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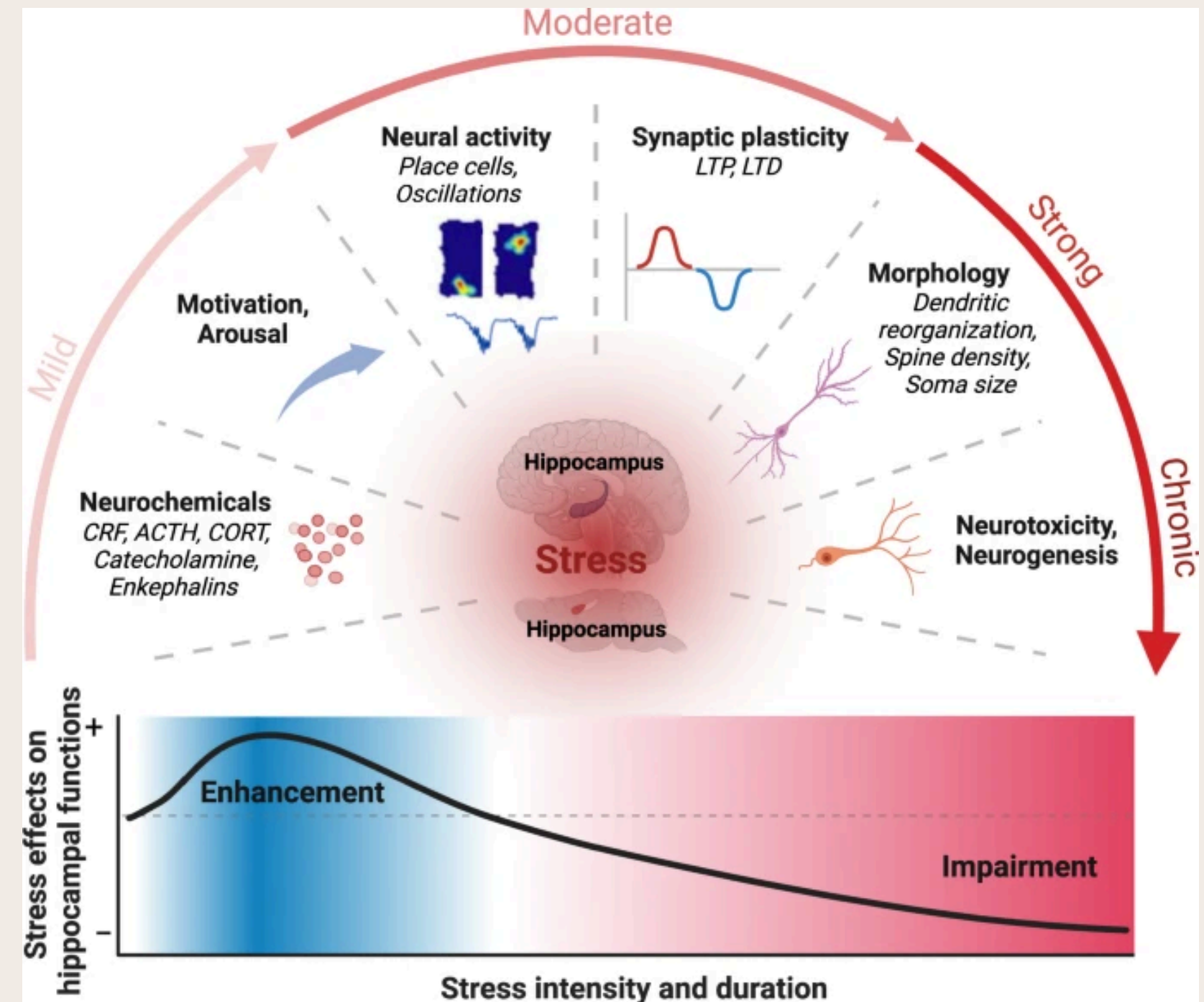
BRAINWAVES FROM FRACTALS: MAPPING STRESS WITH EEG

