Category Representation in Young Infants

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Abstract

Results obtained from a novelty-preference procedure indicate that young infants possess abilities to organize objects into perceptual categories that have conceptual significance for adults. This work suggests that the initial construction of category representations is not dependent on language, formal instruction, or specialized processes, and that category development may proceed through a process of enrichment.

Keywords

infant perception; categorization; knowledge acquisition

Imagine a mental life in which each represented entity (i.e., object, relation, event) was unrelated to every other stored entity, and an environmental experience in which each novel entity encountered was unrelated to all internally represented entities. Intellectual functioning and adaptive responding would be difficult, if even possible, under such conditions because both rely on the ability to relate familiar experiences to each other and to novel experiences. Cognitive scientists believe that our mental life as humans is coherent because of organizing structures called category representations—mental representations for similar or like entities. Category representations are believed to underlie our ability to categorize, that is, to respond equivalently to discriminably different entities from a common class.

A way to think about category representations is to envision file folders. We use file folders to organize information into meaningful groupings, and we may have mental files, or category representations, to hold information about various object classes. In this way, we enable intellectual functioning to be mediated by a cognitive system in which objects are related through a set of interconnected category representations.

HISTORICAL CONTEXT

Because of the recognition that categorization has to begin at some point during development, there has been interest in when and how category representations are initiated. A lingering tradition has been to consider the acquisition of category representations to be a late achievement (i.e., of childhood or even early adolescence) that is dependent on the emergence of naming and language, the receipt of formal instruction, and the possession of logical reasoning skills (e.g., Bruner, Olver, & Greenfield, 1966).

Ideas about the development of category representations during childhood began to change as ideas about adult concepts began to evolve, particularly through the work of Rosch (1978). Embracing the family-resemblance view of concepts originally formulated in the philosophy literature, Rosch argued that object categories can be individuated by bundles of correlated attributes. For example, birds have feathers, beaks, two legs, and an ability to chirp, whereas dogs have fur, snouts, four legs, and an ability to bark. If Rosch’s view is correct, then an organism that can detect such correlations and compile them into separate representations is capable of categorization. It follows that some of the abilities involved in grouping objects into distinct categories may be present before the emergence of language, instruction, and logic. Consequently, it becomes important to examine the categorization abilities of prelinguistic infants, as it may be from these abilities that the complex concepts of adults develop.

CATEGORIZATION IN INFANTS

To study early categorization, researchers have used a procedure that capitalizes on the established finding that young infants prefer novel stimuli. Infants are presented...
with a number of different photographic exemplars, all of which are from the same category, during a series of familiarization trials. Subsequently, during a preference test, the infants are presented with two novel stimuli, one from the familiar category and the other from a novel category. Generalization of familiarization to the novel instance from the familiar category and a preference for the novel instance from the novel category (measured in looking time) are taken as evidence that the infants have on some basis grouped together, or categorized, the instances from the familiar category and recognized that the novel instance from the novel category does not belong to this grouping (or category representation). This conclusion is also contingent on the results of control experiments showing that the preference for the novel category is not simply the result of a preexisting preference or a failure to discriminate among the instances of the familiar category.

Investigations conducted with this familiarization/novelty-preference procedure have revealed that young infants are capable of representing a variety of complex object categories at different levels of inclusiveness. For example, 3- to 4-month-olds can represent instances of animals and furniture at both general (e.g., mammal, furniture) and more specific (e.g., cat, dog, chair, table) levels (reviewed in Quinn, in press-b). Researchers have now moved beyond demonstration studies, and begun to investigate a number of interrelated questions regarding how infants form category representations.

**ISSUES**

Information Used to Form Category Representations

One question concerns the basis for category formation by infants participating in the familiarization/novelty-preference procedure. Given the young age of the infants, and the fact that the stimuli are static photographs, the infants are undoubtedly using perceptual attributes that can be found on the surfaces of the exemplars. One strategy that has been used to identify the cue (or cues) that infants use to form a particular category representation is to demonstrate that infants form the category representation when the cue is present, but not when the cue is absent. Such a strategy has been used to determine how, for example, infants form distinct category representations for cats versus dogs (Quinn & Eimas, 1996). Because the two species have considerable perceptual overlap—both possess facial features, a body torso, four legs, fur, and a tail—the diagnostic information is not obvious.

