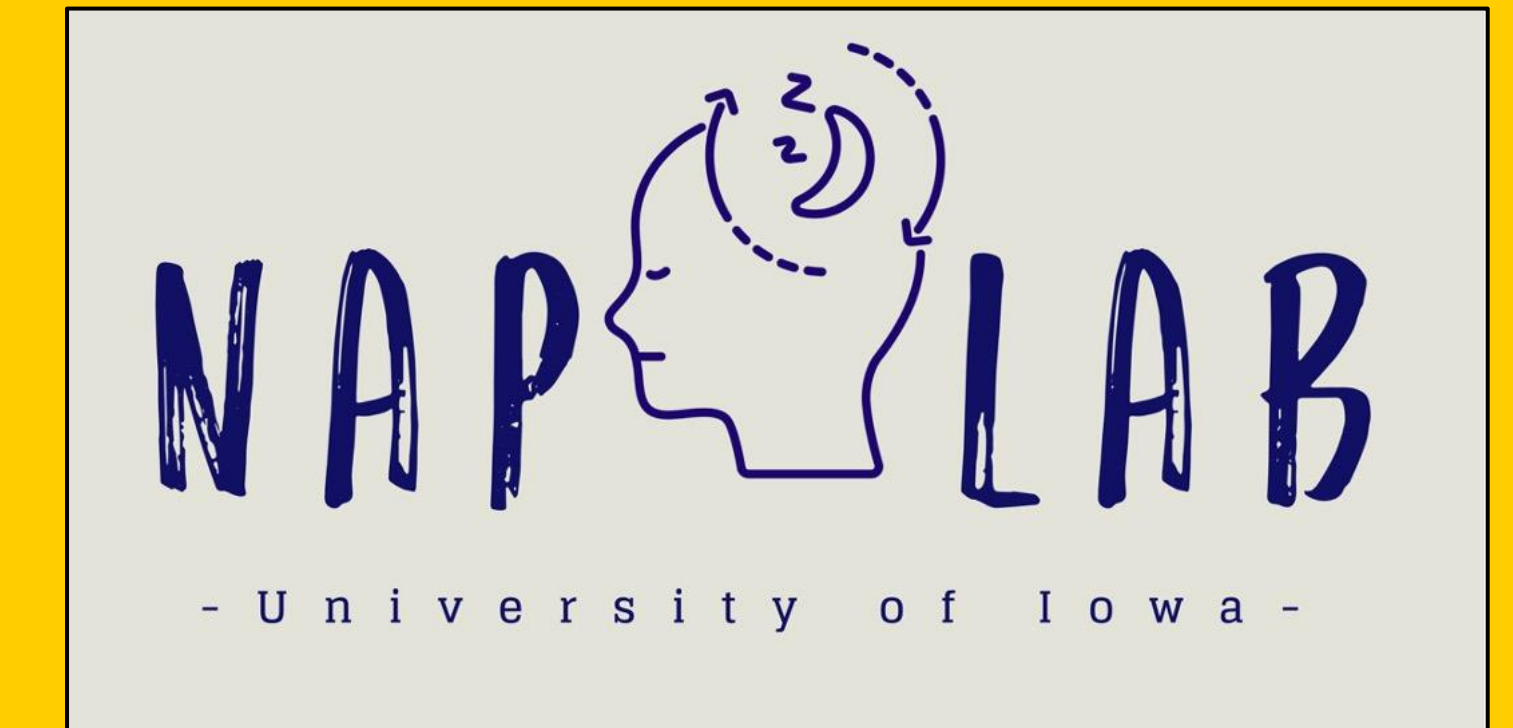


NREM Sleep Oscillations Are Altered in Young Adults with Heightened Trait Anxiety