*THROUGH ANALYSIS OF ALPHA AND
BETA WAVES*



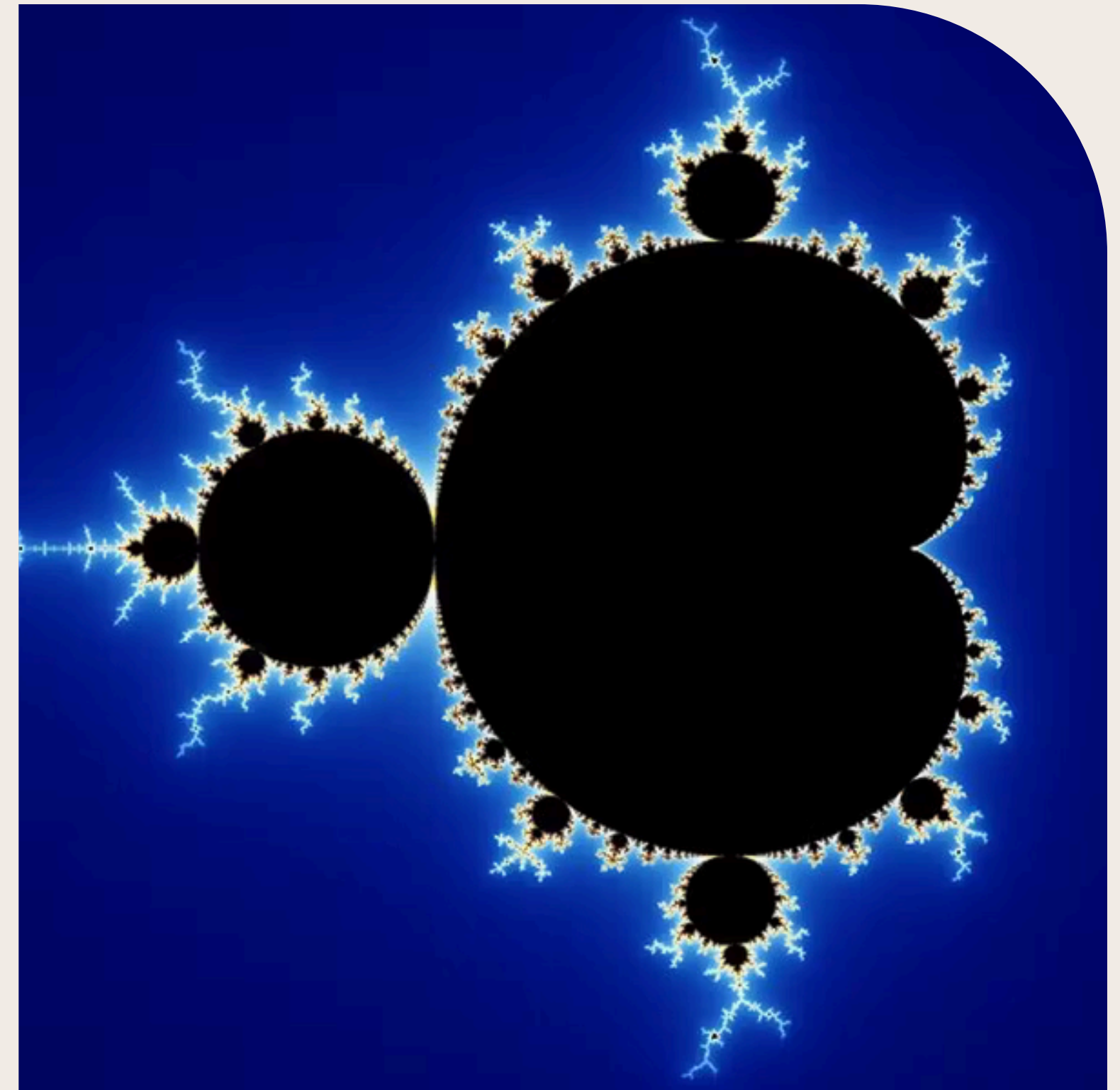
PROBLEM

- Stress is one of the most prevalent experiences in university life, with academic stress being the dominant cause.
- Stressors have been known as the most common reasons of stress among university students (Barbayannis et al. 2022)
- Studies using surveys within university students showed high correlations between high academic stress and poorer mental well-being (Barbayannis et al. 2022)
- Detrimental life-long mental and physical disorders originate due to stress. (Mayo Clinic, 2023).



BACKGROUND

- Fractal shapes have been found to generate the maximal alpha response.
- Public art with fractal patterns has been found to reduce and combat stress with some therapists implementing them in therapy sessions.
- Studies using fMRI have found that fractals activate areas of the brain involved with spatial long-term memory (i.e. the parahippocampal region and dorsolateral parietal cortex) (Taylor et al. 2011).

