The Cognitive Animal

Empirical and Theoretical Perspectives on Animal Cognition

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23 General Signs

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This essay contends that contemporary conditioning methods provide animals with the very "general signs" that John Locke said animals lacked in disclosing their thinking to us. The button pressing of pigeons can reveal mental imagery, visual illusions, and abstract concepts, if we are smart enough to teach these responses to animals and to interpret their actions carefully.

The interrelation between thought and language has been a central and enduring issue in philosophy and psychology. Of particular interest has been the possibility that nonhuman animals think. Although René Descartes and John Locke disagreed on other matters of animal intelligence (Wilson 1995), they did agree that animals are incapable of thinking or any other advanced cognitive feats.

Descartes denied animal thought because animals do not speak. "[T]he reason why animals do not speak as we do is not that they lack the organs but that they have no thoughts" (Descartes 1646/1970, p. 207). Locke, too, believed that animals were incapable of ideation or abstraction because they did not use words to divulge the operation of those advanced cognitive skills.

> I think, I may be positive ... that the power of Abstracting is not at all in them; and ... the having of general *Ideas*, is that which puts a perfect distinction betwixt Man and Brutes; and is an Excellency which the Faculties of Brutes do by no means attain to. For it is evident, we observe no foot-steps in them, of making use of general signs for universal Ideas; from which we have reason to imagine that they have not the faculty of abstracting, or making general *Ideas*, since they have no use of Words, or any other general Signs. (Locke, 1690/1975, pp. 159–160)

Putting aside the question of whether nonhuman animals can be taught a human language (Gardner and Gardner 1984; Pepperberg 1981), my essay concerns Locke's claim that animals lack any other general signs through which we might learn about their intelligence. Locke considered the matter closed; otherwise, he would at least have left open the possibility that new means might be devised that could divulge animal thought. However, the matter is not closed. In fact, the creative application of the trusted methods of classical and operant conditioning (Wasserman and Miller 1997) has flung the door wide open to a fresh, empirical understanding of animal cognition and perception (Wasserman 1993, 1997). These methods provide animals with quite general signs by means of which they can disclose their cognitions and perceptions to us.

Contrary to Locke's unsubstantiated denial, the use of these conditioning methods suggests that animals are capable of advanced cognition and abstraction. Further research suggests that animals experience many of the same perceptual illusions and mental images that we do. All of this scientific work forces us to reconsider the stale convention that thought is impossible without language.

Setting the Agenda

The Darwinian revolution raised the possibility that there was mental continuity between human and nonhuman animals: that "the difference in mind between man and the higher animals, great as it is, certainly is one of degree and not of kind" (Darwin 1871/1920, p. 128).

Charles Darwin and the early comparative psychologists adduced support for this provocative hypothesis with numerous anecdotes of animal genius. But that initial anecdotal evidence did not pass muster; it was of dubious veracity and replicability. The call thus came for more controlled and repeatable evidence. Answering these calls were the fledgling behaviorists, led by John Watson (1913).

For decades, critics (e.g., Griffin 1992) have falsely characterized behaviorism as a dry and conservative school of psychological science. But behaviorism simply insisted on clear empirical evidence of the same psychological processes that had until then been studied only introspectively, through the inward examination of one's own thoughts and feelings.

Watson himself harbored ambitious aspirations for this new branch of psychological science. He was convinced that the full gamut of mental functioning—including perception, memory, imagination, judgment, reasoning, and conception—would eventually yield to objective behavioral analysis: "Psychology as behavior will, after all, have to neglect but few of the really essential problems with which psychology as an introspective science now concerns itself. In all probability even this residue of problems may be phrased in such a way that refined methods in behavior (which certainly must come) will lead to their solution" (Wetson 1913, p. 177). Watson's words were prophetic. Thanks to the innovative behavioral methods of Ivan Pavlov and B. F. Skinner, we can now study an unprecedented range of perceptual and cognitive processes in nonhuman animals—the very mental processes that theorists have for centuries believed animals lacked or that appeared to fall outside the ken of psychological science.

