

Signals of Healing: Quantifying rTMS induced neural changes in treatment resistant depression

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Introduction

Major Depressive Disorder (MDD) affects 280 million people world wide; however, many patients fail to get better despite conventional pharmaceutical treatment and psychiatric therapy. With this predicament in mind, researchers have found that repetitive transcranial magnetic stimuli (rTMS) is a tool used to regulate the neural brain activity. Despite its promising results it is an understudied solution to neuropsychiatric disorders, like MDD. Current research has so far uncovered that there are differences in certain brain waves between people with MDD and without. Thus, researchers are now trying to use rTMS to restore brain activity to normal states. Under the mentorship of Dr. Deborah Won, our team has been analyzing neural patterns pre- and post- rTMS treatment that could exhibit correlations with clinical metrics of MDD. This research currently seeks to uncover important biomarkers of MDD through non-invasive EEG and to improve neuropsychiatric treatment of MDD.

Project Highlights & Activities

Box and Whisker Plots (Figure 1)

Post-rTMS - Pre-rTMS changes in PLI in the alpha band activity across the different pairs of brain regions to illustrate the distribution of neural responses.

Correlation Analysis (Figure 2)

Scatter plots between changes in phase lag index (PLI) and changes in MADRS scores. With the use of MATLAB, we found a weak correlation of -.34 for the alpha band and .3 for the gamma band.

Hypothesis Testing (table with p values)

Evaluated whether changes in EEG features before and after rTMS were statistically significant. p values were tabulated and indicated correlation between alpha band PLI changes and MADRS score changes but great levels of variation across subjects.

