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Metacognition as discrimination: Commentary on Smith et al. (2014)

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Abstract

Smith et al. critique recent “low-level” associative process models of nonhuman metacognition. We agree with many aspects of their critique. However, the alternative account they offer may not help specify the mechanisms of metacognition. We propose a middle-ground approach, based on the methods of comparative psychophysics, by which metacognition is treated as a discrimination problem.

Keywords

metamemory; comparative psychology; primate cognition; comparative cognition

Smith et al. (this issue), criticize recent “low-level” associative accounts of nonhuman metacognition (e.g., Jozefowicz et al. 2009; Le Pelley 2012). They conclude that associative accounts fail because they do not describe performance in all paradigms, do not explain differences between species that they presume have equivalent associative learning mechanisms, do not capture the “true psychology” of animals’ complex cognitive performance, and because any associative model that could account for performance across all paradigms and species would be unacceptably complex. In contrast, they argue that all current data is accurately, parsimoniously, and “intuitively explained if animals are only granted a basic capacity to monitor” their cognitive processes.

They propose three major benefits of the “high-level” account. First, it acknowledges phylogenetic continuity in metacognition, whereas they believe associative accounts of nonhuman metacognition create a strict separation between humans and nonhumans. Second, it makes studies of nonhuman metacognition relevant to studies of human metacognition, learning, and behavioral control; whereas they believe associative accounts are irrelevant to “true” human metacognition. Third, it integrates comparative psychology into human cognitive psychology by fostering constructive dialogs.

The authors provide an informative review of current work in nonhuman metacognition. Smith and colleagues have made many landmark empirical contributions in nonhuman metacognition, and their integration of those and other findings allows us to better understand the current state of the evidence. We very much agree that comparative studies

of executive control in nonhumans are important and will inform our understanding of both human cognition and the evolution of cognition. We also agree that the associative models proposed by Le Pelley et al. and Jozefowicz et al. do not currently explain the breadth of nonhuman metacognitive performance.

While Smith et. al., persuasively identify the problems with current associative models, their alternative “high-level” account is underspecified, as reflected in their argument that it should be favored because it is more “intuitive.” They argue that this intuitive account is more parsimonious than associative accounts, but it seems to us that their alternative runs the risk of replacing a complicated but relatively well-defined and testable model with a simple explanation that is nebulous. An intuitive account that does not help specify mechanisms may not help us understand metacognition. As an analogy, consider the psychology of seeing your favorite flower. The visual system is exceedingly complex, current models cannot explain all properties of human perception, and it can be difficult to think about perception in terms of these models (e.g., Kornmeier and Bach 2012; Overgaard 2012). We could provide a simpler and more intuitive explanation by granting humans a basic capacity to appreciate flowers. But this intuitive explanation would not advance our understanding of the mechanisms of perception.

It is not clear to us that the intuitive account is the best way to help us achieve Smith et al’s proposed goals of better understanding the relations between human and nonhuman cognition. The extent to which nonhuman and human metacognition are similar is an empirical question. One goal of comparative psychology should be to assess cognitive continuity, not to assume it. We agree that we should strive to make comparative psychology relevant to human cognitive psychology, and that this will depend in part on the extent to which common explanatory frameworks are applied across species. But we believe the best way to do so is to be at least as willing to extend explanatory frameworks from nonhumans to humans as we are willing to do the reverse. It is a mistake to take the position that phylogenetically-widespread mechanisms of behavior, such as associative learning, are irrelevant to understanding humans (Shettleworth 2010a). Indeed, much of human metacognitive behavior is probably adequately explained with “low-level” mechanisms (Hampton 2009; Kornell 2013). Smith et al. argue that associative accounts of metacognition predict no differences between species because all organisms are associatively identical. But this premise is false. Associative learning differs both between and within species (Domjan and Galef 1983). Carefully designed studies of nonhumans can help identify the mechanisms of metacognition by encouraging us to think in terms that are concrete, well-defined, testable, and less influenced by introspection. This makes comparative cognition more relevant, not less.

