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The effect of sleep loss on emotional working memory

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Background

Sleep deprivation (SD) affects important functions mediated by the prefrontal cortex such as working memory (WM) and emotion processing. One recent study suggests that although general performance on an emotional WM task decreases during sustained wakefulness, the performance is less adversely affected if stimuli are negative[1]. However, it is unclear whether a beneficial effect of emotional stimuli on WM performance following sleep loss depends on the cognitive load required by the WM task. Previous findings are inconsistent regarding at what cognitive load WM performance is affected by SD, and to date no study has examined the effect of SD on higher cognitive load in emotional WM. The aim of the present study was to examine the effect of one night's sleep deprivation on emotional WM using both low and high cognitive load (1-back and 3-back).

Methods and Materials

As part of an ongoing larger study, so far 43 young healthy subjects (18 females, age range: 18-30 years) were randomized to a total sleep deprivation (SD: n=20) or a normal night sleep (NSD: n=23) condition. Participants performed a two-load (1 and 3) N-back task consisting of positive, negative and neutral pictures from the International Affective Picture System (IAPS). Using sensitivity index (d'), omissions and reaction time (correct responses only) as outcome measures three separate (2x2x3) mixed model analyses of variance were conducted with sleep (SD, NSD) as between subject variable, and cognitive load (1-back, 3-back) and valence (positive, neutral, negative) as within subject variables.

Results

For the **sensitivity index (d')** expected main effects of condition ($p < .001$) and load ($p < .001$) reach significance, with SD adversely affecting sensitivity and 3-back being more difficult than 1-back (Figure 1).

For the **omission rate** a significant main effect of condition ($p = .002$) indicated that SD caused a higher rate of omissions than NSD (Figure 2).

For the **reaction time** a main effect of load ($p < .001$) was observed, with slower reaction time in the 3-back compared to the 1-back, and a main effect of valence ($p = .004$). Post-hoc comparison indicated a slower reaction time for negative pictures compared to positive and neutral pictures (Figure 3).

Regarding **reaction time** there was also a significant interaction between condition and load ($p = .02$). Post-hoc comparisons indicated that SD compared to NSD adversely affected the reaction time on the 1-back more than on the 3-back task (Figure 4).

Conclusion

Current results suggest that sleep deprivation has a detrimental effect on working memory accuracy irrespective of emotional content and cognitive load. The general increase of lapses in performance seen in sleep deprived subjects could be explained by fluctuations in wakefulness suggested by the "wake state instability" hypothesis[2]. Interestingly enough, reaction time was only affected by sleep loss during tasks requiring low cognitive load indicating that in a condition that depend more heavily on higher cognitive functions reaction time remains more intact after sleep deprivation. Moreover, compared to recent findings this study did not find any evidence of emotional stimuli being beneficial for working memory performance after sleep deprivation.

