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Stoicism and the Brain: Using a Portable Electroencephalogram with a Stoic Intervention

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Note: This is a summary of the whole paper. If you wish to read the entire paper, please email me at sam.darby@rdpolytech.ca

Introduction

In recent years, the Hellenistic philosophy of Stoicism has become popular among many people as a philosophical approach to living life (Sellars, 2014). Stoicism has existed since around 300 BC, with Zeno of Citium labelled as its founder. Recently, it has gained traction among many laypeople as a mindset for approaching negative and positive life events without becoming overwhelmed. Brown et al. mention that Stoicism provides a means to manage negative emotions while maintaining human connections, ensuring that one's reactions remain appropriate. Still, it is not emotional detachment, suppression, or a lack of motivation to challenge injustices or confront adverse events (2022). Indeed, Marcus Aurelius, an Emperor of Rome and a Stoic, wrote, “You have power over your mind–not outside events. Realize this, and you will find strength” (Aurelius, 2006). This ideology, which posits that an individual can have power over their reactions to life events rather than trying to control the events themselves, has brought strength, resilience, peace, calmness, and hope to those who follow the teachings of Stoicism (Hammer & Gordon, 2023). Practicing Stoicism has been found to bring about a myriad of benefits, like a decreased tolerance to pain (Calderón et al., 2017; Cagle & Buntle, 2017; Spiers, 2006; Nöelle-Jorand, Joulia, & Braggard, 2001; Yong, 2005), increased quality of life with patients who have muscular dystrophy (Ahlström & Sjöden, 1996), and a better outlook on the concept of death (Castelo et al., 2018; Hammer & Gordon, 2023; Menzies & Whittle, 2022), as well as decreased suicidal ideation (Witte et al., 2012), generally reduced stress levels (Martin, 2015; Trapnel, 1999), increased levels of empathy and self-efficacy, (Brown et al., 2022), and many others. One important thing to note about living a Stoic life is not to confuse it with stoic ideology, which is a gross misrepresentation of the Stoic philosophy and reduces its intellectual complexity to emotional non-expressiveness and suppression (Alfons et al., 2022). An example of this occurring is with some men with cancer living a misunderstood stoic life, who can mistakenly believe they must "remain stoic" by not complaining or seeking help (Brown et al., 2022). This misinterpretation can, unfortunately, increase their risk of suicide (Witte et al., 2012), and in this example, death. Other adverse effects, as listed by Furnham and Robinson (2023), include individuals experiencing less pleasure and joy in life, as they perceive such positive emotions as inappropriate.

Although extensive studies have explored the pros and cons of Stoicism, there is a lack of empirical, neuroscientific research on its effects. Some neuroscientific studies have revealed links between Stoicism and brain activity, although the number of available studies is limited. For instance, an fMRI study described that individuals with strong Stoic traits suppressed facial expressions during intense heat pain, which was associated with heightened frontostriatal activation (Kunz et al., 2011). Another study found increased neural activity correlating with increased suicide rates in males who display higher levels of emotional Stoicism, which is simply another term for Stoic ideology, in various brain areas that overlapped with regions constituting a neuronal network underlying depression (Deshpande et al., 2016).

That being said, due to the lack of research regarding the effects of Stoicism on the brain, this study employed electroencephalography (EEG) to investigate whether individuals newly introduced to Stoicism exhibit increased neuronal synchrony in their brainwaves following Stoic training. The Muse portable EEG device, developed by InteraXon Inc. (marketed as ChooseMuse), was utilized to measure neural oscillations associated with brainwave activity, as there is a growing body of research supporting the experimental use of the Muse EEG, which was initially designed for meditation, but has also been found capable of many experimental procedures, such as recording event-related potentials (ERP; Kringolson et al., 2017), alpha frequency variability (Sidelinger et al., 2023), and general frequency spectra analyses (Pontifex & Coffman, 2023). The Muse EEG has only four electrodes at TP9/10 and AF7/8, with reference at Fpz, resulting in limited data that can be gathered from this device. That being said, those electrodes have been found to measure characteristics associated with Stoic attributes, such as stress reduction and emotional regulation, specifically for alpha, beta, and theta brainwaves (Fahrion et al, 1992; Jung & Lee, 2021; Lee, Kim & Lee, 2022; van der Werf et al., 2013; Wheelock et al., 2016).

In essence, this study hopes to explore Stoicism more deeply by using portable EEG technology to investigate the neural effects associated with the thoughts and practices of this Hellenistic philosophy. Validated behavioural questionnaires will also be used to measure Stoic attitudes and Behaviours, as well as Rumination and Reflection tendencies, to pair with the EEG data. As an active control, a journaling condition will be used to compare to the Stoicism group because the practice of journaling encourages similar levels of introspection like Stoicism does, but also because the Stoic group will have a booklet in which they will be asked to journal their thoughts (Woodbridge & Rust O'Beirne, 2017). A passive control, with no intervention, will be used as a baseline for both the Stoicism and journaling groups.