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Introduction

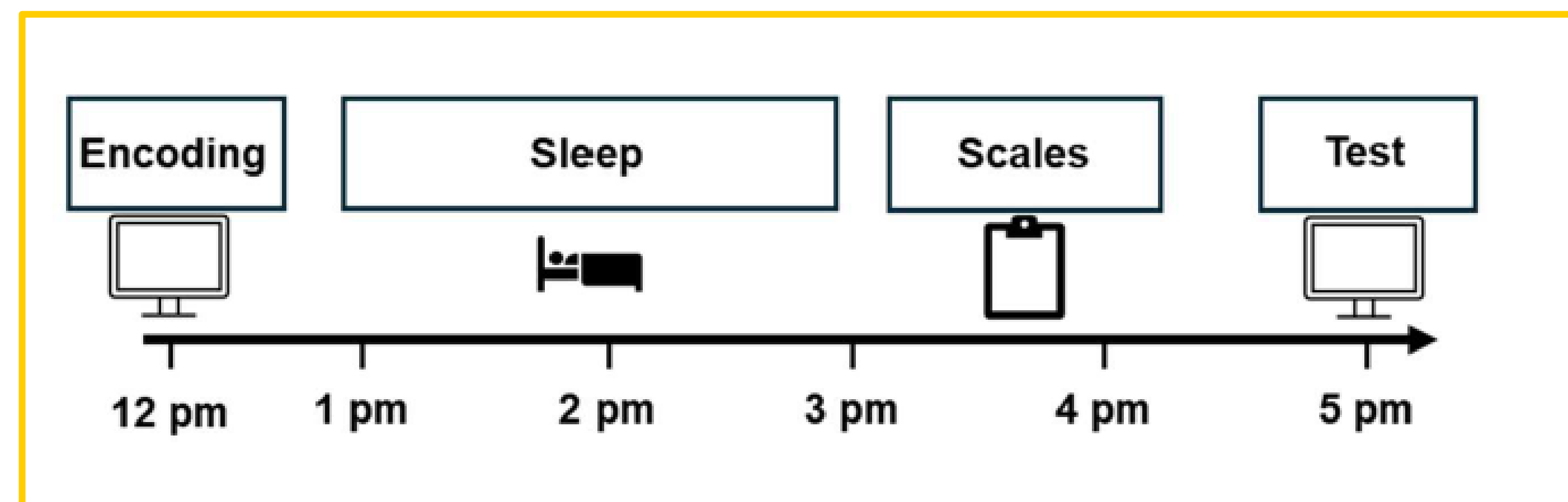
- Sleep is critical for emotional regulation.^{1,2} Disturbances in sleep quality and duration have been linked to heightened anxiety^{3,4} but little is known about the effects of anxiety on non-rapid eye movement (NREM) sleep oscillations—specifically slow oscillations (SOs) and sleep spindles.
- Emerging work has linked NREM oscillations to emotional memory and affective processing during sleep^{5,6,7}
- The present study sought to answer two questions in a non-clinical sample of young adults with heightened anxiety:
 - Do young adults with heightened trait anxiety levels exhibit alterations in NREM oscillations?
 - Are NREM oscillations associated with state anxiety and negative affect upon awakening?

Methods

	Low Anxiety (n:16)	High Anxiety (n:26)	p
Age (years)	18.8±.9	19.6 ± 2.1	.2
Sex	62.7% F	77% F	.8
Positive Affect ^a	31.4±6	30.1 ± 8.1	.6
Negative Affect ^a	17.9± 3.9	22.5 ± 6.8	.02*
State Anxiety ^b	31.3±7.5	38.9±12.5	.03*
Trait Anxiety ^b	31.3±7.5	38.9±12.5	.02*
Depression Symptoms ^c	5.3±3.8	9.6±5.4	.01*