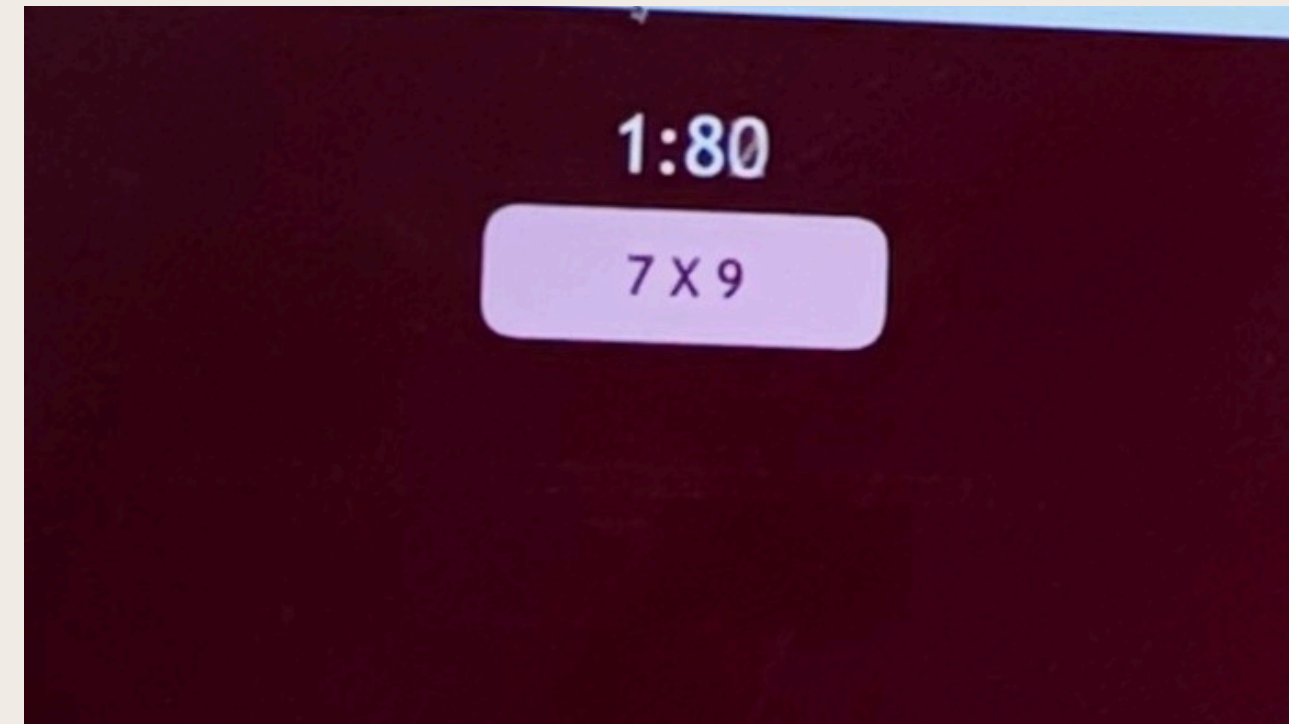


The infamous Mandelbröt set fractal.

BACKGROUND

Studies have shown that:

- Solving math problems under time constraints induces stress, as evidenced by changes in EEG activity (Liu et al. 2019)
- Increase in beta and gamma wave activity (associated with stress and heightened cognitive load) (Liu et al. 2019)



