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Uncertainty monitoring may promote emergents

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Abstract: We suggest that the phenomenon of uncertainty monitoring in nonhuman animals contributes richly to the conception of nonhuman animals' self-monitoring. We propose that uncertainty may play a role in the emergence of new forms of behavior that are adaptive. We recommend that Smith et al. determine the extent to which the uncertain response transfers immediately to other test paradigms.

Smith et al. have offered those who do research with nonhuman animals an invaluable tool: a method for ascertaining not just what types of information subjects learn and retain, but also a measure of how certain those subjects are about their knowledge state. Despite the contribution to the understanding of uncertainty monitoring in nonhuman organisms, there are some problems with the current article, and we will discuss a few of these before noting other contributions of the article. Clearly, the proportions of trials on which the animals touched the box, the star, and the S with the cursor, as depicted in Figure 3 (target article, sect. 6) and elsewhere, are correct within errors of measurement. However, it should be noted that the labels on the graphs are "Sparse," "Dense," and "Uncertain" rather than "box," "star," and "S." Although the facts may be clear, they become "interpreted facts" (cf. sect. 14.2) with great ease and without apparent recognition.

The interpretation of the responses is a major problem throughout the manuscript in that the authors refer to the star response as an uncertain response in some places and as declining the trial in other places. This problem is associated with another problem if the "declining the trial" interpretation is given. Specifically, choosing the star, declining the trial, would seem to be a response that should be paired with choosing some other symbol to indicate that the trial is accepted. In particular, this is an implicit two-stage decision situation. In the first stage, the organism either declines the trial or accepts the trial. If the trial is accepted, then there is a second stage in which the organism indicates that the stimulus is dense or sparse. The analysis of a two-stage decision-making situation is different from an analysis of a single-stage decision-making situation with three alternatives. If the star indicates uncertainty, then the situation is a one-stage decision situation with three alternatives (uncertain, sparse, dense). Given the emphasis on uncertainty monitoring, it can be argued that the three-alternative interpretation is the appropriate one, and that the "declining the trial" interpretation is not germane to the issue of uncertainty monitoring.

We propose that the uncertainty response exhibited by nonhuman animals may be important in what one of us (Rumbaugh) has called emergents (Rumbaugh et al. 1996b; see also Rumbaugh 2002; Rumbaugh et al. 1996a). Emergent behaviors are new patterns of responding with no antecedent in previously learned behavior. Emergent behaviors are applied appropriately to novel situations. Perhaps uncertainty monitoring may lead to the production of emergents. Emergents may occur at moments of uncertainty when what has worked in the past will not work in the present. As noted by Smith et al., uncertainty often promotes hesitation, and we are struck by the notion that what previously has been called insight, which may be a subclass of emergents, often is the outcome of such behavioral hesitation. For example, Köhler (1925) described chimpanzees' attempts to attain out-of-reach foods before stopping, seemingly reassessing the situation, and then arriving at the use of objects to reach those items. One could imagine that the animals were uncertain about how to obtain the foods, but they recognized that a correct solution must have been available. Importantly, Rumbaugh et al. (1996b) noted that emergents "generalize between contexts not on the basis of the specific stimulus dimension, as in stimulus generalization, but rather on the basis of relations between stimuli and/or rules" (p. 59).

This notion of the generalized use of appropriate responses is an aspect of the Smith et al. uncertainty-monitoring paradigm not yet established. By this we mean the following: Human beings' subjective states of uncertainty are similar across situations. For example, when we say that we are uncertain about a person's name, we mean almost exactly the same thing as when we say we are uncertain of the exact time of day or the location of a given city. In each of these cases, we know there is a correct answer, but we also know that the answer that we would produce may not be the correct answer. As such, the feeling of uncertainty is consistent across situations. Although there may be differing levels of uncertainty, we do not qualitatively redefine our feelings across the above situations. Our question is whether nonhuman animals would use the uncertain response on a variety of transfer tasks to demonstrate that the response truly maps onto the same psychological state *from the outset.* Such transfer tests, in fact, would demonstrate consistency across such objectively uncertain states as could be produced by these tasks, but as yet, this is an unanswered question.

We agree with Smith et al. that there is no reason to assume that the use of an uncertain response by nonhuman animals is not consistent psychologically with the use of the same response by human participants. We also agree that when the objective state of the world and the subjective state of the organism coincide sufficiently, the organism relies on learned behavior. If, however, the correspondence of those states is low, the organism may produce novel responses to cope with the situation, and those novel responses may be emergents. Whether uncertainty monitoring provides information about consciousness, or working consciousness (to use the Smith et al. term), is itself uncertain. But, we suggest (along with Smith et al.) that the best possible description of uncertainty monitoring should be based on the high level of behavioral similarity between humans and nonhuman animals demonstrated in these exciting studies.

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Animal metacognition? It's all in the methods

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Abstract: When animals choose between completing a cognitive task and "escaping," proper interpretation of their behavior depends crucially on methodological details, including how forced and freely chosen tests are mixed and whether appropriate transfer tests are administered. But no matter how rigorous the test, it is impossible to go beyond functional similarity between human and nonhuman behaviors to certainty about human-like consciousness.

Devising nonverbal tests for processes normally accessed by verbal report of conscious awareness in humans is one of the biggest challenges in contemporary research on comparative cognition (Shettleworth 1998). It is one of the biggest sources of controversy as well. Many of the issues in the study of metacognition are also evident in research on whether nonhuman animals have episodic memory (Clayton et al. 2001), theory of mind (Heyes 1998), or are capable of intentional deception (Kummer et al. 1996). The challenge is to devise experimental procedures to elicit behavior from animals that is functionally similar to behavior accompanied by distinctive mental states in humans. The term *functional similar-*