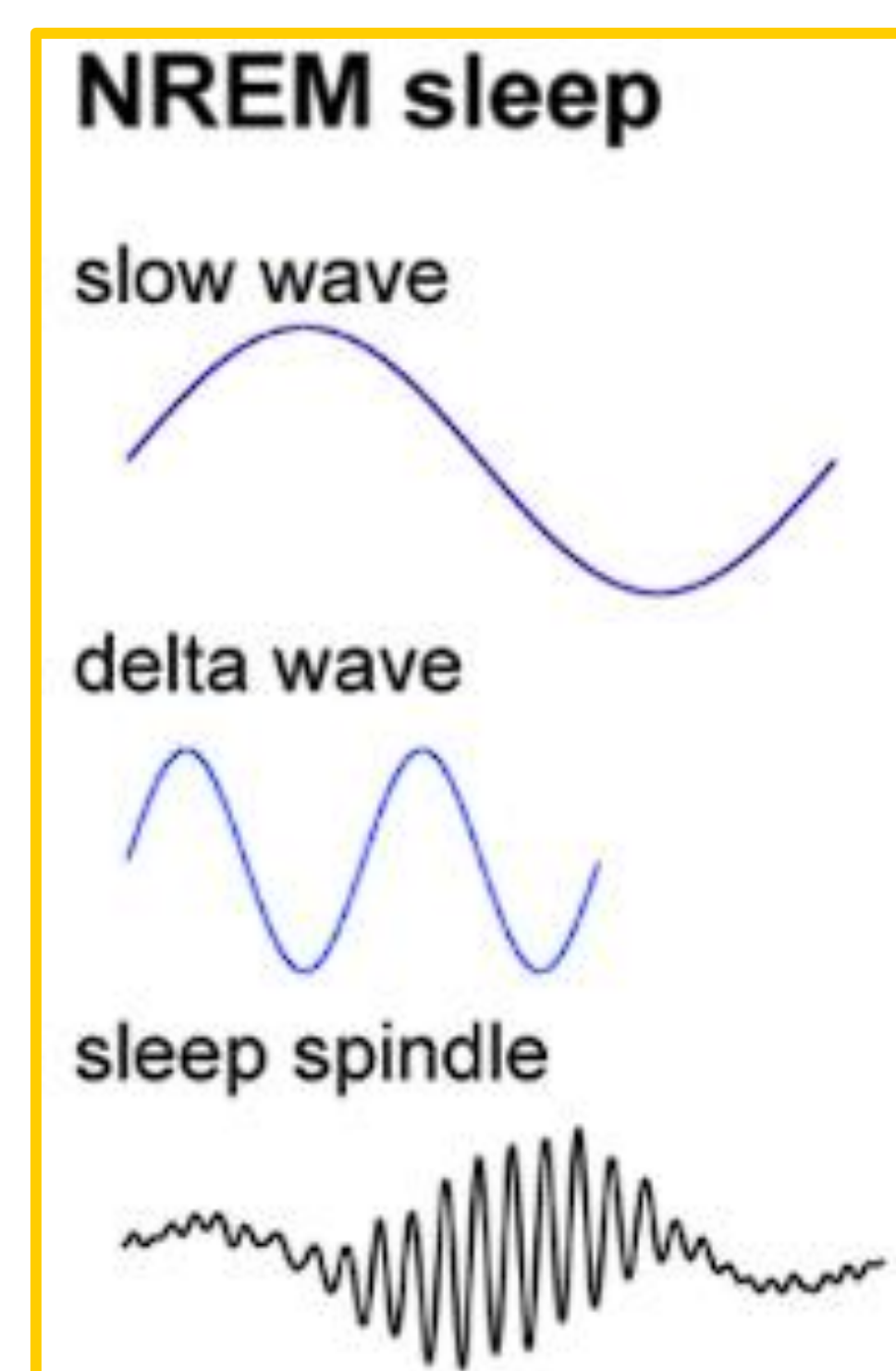
Of a large pool of college freshmen with STAI-Trait scores >2 SD were classified as High Anxiety, and those <2 SD as Low Anxiety

* p<.05
^aPositive and Negative Affect Schedule (PANAS)⁸
^bState-Trait Anxiety Inventory (STAI)⁹
^cQuick Inventory of Depressive Symptomatology (QIDS)¹⁰



