Kieu-Giang NGUYEN

Independent Science Research

During my high school career at Hawai'i Preparatory Academy, I have taken advantage of many opportunities to explore my curiosities and conduct science experiments through the school's Energy Lab. Provided with generous advanced technology and ample support from exceptional teachers and peers, I have the chance to design my own research in neuropsychology using ***electroencephalography (EEG)***, a technology to measure brain electrical activities. Specifically, I employ EEG to study patterns of neural responses under the ***Stroop effect*** in different contexts. This research is a focal part of my quest to understand the causes of conformity in human behavior. In addition, I have also started to apply the same method to study mediation process.

Figure 1: Preparing EPOC headset for testing

Summary of research at Energy Lab

EEG Evaluation of Stroop Effect	• Tools: EEG EPOC/EPOC+ headsets • Softwares: EmotivLifeSciences, TestBench • Evaluate the Stroop effect and related psychological phenomena using brain wave analysis.
Software Development	• Programming language: Python • Program to automate the analysis of ~3.2 million raw data points collected from EPOC/EPOC+ headsets.
EEG* Evaluation of *Meditation	• Tool: MUSE headband • Software: MUSE app • Track and analyze meditation process.

EEG Evaluation of Stroop Effect

Introduction: In a Stroop test, each subject is presented with the name of a color printed in (i) that color (congruent pattern), or (ii) a different color (incongruent pattern). In each case, she is asked to select the color of the text. The *Stroop effect* refers to the psychological phenomenon that it takes longer for the subject to select the correct color from the incongruent pattern than from the congruent one. Under the Stroop effect, the subject has to deliberately direct her mental resource to focus on the color instead of the wording of the displayed text. This cognitive mechanism of directed attention thus slows down her performance.

Figure 2: A sample Stroop test

The Stroop effect highlights the cognitive struggle with non-conforming patterns and provides an ideal setting to test the conditions under which this

cognitive struggle may be intensified or abated. Through studying patterns of neural responses under the Stroop effect using EEG technology, my research aims to uncover the neurological origin of conformity.

Methodology: I use the very popular laboratory EEG tool created by Emotiv, the EPOC/EPOC+ headsets, to measure subjects' brain electrical activities. 128Hz data are collected from the headsets' 14 electrodes, sent to either EmotivLifeSciences or TestBench software, and visualized as 2D graphs of waveforms of varying frequency (in Hertz) and amplitude (in microvoltage). I then detect the most functioning areas of the brain using the standard classification of EEG waveform frequency.

Figure 3: The EPOC headset

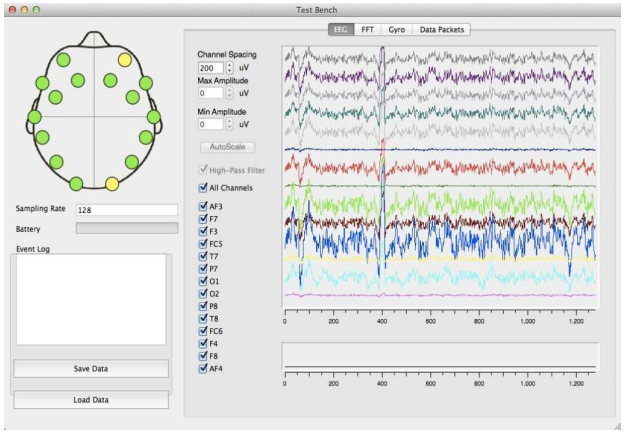

Figure 4: Screenshot from TestBench software

I also use priming method – an implicit memory effect in which exposure to one stimulus influences the response to another stimulus – to evaluate the extent of the Stroop effect under different thinking modes. In the first wave of priming, subjects are asked to do a math problem to be primed into analytical thinking mode. Future waves of priming would utilize other pro-conformity/anti-conformity conditions. After being primed, subjects perform Stroop tests with incongruent patterns. I again observe and analyze the brain areas that exhibit recognizable patterns under the combination of these additional stimuli and Stroop effect.

Analysis: I have collected data from 20 subjects under both non-primed and primed conditions, which results in a total of ~3.2 million data points.

I count peaks of the visualized brain waves to obtain frequency in Hz, then classify them into standard EEG waveforms (α, β, θ, δ). I also classify the amplitude in μV as attenuated, hypersynchronized, or paroxysmal.

I use the statistical *t-test* to test the differences in frequency and amplitude of responses between different settings, including congruent versus incongruent patterns, and non-primed versus different primed sessions.

