical entry for the nonce word as Katz, Baker, and Macnamara (1974) have demonstrated. In the so-called no-word condition, the referent is identified by the indefinite pronouns "something" and "another one." One possible rule-governed binding of these pronouns is to the whole photographs including the action, rather than the individual elements within the photographs. Thus, it is not at all clear, in the no-word condition, that there is real evidence for a predisposition to categorize in terms of thematic relations.

Having introduced the general notion of the induction of attributes from syntactic frames, we are now in a position to consider how the four factors I presented at the beginning interact in early lexical acquisition. Let us take as an example a situation in which a child sees a wet dish towel lying on a redwood table, and hears his or her father say, "Could you bring me the towel?" The child has not yet learned the word *towel*, but he or she has seen towels frequently and has developed a weak cluster from the correlated attributes of towels, as opposed to other household objects and things made of cloth. Biological substrates have already operated in a variety of ways in shaping this cluster. They provide

the child with dimensions of texture to judge the quality of towels. They allow the child to perceive the identity of the towel through transformations of folding and getting wet. Now the child hears the not-yet-learned form *towel* and, as argued in MacWhinney (1978, 1982), seeks to associate this form with some function. In doing this the child can be aided by language and social interaction, as well as by the presence of already-present attribute clusters. From language, the child learns that, because the word *towel* follows the word *the* it must refer to a countable nonproper object. Although the child has made a complete episodic encoding of the towel along with the redwood table, he or she now realizes that, because they are clearly separate objects, the word *towel* must refer to only one. Furthermore, because there is only one of the objects that could reasonably be the object of the verb *bring*, the label *towel* must relate most closely to the cloth object on the table. The syntactic frame also encourages the child to assume that the word *towel* is a common and not a proper noun. Thus, although the child first encodes *towel* as referring to this nonprototypical dish towel, this encoding is accompanied with the information that *towel* must eventually be generalized to a broader range of referents. If the dish towel is close enough to the core of the *towel* attribute cluster, and if that cluster is sufficiently strong, the child will be more likely to simply identify the new object as an instance of the cluster and learn the name as the name of the cluster. However, if the nearby cluster already has a name, the child will attempt to maintain his or her encoding of the new object and new label. The closer the object is in semantic space to some attribute cluster, the more difficult it will be to maintain this encoding. The child will attempt over time to discover attributes of the new item that will allow him or her to eliminate the potential synonymy. To the degree that adults help the child in identifying such distinguishing attributes, his or her task will proceed quickly and with minimal error.

This analysis also has consequences for Markman's work on class inclusion. If we call something a *dax* we are treating it as a count noun; if we speak of a *piece of dax* we are treating *dax* as a mass noun or a collection noun. The finding that we need to explain is why the class-inclusion problem becomes easier when the superordinate is a collection noun. It seems to me that collection nouns differ from other superordinates in that they contain specific instructions that encourage the listener to think of the member types of the set. Unlike nouns such as *toys*, which do not evoke any small set of members, nouns like *furniture* and *silverware* evoke a small set of potential members. I would guess that it is this evocation supported by words like *piece of* that support the child's superior performance on the class-inclusion task with collection nouns.

In summary, we have seen that a full picture of the development of categorization must not only show us how categorization arises from biology, from cognition, from social interaction, and from language, but a full picture must also show us how these very different impacts on categorization compete and coexist. It is precisely when we consider these interworkings that we realize that we are in the deepest ignorance and it is here that the issues seem the most fascinating.

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