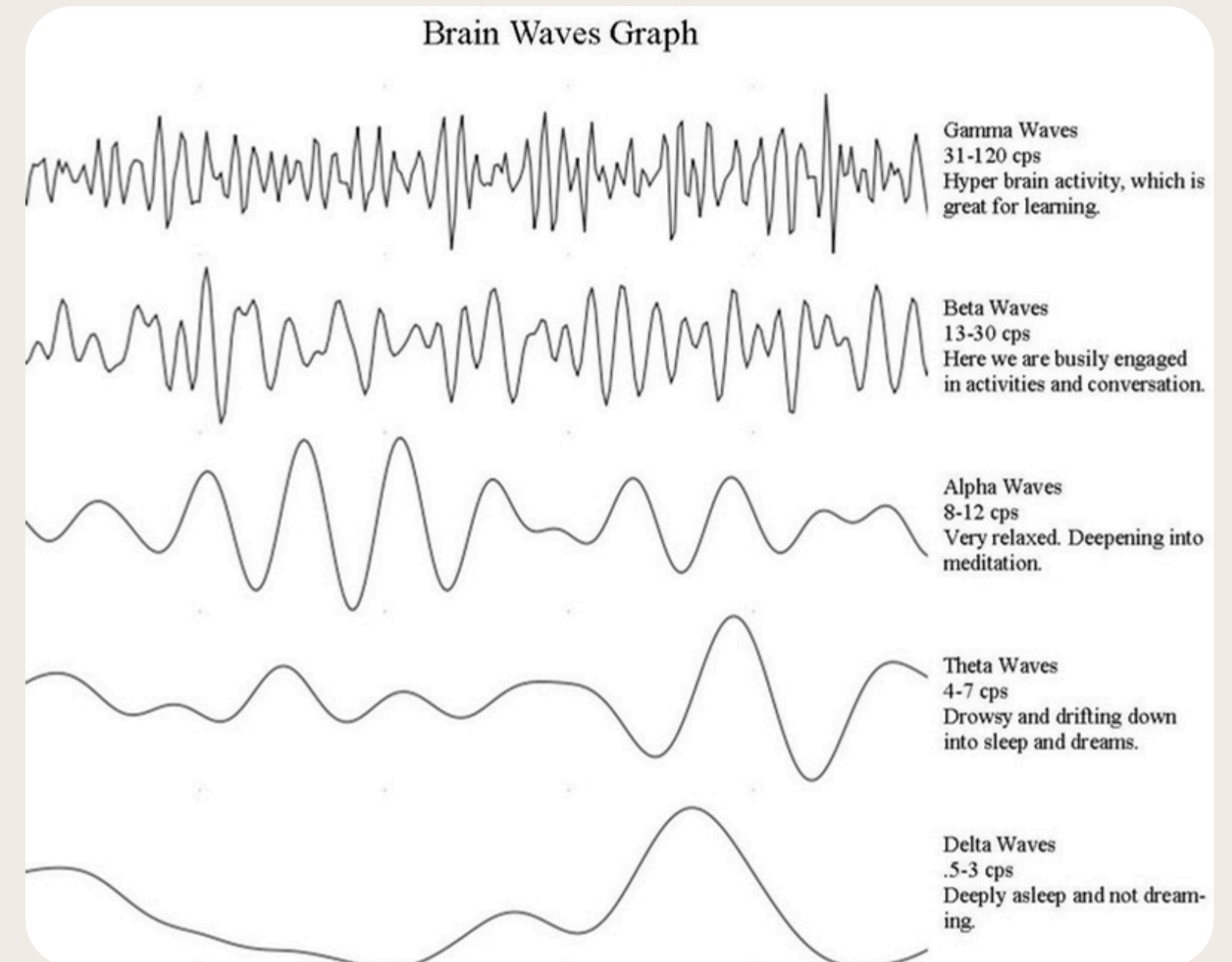
OPERATIONAL DEFINITION

HOW ARE WE DEFINING A STRESS RESPONSE BEING ELICITED VS A CALM STATE?

Stressed State: Beta Waves (13-30 Hz) and Gamma Waves (30-100 Hz).