It is interesting that the use of behavioral tools—especially arbitrary conditioned responses—to investigate perception and cognition in nonhuman animals was advocated by Edwin Boring, the esteemed historian of experimental psychology and a student of America's best-known introspectionist, Edward Titchener. Boring (1953, p. 183) disagreed with the common view, "that you learn about human consciousness by direct observation of it in introspection, but that animal consciousness is known only indirectly by analogical inference." Instead, he championed Max Meyer's (1921) psychology of "the other one": "an argument that your own personal consciousness is not material for science, being particular and not general, and that psychology always studies other organisms—other people, other animals" (Boring 1953, p. 183). Boring (1953, p. 183) believed that "both the animal's conduct and man's words are introspection if they are taken as meaning something about the subject's consciousness."

Boring's ideas represent what modern theorists (Zuriff 1985) call "methodological behaviorism" rather than Skinner's radical behaviorism. Methodological behaviorism pursues Watson's ambition of deciphering mental processes with behavioral rather than introspective methods, whereas radical behaviorism emphasizes the study of behavior in its own right, irrespective of its relevance to mental or neural processes (Skinner 1938). I am not able to engage this debate here, having discussed it earlier (Wasserman 1981, 1982, 1983).

Proving the Point

It is one thing to suggest that we can use arbitrary conditioned responses to tell us about perception and cognition in nonhuman animals; it is quite another thing to accomplish that feat. In the next three sections, I document how the use of operant conditioning methods has disclosed some remarkable examples of perception and cognition in the pigeon. I then return to Locke's notion of general signs and relate these examples to that intriguing notion.

Abstraction in Pigeons

Despite his certainty that nonhuman animals are incapable of abstraction and conceptualization, Locke may have been premature in his assessment. Mounting behavioral evidence suggests that nonhuman animals—even pigeons—can learn abstract concepts (Allen and Hauser 1991; Delius 1994; Thompson 1995).

In our own initial experimental investigation of abstraction in pigeons, we (Wasserman et al.

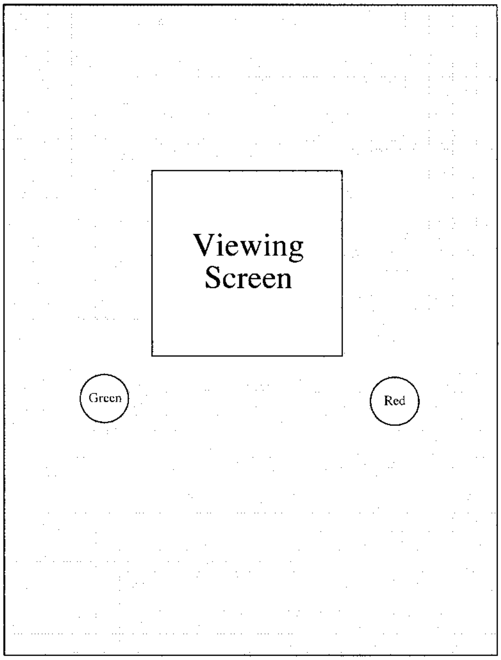


Figure 23.1
The pigeon's stimulus-response panel, including the viewing screen and the two differently colored choice buttons.

