# Will Changes in Cortical Excitability due to Slow Wave Sleep Disruption Impact Changes in Aggressive, Impulsive Behavior?

Chinyelu Ojukwu
cojukwu@sas.upenn.edu
College of Arts and Sciences
Class of 2024

Mentor and PI: Jennifer R. Goldschmied[1], University of Pennsylvania, Department of Psychiatry

Elly Goldstein[1], Sarah Song[1], Grace Estabrook[1], Emma Palermo[1], Zach Zamore[1], Kendall Owens[1], Samantha Costell[1], Tahira Khan[2]
1. Sleep Slow Wave Activity Lab, University of Pennsylvania 2. Penn Undergraduate Research Mentoring Program, University of Pennsylvania

## Introduction

Cortical excitability is the strength of response that is generated in cortical neurons following stimulation (Gaggioni et al, 2016). Prior biological research has discovered a direct relationship between cortical excitability and aggressive, impulsive behavior (AIB) (Delgado et al, 2019), proposing that the higher the cortical excitability, the more prone an individual is to expressing AIB (Bolu et al, 2015).

Research has also found that slow wave sleep, or deep sleep, influences cortical excitability in a downregulating manner (Tononi & Cirelli, 2003). If slow wave sleep causes a decrease in cortical excitability, then slow wave sleep disruption could cause cortical excitability and synaptic strength to increase during sleep, influencing AIB.

## Objective

In the present study we were interested in investigating the effects of slow-wave sleep disruption (SWSD) on AIB.

## Methods

Inclusion criteria for eligibility: right-handed, 25-50 years old, consistent 6–8-hour sleep schedule. Exclusion criteria: history of psychiatric conditions except for depression, anxiety, and ADHD, history of medical conditions except for medically controlled thyroid disorder, antidepressant use, and history of recent head trauma or concussions.

The participants were confirmed to have major depressive disorder (MDD), with the confirmation of a SCID assessment.

Participants completed two overnight visits, a baseline and disruption visit, one week apart. SWSD only occurred during the disruption visit, while tasks, questionnaires, and TMS protocol were completed during both visits (see Fig 1)..

The Hamilton Rating Scale for Depression, Brief Irritability Test (BITe), and anger subscore of the Profile of Mood State Short Form (POMS) were questionnaires used to determine the mood, irritability, and anger of the participants, respectively. The Go/No-go auditory task reaction times (RT) were used to measure impulsivity. TMS was used to measure the effects of SWSD, using data from motor evoked potentials (MEP), following the overnight visits.

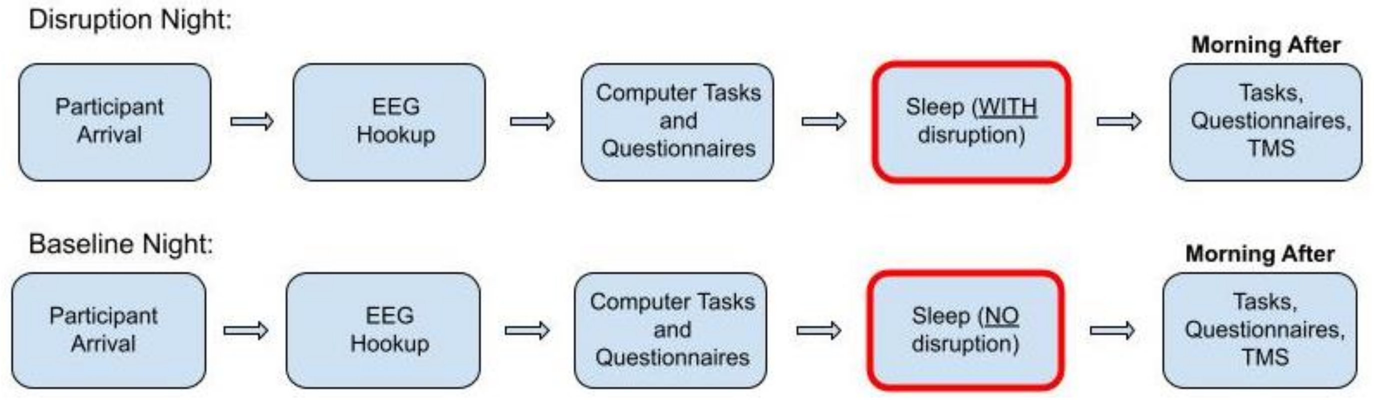
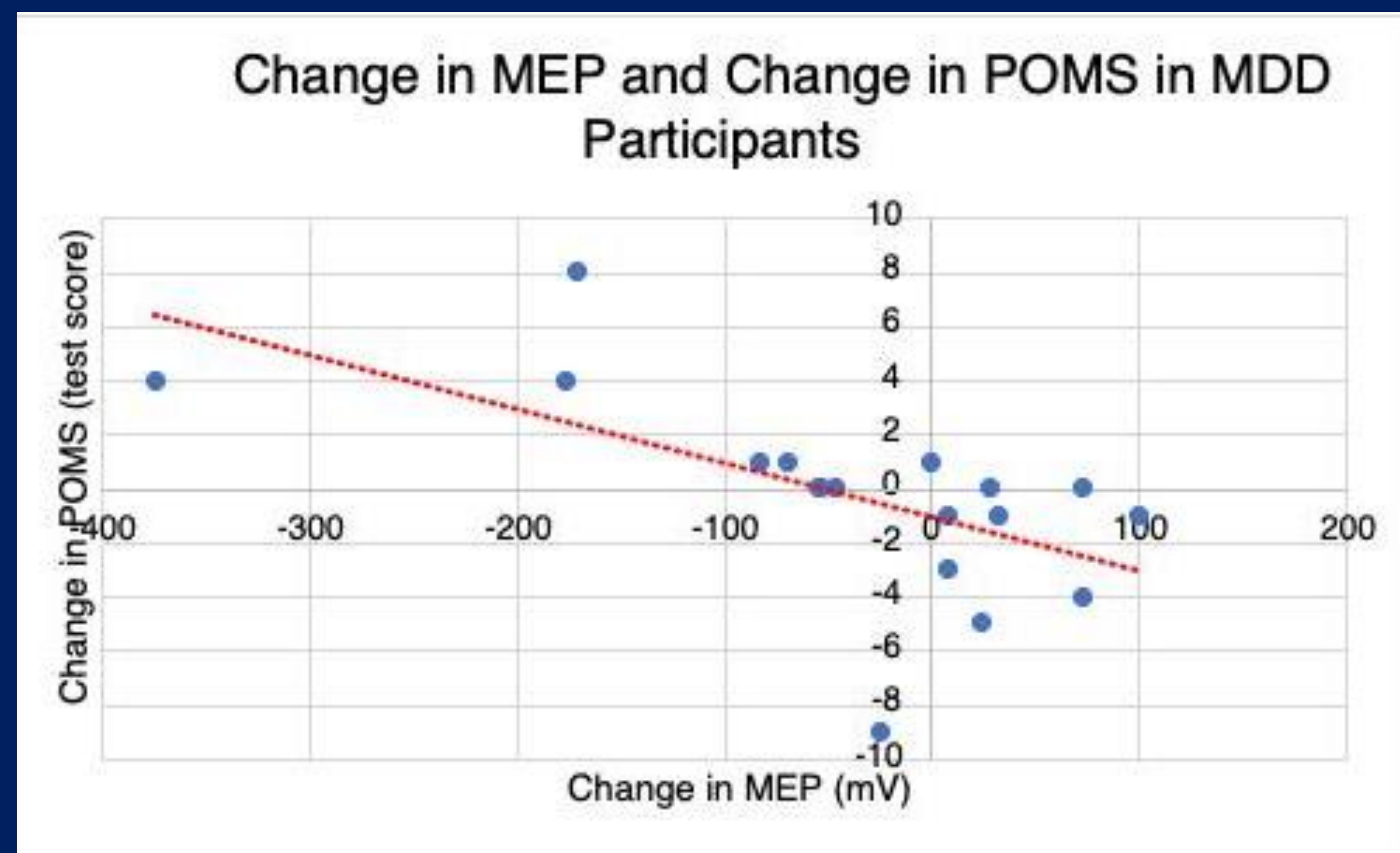



