

EEG- Electroencephalogram



Picture taken in the Frohlich Lab

- The brain is an electrical organ
- Natural oscillation patterns at different speeds (alpha, theta, etc.)
- EEG-> helps collect data on the ongoing electrical brain activity
- A small amount of gel is placed under each electrode to better

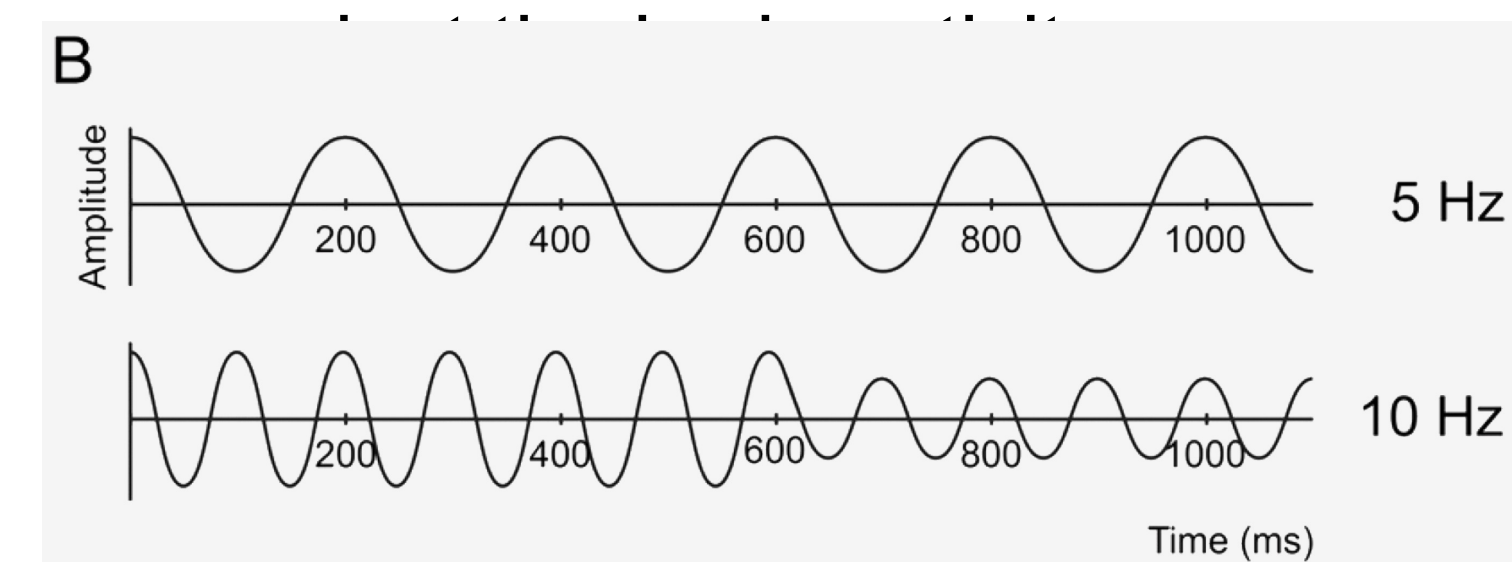


Image from Emotiv, Figure 7 in Basics of Neural Oscillations

TMS- Transcranial Magnetic Stimulation

- Non-invasive stimulation that uses a magnetic field to stimulate electrical activity in neurons
- Rhythmic TMS are pulses of stimulation that drive oscillations (2 types)
- In-phase -> rhythmic TMS with the natural electrical patterning of the brain
- Anti-phase -> rhythmic TMS against the natural electrical patterning.
- Arrhythmic TMS does not follow a pulse to time ration and is not successful in driving oscillations

