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Conceptualization in pigeons: The evolution of a paradigm

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ABSTRACT

Keller and Schoenfeld (1950) proposed a unique behavioral perspective on conceptualization. They suggested that concepts refer solely to an organism's behavior and to the conditions under which it occurs; as such, conceptual behavior need be neither verbal nor uniquely human. Herrnstein and Loveland (1964) advanced that behavioral perspective by deploying an elegant training procedure to teach visual concepts to pigeons. Keller and Schoenfeld's perspective and Herrnstein and Loveland's methodology have inspired my own research into conceptualization by pigeons. Using a system of arbitrary visual tokens, my colleagues and I have built ever-expanding nonverbal "vocabularies" in pigeons through a variety of different concept learning tasks. Pigeons have reliably categorized as many as 2000 individual photographs from as many as 16 different human object categories, even without the benefit of seeing an item twice. Our formal model of conceptualization effectively embraces 25 years of empirical evidence as well as generates novel predictions for both pigeon and human conceptual behavior. Comparative study should continue to elucidate the commonalities and disparities between human and nonhuman conceptual behavior; it should also explicate the relationship between associative learning, object recognition, conceptualization, and language.

1. Introduction

In 1964, Herrnstein and Loveland reported that pigeons readily learned to distinguish color photographs that depicted human beings from otherwise similar photographs that did not. The essence of their elegant training procedure was to provide pigeons with food after they pecked a small screen displaying photographs containing one or more humans, but not to provide food when the birds pecked at photographs without humans. Not only did the pigeons learn this go/no go discrimination with numerous and varied photographs, but they reliably transferred the discrimination to novel stimuli from the same two categories of photographs. Later research from Herrnstein's Harvard laboratory (reviewed by Herrnstein, 1985) found that visual concept learning was not confined to stimuli with which pigeons were likely to be familiar (e.g., humans, trees, and water); such concept learning could also involve stimuli that had never before been seen by pigeons (e.g., underwater pictures of fish).

Herrnstein's pioneering research markedly departed from traditional work on discrimination and generalization in that the controlling stimuli were complex and lifelike, and did not differ along easily identifiable and manipulable physical dimensions. His work suggested that conceptualization—at least involving such concrete stimuli as real life objects—is not solely a human intellectual ability, but one which is readily demonstrable in animals of such presumably primitive intellect as pigeons (Whitman, 1919).

2. Defining concepts

Herrnstein and Loveland provocatively entitled their innovative research report, "Complex visual concept in the pigeon," thereby provoking both surprise and skepticism among critical readers. In fact, since C. Lloyd Morgan's (1894) early consideration of the issue, comparative psychologists have struggled mightily with answering the challenging question: do animals learn concepts?

As is often the case with difficult issues in comparative cognition (Zentall and Wasserman, 2012), providing a clear operational definition of the cognitive process under consideration is the critical first step. Here, even a cursory examination of prior thinking about conceptualization in both psychology and philosophy discloses a raft of thorny problems and disputable distinctions.

Some cognitive psychologists define categorization as the mental process of grouping objects or events into classes and responding to these classes in a similar manner (e.g., Medin and Aguilar, 2001). Concepts, on the other hand, are often thought

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to be the elements of knowledge that assist categorization (e.g., Hampton, 2001; Smith and Medin, 1981). Other authors suggest that the term *category* should be used to refer to the actual class of items, whereas the term *concept* should be used to refer to the mental representation of that class (Laurence and Margolis, 1999). Still other authors propose that the term *concept* should be used to refer to *well-defined* classes that can be specified by a set of necessary and sufficient features, whereas the term *category* should be reserved for *ill-defined* or *fuzzy* classes with gradual membership (Medin, 1998). In any case, concepts and categories are frequently treated as *entities*: things to be found either in the environment or in one's mind.

Several years before Herrnstein and Loveland published their famous empirical report, Keller and Schoenfeld (1950) developed a behavioral definition of concepts that liberated the experimental analysis of conceptualization from the realm of mentalism and made concepts suitable for empirical investigation in animals. These authors began their unique behavioral analysis by noting that "one does not *have* a concept, just as one does not *have* extinction—rather, one demonstrates conceptual behavior, by acting in a certain way (p. 154)."

So, just what behavior is it that we conventionally call conceptual? Keller and Schoenfeld proposed that organisms exhibit conceptual behavior when they respond similarly to members of one class of stimuli and they respond differently to members of other classes of stimuli: "Generalization *within* classes and discrimination *between* classes—this is the essence of concepts (p. 155)." In other words, when a child says 'puppy' if she sees a dog but not if she sees a cat, or when a pigeon pecks the viewing screen if a human being is displayed but it refrains from pecking if no human being is displayed, we would say that the child and the pigeon have each behaved conceptually.