Figure 1: Study Flow

Those who showed **greater increases** in cortical excitability, due to slow wave sleep disruption, showed **greater reductions** in anger




SCAN TO ACCESS FULL PAPER

## Results

| Percentage Female | Percentage Male | Average Age | Average Hamilton Score | Mode Level of Education | Percentage White | Percentage Non-white |
|---|---|---|---|---|---|---|
| 59% | 41% | 32.4 (6.0*) | 5.2 (3.6*) | Completed College | 76% | 24% |

*standard deviation

Change scores were computed to look at the impact of SWSD on AIB. Results from the correlational analysis revealed that change in MEP had a statistically significant negative correlation with change in the anger sub-score of POMS-SF ($r = -0.60$, $p < 0.05$) (see Figure 2). A significant correlation was not found between change in MEP and change in RT or BITe, respectively.

## Conclusions

These results demonstrate that participants who showed greater increases in MEP due to SWSD showed greater reductions in anger. On the other hand, the data demonstrates that impulsivity and irritability do not have a significant correlation with MEP and, more specifically, with cortical excitability.

These results could indicate that in this sample of participants, the increased cortical excitability, which occurred as a result of SWSD, did not occur in subcortical regions of the brain expressing emotion and reactive aggression, but instead occurred in frontal cortices which have top-down regulation on the subcortical regions (Paret et al, 2014).

Possible limitations present in this study include a small sample size that was majority female and white, and impulsivity being measured by only the Go/No-go task.

More research is needed to investigate the impact of SWSD on aggressive, impulsive behavior.

Acknowledgements
NIHK23MH118580

## References

Bolu, Abdullah, et al. "Cortical Excitability and Aggressive Behavior in Post-Traumatic Stress Disorder." *Noro Psikiyatri Arsivi*, vol. 52, no. 1, Mar. 2015, pp. 73–77, https://doi.org/10.5152/npa.2015.7031.
Delgado, A. Rodriguez, et al. "Effect of Repetitive Transcranial Magnetic Stimulation on Aggressive Impulsive Behavior in Subjects with Bpd in a Social Exclusion Paradigm." *Brain Stimulation: Basic, Translational, and Clinical Research in Neuromodulation*, vol. 12, no. 2, Mar. 2019, p. 512, https://doi.org/10.1016/j.brs.2018.12.681.
Paret, Christian, et al. "Down-Regulation of Amygdala Activation with Real-Time Fmri Neurofeedback in a Healthy Female Sample." *Frontiers*, Frontiers Media SA, 1 Jan. 1AD, https://www.frontiersin.org/articles/10.3389/fnbeh.2014.00299/full.
Tononi, Giulio, and Chiara Cirelli. "Sleep and Synaptic Homeostasis: A Hypothesis." *Brain Research Bulletin*, vol. 62, no. 2, Dec. 2003, pp. 143–50, https://doi.org/10.1016/j.brainresbull.2003.09.004.