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ASSESSING THE INFLUENCE OF COGNITIVE DUAL-TASK DEMANDS ON POSTURAL CONTROL: AN EVENT-RELATED APPROACH USING CONTINUOUS FORCE-PLATE DATA

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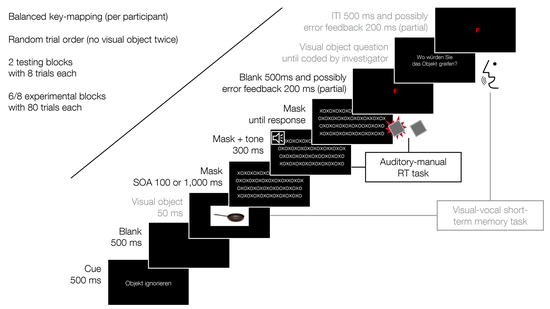
INTRODUCTION

Cognitive-processing demands can affect postural control. Traditional methods of analyzing postural control aggregate sway data, making it difficult to isolate the specific influence of cognitive processes on postural control. Recently, postural-control parameters were measured continuously with a force plate during standing and analysed in an event-related approach while participants completed a Simon Task (Johannsen et al., 2023). Resolving response conflict in the Simon Task reduced variability in postural control prior to the manual response.

METHOD



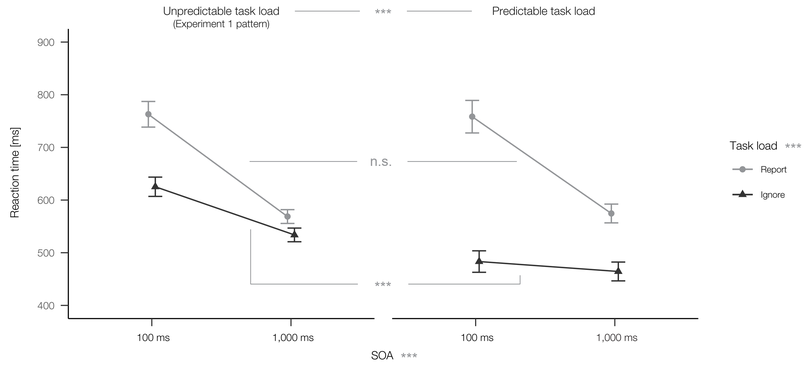
In the present study, this event-related approach is used during a cognitive dual task (see Koch & Rumiati, 2006) to explore how cognitive processes involved in executing two tasks in rapid succession influence postural control processes.

This dual task comprises a visual-vocal short-term memory task with a delayed vocal response and an auditory-manual reaction time (RT) task. We varied dual-task interference by manipulating the stimulus-onset asynchrony (SOA: 100 vs. 1,000 ms; Koch et al., 2018) between the stimuli and whether participants had to report or ignore the visual object (task load). These were applied on a trial-by-trial basis (Experiment 1) or in blocks (Experiment 2; predictable vs. unpredictable task load).

RESULTS

N = 48 per Experiment

Memory-consolidation bottleneck (SOA effect) and residual processing of the object in unpredictable report trials.

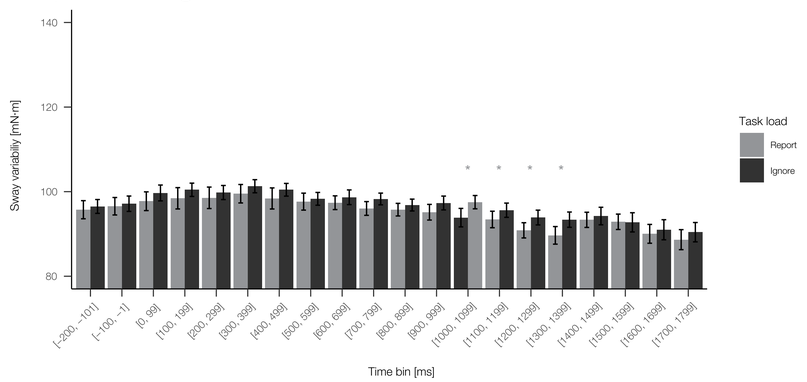


Plot for the RTs of the auditory-manual RT task in Experiment 2 as a function of SOA, task load, and task load predictability. Experiment 1 had the same patern as unpredictable blocks of Experiment 2.

