When a nap is not enough: sleep-related offline improvement of perceptual visual learning as assessed by fMRI.

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Objectives: We aimed at observing the influence of diurnal and nocturnal sleep on offline processing of visual perceptual memory, using a coarse orientation discrimination (COD) task and functional magnetic resonance imaging (fMRI).

Methods: Sixty volunteers were assigned to one of four experimental groups who performed a fixed orientation COD task in the lower right visual quadrant, with increasingly low signal to noise ratios (SNR), in a within-subject training-retest paradigm. These sessions were flanked by exposure sessions in which volunteers still had to discriminate between orientations, but without extensive training. In these tests, we presented stimuli with two fixed SNR values, a low noise (easy condition) and a high noise (difficult), as well as different orientations and quadrant positions. The cerebral activity of the exposure sessions was assessed using a 3T scanner recording fMRI series, analyzed with SPM5.The four groups differed in the time of day of their first training session, as well as the duration and the quantity of sleep between training and test. The NAP and NONAP groups were trained in the morning and underwent respectively a 1 hour 30 min. nap or an equivalent time of monitored quiet rest before retest in the afternoon; the SLEEP group was trained in the evening and retested after a full night of sleep the following morning; and the WAKE group was trained in the morning and retested after 8 h of monitored quiet rest.

Results: A repeated-measures ANOVA on SNR with blocks and sessions as within-subjects factors and group as between-subjects factor confirmed a significant improvement in the COD task overnight in the SLEEP group and not in the WAKE group ($F(1;21) = 6.39$; $P = 0.019$). On the other hand, neither the NAP nor the NONAP group showed any kind of improvement between training and test. At the cerebral level, a two-sample t-test between SLEEP and WAKE groups comparing trained, highly noisy stimuli versus untrained stimuli between training and test sessions showed a higher activation for the SLEEP group in an area compatible with the left Lateral Occipital Cortex (LOC) ()32)88)8 $Z(1,21) = 3.28$; psvc = 0.026). No change in brain learning related responses were observed at retest in the NAP or NONAP groups.

Conclusions: The data suggest that only nocturnal sleep can modulate the offline processing of an orientation-specific discrimination task by differentially activating an occipital area responsible for object recognition in an orientation and location specific way.