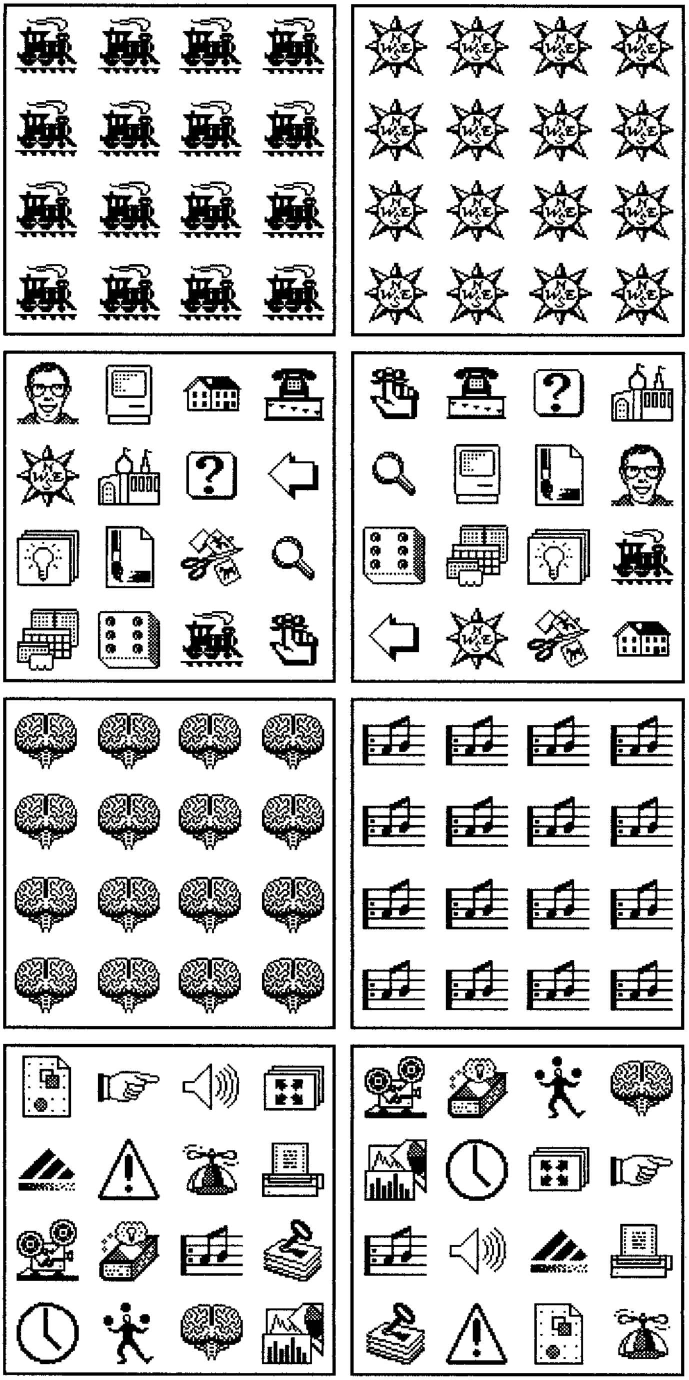
1995) first used food reinforcement to teach feral pigeons to peck a red button when they saw any of 16 4 × 4 displays that contained 16 copies of the same visual icon and to peck a green button when they saw any of 16 other 4 × 4 displays that contained 1 copy of 16 different visual icons. Figure 23.1 provides a bird's-eye view of the stimulus-response panel of the Skinner box. The top half of figure 23.2 illustrates 2 of the 16 same displays and 2 of the 16 different displays in the training set of displays (set 1) for half of the pigeons. The 16-icon arrays were first shown to the pigeon for several seconds and then the choice buttons were illuminated. A single choice response was permitted. If the correct button was chosen, then food was given; if the incorrect button was chosen, then no food was given. Daily sessions consisted of dozens of these same and different training trials.

After the pigeons had reached a high level of discrimination accuracy (exceeding 80 percent correct choices; the chance score was 50 percent correct), in testing sessions we showed the birds 16 new same displays and 16 new different displays, which contained icons that they had never seen before. The bottom half of figure 23.2 illustrates 2 of the 16 same displays and 2 of the 16 different displays in the testing set of displays (set 2) for these pigeons. The other half of the pigeons were first trained with stimuli from set 2 and later tested with stimuli from set 1.