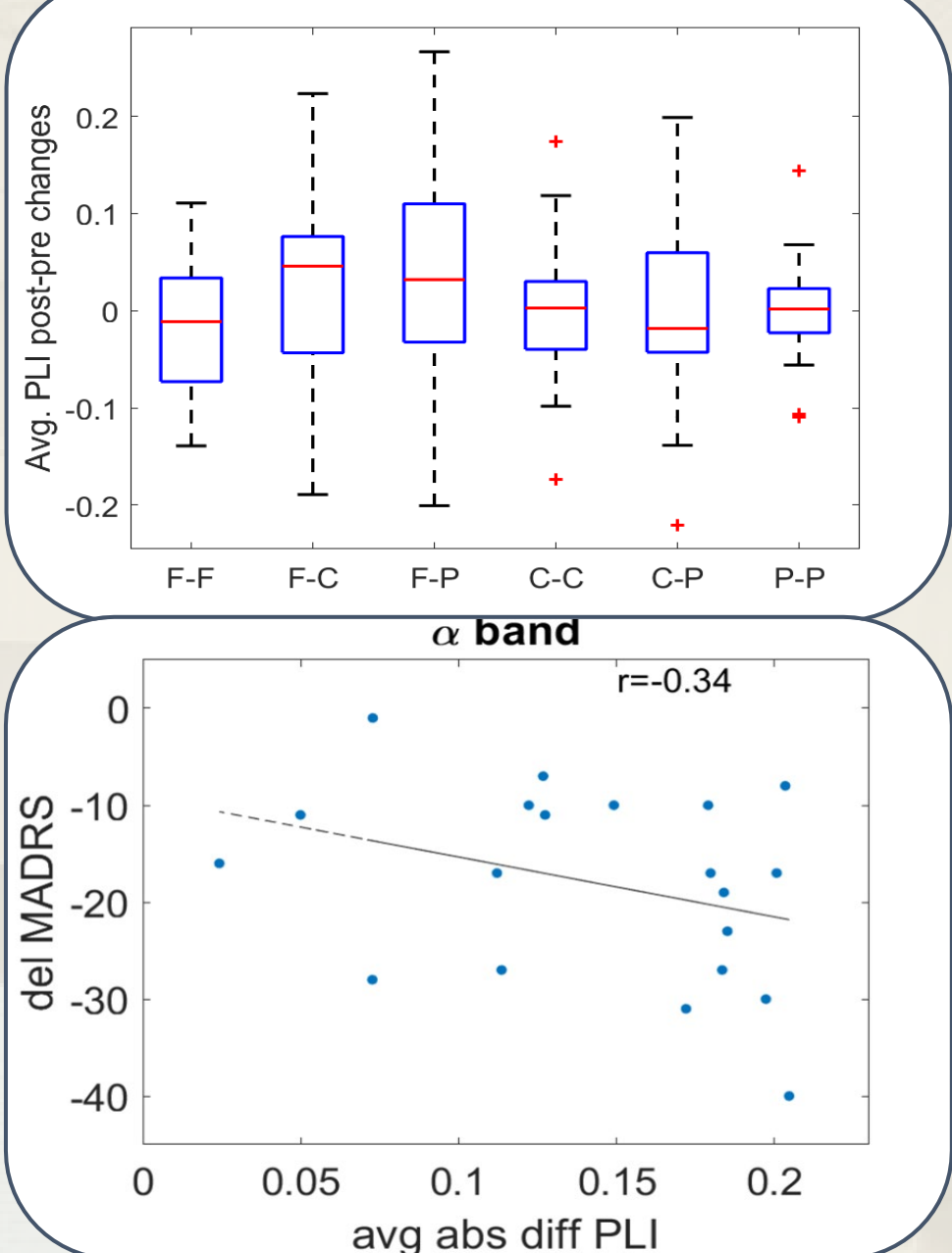


Figure 1. Box-and-whisker plot of average post-pre changes in Phase lag Index (PLI) across region pairings (Front-Frontal, Frontal-Central, etc.).

Figure 2. Scatterplot showing the correlation between average absolute difference in PLI and change in MADRS scores in the alpha (alpha) frequency band.

IntelliMed Testimonials

Ashley

My experience with the SMART Internship program has been incredibly impactful in shaping my academic and career journey. Working on the "Signals of Healing" project allowed me to apply my passion for neuroscience to real-world research focused on treatment-resistant depression. Through hands-on experience with EEG data, MATLAB, and correlation analysis, I gained valuable technical and analytical skills. I also deepened my understanding of how brainwave patterns, particularly in the alpha and gamma bands, can reflect changes in mental health. With a supportive team, Derek Soriano, Andrea, and Arthur, and mentor, Dr. Deborah Won, this gave me insight into the power of interdisciplinary research and the importance of innovation in psychiatric treatment. This internship has strengthened my confidence as a future neuroscientist and reaffirmed my goal of becoming a neuro-pediatrician who integrates research, compassion, and community impact.

Andrea

Thanks to STEM Core Program I had a rewarding summer at CSULA. As a SMART and IntelliMed student I learned how to read research papers with thorough, the reality behind a research investigation, how to begin a projects from scratch, collaborative work is better than solitary work, and that google will be your new best friend. To be successful you must be on time and diligent but also have fun in your own learning experience. Working with Dr. Won, better known as "Debbie~" has been a wonderful experience. Her passion, insight, and extrovert attitude has made me take away the most and furthered my interest in the medical field. This was the first time I've ever been part of an important project. EEG, rTMS, PLI, MADRS Scores, are acronyms that I now use and think about from my day to day. I've been challenged to think, analyze, and project my ideas. As a first generation Latina, this internship marked the first time I saw intellectual work recognized and compensated. It was an eye opening shift from what I've always known. This experience not only challenged me academically, but also changed how I view my own potential. I leave this internship with gratitude, clarity and confidence in the path ahead.

Arthur

My experience with the SMART internship program has provided me with a tremendous opportunity to improve my technical skills and develop problem-solving abilities. I had the honor of working alongside engineers from the IntelliMed group, where we utilize data from non-invasive electroencephalography (EEG) biomarkers to assess bandwidths of patients suffering from major depression disorder (MDD). Our mentor, Dr. Won, provided us with a tour of her research project and introduced us to MATLAB to better identify correlations in various bandwidths between PLI and MADRS. As an aspiring biomedical engineer, I quickly recognize the importance of building a strong foundation in computer programming and signal processing, statistics, and neuroscience to become well verse with our daily meetings. My time here at CSULA has provided me with essential skills and resources in my field of study, reinsuring me to excel in any and all future projects.

We'd like to give a special thanks to Isuru & Derreck for helping us throughout the learning portion of the investigation!

Key Technologies and Tools

EEG

- EEG = electroencephalography
- records electrical brain activity to identify biomarkers
- multiple electrodes over different regions of brain
- brain waves in different frequency bands: alpha, beta, gamma, and theta band waves

rTMS

- rTMS = Repetitive Transcranial Magnetic Stimulation
- non-invasive neuromodulation technique
- apply magnetic pulses to specific regions of the brain to stimulate neurons
- can alter brain network activity and activity patterns that can alleviate depression



Figure 3. A.A. Trying on an SEEG Cap with IntelliMed Group

MATLAB - Data Processing

- tool to process data
- in the IntelliMed lab, utilized MATLAB to
 - calculate PLI. PLI measures phase differences between two EEG signals
 - create linear correlation graphs with MADRS scores and the average absolute difference in PLI. MADRS = clinical questionnaire that assesses people's severity of depression
 - use box and whisker plots and scatter plots to determine whether the subject have made major improvements with rTMS treatment

