Working memory load affects chronotype- and time-of-day dependent cerebral activity modulations

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As compared to evening types (ET), morning types (MT) find it more difficult to maintain performance over a normal waking day. It has been hypothesized that the specific pattern of this time-of-day modulation depends on the investigated cognitive domain. Here, we explored the cerebral correlates of time-of-day and chronotype effects according to task difficulty using the n-back paradigm for which we created different complexity levels by manipulating the working memory load (0-,2-,3-back). The experimental stimuli consisted of pseudorandom sequences of letters and subjects had to indicate whether a probe letter matched the stimulus presented n-back trials ago. Sixteen ET and 16 MT participated. Each subject underwent 2 functional magnetic resonance imaging (fMRI) sessions, one 1h30 (morning) and the other 10h30 (evening) after wake-up. Only subjects whose performance level in terms of correct responses was higher than 70% for all conditions were included in the analysis (11ET; 10MT). Although a repeated-measures ANOVA on accuracy including the three variables (memory load*chronotype*time of day) did not reach significance ($F(1,19)=2.2$; $p=.16$) it was noticed that for the 3-back, MT and ET differed in their performance levels according to time of day. When we performed an ANOVA on the 3-back condition separately, there was a trend toward an interaction between chronotype and time of day ($F(1,19)=4,2$, $p=.054$), with ET performance improving from the morning to the evening hours ($p<.05$) and tending to be better in the evening as compared to MT ($p=.078$). From a functional neuroimaging point of view, our preliminary findings indicate that activity in a thalamic region (x=-6; y=-6; z=4; z-score=3.26) was simultaneously modulated by all 3 variables of interest. Activity in frontal brain areas such as the left middle frontal gyrus (x=-24; y=48; z=12; z-score=4.39) behaved similarly. This interaction effect indicates that chronotype-dependent time-of-day modulations at the cerebral level act differentially depending on memory load. Our data argue in favour of the assumption that interindividual differences have to be considered while studying state effects in task-related brain activity. They may be interpreted in the context of the hypothesis that higher task complexity, consecutive to higher memory load, leads to a temporal increase in thalamic-related arousal levels in ET only, which might favour optimal performance on this task condition during the evening hours.