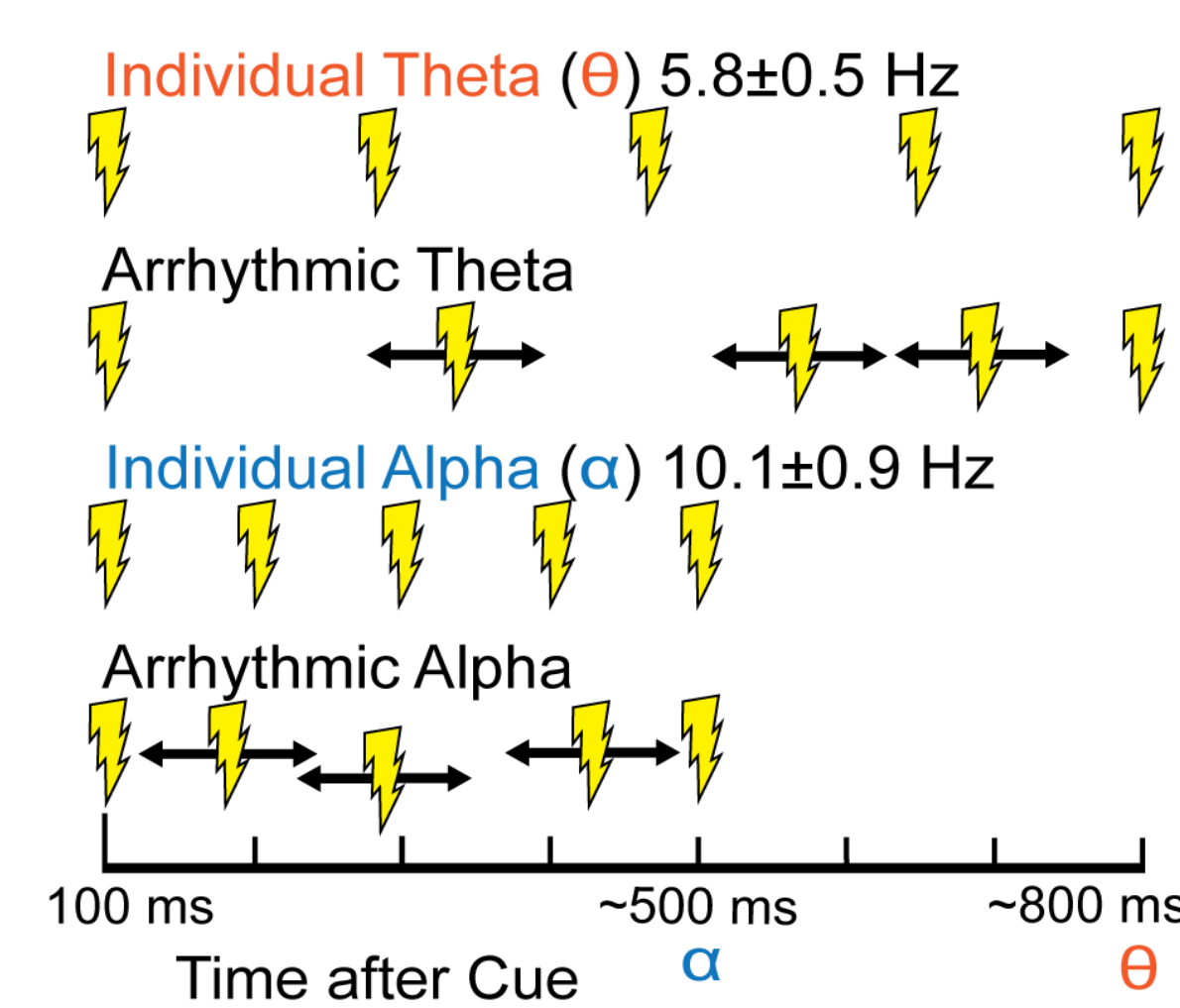