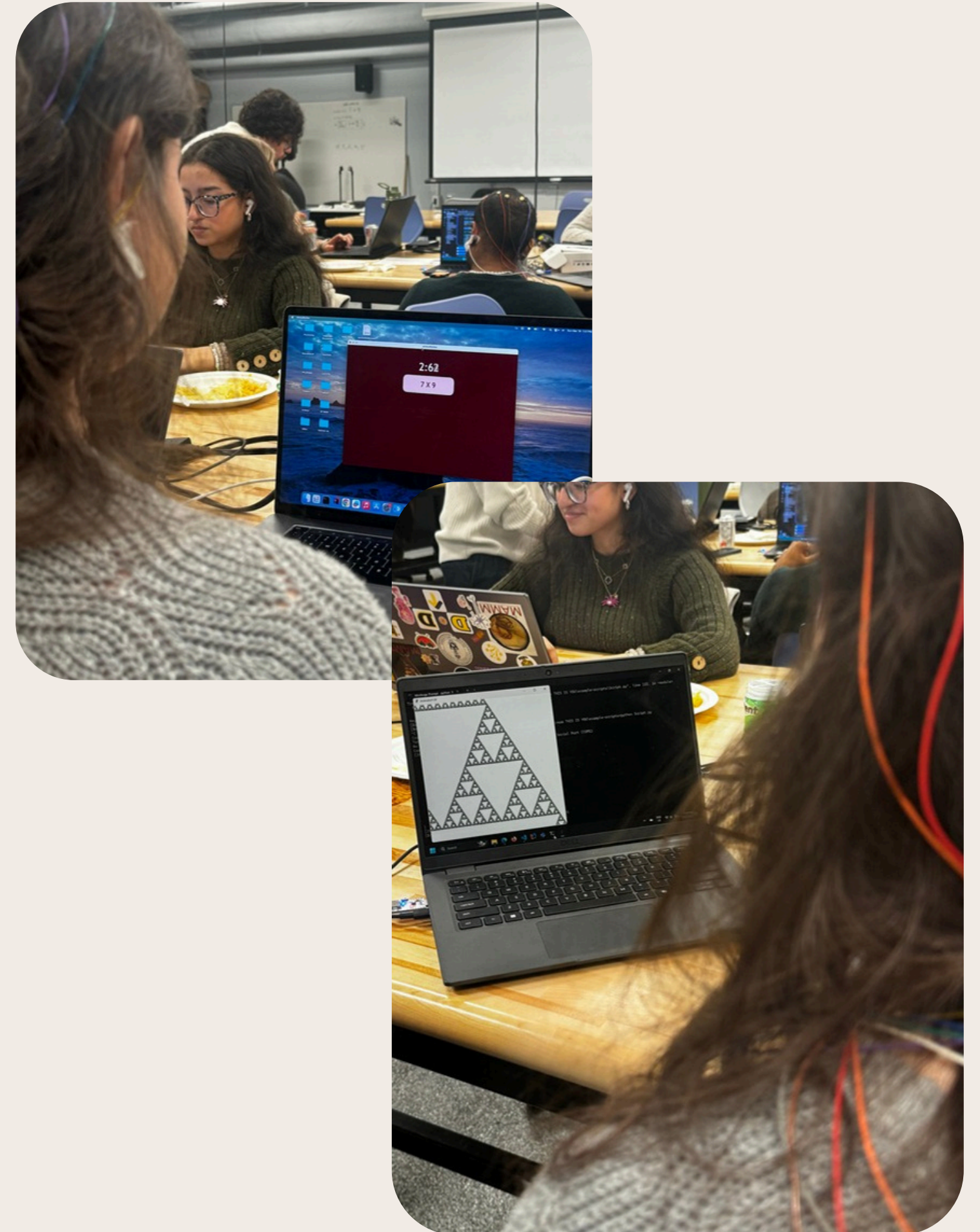
Calm/Regular State: Alpha Waves (8-13 Hz).

Stress being “Regulated”: When the alpha waves are lower than the initial calm baseline and beta waves are higher than the initial beta baseline.



SYSTEM DESIGN

- We will continuously monitor our participants' EEG signals over six minutes
- When their EEG activity falls within the beta-gamma range, indicating stress, we will implement a stress-reduction strategy using fractal patterns to promote relaxation [Fractals, in our case]
- Conversely, when their EEG signals shift to the alpha range, signifying relaxation, the system will introduce a cognitive stressor [Timed multiplication questions with a visible countdown]



PROCESSING OF DATA (CODE)



