Commentary

Animals know more than we used to think

Donald R. Griffin*

Concord Field Station, Harvard University, Old Causeway Road, Bedford, MA 01730

The scientific investigation of mental experiences is enjoying a productive renaissance. Rebounding after decades of repression by behaviorism and reductionism, neuroscientists have joined psychologists and philosophers in seeking to learn what distinguishes conscious from nonconscious functioning of brains (1–6). But despite the well known power of a comparative approach to challenging biological problems, nonhuman consciousness is only beginning to participate in this renaissance. Indeed, there are strong objections to consideration of animal awareness even from scientists who are successfully engaged in analyzing animal cognition (7, 8). The paper by Hampton in this issue of PNAS (9) contributes significantly to this productive ferment of experiments and ideas.

One significant area of investigation and debate about mental experiences centers on the distinction between two types of learning and the resulting memory. Explicit or declarative memory is what we consciously remember and can describe to others. Nondeclarative or implicit learning changes our perceptions or behavior without our consciously being aware of what caused the change. Many believe that animals are capable of only nondeclarative learning and memory, or at least that there is no way to test whether any of their learning is declarative because they cannot tell us what they remember (refs. 10–12, including commentaries in ref. 12). A related area of skepticism about animal mentality is the claim that animals may know many facts that are important in their lives but do not know that they know (13).

Hampton developed an ingenious method by which two rhesus monkeys were trained in a match to sample procedure to report, by pressing the appropriate image on a touch-sensitive video monitor, whether they did or did not remember one of four visual patterns they had seen a short time previously. In these tests touching the correct image yielded a favorite food, but pressing the wrong image produced no food at all. Before the apparatus presented four images, of which one had been seen previously, the monkey had the opportunity to press either of two different images, one of which caused the test stimuli to appear, whereas the other avoided the test and yielded a food item that was less preferred than what would be delivered after a correct choice in the test.

The monkeys learned to avoid the test when they did not remember the images well enough to believe they could make a correct choice. When the four images had been seen only 15 to 30 sec previously they almost always chose to take the test, touched the correct image, and received the preferred food reward. But when this interval was 2 to 4 min they made many more errors if they chose to take the test. One monkey always declined the test after intervals of this length, and the other was much more likely to do so. These rhesus monkeys certainly seemed to know when they did and did not remember a visual pattern. Their performance was not perfect, however; strictly speaking they often—and far more often than by chance—showed that they did or did not remember.

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These experiments mesh with the several other recent discoveries in revealing that animals are capable of mental processes once thought to be uniquely human. Relevant examples include the following: (*i*) Monkeys exhibiting "blind sight" in parts of the visual field where they are blind by ordinary criteria because of large lesions in the striate cortex have been trained to press a key meaning that they cannot see anything even when the can respond to high contrast stimuli in the "blind" area (14). They are in effect reporting that they cannot see in the affected part of the visual field even though in other tests they respond to stimuli in that area above chance levels. (*ii*) Monkeys can be trained to indicate which of two stimuli they are paying attention to (15). This behavior is also a simple form of reporting about their thoughts. (*iii*) "Mirror neurons" in the monkey cortex are activated both when the monkey performs a specific movement and also when it sees another monkey or human doing the same thing (16, 17). (*iv*) Food-storing birds remember not only events but how these are related in time and space (18, 19). (*v*) Activity in hippocampal cells of sleeping rats is similar to the firing patterns of these cells during correct orientation in a radial maze, indicating the availability of an objective neural correlate of dreaming (20).

Another significant source of information about the subjective, conscious experiences of animals is available from their communication, which often gives every evidence of expressing simple feelings and thoughts (7, 8, 13). When they communicate about something they have learned, they are "declaring" this by means other than human language. Furthermore, apes, dolphins, and African grey parrots have learned adaptations of human communication systems well enough to report what amount to declarative memories (8).

Hampton recognizes that "it is probably impossible to document *subjective*, *conscious* properties of memory in nonverbal animals." But by "document" he seems to mean obtaining evidence that is totally conclusive. Yet in other areas of comparative psychology perfect proofs are seldom available. There is no need for a double standard by which evidence of animal consciousness is accepted only if it provides perfect proof, whereas in other areas of science we are accustomed to weighing and evaluating imperfect or ambiguous data. This consideration is especially relevant when dealing with areas where we know very little, as is clearly the case with nonhuman consciousness. Hampton's experiments, along with the other recent discoveries listed above, have increased the probability of simple subjective, conscious experience in at least some animals to the level where the burden of proof rests on those who are inclined to deny its presence.

See companion article on p. 5359.

*E-mail: griffin@fas.harvard.edu.

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