

its monitoring. More generally, one could investigate the conditions under which animals (including humans) override their monitoring, responding on other bases (e.g., desperation, compulsion, perseverance, drive). We believe that the dissociation between monitoring and control may offer another small window through which to examine issues concerning the role of conscious awareness in cognition, metacognition, and behavior.

ACKNOWLEDGMENT

We gratefully acknowledge support of this project by the German Federal Ministry of Education and Research (BMBF) within the framework of German-Israeli Project Cooperation (DIP).

Significant uncertainty is common in nature

Donald R. Griffin

Concord Field Station, Harvard University, Bedford, MA 01730.
griffin@fas.harvard.edu

Abstract: In animals' natural lives, uncertainty is normal; and certainty, exceptional. Evaluating ambiguous information is essential for survival: Does what is seen, heard, or smelled mean danger? Does that gesture mean aggression or fear? Is he confident or uncertain? If they are conscious of anything, the content of animals' awareness probably includes crucial uncertainties, both their own and those of others.

Our scientific thinking about uncertainty monitoring and metacognition in animals tends to be framed in terms of laboratory animals, whose lives have much more certainty and much less stress and danger than is usual under natural conditions. A broader consideration of the behavior and cognition of animals during their normal lives can add significant evidence about awareness of uncertainty. Smith et al. recognize that "Working consciousness is the perfect referee for life's close calls. . . . [and] . . . may thus have substantial phylogenetic breadth" (sect. 15, second last para.). A comparable view has been expressed by Dickinson and Balleine (2000) concerning the goal-directed action by laboratory rats.

The content of animal consciousness is doubtless very simple and limited in comparison with ours; but it can nevertheless be important to the animal for its survival.

Under natural conditions animals must wonder whether a marginally visible movement of vegetation or a barely audible rustling means that a dangerous predator is present. But wind and other harmless events cause very similar rustlings. Seed-eating animals probably wonder whether a particular speck on the ground is a pebble or a partly buried seed. Social signals often have uncertain meaning: Does that slight movement of a furry shoulder mean he will attack, or does that brief glance mean that she will be friendly? Which of those infant distress calls is from my baby? Such uncertainties are often vitally important for the animal and are therefore likely to be consciously experienced and evaluated.

I suggest that we adopt the potentially testable working hypothesis that many animals are consciously aware of whatever is critically important in their lives, and that simple perceptual consciousness is a core function of central nervous systems. Selecting actions the animal believes will obtain what it wants or avoid what it dislikes or fears is an efficient way to use a central nervous system. This ability is adaptive because it makes appropriate decisions more likely and thus increases the animal's evolutionary fitness. If animals are aware of anything, the many uncertainties that are critical for survival must often require conscious attention.

A major obstacle to evaluating this hypothesis is the widespread opinion that it is impossible to determine with absolute certainty whether an animal is or is not conscious. Yet we seldom if ever demand perfect proof before evaluating imperfect evidence about other difficult questions in the behavioral sciences, so that this double standard is a form of paralytic perfectionism that discourages research. Furthermore, there is now abundant evidence of

nonhuman cognition and consciousness, as reviewed by Heyes and Huber (2000), Griffin (2001), and Bekoff et al. (2002). Considerable information about the content of consciousness is readily available. We make inferences about the conscious states of our human companions by interpreting their communicative behavior, both linguistic and nonverbal. This is increasingly feasible with animals as more is learned about the versatility of their communication. They often appear to be communicating their conscious experiences, which amounts to declarative consciousness, even though their communication systems differ from human language.

Smith et al. are concerned primarily with metacognitive thinking about uncertainty itself in contrast to thinking about alternative possibilities on the basis of imperfect information. I suspect that many animals are keenly aware of uncertainties about the meaning of sensory information that may or may not mean danger or opportunity; but whether they think about uncertainty as an abstract concept is much more difficult to judge. Perhaps we should search for communicative behavior that reports awareness of uncertainty itself. This might occur naturally, once we learn where to look for it, or it might be instilled by extensions of the types of experiments reviewed in the target article. In many challenging situations when animals are uncertain what to do, they actively seek better information, peering, listening, tasting, probing, or sniffing. Prey animals often show greater anxiety and caution when moving through thick vegetation where predators are more difficult to see than out in the open. And dangerous predators are sometimes inspected cautiously, apparently in search of an indication of the intention to attack. Sometimes this information quest entails exchanging communicative signals with other animals.

