Impact of circadian phase and prior wakefulness on cognition-related cerebral activity in humans

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Circadian and sleep-wake homeostatic processes modulate cognitive performance and its underlying cerebral correlates. We investigated brain activity during working memory performance in 24 healthy young participants by applying a 40-h multiple nap (NP) and sleep deprivation protocol (SD) in a within subjects design. Bloodoxygen- level-dependent (BOLD) activity was assessed using functional magnetic resonance imaging while performing a 3-back task at the end of the biological day (13 h after habitual wake-up) and night (21 h after habitual wake-up). Nap sleep efficiency (SE) assessed immediately after scanning under NP was considered to reflect the participants' strength of circadian wake (end of biological day) and sleep (end of biological night) promotion, respectively. At the end of the biological day, higher SE was negatively linked to anterior hypothalamic BOLD activity (Pcorr < 0.05), particularly during SD. Furthermore, higher BOLD activity in this region was associated with better 3-back scores at the end of the biological day, independent of sleep pressure condition (P < 0.05). In the early morning hours, higher SE was linked to reduced BOLD activity in a task-active cortical network (e.g. bilateral middle frontal, cingulate, premotor cortex, Pcorr < 0.05). Circadian wake promotion in the late evening hours seems thus associated with higher task-related hypothalamic BOLD activity, itself linked to better 3-back scores, while night-time circadian sleep promotion is mirrored by a reduced recruitment of cortical regions implicated in successful working memory performance.

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