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Figure 1

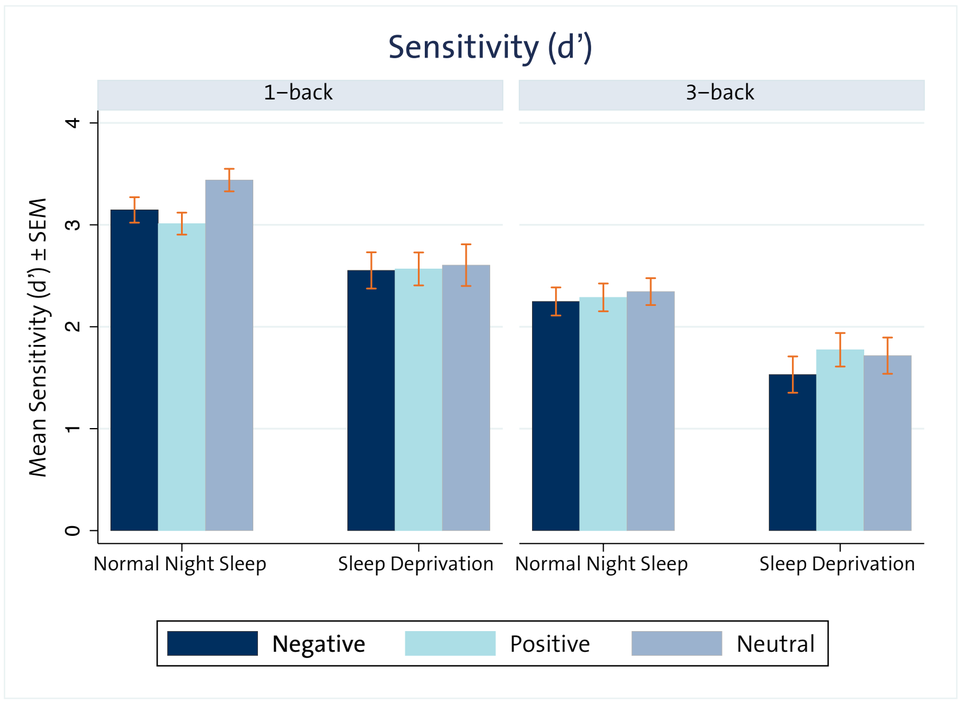


Figure 2

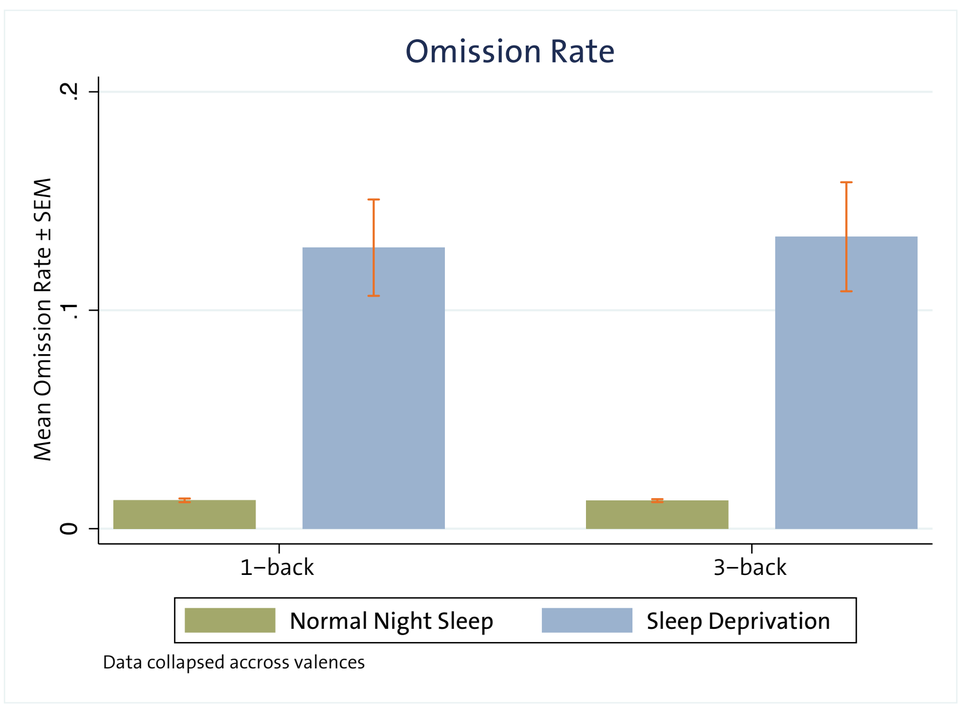