Blocks with unpredictable task load:
- *SOA x task load $F(1, 47) = 114.66$, $p < .001$, $\eta_p^2 = 0.71$*
- *The dual-task costs were larger at short SOA (138 ms) than at long SOA (35 ms)*

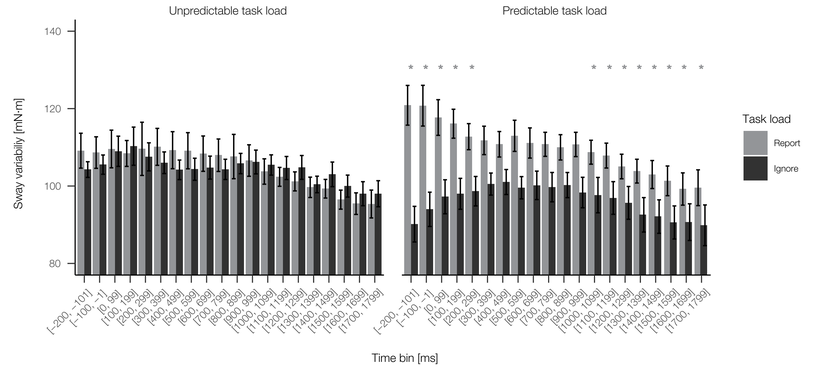
Blocks with unpredictable task load:
- *$F(1, 47) = 112.12$, $p < .001$, $\eta_p^2 = 0.70$*
- *The dual-task costs were larger at short SOA (275 ms) than at long SOA (110 ms)*

Cluster permutation analysis shows significant effect of task load after visual target onset with less sway variability for report compared to ignore trials ($p = .007$, cluster mass of 37.49).



Plot for sway variability over the course of a trial in Experiment 1 as a function of task load. All blocks had unpredictable task load. Data were aligned at cue onset. The visual target appears at 1,000 ms.

Difference between report and ignore trials only in blocks with predictable task load (both clusters $p < .001$, added cluster mass of 246.20).



Plot for sway variability over the course of a trial in Experiment 2 as a function of task load and task load predictability. Data were aligned at cue onset. The visual target appears at 1,000 ms.

DISCUSSION

We experimentally varied cognitive load created by the interference of memory consolidation and response selection processes by manipulating the SOA and the relevance of a visual-vocal short-term memory task.

For RT, we replicated well-known main and interaction effects of SOA and task load, demonstrating that memory consolidation processes can create a functional processing bottleneck at the level of response selection processes.

Assessing the postural correlates revealed no process-specific influence of SOA on postural control processes, but a reduction of sway variability after visual target onset in report but not in ignore trials. Moreover, a difference in sway variability over the course of a trial in report vs. ignore trials occurred in predictable blocks only.

Assuming that postural control processes operate with intermittent control impulses (Gawthrop et al., 2011), we propose that the influence of capacity limited cognitive processes on postural control processes is temporally modulated and operates in a predictive manner.

Gawthrop, P., Loram, I., Lakie, M., & Gollee, H. (2011). Intermittent control: A computational theory of human control. *Biological Cybernetics, 104*, 31–51.

Johannsen, L., Stephan, D. N., Straub, E., Döhring, F., Kiesel, A., Koch, I., & Müller, H. (2023). Assessing the influence of cognitive response conflict on balance control: An event-related approach using response-aligned force-plate time series data. *Psychological Research, 87*, 2297–2315.

Koch, I., & Rumiati, R. I. (2006). Task-set inertia and memory-consolidation bottleneck in dual tasks. *Psychological Research, 70*(6), 448–458.

Koch, I., Poljac, E., Müller, H., & Kiesel, A. (2018). Cognitive structure, flexibility, and plasticity in human multitasking – An integrative review of dual-task and task-switching research. *Psychological Bulletin, 144*(6), 557–583.

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Postural control adjustments are temporarily suppressed during capacity limited cognitive processes and can be executed dynamically depending on upcoming cognitive load.