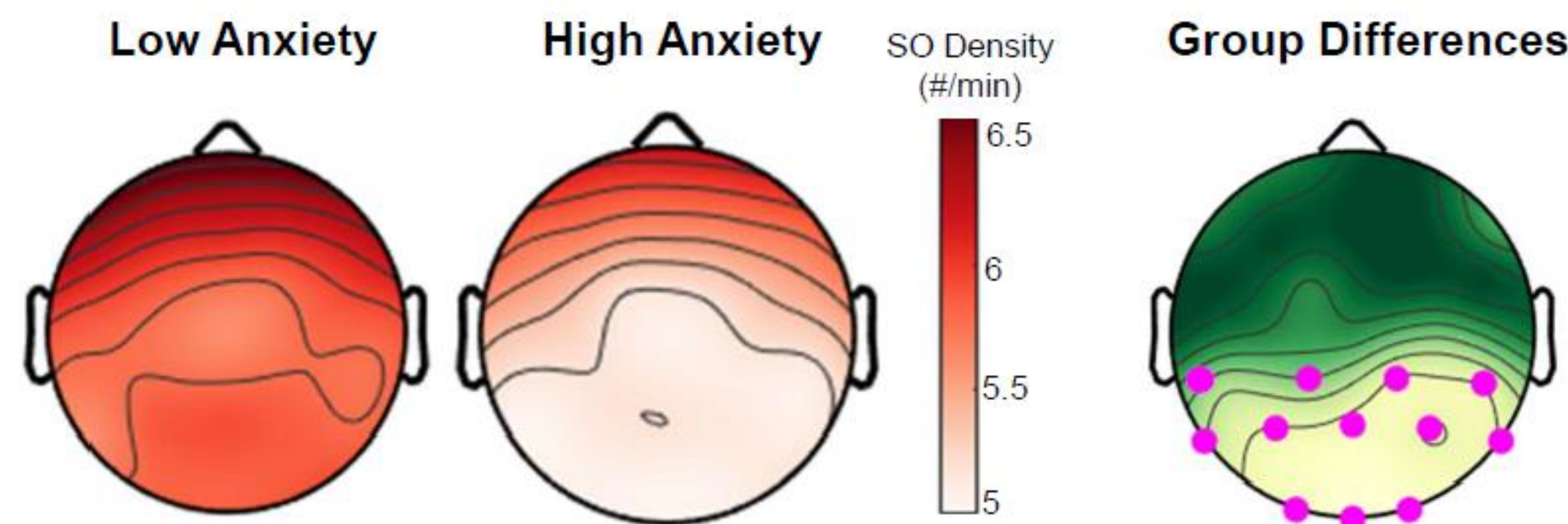
Polysomnography

- 32 channel Brainvision Liveamp EEG Acquisition system.
- NREM Stage 2 and 3 sleep spindles and slow oscillations (SO) were detected at each electrode using custom scripts (REF). Outcome measures were Density (number/min) and Amplitude (Define) of detected oscillations.
- Cluster-level correction for multiple comparisons applied for all analyses¹¹.