Across both groups of birds, accuracy averaged 83 percent correct responses to the same and different displays from the training set; accuracy averaged 71 percent correct responses to the same and different displays from the testing set. These high levels of accurate responses to both familiar and novel displays are consistent with the pigeons' having learned a general same-different concept. So too are the even stronger results of a replication (Young and Wasserman 1997) of this first project, in which the pigeons' accuracy of choice averaged 93 percent correct responses to stimuli from the training set and 79 percent correct to stimuli from the testing set. Finally, pigeons successfully learned and generalized a same-different discrimination with lists of successively presented icons (Young et al. 1999), thereby proving that low-level perceptual mechanisms such as texture discrimination cannot explain the pigeon's conceptual behavior.

The Ponzo Illusion in Pigeons

Consider the two drawings in the right half of figure 23.3. Do the two horizontal lines appear to be equally long in each? No. The horizontal line in the upper drawing looks longer than the one in the lower drawing. However, the two horizontal lines are actually the same length. The



Set 1 Same

Set 1 Different

Set 2 Same

Set 2 Different

Figure 23.2
Sample same and different arrays from sets 1 and 2 of computer icons. Each set contained 16 icons.

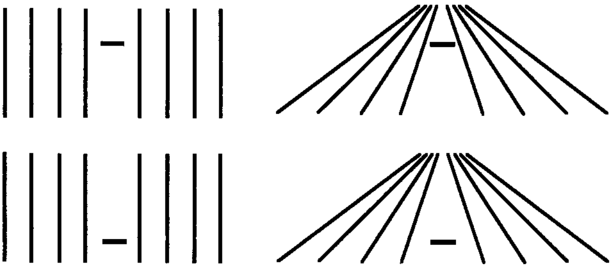


Figure 23.3
Left: Same-sized horizontal lines appearing in the parallel vertical line arrays used by Fujita et al. (1991) during original discrimination training. During this training, short and long lines appeared at various heights in the parallel vertical line field, as in the top and bottom portions of this figure. Right: Same-sized horizontal lines appearing in the nonparallel line arrays used by Fujita et al. (1991) during testing for the Ponzo illusion. During testing, the same-sized lines appeared at various heights in the nonparallel line field, as in the top and bottom portions of this figure. To our eyes, the horizontal lines in the left half of the figure appear to be of the same length, whereas the horizontal lines in the right half of the figure appear to be of different lengths; the top line appears to be longer than the bottom line. The results of this experiment suggest that pigeons also experience the same visual illusion. These drawings were adapted from those depicted in figure 3 of Fujita et al. (1991).

apparent difference in the lengths of the two lines is called the "Ponzo illusion."

This and dozens of other instances of nonveridical or illusory perception are not isolated curiosities; rather, they betray the fundamental and imperfect operating characteristics of our sensory systems. An understanding of the functioning of these sensory systems requires the elucidation of such perceptual illusions.

Of course, most subjects in investigations of illusory perception are adult human beings. However, nonhuman animals can also be studied in this type of research (Blough and Blough 1977). Instead of using verbal behaviors to disclose illusory perception, nonverbal behaviors are conditioned through contingencies of reinforcement. A case study of illusory perception in animals discovered that when pigeons viewed the stimuli in the right half of figure 23.3, they too reported that the upper horizontal line looked longer (Fujita et al. 1991, 1993).

The first stage of the pigeons' training established two different pecking responses to two different sets of stimuli. Through differential food reinforcement, the birds learned to peck one ("long") button when one out of a set of relatively long horizontal lines was positioned at different heights between parallel vertical lines and to peck a second ("short") button when one out of a set of relatively short horizontal lines was similarly positioned between the same parallel vertical lines (see the drawings in the left half of figure 23.3). Then in testing, the birds saw a novel horizontal line of intermediate length that was positioned between nonparallel lines (see the drawings in the right half of figure 23.3). When the novel line was positioned high in the display near the apex of the converging lines, the pigeons were more prone to peck the "long" button than they were when the test line was positioned low in the display, far from the apex of the converging lines.

This pattern of pigeons' pecking responses closely accords with the verbal responses of human beings who also report that the lines are of different length in analogous experiments. In this sense, we can say that the pigeons experience the Ponzo illusion in the same way as human beings.