Method

Materials

Thirty-four healthy undergraduate students from a Red Deer Polytechnic (RDP) statistics class volunteered for this study. Their Stoic tendencies were measured using the Stoic Attitudes and Behaviours Scale (SABS 5.0), a 60-item, seven-point Likert questionnaire developed by Modern Stoicism, which includes questions such as, "to flourish as a human being all you need is good character and understanding of what really matters in life," and "nothing except our judgements and voluntary actions are truly under our control in life" (2020). Higher scores indicate greater alignment with Stoic principles. Likewise, the Rumination Reflection Questionnaire (RRQ), a 24-item, seven-point Likert questionnaire developed by Trapnell and Campbell (1999), was used to measure scores on two subscales: Rumination, which refelcts negative self-focus associated with neuroticism, and Reflection, which captures intellectual and positive self-focus, which is linked to openness to experience. The RRQ includes questions such as “long after an argument or disagreement is over with, my thoughts keep going back to what happened,” and “people often say I’m a ‘deep,’ introspective type of person.” Participants completed the surveys in person using the digital platform Simple Survey (2025), which was accessed via a laptop.

The participant's electroencephalograms were acquired using the Muse (1st ed.) portable EEG, which features electrodes analogous to AF7/8 and TP9/10, with Fpz serving as the reference electrode from the standard 10-10 layout, set at a sampling rate of 500 Hz. Researchers obtained EEG recordings with the Mind Monitor mobile app, developed by Clutterbuck (2015), which uploaded participant recordings to Dropbox. Data uploads contained bandwidths for alpha, beta, theta, delta, and gamma across each electrode (20 samples total: five bandwidths for each of the four electrodes), as well as the raw output for each electrode (four total) and accelerometer and gyro information for X, Y, and Z axes.

The Stoic Week Handbook for Students, developed by Modern Stoicism, was used to introduce participants to Stoicism through daily themes such as emotions, resilience, friendships, nature, and character, and guided them through journaling activities to reflect on their experiences of trying to live like a Stoic for each day. Modern Stoicism designed the booklet for university students, tailored to the demographic used in this study, which gave concise, easy-to-understand, and coherent Stoic training for them to complete on their own daily during the following week (2021, link in references). Those in the journaling condition were given a 32-page Hilroy Canada Journal to record their writings.

Procedure

During an in-person meeting, the principal investigator (PI) asked participants to complete the SABS 5.0 and the RRQ and performed a brainwave measurement using the Muse portable EEG. Participants had the option to skip questions if they so chose to. During the EEG recording, the PI asked them to think about and try to relive a recent stressful experience. Each EEG recording took 45 seconds. The entire collection process took about 15 minutes per participant, and the acquired data served as an initial measurement to compare the post-experimental data.

Participants were split into three groups after collecting their data in the pretest session. The Stoicism group (n = 11) completed the Stoic Week Handbook for Students (2021) and journaled their thoughts about their day while practicing Stoicism every day throughout the week. The journaling group (n = 10) served as an active control. They were given no specific direction on what to journal about, but were asked to journal about their day every day throughout the week. The passive control group (n = 11) did not participate in any activities during the week.

At the end of their respective intervention weeks, each participant returned to complete the questionnaires again and also to obtain new EEG recordings while being asked to think about a different stressful experience. The PI also kept an anonymized copy of their own writings from the week to assess whether participants completed the tasks assigned to their respective conditions, serving as a manipulation check.

Results

Behavioural Data

A mixed ANOVA was conducted for each subscale of the RRQ, with intervention as the between-subjects factor and session as the within-subjects factor. For *Rumination*, there was a significant session x condition interaction with a small effect size, $F(2, 29) = 3.540$, $p = .042$, $n_p^2 = .196$. A simple main effects analysis performed on the interaction effect revealed a significant difference between conditions in the pre-test, $F(2, 29) = 4.142$, $p = .026$, $n_p^2 = .222$, but not for the post-test, $F(2, 29) = 0.974$, $p = .063$. Based on this, the interaction effect of *Rumination* appears to stem from the inverse increase in journaling, while Stoicism decreases after the intervention, explaining why there were significant differences before the intervention but not after. There was also a significant main effect for session, $F(1, 29) = 4.987$, $p = .033$, $n_p^2 = .147$, but the main effect of condition was not significant, $F(2, 29) = 2.506$, $p = .099$. Pairwise comparisons revealed a significant reduction in *Rumination* post-intervention for the Stoicism group ($p = .005$), but there were no significant increases for journaling ($p = .468$) or decreases in the control group ($p = .110$).

For *Reflection*, no significant effects were found for the interaction $F(2, 29) = 0.603$, $p = .554$, session $F(1, 29) = 2.349$, $p = .136$, or condition $F(2, 29) = 0.417$, $p = .663$, indicating no changes in reflective behaviours within or between groups.