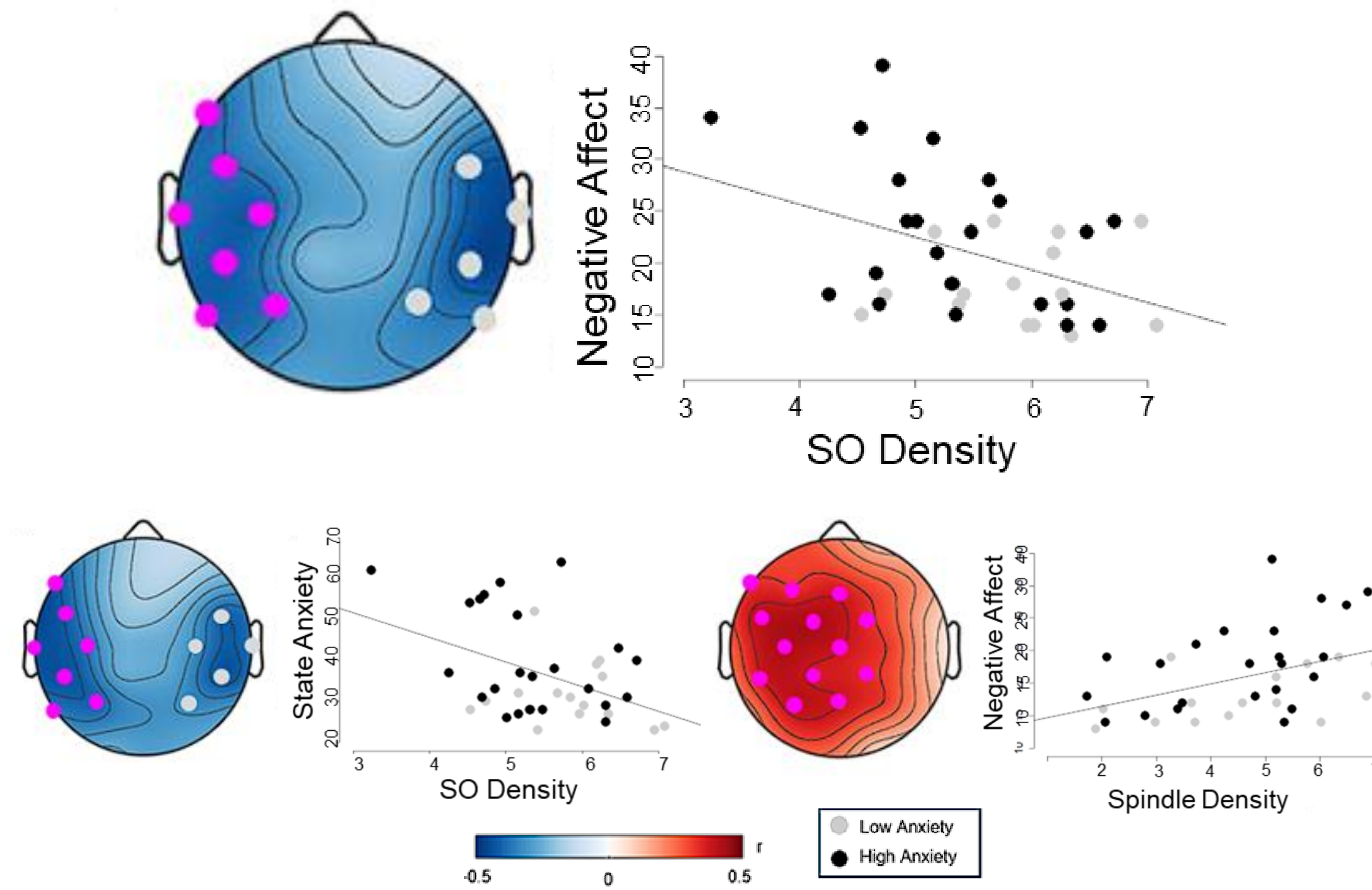
Results

Reduced SO Activity in the High Anxiety Group



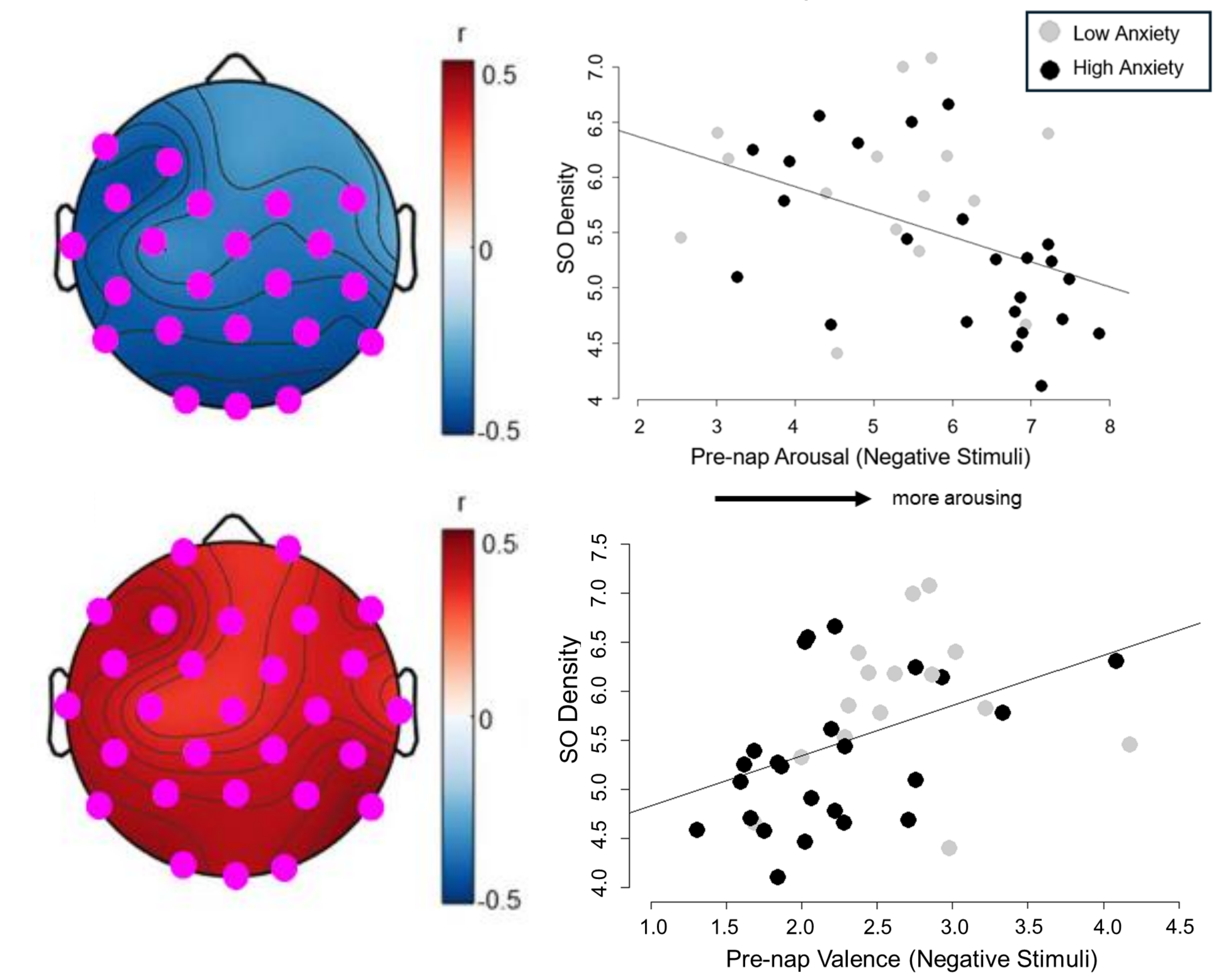
- No group differences in sleep duration, efficiency or time spend in each sleep stage (all p 's>.15)
- Slow oscillation density was significantly reduced in the High Anxiety group (12 electrodes, $t_{sum}=-30.29$, $p_{corrected}=.04$).
- Beyond detected SOs, we also observed a significant reduction in delta power in the High Anxiety group (21 electrodes, $t_{sum}=-49.31$, $p_{corrected}=.04$).
- There were no group differences in the density, amplitude or other characteristics of sleep spindles.