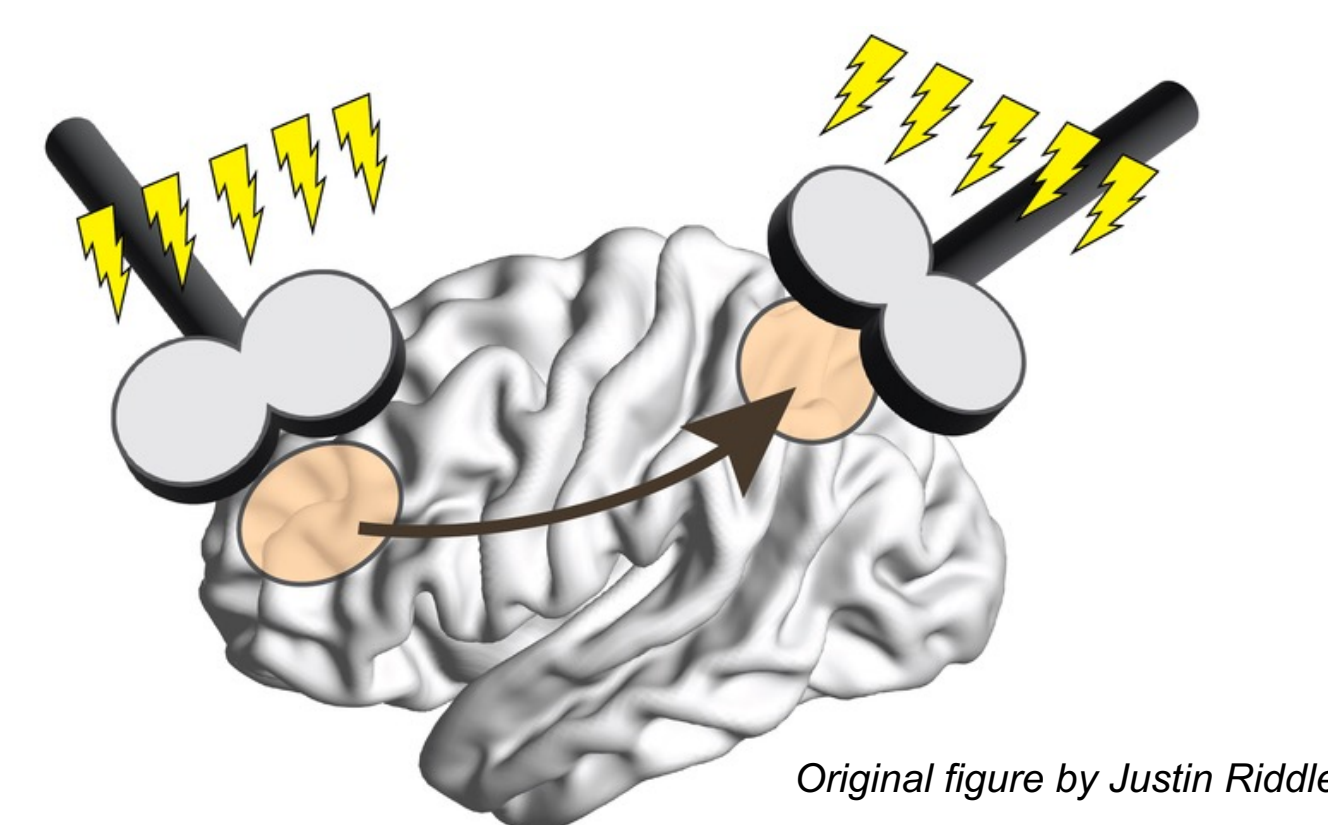