Figure 3

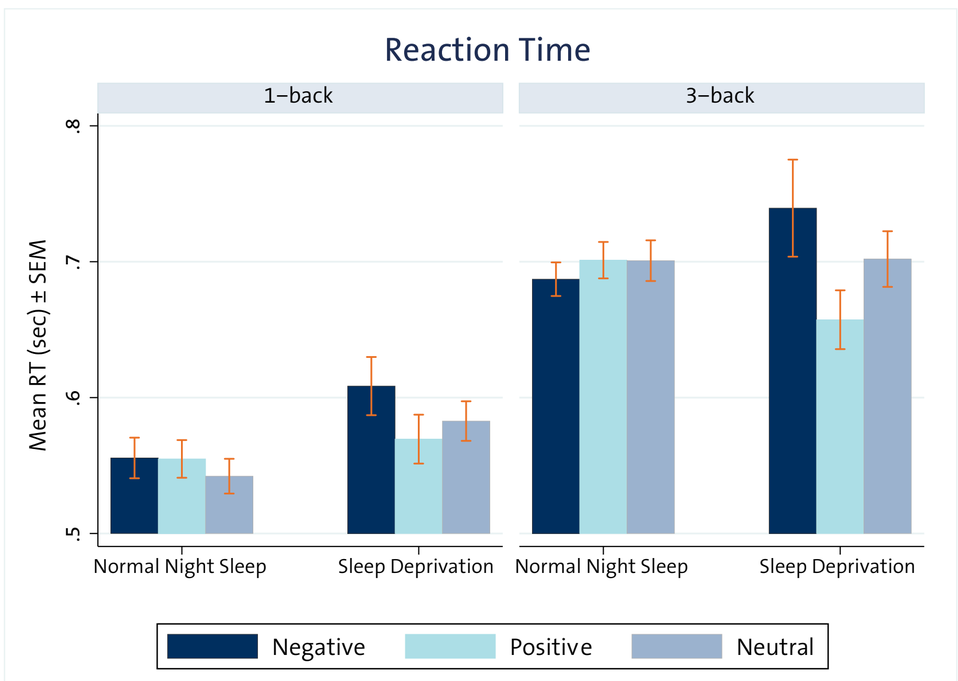
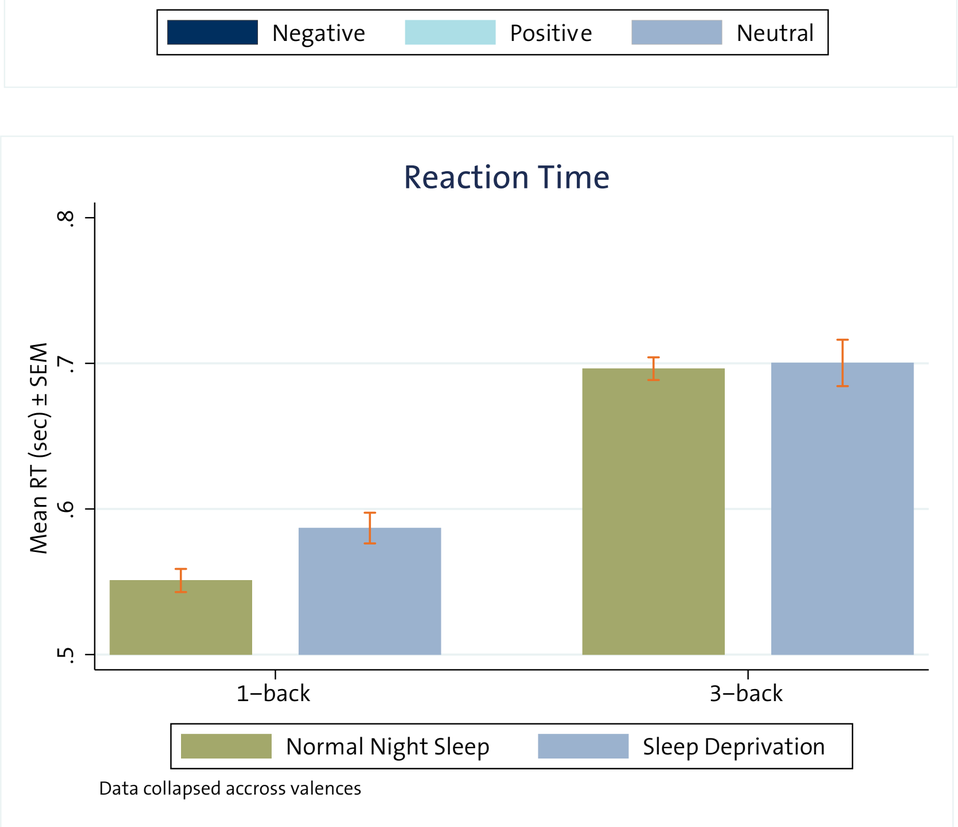


Figure 4



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