NREM oscillations are related to anxiety and affect



- Higher SO density during the nap correlated significantly and negatively with subsequent state anxiety (7 electrodes, $t_{sum}=-18.74$, $p_{corrected}=.046$) and negative affect (7 electrodes, $t_{sum}=-17.98$, $p_{corrected}=.045$). Similar relations were observed for SO amplitude and negative affect (6 electrodes, $t_{sum}=-17.41$, $p_{corrected}=.04$).
- Sleep spindle density (13 electrodes, $t_{sum}=31.57$, $p_{corrected}=.02$) was positively associated with subsequent negative affect, and sleep spindle amplitude was positively associated with state anxiety (13 electrodes, $t_{sum}=31.23$, $p_{corrected}=.03$)
- The effects of SOs and spindles were independent from each other (VIF=1.02 for negative affect, VIF=1.11 for state anxiety).

Pre-sleep emotionality ratings were associated with reduced SO activity



- SO density correlated significantly and negatively with both arousal (23 electrodes, $t_{sum}=-61.83$, $p_{corrected}=.01$) and valence (28 electrodes, $t_{sum}=-71.60$, $p_{corrected}=.01$)
- No group difference was observed in the emotional memory task, or ratings of emotional stimuli

Discussion

- We observed significant reductions in NREM slow oscillatory activity in high trait anxiety individuals in the context of no disruption in sleep duration or architecture.
- SO activity was negatively related to state anxiety and negative affect. In other words, participants with higher SO activity reported being less anxious and having less negative affect as they woke up. In addition to that, individuals who rated negative stimuli as more negative and more arousing before nap had reduced SO activity during the nap. This finding suggests that SO activity may be a potential target to enhance emotional regulation.
- In contrast, spindle activity demonstrated a positive correlation with state anxiety and negative affect, meaning that individuals with higher spindle activity reported higher anxiety and negative affect. While seemingly controversial, these findings are in line with a recent study that demonstrates increased spindle activity following a stress manipulation in adults with PTSD¹².
- Limitation: No anxiety/affect measurements before nap, no wake group, small sample size and unequal group distribution.
- Future Plans: Testing the hypothesis that changes in NREM oscillations will predict response to neuromodulation therapy in psychiatric disorders.

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