Light impact on cognitive brain function depends on circadian phase, sleep pressure and *PER3* polymorphism.

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Objectives

Light stimulates human performance, alertness, and cognition. These effects are likely to be mediated through outputs from photosensitive melanopsin-expressing retinal ganglion cells which are maximally sensitive to shorter-wavelength (blue) light. The brain mechanisms involved are starting to be elucidated, but how they are affected by changes in circadian phase and sleep pressure is not known. In addition, markers of inter-individual differences in the impact of light are largely unknown.

Methods

We used fMRI to assess brain responses to an auditory working memory task, in the morning, right after sleep and during sleep-loss, and in the evening, in 2 populations stratified according to a genetic marker (*PERIOD3* polymorphism) for inter-individual differences in the build-up of sleep pressure and in performance vulnerability to sleep-loss ($PER3^{5/5}$ – N=12 - and $PER3^{4/4}$ – N=15), while participants were exposed to alternating 60s blue (473nm – 10^13 photons/cm^2/s) and green (527nm – 10^13 photons/cm^2/s) light.

Results

Results show that, compared with green light, blue light exposure increased brain responses in higher-order frontal and parietal cortical areas and in the pulvinar. These effects were only observed in the sleep-loss-vulnerable genotype ($PER3^{5/5}$) during sleep-loss, and in the less-vulnerable genotype ($PER3^{4/4}$) right after sleep, while no effect were observed in either genotypes in the evening wake-maintenance zone. Connectivity analyses suggest that light acts through a thalamo-fronto-parietal network to affect the ongoing cognitive process.

Conclusion

These data demonstrate that the impact of light on non-visual brain responses vary with circadian phase and sleep pressure in key areas for cognition and arousal regulation. They also establish a polymorphism in *PERIOD3* as markers of inter-individual differences in the impact of light on non-visual cognitive brain functions.

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