RATIONALE

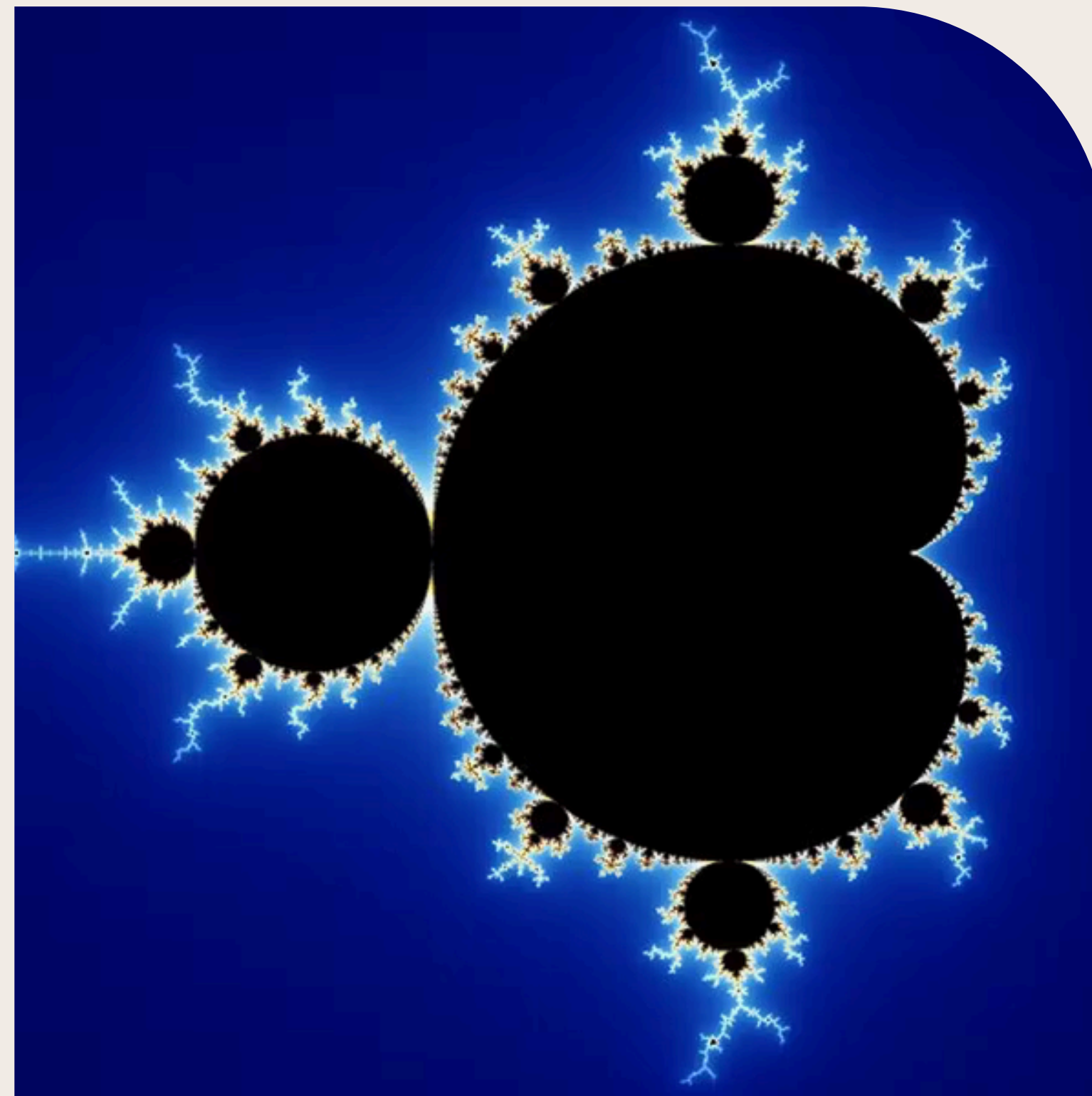
- The visualization of fractals as stimuli to decrease the stress response has not been previously studied. We simply know that looking at them, generates alpha waves.
 - Several studies have focused on how fractals impact stress through self-reported mechanisms. This study, however, would allow us to quantify the impact of fractal exposure on stress responses with physiological evidence.
- Understanding the role of fractals in the stress response has potential for other clinicians, psychologists, and even meditation apps to implement them in real-time. This is particularly relevant for EEG therapy.

IMPLEMENTATION

- EEG therapy or neurofeedback is an approach for treating brain-based disorders (i.e. ADHD, anxiety, TBI) by regulating imbalances in brain activity.
- Fractals have been found to decrease mental fatigue/cognitive load (Robles et al. 2021). There's potential to use it as a flickering visual stimulus in paradigms.

