Commentary

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Reinstating the Frontal Lobes? Having More Time to Think Improves Implicit Perceptual Categorization: A Comment on Filoteo, Lauritzen, and Maddox (2010)

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According to Filoteo, Lauritzen, and Maddox (2010), participants who learned a complex information-integration three-dimensional (II-3D) perceptual categorization task while also completing a secondary working memory (WM) scanning task outperformed participants who learned only the categorization task. Filoteo et al. explained this counterintuitive result in terms of the COVIS (competition between verbal and implicit systems) model (Ashby, Paul, & Maddox, 2011). This account holds that when WM resources are being used for another task (i.e., when the frontal lobes are "removed," as Filoteo et al. phrased it), control of performance on the category-learning task is more readily transferred from the verbal (explicit) system to the implicit system. The implicit system yields superior accuracy on the category-learning task because it predecisionally integrates information from the multiple dimensions present in the information-integration category structure (see also Maddox, Ashby, Ing, & Pickering, 2004).

This striking finding led Filoteo et al. to claim that their results have substantial applied implications. For example, they suggested that "it may be possible to enhance the training of radiologists by having them perform a secondary task while learning to read X-rays" (p. 422).[1] However, a methodological confound in their study design compromises this conclusion. In their experiment, participants given the WM task also had an additional 2,500 ms of intertrial interval (ITI) in which to process corrective feedback from the category-learning task (Fig. 1). This confound leaves open an alternative explanation for the "paradoxical effect" (p. 417) found by Filoteo et al.: Participants given the additional WM task may have outperformed those learning the category task alone because the former had more time to think (explicitly) about the feedback.

To test this alternative account, we ran an experiment with the same II-3D stimuli, WM scanning task, and number of trials (600) as used by Filoteo et al., but we crossed the duration of the ITI (short: 2,000 ms; long: 4,500 ms) with the position of the WM task in the trial sequence—before (WM-II-3D) or after (II-3D-WM) the category-learning task—in a 2 × 2 between-subjects design (i.e., the four conditions surrounded by the black rectangle in Fig. 1). Given this design, the COVIS model predicts that participants who complete the WM task after the category-learning task and who are given a short ITI (II-3D-WM-short) should be most accurate in performing the categorization task because they have maximum opportunity to disengage the "suboptimal" explicit system and switch to the "superior" implicit one. In other words, because time to process feedback in this condition is more limited, and because this limited time is interrupted by the WM task, participants should rely on the implicit system. The poorest performance should be seen in participants who complete the WM task before the category-learning task and who are given a long ITI (WM-II-3D-long). These participants experience no disruption because the WM task is completed before the category-learning task, and they also have more time to think—factors that should lead to perseveration with the explicit system.

Our alternative explanation makes the opposite prediction: The WM-II-3D-long condition allows uninterrupted thinking and therefore greater accuracy, whereas the II-3D-WM-short condition disrupts processing and therefore should reduce accuracy. According to both accounts, accuracy in the remaining two conditions (WM-II-3D-short, II-3D-WM-long) should fall between these two extremes.

Method

We tested 80 University of New South Wales undergraduate participants[2] (mean age = 19.4 years; 48 females, 32 males). Each participant was randomly assigned to one of the four

