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Structure-based dissociations provide agnostic evidence to the multiple-systems debate

Minda and colleagues review the literature in favour of multiple-systems accounts of category learning (Minda, J. P., Roark, C. L., Kalra, P. & Cruz, A. Single and multiple systems in categorization and category learning. *Nat. Rev. Psychol.* **3**, 536–551 (2024))[1], and focus on the competition between verbal and implicit systems (COVIS) model[2]. Their Review provides a comprehensive and nuanced account of the evidence, and mostly focuses on experiments that report dissociations between learning in rule-based category structures (in which optimal categorization can be achieved using simple verbalizable rules) and information-integration structures (in which optimal learning requires participants to predecisionally combine information from two or more incommensurate stimulus dimensions). However, there is a substantial issue in the interpretation of these results that might undermine the authors' conclusions.

The COVIS model hypothesizes that there are two learning systems: an 'explicit system' that implements verbalizable rule strategies using working memory and an 'implicit system' (or procedural system) that uses a strategy of combining stimulus features and associating them with a response[2]. Critically, the COVIS model predicts that participants sometimes switch learning systems. In rule-based conditions, participants start learning using the explicit system with its easily verbalizable rules, find that it results in high accuracy and continue using that system. By contrast, in information-integration conditions, participants start learning using the explicit system but discover that it does not result in optimal responding because the structure is difficult to verbalize and applying rules results in poor accuracy, which motivates a switch to the implicit system. Thus, the COVIS model predicts that in information-integration conditions, there is always a portion of the experiment in which participants use the nonoptimal explicit system. For a researcher to draw conclusions about the properties of the implicit and explicit systems from experimental data, they first need to determine which system the participant used during the experiment.

The typical method to determine which system is used is decision-bound modelling[3]. This method finds the decision bound (most typically a straight line through stimulus space) that best separates the stimuli that the participant judges as one category from the other. In the COVIS literature, some decision bounds are assumed to correspond to rule-based strategies and – as only the explicit system can implement rule-based strategies – participants classified in this way are assumed to be using the explicit system. Other sorts of decision bounds are associated with the absence of rule use and – as only the implicit system could implement those strategies – these participants are assumed to be using the implicit system. Thus, unlike what Minda and colleagues suggest, the most important contribution of this analysis is not determining what strategy participants are using per se. Rather, it confirms that participants are using a strategy that would be consistent with the system they are purportedly using[4,5]. As each system is hypothesized to implement a distinct set of strategies, by identifying the individual strategy a participant uses, one can infer which system was in control of responding. Thus, decision-bound modelling in this context is a manipulation check. For instance, if a participant's responses are best described by a diagonal boundary through stimulus space, this strategy is consistent with the predictions of the implicit system, but not the explicit system. Only if the participant's strategy could be implemented by that system can the effect of the manipulation be used to infer properties or features of that system.

However, previous work has shown that decision-bound modelling results are biased by the category structure of the task[5]. Rule-based decision-bound models are more likely to be found in rule-based tasks, and information-integration models in information-integration tasks – regardless of what the participant was actually doing. Thus, decision-bound modelling cannot reliably determine participants' strategies and therefore cannot be used to infer which system the participant is using.

As a consequence of this bias, decision-bound modelling cannot be used as a manipulation check. Without a method to prove that participants use a certain system, one cannot assume that any dissociations in task performance are due to the manipulation selectively interacting with a specific system. However, it is precisely this type of evidence that Minda and colleagues review in support of the COVIS model. Without a clear determination of the system in use, the evidence for the existence of multiple categorization systems is at best ambiguous. Participants in those experiments might have been using multiple systems optimally (according to the COVIS model), but we cannot tell using the available evidence.

There is a reply to this letter by Roark, C. L., Minda, J. P., Kalra, P. & Cruz, A. *Nat. Rev. Psychol.* https://doi.org/10.1038/s44159-024-00396-9 (2025).

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Competing interests
The authors declare no competing interests.