It is possible that subtle differences, not noticeable upon cursory inspection, in one attribute, the pattern of correlation across a number of attributes, or the overall Gestalt might be used to form the category representations. Interestingly, in one study, infants formed the category representations when the exemplars presented during familiarization and test trials displayed only information from the head region (minus the body region), but did not form the category representations when the exemplars displayed only information from the body region (minus the head region). In another study, infants were familiarized with whole cats or dogs, and the test stimuli were hybrids: a novel cat head on a novel dog body versus a novel dog head on a novel cat body (Spencer, Quinn, Johnson, & Karmiloff-Smith, 1997). Black-and-white examples of the test stimuli are presented in Figure 1. The infants’ performance indicated that their category representations were based on the head region (and not the body region). These studies suggest that information from the head region provides infants with a sufficient (and possibly necessary) basis to form individuated category representations for cats and dogs.

Although the experiments were successful in demonstrating that head information is used by infants to form category representations for cats versus dogs, some limitations should be acknowledged. Given the silent, static nature of the stimuli, we do not know the extent to which infants might rely on head information when categorizing instances of cats and dogs encountered in the natural environment. Real cats and dogs display different movement patterns and make different communicative sounds, and it is possible that such

![Fig. 1. Black-and-white examples of the cat-dog hybrid stimuli used in Spencer, Quinn, Johnson, and Karmiloff-Smith (1997). Copyright by John Wiley & Sons. Reprinted with permission.](image-url)
movement and sound information might also be diagnostic of category membership. Another limitation is that we do not know the extent to which the head information would be relied on by infants who are presented with different category contrasts. When cats or dogs are contrasted with birds, horses, or humans, for example, other cues, such as the number of legs, the shape of the body, or the typical posture, may become important in the formation of exclusive category representations for cats and dogs.

These examples suggest that category representations may be anchored by multiple static and dynamic attributes, any one or subset of which may be used by infants in a particular context. The task of determining those attributes and identifying the conditions in which they are diagnostic of category membership has begun, and will likely continue for some time, given the cognitive complexity created by the large number of categories, each of which must be differentiated from a large number of contrast categories.

**Category Formation Versus Category Possession**

Another issue regarding the category representations of infants is whether they are formed on-line, during the course of each experiment, or whether the experiments simply tap into category representations that were constructed on the basis of previous experience. One variable to consider in deciding this issue is the experimental task. Data from the familiarization/novelty-preference procedure have been interpreted in terms of category formation. That is, infants are presumed to construct a category representation as more and more exemplars from the familiar category are presented (see Mareschal, French, & Quinn, 2000, for an explicit computational model of the on-line category-formation process). Another variable to consider is age. With increasing age, infants have more real-world experience, and are thus more likely to tap their own knowledge base when performing in laboratory experiments.

Even with task and age as guidelines, it is difficult to determine the precise mix of perceptual process and knowledge access responsible for the category representations mediating performance in a particular experiment. Consider, for example, the performance of young infants presented with a mammal-furniture contrast in a familiarization/novelty-preference experiment. Given that the infants are not likely to have observed (at least directly) mammals such as elephants or hippopotamuses or the particular furniture exemplars presented in the task, one might be tempted to say that the participating infants rely largely, if not exclusively, on perceptual processing, and that they form the category representations during the course of the familiarization trials. However, parents are known to read to infants from picture books that may depict exemplars of animals, and infants are likely to have at least some visual experience with generic furniture items such as chairs and tables. Moreover, even young infants may be able to recognize that unfamiliar mammals are more like familiar animals (e.g., humans) than furniture items (Quinn & Eimas, 1998). Thus, even in an experiment that is designed as a study of category formation, young infants may recruit information from a preexisting knowledge base that in part determines their preference behavior.

