Association between locus coeruleus activity during wakefulness and sleep features

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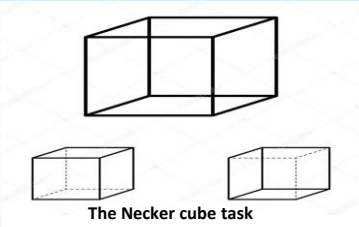
Introduction

- The locus coeruleus (LC) contributes to multiple processes such as sleep.
- Only limited imaging studies evaluated whether the LC is related to sleep variability due to the difficulty of imaging such a small size nucleus in vivo.
- **Our goal: investigate the link between LC activity during wakefulness and EEG features of sleep using ultra-high-field 7-Tesla functional MRI.**

Methods

Participants. 50 healthy volunteers (age: 35.55y ± 4.2y; 41 women)
fMRI task. Perceptual rivalry task: observing the Necker cube for ~10 minutes with 10s breaks every minute → Pressing a button when perception changes
Sleep protocol. Habitual and baseline sleep was recorded in-lab under EEG to extract 4 sleep features of interest: cumulated power of the theta frequency band during REMS, slow wave energy (SWE), sleep onset latency, and REM sleep percentage.
Data analysis. **MRI preprocessing:** remove background, auto reorientation, segmentation, BET. **fMRI preprocessing**: auto reorientation, realign and unwarp, BET, smoothing, coregistration. **LC segmentation steps:** Upsampling whole brain structural image, manual realignment of LC slab to upsampled image, coregistration of the LC slab to the upsampled image, segmentation of LCs by 2 raters, extracting conjunction of both masks and extracting each individual LC betas by REX toolbox
Statistical analysis: 1) GLM over the entire brain 2) GLMMs to test for associations between the activity of the LC and EEG features of sleep, including age, sex, BMI, and total sleep time as covariates.


The Necker cube task

Results

Perceptual switches were associated with increased activation in the left LC after controlling for age, sex, BMI, and total sleep time (whole brain FDR-corrected p<0.01; t > 3.055) (Fig1)
The GLMM showed a **positive association between the bilateral LC activity and SWE (p = 0.02, F= 5.1), which reflects slow wave sleep intensity, as well as EEG cumulated power of the theta frequency band during REM sleep (p= 0.03, F=4.8), which is the dominant oscillatory mode of REM sleep (Fig2).**

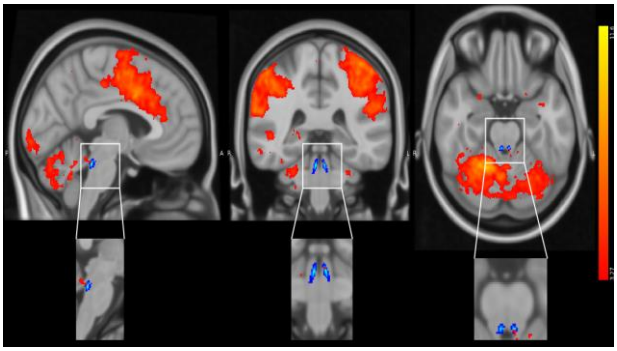


Figure 1. Locus coeruleus activity at perception switch during perceptual rivalry task.
Top: whole-brain response (p < 0.001 uncorrected, t > 3.27). Bottom: LC probabilistic template and the significant activation detected within this mask (p < 0.01 FDR corrected).

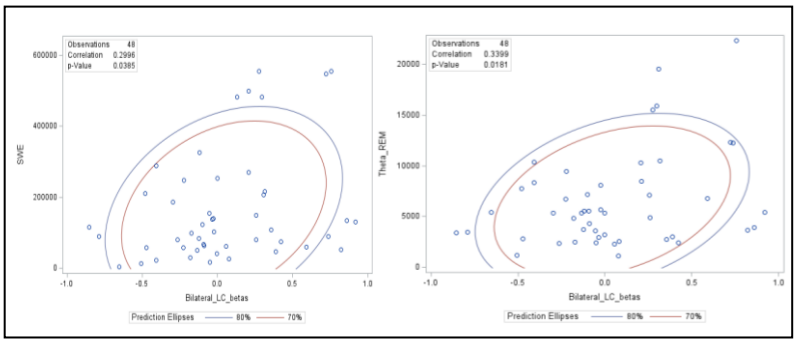


Figure 2. The associations between the locus coeruleus activity and sleep features (refer text for GLMM outputs)

Conclusions

These results show, that in the context of perceptual rivalry task, more LC activity during wakefulness is associated with more intense slow wave sleep and REM sleep.
Future analyses will consider the relationship between LC activity and sleep microstructure.

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