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.

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Significant uncertainty is common in nature

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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 cannot 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 communicative behavior. 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 wherein 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 vitaly important decision.

Metacognition as evidence for explicit representation in nonhumans

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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., Koriat 1996), but in many other cases monitoring is indirect or inferential (Flavell 1979). Contrast the following two situations requiring a metacog-
Commentary/Smith et al.: The comparative psychology of uncertainty monitoring and metacognition

Parsimonious explanations and wider evolutionary consequences

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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 that uncertain responses in rhesus monkeys and dolphins increased when the demands on memory or perceptual sensitivity