One example is the exchange of symbolic gestures by swarming honeybees recently reviewed by Griffin (2001). When it is necessary that the swarm find a suitable cavity into which they can move, some scout bees that have located reasonably suitable cavities report their distance, direction, and desirability by the same symbolic gestures ordinarily used to report the location of food sources. Some follow dances of a sister that describe a better cavity. Occasionally, the first bee then changes her dance message to that describing the better cavity about which she has learned as a dance follower. Sometimes this occurs *without first inspecting the second cavity herself*. This appears to be an example of the "substantial phylogenetic breadth" of working consciousness, recognized by Smith et al., applied in a situation where the bees are uncertain which is the better cavity and are seeking additional information before making this vitally important decision.

Metacognition as evidence for explicit representation in nonhumans

Robert Russell Hampton

Laboratory of Neuropsychology, National Institute of Mental Health, Bethesda, MD 20892. robert@ln.nimh.nih.gov

Abstract: Metacognition is either *direct*, as when information is recalled before making a confidence judgment, or *indirect*, as when the probability of successful future retrieval is determined inferentially. *Direct* metacognition may require an explicit mental representation as its object and can only be demonstrated under specific experimental circumstances. Other forms of metacognition can be based on publicly observable stimuli rather than introspection.

Metacognition requires two distinct components, an object-level mental process, such as a memory, and a meta-level, or executive, process that monitors the object-level process (Nelson & Narens 1996). In some cases, the meta process has direct access to an explicit representation at the object level (e.g., Koriati 1996), but in many other cases monitoring is indirect or inferential (Flavell 1979). Contrast the following two situations requiring a metacog-

nitive judgment: (1) A colleague asks if you remember how much money President Bush suggested allocating to hydrogen car research in his state of the union speech, and (2) a friend calls and asks whether you can answer a question his eight-year-old child has about psychology. In the first case, one would surely check the contents of memory and determine whether one retrieves a memory of this piece of Bush's speech. The meta-level judgment of knowing thus depends on the success or failure of attempted access to the primary explicit or declarative memory (hereafter *direct* metacognition). By contrast, in the second case your friend has not asked you to retrieve a specific memory. But if you are an expert in psychology you might feel confident that you can answer the question of an eight-year-old. Your confidence is not dependent on a direct evaluation of the contents of your memory, but rather on your history of expertise, past ability to answer such questions, and assessment of the intellectual capacity of an eight-year-old (hereafter *indirect* metacognition). It is significant that in this second case your friend could make a judgment about your ability to answer correctly that is about as accurate as your own judgment. This would not be true if you were directly accessing a specific explicit memory, in which case you as the introspecting individual would have a distinct advantage in estimating the probability of a correct response.

Evidence for *direct* metacognition in nonhumans supports the position that nonhumans have declarative or explicit mental representations (Hampton 2001). It is possible to demonstrate direct metacognition only under circumstances that rule out alternative, potentially subtle, sources of information that could inform the meta-level process. For the purpose of testing for explicit representation in nonhumans, the strategic decision to avoid some tests (a behavioral choice driven by the meta-level process) is not the phenomenon of primary interest; it is merely the behavioral output that demonstrates explicit mental representation. To demonstrate that an object-level representation is explicit, and therefore capable of supporting direct metacognition, most of the experimental effort is spent eliminating indirect sources of information for the meta process. In the absence of indirect sources of information, we can conclude that the meta process is monitoring the object-level representation directly. Thus, direct metacognition may tell us more about the nature of the object-level representation than it does about the meta-level processes. In investigations of the meta-level process per se, the painstaking avoidance of subtle cueing may be less relevant, and an indirect metacognition paradigm suitable. Indeed, in educational settings students are encouraged to examine manifest features of the study material, such as quantity, complexity, and format, then to allocate study time appropriately (a meta-level process) on the basis of these publicly observable properties of the to-be-learned material. Here, the strategies used are of primary interest, whereas the basis on which particular strategies are chosen is less critical. Experiments examining whether or not nonhumans can alter the character of information processing strategically might well emulate this emphasis on overt cues informing the meta-level process.

