Sleep loss changes executive brain responses in the wake maintenance zone

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Objectives: Brain mechanisms underlying executive processes are regulated by circadian and sleep homeostatic processes. Furthermore, during sleep deprivation (SD), cognitive performance and neural responses are differentially modulated by a clock gene PERIOD3 polymorphism. Here, we investigated inter-individual differences on executive brain responses under SD. Critically, we focused on the circadian evening wake maintenance zone (WMZ), a key time-point for sleep-wake regulation.

Methods: Thirty healthy young volunteers, genotyped for the PER3 polymorphism (10 PER3⁵/⁵; 20 PER3⁴/⁴ homozygotes), underwent 42-h SD under constant routine conditions. They performed a 3-back working memory task in 13 successive fMRI sessions. To compare neural activity in the WMZ before and during SD, sessions were realigned according to individual dim light melatonin onset.

Results: We tested for a group (PER3⁵/⁵>PER3⁴/⁴) by session effect (WMZ before vs. during SD). From the first evening WMZ (i.e. during a normal waking day) to the second (i.e. following 40h of continuous waking), PER3⁵/⁵ individuals relative to PER3⁴/⁴ showed significantly larger increase in responses in the left mid-cingulate, bilateral precuneus and thalamus. Interestingly, these regions are involved in executive processes and arousal regulation (thalamus).

Conclusions: These results show that the strong circadian wake-maintenance signal depends on sleep pressure, in a PER3-genotype dependent manner. Interestingly, pronounced genotype differences were observed in the thalamus, an area that compensates potential lower cortical activity under SD.

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