The Keller–Schoenfeld definition also suggests a useful distinction between conceptualization and discrimination: we speak of conceptualization when the organism discriminates among *classes* of multiple stimuli rather than among individual *instances* of each class. So, if an organism has learned to make one response to a single photograph of a car and to make a second response to a single photograph of a chair, then we say that the organism discriminates the car from the chair. But, if an organism has learned to make one response to multiple exemplars of cars and to make a second response to multiple exemplars of chairs, then we say that the organism conceptualizes cars and chairs. Conceptualization thus entails a subset of discriminations in which multiple stimuli are associated with a common response.

Suppose, however, that we were to successfully train an organism to associate a dozen photographs of cars with one response and to associate a dozen photographs of chairs with a second response. Is such learning in and of itself enough to claim that conceptual behavior has been exhibited? No, it would not, because the organism might master this task by merely memorizing all 24 photographs. Therefore, we need to elaborate our definition: true conceptual behavior ought to be generalizable from familiar to novel instances of the training categories. Only if the organism can produce the correct response in the presence of novel cars and novel chairs should we properly speak of conceptual behavior.

Yet, even this additional requirement may be not sufficient to define conceptual behavior. What if the novel cars and novel chairs shown in testing were perceptually undistinguishable from the familiar cars and familiar chairs shown in training? In that case, the organism's performing the correct responses in the presence of the novel testing stimuli would be a trivial failure to discriminate. A fully embellished Keller–Schoenfeld definition of conceptual behavior requires that the organism learns to respond *similarly* to members of one stimulus class and to respond *differently* to members of another stimulus class, as well as to *generalize* these differential responses to *novel* and *discriminably* different members of these stimulus classes (Wasserman et al., 1988).

Of course, the very notion of a class of stimuli raises the critically important question of what binds the class members together. The perceptual and associative origins of stimulus classes will be discussed later.

3. Comparative implications

Beyond these weighty definitional matters, it is important to appreciate that Keller and Schoenfeld also proposed that there was no compelling reason to believe that conceptual behavior is unique to verbal humans or, indeed, to human beings at all. This view reflects a longstanding and unsubstantiated bias:

> It is curious to note the resistance that may be shown to the notion that the term *concept* need not be limited to matters capable of being verbalized or found only in the behavior of human adults. We seem to have here a problem in our own behavior. *We* have formed a concept of conceptual behavior which is based upon such factors as the age of the subject, his [or her] ability to verbalize, and the fact that he [or she] is human (p. 159).

Keller and Schoenfeld's behavioristic proposal was provocative when it was offered and, unsurprisingly, it has failed to gain acceptance beyond the narrow realm of behavior analysis. Behavioristic approaches to cognition necessarily run against the grain of cognitive and mentalistic orthodoxy ((e.g., Griffin, 1992; Ristau, 1991) also see Fodor and Pylyshyn, 1988 for the related distinction between eliminativist and representationalist vocabularies in psychological theorizing). Nevertheless, I believe that their proposal is indeed correct. I further believe that the evidence I will review resoundingly confirms the fact that, despite lacking language, animals too are quite capable of conceptualization.

3.1. Initial paradigms for investigating concepts

Much of the empirical research inspired by Herrnstein's pioneering studies has continued to employ a single target category (for example, *fish*) together with its complementary category (for example, *non-fish*) in a go/no-go paradigm. Using this method, both pigeons and primates have been shown to be able to learn several different basic-level concepts and to transfer their performance to novel instances of the target concept (e.g., Aust and Huber, 2002; Matsukawa et al., 2004; Schrier and Brady, 1987; Vogels, 1999).

Yet another simple categorization procedure simultaneously displays varied photographs from two categories and requires the animal to choose stimuli from just one of them: for example, choose dogs but not humans. Using this two-alterntive forced-choice method, pigeons, dogs, bears, and primates have succeeded in learning a variety of perceptual concepts and transferred their behavior to new examples of the target concept (Range et al., 2008; Roberts and Mazmanian, 1988; Vonk et al., 2012).

Nevertheless, Premack (1976) argued that, although many different species of animals can learn such simple, dichotomous classifications, "only primates may sort the world, i.e., divide it into its indeterminately many classes (p. 215)." Yet, despite this apt and pointed criticism, these two simple paradigms are still the most frequently deployed in research on animal concept learning. Such an extremely limited base of empirical support renders research in the realm of animal conceptualization vulnerable to the criticism of irrelevance when parallels to human conceptual behavior are drawn.