In making sense of the work reviewed in the target article, the distinction between *direct* and *indirect* metacognition is critical. The evidence reviewed clearly indicates that some nonhumans are capable of some form of metacognition, shown by the fact that monkeys, dolphins, and sometimes pigeons can strategically avoid tests when they are unlikely to perform correctly. However, the excitement with which one responds to these findings may depend on what stimuli control the animals' choice to avoid a test. For example, if the duration of the delay since study controls the choice to take or avoid a memory test, this would be a clear case of *indirect* metacognition. By timing the delay on each trial, the animals indirectly monitor their memory state and avoid tests when memory is likely to be weak. But such a result would not indicate declarative or explicit representation of knowledge in a nonhuman, because the ability depended on an external stimulus rather than on a judgment based on introspection.

With respect to the question of explicit representation, the pro-

cedures used by Inman and Shettleworth (1999) and Hampton (2001) are distinct from the other procedures described in the target article. In both studies, the subjects were required to make *prospective* judgments of knowing or certainty, *in the absence of the primary test stimuli*. By ruling out sources of indirect information for the metacognitive judgment, this procedure constitutes a strict test of the hypothesis that the metacognitive judgment is based on introspection directed at explicit mental representations. As one example, under these conditions subjects cannot use their own vacillation or hesitation (Tolman's "runnings back and forth" referred to by the authors) as a basis for the metacognitive response, because they are not engaged in the test at the time they make the metacognitive judgment. Because these ancillary behaviors could be the result of the subject's inability to rapidly complete the test, rather than a reflection of the subject's knowledge that it (he/she) cannot complete the test, such behaviors can constitute an overt cue that could control the choice to avoid a test. From a comparative perspective, it is striking that under strict test conditions pigeons have so far failed to show direct metacognition and explicit representation, but monkeys have succeeded (Hampton 2001; Inman & Shettleworth 1999; J. E. Sutton & S. J. Shettleworth, personal communication, February 12, 2003). However, under less strict conditions, where the pigeons made the metacognitive judgment in the presence of the test stimuli, they behaved in a way much more consistent with metacognition. Although more work remains to be done, these results point to the possibility that animals as diverse as humans, pigeons, and monkeys are capable of behavior that is superficially similar and apparently metacognitive. However, monkeys and humans, but not pigeons, can accomplish this behavior through introspection directed at explicit mental representations. This does not deny pigeons' minds, but it does suggest that carefully controlled experiments show their minds to differ from ours.

ACKNOWLEDGMENT

Preparation of this commentary was supported by NIMH IRP.

Parsimonious explanations and wider evolutionary consequences

James E. King

Department of Psychology, University of Arizona, Tucson, AZ 85721.

kingj@u.arizona.edu

Abstract: The uncertainty response adds an important new dimension to conventional animal learning and memory studies. Although the uncertainty response by monkeys and dolphins resembled that of humans, parsimony alone does not necessarily indicate that the monkeys and dolphins had a full self-awareness. However, the uncertain response may be an index of an evolutionary precursor to full self-awareness of uncertainty and a theory of mind.

Studies of two-choice problems including memory, discrimination, and matching tasks have a long and venerable history in animal learning research. However, interest in these problems has been recently eclipsed by more complex and exotic variations, particularly in the realm of primate studies where research on complex learning, theory of mind problems, and language have largely replaced the old discrimination and learning-set paradigms (see Tomasello & Call 1997).

Smith et al. have described an interesting and potentially important new dimension to simple learning and memory problems. The uncertain response yields a certain outcome that is less attractive than that following a correct response but more attractive than the outcome of an incorrect response. The most important findings of the research reviewed by Smith et al. was not simply that uncertain responses in rhesus monkeys and dolphins increased when the demands on memory or perceptual sensitivity