# Categorical Learning and the Cognitive Foundations of Language Evolution and Development

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Categorical Learning is an important foundation of language development (Ibbotson 2020). Here we aim to shed light on the evolutionary origins of human categorical learning and its evolutionary roots shared with non-human animals. Bringing together comparative cognitive and behavioral data on the one hand, and data on its neurological bases on the other, we stress the importance of categorical learning in language evolution. The reviewed data suggest that categorical learning itself is a mosaic of underlying mechanisms and human categorical learning evolved to combine different processes of category formation. Our view fits in with a model of language evolution that describes language as a mosaic of different cognitive processes that form an integrated system, with the individual elements having an evolutionarily continuous trajectory.

In invertebrates, honeybees have been shown to be able to learn certain abstract conceptual distinctions (Avarguès-Weber et al. 2012). In birds, a large amount of data with various types of stimuli have been recorded on categorical learning in pigeons (Huber 2001). Furthermore, using RB-II (rule-bases and information-integration) dissociative tasks, by which the rotation of the dimensional axis from II to RB will tell whether strong and rapid learning occur in the tested species, categorical learning in pigeons show no significant advantage of RB over II in both forward and backward learning (Smith et al. 2011). This is in contrast with primates including humans, who display RB preference to II (Smith et al. 2012). However, only humans can easily transfer their rule knowledge to new stimuli (Smith et al. 2016). This suggests that vertebrates exhibit a continuum in terms of multiple systems for categorical learning (Smith et al. 2012).

From a neural perspective, as an evolutionarily conserved neural system, the basal ganglia system has been identified as a major contributor to category learning in animals, especially when it comes to navigation and the tracking of visual cues (Mizumori et al. 2009). Studies have shown that animals with intact basal ganglia systems perform better at difficult associative learning tasks than those without them (Ashby & Ennis 2006). The basal ganglia play an important role in the acquisition and storage of information in order to make informed decisions to recognize and categorize patterns based on learned environments. Consequently, abnormalities within this area can lead to deficits in recognizing categories and responding to stimuli with consistent behavior. In humans, basal ganglia-mediated category learning involves a process in which cognitive control of the prefrontal cortex and striatum is used to assign categories to objects or stimuli in order to recognize them more quickly and efficiently (Avarguès-Weber et al. 2012). This has been found to be especially beneficial for rapid reporting on information in a timely fashion and differentiating among similar objects to improve decision-making. Additionally, basal ganglia-mediated category learning can help to automate tasks that use repeated patterns, allowing for greater efficiency when performing them.

As these data indicate, integrating comparative and neural perspectives on categorical learning can help elucidate the structure and evolution of this ability central to language development and development.

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