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The Effects of Working Memory Load on Transitive Inference

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Introduction

Cognitive scientists are interested in the brain mechanisms supporting transitive inference (TI) reasoning. In a TI task, participants learn correct responses to premise pairs ($A > B$, $B > C$, $C > D$, $D > E$) from which they can infer a relational hierarchy ($A > B > C > D > E$). The hierarchy allows them to respond appropriately to novel pairings of non-adjacent members of the hierarchy ($B > D$). It has been demonstrated that both the hippocampus and the prefrontal cortex, with its ability to support working memory (WM) (Barrouillet, 1996) are necessary for successful TI in humans. However, the relationship between WM and TI has never been directly tested.

In the current experiment we examine the effect of a working memory load on TI. We load working memory in two ways – by preventing rehearsal with a math task and by using unfamiliar stimuli, making it more difficult to encode the information in WM. We hypothesized that loading working memory would impair participants' ability to learn the premise pairs, their ability to engage in TI, and the degree to which they are aware of the TI hierarchy.

Methods

Stimuli and Procedure

During training blocks, Oakland University students learned the correct response to the premise pairs. The stimuli in the **Unfamiliar** conditions consisted of five hiragana characters. Those in the **Familiar** conditions consisted of five familiar shapes (See Figure 1). Following each premise pair, participants in the **Math** conditions were presented with a subtraction task. Feedback as to premise pair and subtraction task accuracy was provided for each of the 40 training trials in each training block.

Following completion of each training block, participants were tested on their discrimination of the four premise pairs, and the transitive inference pair (BD). Feedback was not provided during the testing blocks. If participants reached 80% accuracy on the premise pairs during testing, training ended. Otherwise, they continued on to the next training block. This continued until criterion performance was reached or four testing/training blocks were completed. After testing, all participants were given a questionnaire assessing their awareness of the hierarchical relationship between pairs.

Results

There were significant main effects of math task, $F(1,141) = 6.12$, $p < .05$, and familiarity, $F(1,141) = 8.14$, $p < .01$, on avg. premise pair performance during testing. Participants given the math task performed less accurately (72% correct) on the premise pairs than those not given a math task (77%). Those given unfamiliar stimuli performed less accurately (76%) than those given familiar stimuli (83%). There was a marginal main effect of familiarity, $p < .10$, on average TI performance during testing. Those given unfamiliar stimuli were less accurate on the BD pairs (68%) than those given familiar stimuli (75%). There was a marginal effect of familiarity on awareness of the TI hierarchy, $X^2 = 3.09$, $p = .10$. Participants given unfamiliar stimuli were more likely than those given familiar stimuli to engage in TI while reporting no conscious awareness of the hierarchy.

Discussion

Our predictions were confirmed. Both preventing rehearsal of premise pairs during the ITI and making it more difficult to encode the information in WM adversely affected participants' ability to engage in transitive inference. With a working memory load, participants were less accurate on both the premise and transitive inference pairs during testing. Additionally, loading WM affected participants' awareness of the TI hierarchy even when they performed accurately on the novel TI pair. This suggests that in humans the prefrontal cortex and the hippocampus interact to support deductive reasoning tasks such as transitive inference.



Figure 1: Familiar and unfamiliar stimuli.

References

- Barrouillet, P. (1996). Transitive inferences from set-inclusion relations and working memory. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, 22, 1408-1422