We can also say that when different members of the same or different species respond in accord with such illusory perceptions, we gain considerable confidence in the basic nature of visual processing, irrespective of experiential or genetic influences. We then expect that the neural mechanisms of visual perception may be quite general indeed.

Mental Imagery in Pigeons

Rilling and Neiworth (1987) studied mental imagery in animals. Here the challenge was to retain the methodological rigor of behaviorism while simultaneously conducting psychologically valid research on a process that most theorists presume to be uniquely human.

Calling on classic human research by Shepard and Cooper (1982), Rilling and Neiworth's experimental response to this daunting challenge was to have a pigeon view a moving clock hand on a computer monitor for a short time, for the clock hand to disappear briefly, and for the pigeon to report whether the location of the clock hand when it reappeared at test was in the proper spot given its earlier position and trajectory. Two buttons were provided: one that was to be pecked when the clock hand appeared at the proper spot and a second that was to be pecked when the clock hand appeared at an improper spot; this could be either a spot that was too near the disappearance point or a spot that was too far from the disappearance point. Through differential reinforcement, Rilling and Neiworth taught pigeons entirely nonverbal behaviors for describing the projected motion of an absent stimulus—a task that can quite reasonably be said to require mental imagery.

The data provided strong empirical support for the possibility that pigeons can properly project the trajectory of a moving stimulus, despite its absence for a period of time. The pigeons not only made correct reports on trials with familiar starting points, trajectories, and stopping points, but they also did so on trials with new starting points, trajectories, and stopping points, thereby attesting to the generality of their imagery knowledge; the pigeons had acquired a concept of "motion," if you will.

Button Pecks as General Signs

There are two buttons. One or the other must be pecked to indicate: (1) that several visual items are the same as or different from one another, (2) whether a horizontal line is relatively short or long, or (3) whether the clock hand that has just reappeared is in the correct or the incorrect position given the hand's location and trajectory prior to its disappearance.

Except for the training procedures themselves, nothing should incline a pigeon to make the correct responses in each of these three experimental examples; the functional significance of these particular button assignments for the receipt of food is completely arbitrary. So I would argue that pigeons' button pecks are truly general signs.

What might Locke say about my analysis of button pecks as general signs of animal perception and cognition? I will not presume to answer this question for the reader. What I will do is to underscore Locke's own distrust of language for communicating mental states and processes: "[I]t is easy to perceive, what imperfection there is in Language, and how the very nature of Words, makes it almost unavoidable, for many of them to be doubtful and uncertain in their significations" (Locke 1690/1975, pp. 475–476).

If not through words, then just how might we best understand the nature and processes of perception and cognition? I believe that carefully devised behavioral studies—of both humans and animals—can and will yield the very kind of verifiable data that can make what was once a purely philosophical undertaking a truly natural science of mind. Pursuit of this path will continue to yield new secrets of adaptive behavior and cognition (Wasserman 1993).

Behavioral science may have its limits, but those limits do not prohibit the systematic study of cognition and perception. The fact that we have been able to make unprecedented progress in investigating these processes in as "intellectually challenged" a beast as the pigeon testifies to the potential of this behavioral program. It also testifies to the continuity of mental processes in human and nonhuman animals—a strong rebuttal of a cornerstone of Cartesian philosophy.

Finally, it will come as little surprise to readers that the perceptual and cognitive processes on which I have focused in this essay—mental imagery, visual illusions, and abstract concepts—have long been held to be central to an understanding of human mental function. We know no mind better than our own. So at least part of the agenda of the study of comparative cognition has a decidedly anthropocentric character (Wasserman 1997). Nevertheless, to the degree that organisms as phylogenetically, ecologically, and physiologically different as humans and pigeons see and think alike, we gain considerable confidence in the adaptive value of advanced perception and cognition. We also place further trust in the worth of general signs as valid markers of these processes. These and other considerations place research in comparative cognition squarely at the center of evolutionary biology.

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