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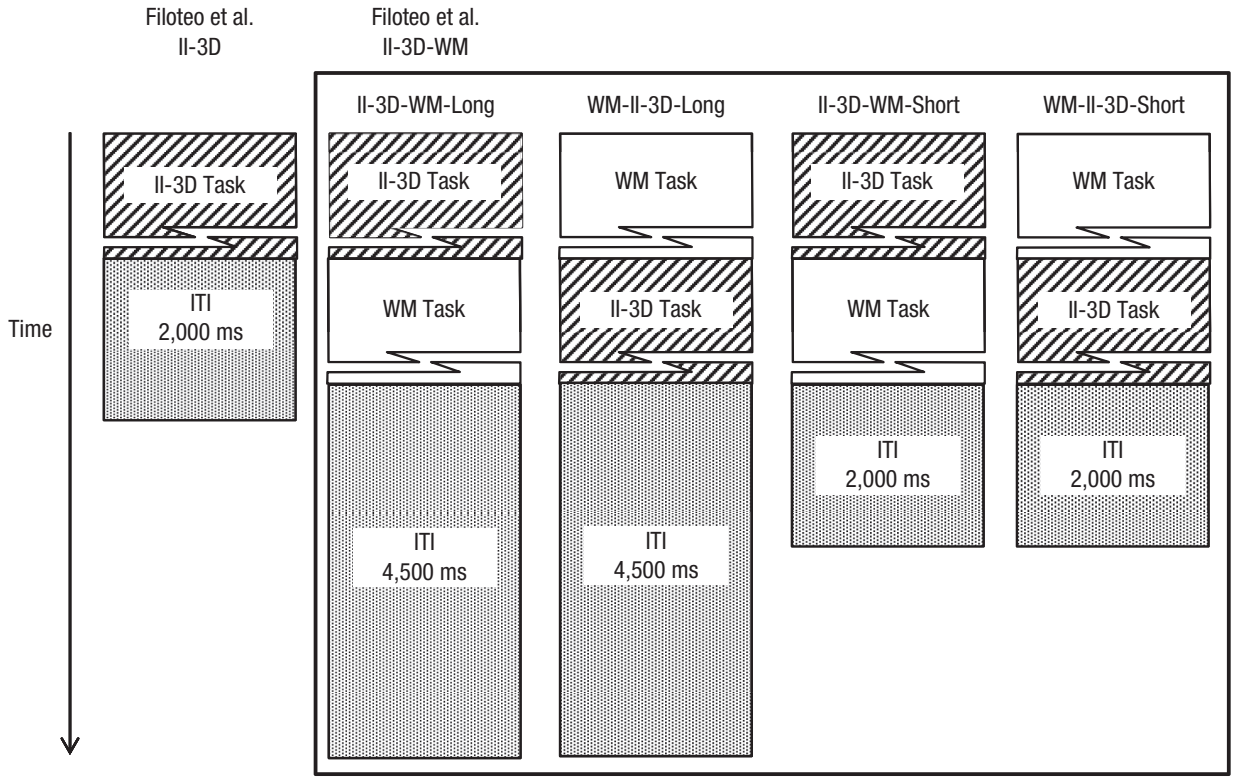

Fig. 1. Schematic showing the order and durations of the information-integration three-dimensional (II-3D) perceptual categorization task, the working memory (WM) task, and the intertrial interval (ITI) in the experiment by Filoteo, Lauritzen, and Maddox (2010) and in the current experiment. The experiment by Filoteo et al. included the conditions portrayed in the two left-most columns; the presence of the WM task was confounded with a longer ITI. Our experiment used the four conditions encapsulated by the black rectangle; we crossed the duration of the ITI and the position of the WM task to eliminate the confound. The jagged lines inside the task boxes indicate that the tasks were response terminated and thus of varying duration across participants. For more detail on the tasks and timing, see the Supplemental Material available online.

cells of the 2 (task order: WM-II-3D vs. II-3D-WM) × 2 (ITI: 2,000 ms vs. 4,500 ms) between-subjects design. We followed the procedures of Filoteo et al. as closely as possible. For further details about our stimuli and study design, see the Supplemental Material.

Results and Discussion

Performance on the category-learning task across the 600 trials is illustrated in Figure 2a. As expected, accuracy increased across trial blocks: linear-trend contrast, $F(5, 80) = 115.54$, $p < .001$. Any account would, of course, predict little difference among conditions early in the experiment because all participants start at chance-level performance. The COVIS model, however, specifically predicts that participants must engage in some failed hypothesis testing before switching to the implicit system (e.g., Ashby et al., 2011). Therefore, we made an a priori decision to focus our primary analysis on the final block of 100 trials, for which we expected the clearest difference between how well the predictions of the two accounts matched the results. Figure 2b shows that in the final block, the greatest accuracy was achieved by participants in the WM-II-3D-long condition; participants in the II-3D-WM-short condition were the least accurate. This pattern is predicted by our alternative explanation because participants in the WM-II-3D-long condition had the most uninterrupted time to process corrective feedback, and those in the II-3D-WM-short condition had the least. This pattern is opposite to that predicted by the COVIS model.

As Figure 2 shows, ITI length was more important than task order for determining accuracy. This observation was supported by a 2 (task order) × 2 (ITI length) analysis of variance (ANOVA) conducted on accuracy scores in the final block, which revealed a significant main effect of ITI, $F(1, 80) = 5.597$, $p < .05$; accuracy improved at the longer ITI. The ANOVA did not reveal a significant main effect of task order, $F(1, 80) = 1.404$, $p > .05$, or a significant interaction, $F(1, 80) = 0.839$, $p > .05$.