Interns in Action



Figure 4. A.M. Analyzing Alpha Band Graphs



Figure 5. A.H. Note taking the days findings

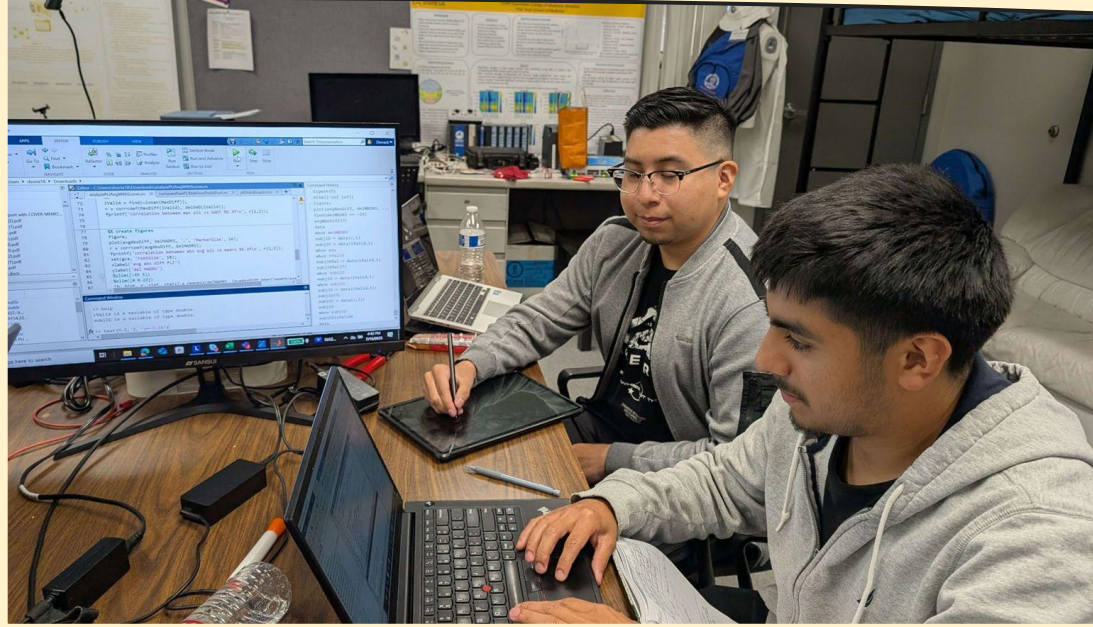


Figure 6. A.A & Derreck discussing the investigation

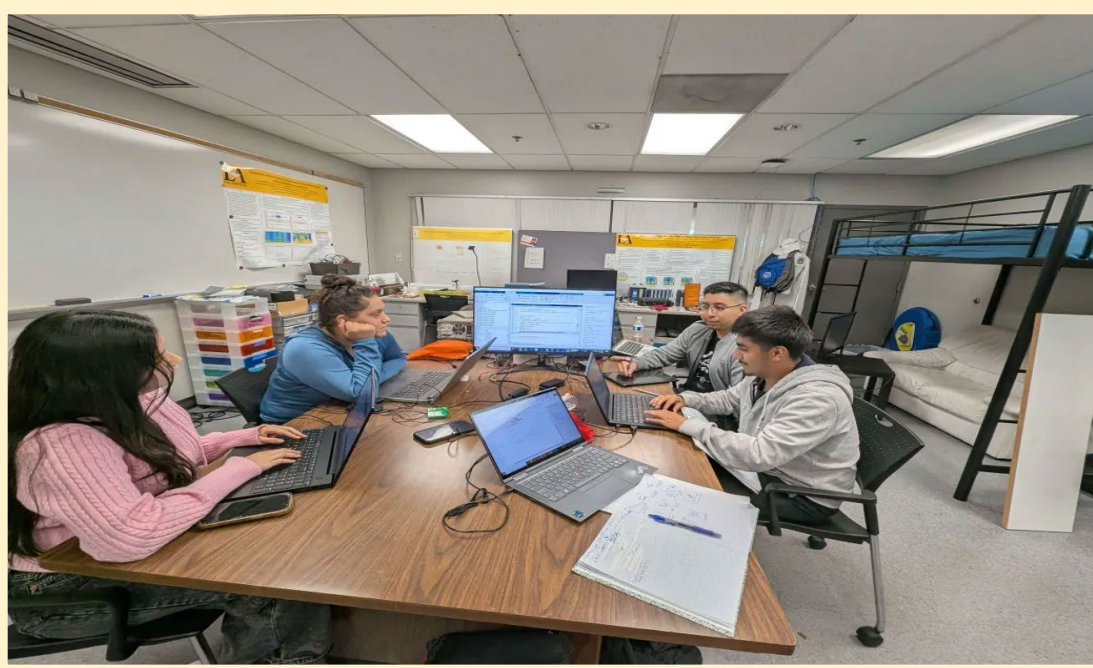


Figure 7. IntelliMed Team Observing data