Image from Figure 1 of Casual Evidence for a Role of Theta and Alpha Oscillations in the Control of Working Memory, Riddle, Current Biology

MRI- Magnetic Resonance Imaging

- Provides an internal scan of the brain and localizes areas activated during a task performance
- Participant completed the task while in the MRI machine
- Significant difference was that instead of color-matching with the joystick, a true-false method of testing was used because of space limitations

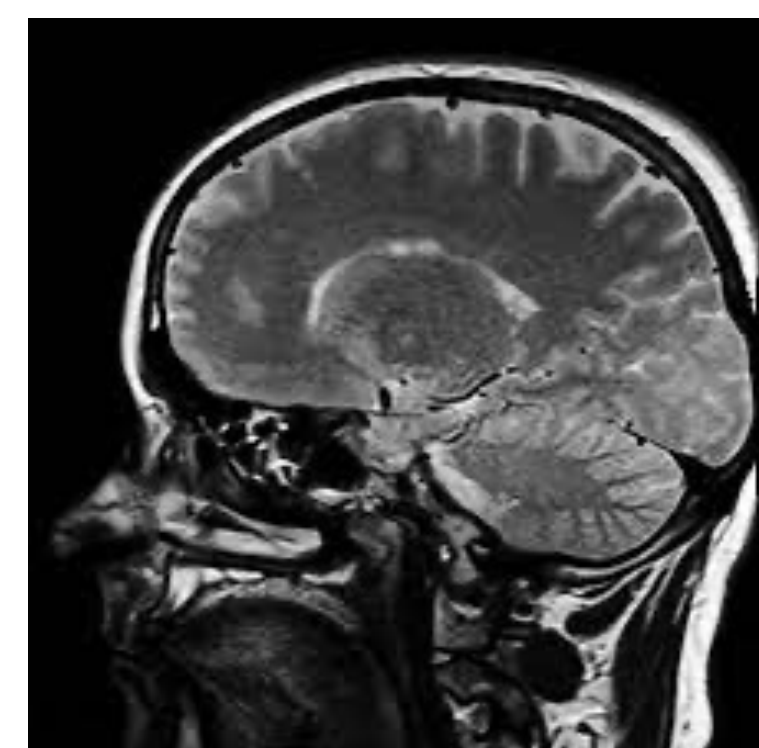


Image from Wallpaper Flare Image Archives

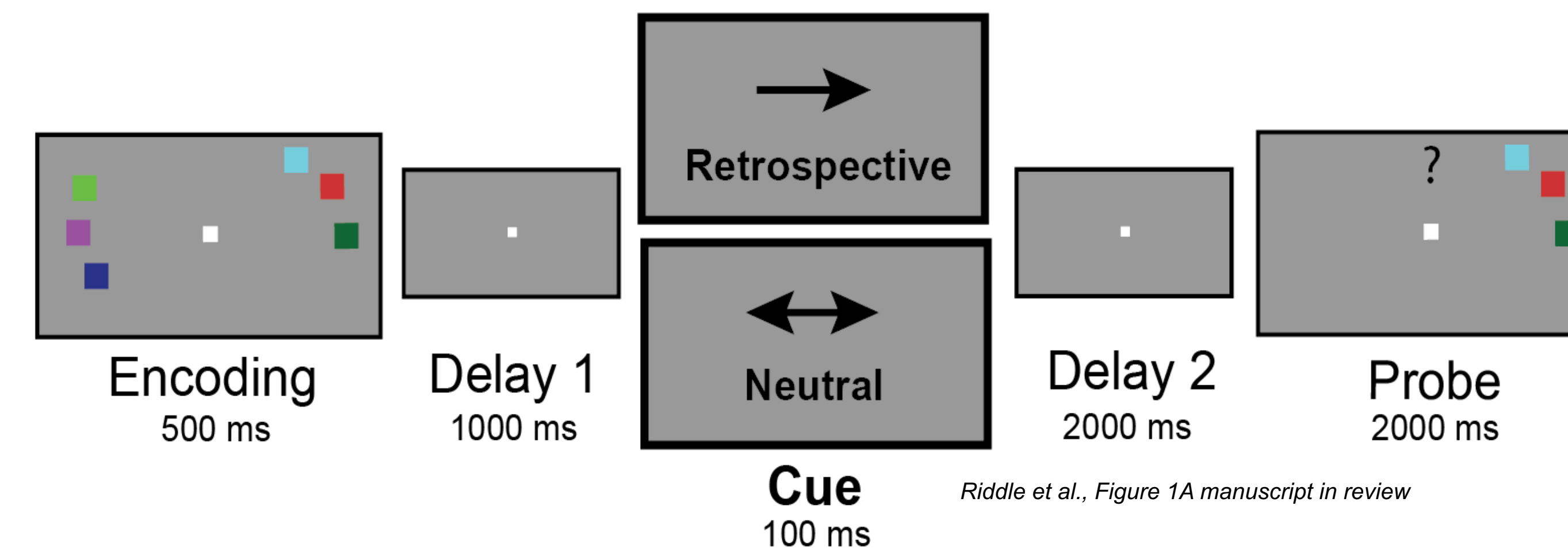
Introduction

- Previously it has been established that frontal theta (4-8 Hz) oscillations prioritize, and parietal alpha oscillations (8-13 Hz) suppress information¹
- When frontal and parietal regions are stimulated according to their endogenous patterns, memories were prioritized and suppressed, respectively
- Both regions communicated with one another in the theta frequency so in this experiment non-invasive brain stimulation will be delivered to both sites at the theta frequency, hoping to increase this connectivity

Methods and Data Collection

1) Screening -> completing the working memory computerized task

- Exclusion criteria enforced to where participant had to benefit from the retro-cue
- For example, the retro-cue could point to the right, informing the participant to prioritize the colors on the right side and suppress the ones on the left
- Participant has a joystick to color-match from the entire color wheel



Riddle et al., Figure 1A manuscript in review

2) Baseline -> EEG used during the working memory task

- Collects the electrical brain activity of the participant while completing the task
- Most important aspect is the time of prioritization (when retro cue is on the screen)

3) MRI -> a functional MRI was used to isolate specific regions of the brain that were activated during the same task

4) TMS 1 -> brain-stimulation day one

- Each participant's motor-threshold was determined, which calibrates the intensity of the stimulation to the participant's endogenous brain excitability
- Markers from the fMRI were used alongside the Localite navigator to specifically stimulate the areas of the frontal and parietal lobe that were activated during the prioritization aspect of the task