**Order of Emergence**

Category representations may exist at different levels of inclusive-ness and form hierarchically organized systems of knowledge representation. Human adults can, for example, represent “mammal” or “animal” at a global or superordinate level, “cat” at an intermediate or basic level, and “Siamese cat” at a specific or subordinate level. The conventional wisdom was that the basic level was the first to be acquired by children, and that development consisted of grouping together basic-level representations to form the superordinate level, and differentiating the basic level to form the subordinate level. However, experimental evidence supporting the basic-before-superordinate view has been called into question, and a number of recent studies of infants from a variety of age groups, as well as simple computer simulations, have provided evidence that global category representations are formed earlier and more readily than basic-level representations (reviewed in Quinn, in press-b). The greater efficiency of global category representation may be due to the attributes that characterize a global category being more discriminable and more frequently encountered (e.g., legs vs. wheels in the case of animals vs. vehicles) than the properties that distinguish each basic-level category from the same global structure (e.g., specific values of the same features—leg length, wheel diameter). Increasing frequency of experience with objects in a domain should result in a greater likelihood that those objects will be represented at the basic and eventually subordinate levels. The results of these latest studies thus support a differentiation-driven view of early category development.

**Category Representations Are Not Just for Objects**

Can young infants also form category representations that are de-
fined by the positional relations of objects? Recent studies suggest that infants between 3 and 10 months of age can form category representations for spatial relations such as above versus below, left versus right, and between (Quinn, in press-a). These studies have also provided evidence for two developmental changes. First, category representations of spatial relations may initially be limited to the objects depicting the relations. The idea is that the early representations are in terms of specific objects, so that “a above b” and “c above d” have nonoverlapping representations. Later representations become more abstract so that various objects can be presented in the same relation and the equivalence of the relation is maintained despite this variation (Quinn, Cummins, Kase, Martin, & Weis- man, 1996). Second, category representations for different spatial relations may emerge at different points during development. In particular, infants may initially encode the location of a target relative to a single landmark (e.g., “the bowl is above the table”), and later encode the location of a target in relation to multiple landmarks that define a local spatial framework (e.g., “the bowl is between the fork and spoon”; Quinn, Norris, Pasko, Schmader, & Mash, 1999). The ability to form category representations for spatial relations early in development should make it possible for infants to experience objects in organized spatial arrangements, rather than as spatially disconnected entities located in unrelated positions.

**IMPLICATIONS**

Infants’ early, but nevertheless correct, parsing of the world implies that some of the conceptual representations of children and adults are informational enrichments of the perceptual category representations formed by young infants (Quinn & Eimas, 1997). For example, in the domain of objects, infants may develop a category representation for “animal” by encountering various animals over time and joining together into a common representation perceived attributes such as an elongated body shape, skeletal appendages, facial attributes bounded by a head shape, movement patterns, and communicative sounds. The observable static and dynamic attributes that can be detected from the surfaces and trajectories of exemplars via perception can subsequently be supplemented by a name and by less apparent information regarding biological structures and functions, acquired by means of tutors and language, such as “has a heart” and “can reproduce” (Milikan, 1998; Waxman & Markow, 1995). Language can thus serve as an additional input system that delivers information that further defines representations already established through vision (and other sensory modalities), with the result that conceptual representations such as “animal” or “animate” become possible.

This view does not deny that innate core knowledge or specialized abstraction processes may also serve as supports in the process of further knowledge acquisition by older infants, children, and adults (Carey, 2000; Mandler, 2000). However, the work reported here suggests that (a) young infants correctly parse much of the world about them and (b) these parsings underlie the process of further knowledge acquisition. The representation of category information by young infants appears to form the primitive base from which adult conceptions are developed.

Current questions center on the factors that govern the early parsing abilities of infants and how the initial parsings can lead to complex knowledge categories. Future research will continue to focus on the nature of the attributes that infants use to represent category information, the mix of on-line learning versus access of previously acquired knowledge used in generating category representations, and the order of emergence of category representations at different levels of exclusiveness.

**References**


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Note

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