Conclusion

In summary, we reexamined the surprising, paradoxical finding that participants performed a complex categorization task more accurately when they also completed a secondary WM

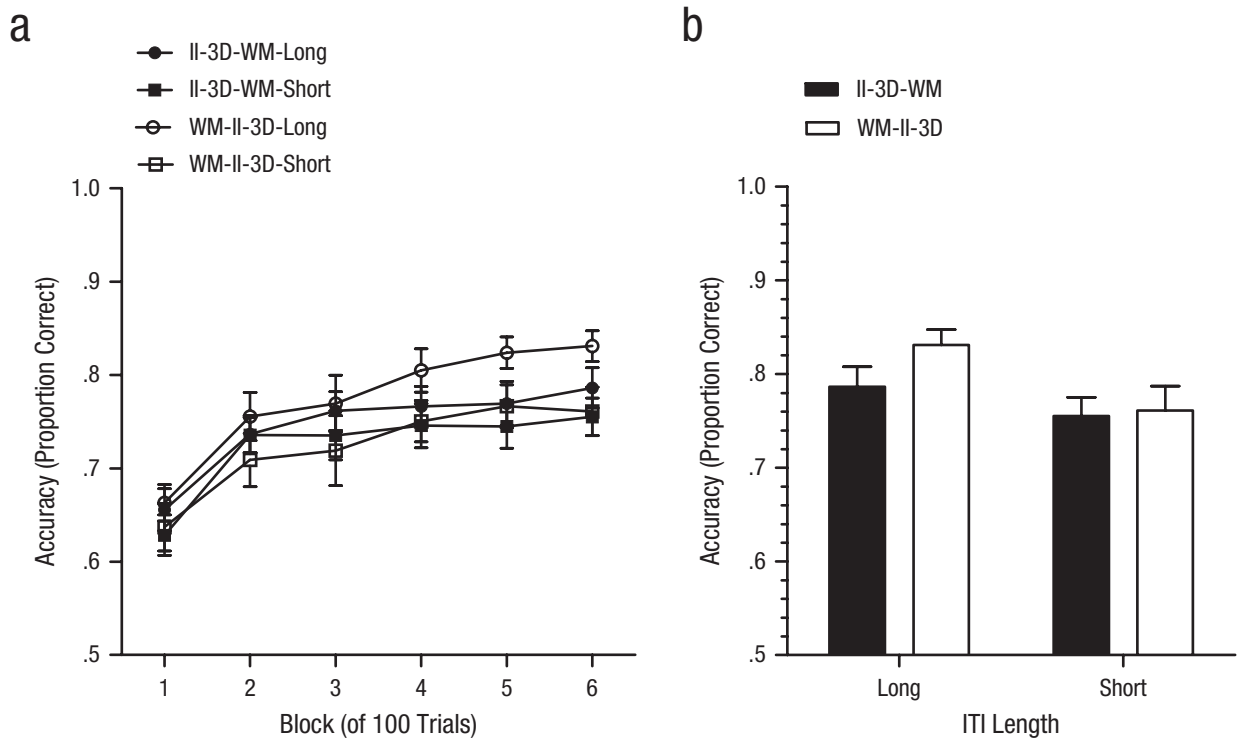

Fig. 2. Results: (a) average proportion of correct responses as a function of trial block and condition and (b) average proportion of correct responses in the final (sixth) block as a function of condition. The conditions differed in the order of the tasks and the length of the intertrial interval (ITI; long: 4,500 ms; short: 2,000 ms). The order of the tasks in the condition labels indicates the order in which the tasks were performed. Error bars represent standard errors of the mean. II-3D = information-integration three-dimensional perceptual categorization task; WM = working memory task.

task (Filoteo et al., 2010). Filoteo et al. explained this finding by suggesting that when WM resources are being used for another task, control of performance on the category-learning task is more readily transferred from the explicit system to the implicit system. We found evidence for an alternative, less surprising explanation. In our experiment, participants who had more time to process feedback (a longer ITI) on the II-3D task performed more accurately on that task regardless of the positioning of the WM task. The simple story that emerges from these data is that when one is learning a complex category structure, having time to think—and presumably to test hypotheses—is beneficial. This account requires no counterintuitiveness, no frontal lobectomies, and no recourse to implicit processes. The apparently beneficial effects of a secondary WM task in the experiment by Filoteo et al. likely stemmed from a failure to equate ITI (and hence thinking time) across the conditions of that experiment.[3]

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Andy J. Wills is now at the School of Psychology, University of Plymouth.

Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

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Supplemental Material

Additional supporting information may be found at http://pss.sagepub.com/content/by/supplemental-data

Notes

1. Filoteo et al. assumed that reading X-rays is a real-world example of an information-integration categorization task.
2. A total of 92 participants were tested, but data for 5 were lost because of computer error. An additional 7 participants were excluded for failing to exceed the learning criterion on the category-learning task (50% accuracy in the final 100-trial block, as per Filoteo et al., 2010) or for not reaching 80% accuracy on the WM task.
3. Filoteo et al. also tested participants' learning of conjunctive category structures. The implication of this alternative account for performance in that condition is discussed briefly in the Supplemental Material.

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