The influence of cognitive strategies on performance in working memory tasks

Nijboer, Menno; Borst, Jelmer P.; Van Rijn, Hedderik; Taatgen, Niels A.

Published in:
Proceedings of ICCM 2015 - 13th International Conference on Cognitive Modeling

The Influence of Cognitive Strategies on Performance in Working Memory Tasks

Menno Nijboer (m.nijboer@rug.nl)
Department of Artificial Intelligence, Nijenborgh 9
9747 AG Groningen, The Netherlands

Jelmer P. Borst (jelmerborst@gmail.com)
Department of Artificial Intelligence, Nijenborgh 9
9747 AG Groningen, The Netherlands

Hedderik van Rijn (hedderik@van-rijn.org)
Department of Experimental Psychology, Grote Kruisstraat 2/1
9712 TS Groningen, The Netherlands

Niels A. Taatgen (n.a.taatgen@rug.nl)
Department of Artificial Intelligence, Nijenborgh 9
9747 AG Groningen, The Netherlands

Keywords: cognition, multitasking, ACT-R, threaded cognition, computational modeling.

Introduction

Working memory is normally considered a capacity-limited system. This suggests that working memory performance is purely determined by the structure of the underlying architecture and the storage requirements of the task. Here, we argue instead that working memory performance is much more flexible and dependent on task-specific strategies.

Paradigm

In a concurrent dual-task, three working memory tasks were performed in pairs simultaneously. These tasks were an n-back task, a tone-counting task, and a spelling task that required the concatenation of individual letters to form a word. The tone-counting and spelling tasks were designed to be comparable on all aspects, and especially capacity. The difference between the two tasks is that compared to tone-counting, the spelling task was expected to require an additional memory resource to update the information in working memory when a new stimulus is presented. Crucially, this resource is also required by the n-back task.

Model

We used the ACT-R cognitive architecture (Anderson, 2007) to build a threaded cognition model (Salvucci & Taatgen, 2008) of the three tasks discussed previously. The crucial aspect of the model is the difference between spelling and tone-counting in terms of the cognitive working memory resources these tasks require. The spelling task model relies more on the problem state resource (Borst, Stocco, Van Rijn & Taatgen, 2010; Borst, Taatgen & Van Rijn, 2010), while the tone-counting task relies more on the declarative memory resource. Finally, the 2-back task uses both of these resources extensively. Previous research has shown that overlap in resource use leads to task interference (Nijboer, Borst, Van Rijn & Taatgen, 2014). Thus, our paradigm should produce a distinct interference pattern for the dual-task conditions, where spelling and tone-counting interfere strongly with the 2-back due to contention for resources. However, these tasks should interfere less with each other, due to the reliance on different resources.

Results

As presented in Figure 1, the amount of observed interference during the spelling task depended on the second task: The model replicates these results, which indicates that a difference in working memory strategy – without a difference in capacity requirements – can result in greater interference between tasks, as different resources are recruited. This suggests that there is a strategic and task dependent factor determining performance in working memory constrained tasks.

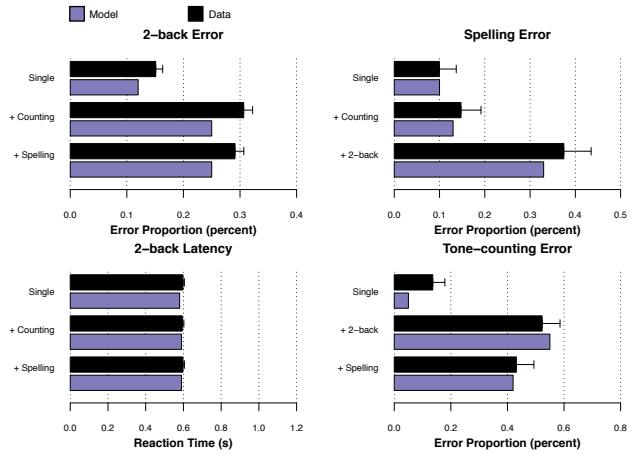

Figure 1: Behavioral results compared against model results.

Acknowledgments

This research was funded by ERC-StG grant 283597 awarded to Niels Taatgen.

References

Anderson, J. R. (2007) How Can the Human Mind Occur in the Physical Universe? New York: Oxford University Press.

Borst, J. P., Taatgen, N. A., Stocco, A., & Van Rijn, H. (2010). The Neural Correlates of Problem States: Testing fMRI Predictions of a Computational Model of Multitasking. *PLoS ONE*, 5(9), e12966.

Borst, J. P., Taatgen, N. A., & Van Rijn, H. (2010). The problem state: a cognitive bottleneck in multitasking. *Journal of Experimental Psychology. Learning, Memory, and Cognition*, 36(2), 363–382. doi:10.1037/a0018106

Nijboer, M., Borst, J.P., Van Rijn, H., & Taatgen, N.A. (2014). Single-task fMRI Overlap Predicts Concurrent Multitasking Interference. *NeuroImage* 100, 60-74.

Salvucci, D. D., & Taatgen, N. A. (2008). Threaded cognition: an integrated theory of concurrent multitasking. *Psychological Review*, 115(1), 101–130. doi:10.1037/0033-295X.115.1.101 Salvucci, D. D., & Taatgen, N. A. (2008). Threaded cognition: an integrated theory of concurrent multitasking. Psychological Review, 115(1), 101–130. doi:10.1037/0033-295X.115.1.101