If the work we are doing together is successful, metacognition will eventually be accounted for by well-defined mechanisms. Smith et al. may be correct that such accounts will be complex. But to the extent that new models are accurate and their constituent components are well-specified, our field will progress. Thus we encourage Le Pelley et al., Jozefowicz et al., and others to continue their modeling work, replacing free parameters with restricted or constant parameters that are neurologically realizable. Our own work has sometimes similarly failed to adequately specify mental mechanisms. For example, our investigations

of information-seeking failed to substantively test alternative hypotheses, and our report ended with the vague conclusion that some species may or may not “have” memory awareness (Basile et al. 2009). For the field to advance, we need to be more specific about the cues subjects use to solve metacognition tasks. We are agnostic about whether these mechanisms should be “low-level,” but we do believe that they should be as concrete and specific as the state of the field allows.

METACOGNITION AS DISCRIMINATION

We argue that one way we might better specify the mechanisms underlying metacognition is to treat metacognition as a discrimination problem (Hampton 2005). This discriminative approach is borrowed from comparative psychophysics. How other animals experience the world may be unknowable (Nagel 1974), but comparative psychophysicists have made remarkable empirical progress by determining how species differ in sensitivity to external stimuli (Sarris 2006; Shettleworth 2010b). Researchers create situations in which a target signal varies (e.g., high- and low-frequency tones) and subjects are rewarded for accurately discriminating among those variations. We infer that subjects sense a stimulus when that stimulus controls discriminative responding. To identify what features of a signal control discriminative responding, additional experiments might be conducted; for example, one might vary amplitude while holding frequency constant. So, while we may never know what subjective perception feels like to another animal, we can empirically know what they hear and see, and compare that to what humans hear and see.

Most studies of metacognition already use the methods of the discriminative approach, and the field might benefit if we adopt it more explicitly. Sensitivity to internal signals, such as memory, can be evaluated in the same way as external signals, such as a light or tone. Consider the case of metamemory. First, we create a primary task in which memory varies (e.g., Smith et al. 1998). Second, we setup a secondary task with contingencies that encourage discrimination: subjects are reinforced for responding in one way if the memory is strong and in another way if it is weak (e.g., Hampton 2001). Third, we evaluate plausible alternative cues that might control behavior (e.g., Call 2010). We infer that subjects can monitor their memory in the primary task if they can use it as a discriminative cue in the secondary task. Importantly, identified discriminative cues can be further specified. For example, appropriately designed experiments might determine whether it is the strength, content, or ease of retrieval that controls discriminative responding. The end result should be identification of which internal signals can and cannot be used as discriminative cues, and the extent to which those differ between species.

We identify four strengths of the discrimination approach. First, it promotes stepwise improvements in the specificity with which controlling stimuli are described. Whereas determining that monkeys use “memory” as a discriminative cue for metacognitive responding loosely defines the controlling stimulus, our definition of the stimulus will become increasingly satisfying and explanatory as subsequent experiments help determine which types of memory can act as discriminative stimuli, and which aspects of these memories are critical for stimulus control. Second, all well-specified alternatives are testable within this framework. Any proposed discriminative cue, internal or external, can be

assessed and potentially falsified using similar methods. Third, the discriminative approach is agnostic about which cues are of interest. Individual researchers may be interested in the monitorability of “high level” or “low-level” signals, and the discriminative approach can be applied similarly to both. Fourth, it does not presuppose mutually-exclusive signals. Just as we can sense both volume and pitch, monkeys may sense both the strength of memory and the speed with which they choose a response. A weakness of the discriminative approach is that it does not address subjective experience or self-awareness. However, such questions may be unanswerable, and thus best avoided to ensure a productive empirical approach. We may never know how monkeys subjectively experience cognition, but we can know which aspects of cognition can be used, by which species, as discriminative cues in metacognition.

In conclusion, understanding metacognition requires specifying mechanisms, whatever form those mechanisms take. Broad claims that some species simply “have” metacognition do not bring us closer to specifiable mechanisms. Current associative accounts are built of relatively well-specified mechanisms, but do not yet accurately describe metacognitive behavior. The discriminative approach to metacognition encourages researchers to be more specific about the cues that subjects might be monitoring, and thus brings us closer to knowing what we mean when we say that a monkey knows he knows.

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