- Either alpha or theta stimulation was delivered to both sites (random)

5) TMS 2 -> brain-stimulation day two

- Repeat of session 4
- If alpha stimulation was previously delivered, theta stimulation would be delivered in this session (and vice versa)

Discussion

- Based on previous experiments and the layout of this experiment, it can be predicted that by stimulating the theta oscillation connectivity, the prioritization mechanism will be bettered
- By strengthening the oscillatory pathway between the frontal and parietal lobes, the prioritization for information is enhanced while suppression is diminished.
- The in-phase theta stimulation at both sites will provide the greatest increase in prioritization and therefore accuracy
- The anti-phase stimulation serve as a control since no benefit should be observed since it does not match the endogenous patters (serves as a control)
- Alpha stimulation also serves to be a control as no benefit should be noted. This frequency of oscillation is foreign to the prioritization pathway as it communicates in the theta frequency.
- The efficacy and impact of stimulation was measured through the accuracy of color-matching during the task

Future Directions

- Better understanding the theta oscillation connection between the frontal and parietal lobe helps further analyze the workings of memory prioritization
- This can be used to develop treatments for psychiatric and neurological illnesses that involve a detriment in cognitive control.
- Some examples are Schizophrenia, Alzheimer's, and other affective disorders
- In specific, TMS can be used to improve the theta oscillation pathway between the frontal and parietal lobes that impact the ability to prioritize
- TMS therapy is slowly gaining popularity to resolve treatment-resistant depression. A similar therapy can be developed based on the results of this experiment.



Experimental TMS Setup: Picture taken in the Frohlich Lab



Clinical TMS Setup: Image from Transformations TMS Website

References

1. Riddle et al., Current Biology 2020, Casual Evidence for a Role of Theta and Alpha Oscillations in the Control of Working Memory