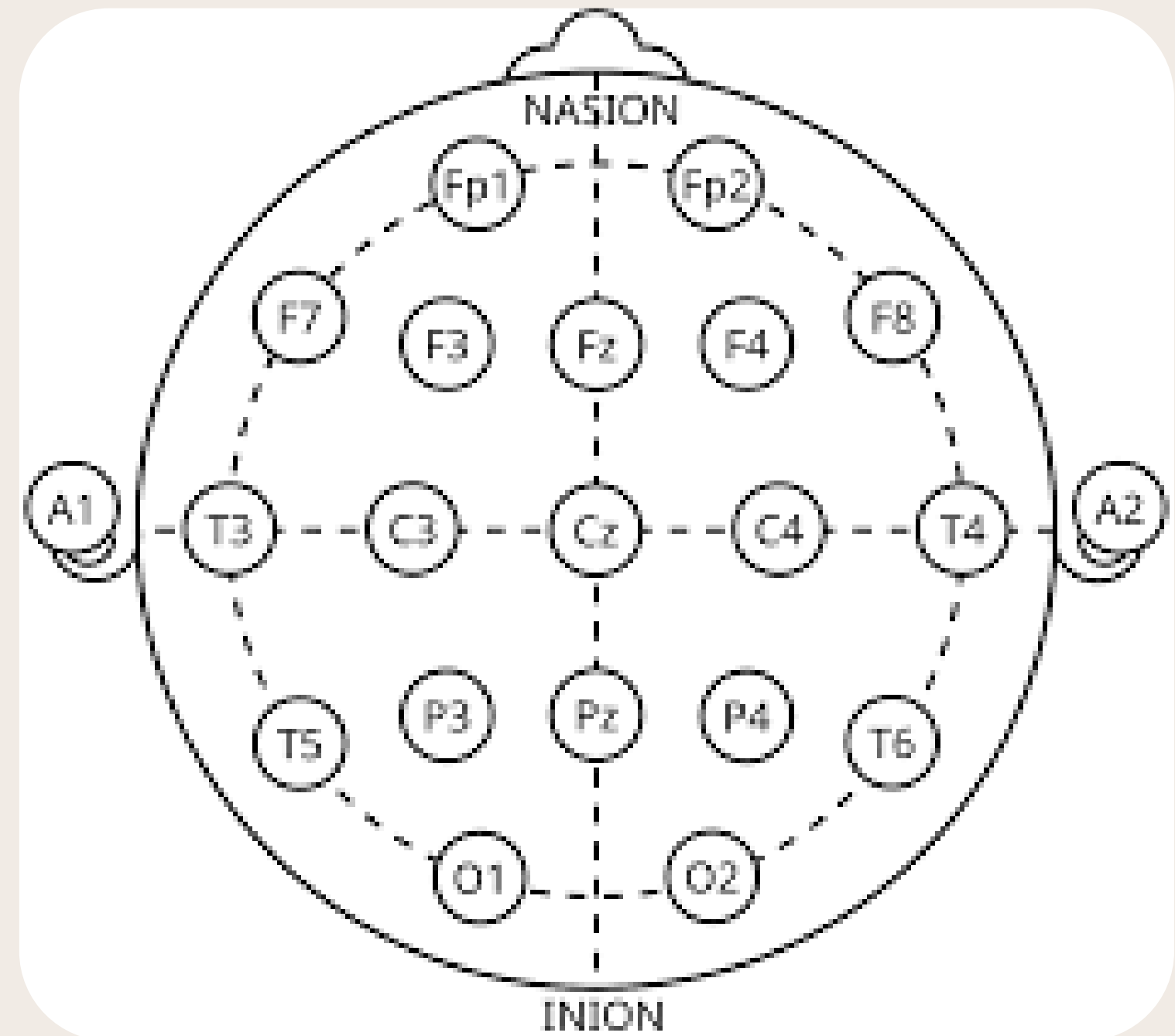


LIVE DEMONSTRATION



CHALLENGES

- The 10-20 system with only eight electrodes may have provided limited accuracy in capturing EEG data compared to the 10-10 system (16-32 electrodes).
- Noise- low SNR.
- Only observing specific frequency ranges.
- Baseline based on initial relaxation state.
- Limited implementation ability (not everyone will respond the same to fractals).



FUTURE WORK

- Future work should use fractals as a possible stimulus for SSVEP paradigms to see if it increases the SNR and power. They should explore if it increases classification accuracy as it has potential to decrease cognitive load.
- Rather than using artificial-stress, future research should see the impact of fractals on individuals living with stress-related conditions to allow for real implementation in EEG therapies.