Results: I have obtained results across the following statistical tests:

1. Response frequencies are significantly stronger with incongruent patterns than congruent ones, which confirms the neurological aspect of the Stroop effect.
2. When put under the Stroop effect, response frequencies are significantly weaker when subjects are primed into analytical thinking mode than when they are not.

The tests prove that observed non-conforming patterns create a cognitive struggle for the subject: it is cognitively easier to perform conforming actions. Analytical thinking mode helps reduce this cognitive burden, and makes it easier to perform non-conforming actions. That is preliminary evidence of the neurological origin of the psychological phenomenon of conformity.

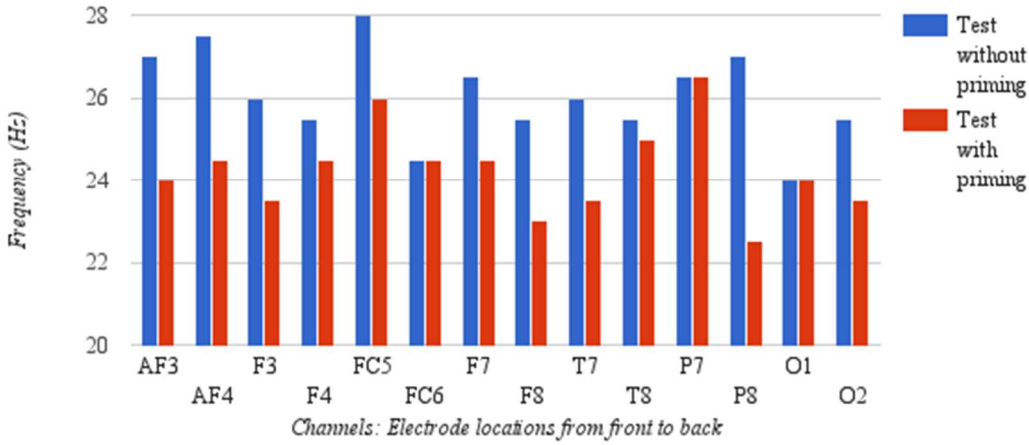

Figure 5: Brain wave frequencies in Stroop tests under priming

Software Development

As a side project of the first project, I am developing a software to automatically analyze data from EEG. Previously, I manually counted wave peaks in 2D graphs of brain waves to obtain the wave frequencies. That was inefficient and prone to measurement errors. To address that concern, I first convert the graphs into raw data using TestBench. I have thought of an algorithm to treat the data, and I have been learning the programming language Python implement this algorithm. I hope this program could help researchers in the field understand and process EEG data faster.

EEG Evaluation of Meditation

Meditation has been scientifically shown to reduce symptoms associated with stress, depression and anxiety as well as improve productivity and quality of life. I use MUSE, an EEG headband designed specifically for mediation, to study brain activities during the mediation process and to identify best conditions for meditating. MUSE headband uses seven finely calibrated sensors – two on the forehead, two behind the ears, and three reference sensors – to measure brain activities and give real time feedback on what is happening inside the brain during meditation.

I ask subjects to meditate in different environments with the MUSE headband on and track their brain waves during the process. I then analyze the data collected from both cross-sectional and longitudinal perspectives to separate between-subject variation within the same environment from within-subject variation in different environments. My preliminary results show a significant level of between-subject variation, consistent with my initial hypothesis that meditation is a personal experience which can be greatly enhanced by brain fitness tools such as MUSE.

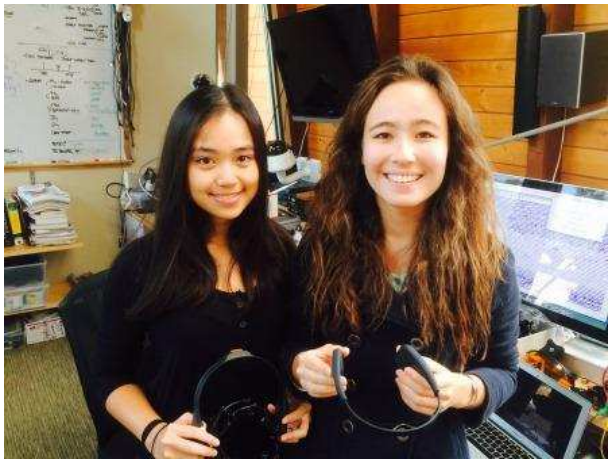

Figure 6: Me and my subject saying hi from Energy Lab