A mixed-ANOVA revealed no significant interaction effect, $F(2, 29) = 0.603$, $p = .554$, nor was there a significant main effect for condition, $F(2, 29) = 0.417$, $p = .663$. However, a significant main effect of session was found with a small effect size, $F(1, 29) = 4.543$, $p = .042$, $n_p^2 = .135$, with pairwise comparisons revealing a significant increase for the Stoicism group ($p = .003$), meaning that as expected, the Stoicism group did significantly increase in their Stoic attitudes and behaviours after their Stoic training.

To further add to the results from the SABS 5.0, a *z*-test was calculated using the SABS 5.0 population mean from Modern Stoicism's 2020 Stoicism Mindfulness and Resilience Training (SMRT) month-long course, utilizing the pre-test results as a general population of people who are representative of having an interest in Stoicism (LeBon, 2020). Using the post-test scores from this experiment ($M = 303.546$) and the pre-test scores from the SMRT 2020 course ($M = 291.6$, $SD = 24$), a significant z-score was found, $z(N = 11) = 1.65$, $p = .05$ (one-tailed), indicating that this Stoic intervention of only one week was indeed enough to significantly improve an individuals Stoic attitudes and Behaviours compared to the general population.

EEG Results

The EEG results were analyzed using both data-driven and theory-driven approaches. A significant improvement in Stoic qualities would be due to the increased synchrony and amplitude within specific wavelengths and electrodes, with a higher mean amplitude indicating more synchrony since more neurons are firing the same signal simultaneously (Fahrion et al, 1992; Hollandt et al., 2023). For the data-driven approach, 20 mixed-ANOVAs were performed for each of the four electrodes (AF7/8 and TP9/10), which had an output measured in bels for alpha, beta, theta, delta, and gamma waves. Each of those bandwidths at each electrode was compared before and after the intervention, as well as between the control, journaling, and Stoicism conditions, resulting in 4 electrodes × 5 frequency bands = 20 mixed-ANOVAS. The only significant differences found across all 20 mixed-ANOVAs were due to changes in the control group for the Delta AF7 effect of session, $F(1, 28) = 4.727, p = .038, n_p^2 = .144$ (control increased, $p = .033$), the Theta TP10 interaction: $F(2, 28) = 3.434, p = .046, n_p^2 = .197$ (control decreased, $p = .028$), and the Gamma AF7 interaction: $F(2, 28) = 3.994, p = .030, n_p^2 = .222$ (control decreased, $p = .026$). No other effects, electrodes, or bandwidths were found to be significant. That being said, it is unlikely that these EEG results are clinically significant as delta and gamma wavelengths are not associated with markers of stress or other attributes of Stoicism, such as resilience or emotional regulation (Fahrion et al, 1992; Jung & Lee, 2021; Lee, Kim & Lee, 2022; van der Werf et al., 2013; Wheelock et al., 2016). Additionally, the control group was the only significant factor, suggesting a possible confounding variable that may have skewed the results. Theta, conversely, has been found to correlate with these attributes, which prompted the theory-driven approach.

The theory-driven approach only considered the Stoicism condition, specifically at specific brainwaves, namely theta, beta, and alpha. Seeing as the current study aimed to determine whether Stoicism can enhance synchrony in an individual's brain and reduce stress, these wavelengths are most closely correlated with Stoic attributes. Therefore, paired samples t-tests were performed for each bandwidth and electrode, similar to the mixed-ANOVA. However, instead of performing 20 comparisons, only 12 were conducted (4 electrodes × 3 frequency bands = 12 mixed ANOVAS). No significant effects were found. However, Theta TP9 (M_{pre} = 0.4702421447, M_{post} = 0.6581143828), $t(10) = 1.622$, $p = .068$ (one-sided), and Theta TP10 (M_{pre} = 0.3305608727, M_{post} = 0.5211720088), $t(10) = 1.682$, $p = .062$ (one-sided) yielded meaningful trends (Fig. 4 & Fig. 5), indicating that there were some increases in theta-wave amplitude bilaterally in the temporal lobe. Limitations in study design necessitated the use of a relatively low sample, thereby offering reduced statistical power.

Discussion

This study utilized a portable EEG device and self-report questionnaires to determine the effects of a week-long Stoic intervention on brainwave synchrony, rumination, reflection, and Stoic attitudes and beliefs. Statistically significant decreases in rumination, as measured by the RRQ, were observed in the

Stoicism group, while the reflection subscale remained unchanged. The SABS 5.0 revealed significant improvements in Stoic attitudes and behaviour following the intervention. As a whole, the EEG data did not reveal statistically significant changes. However, bilateral trends in the temporal lobe suggested increased neural synchrony associated with coherent theta wave oscillations.

An unplanned but ultimately beneficial confounding variable emerged during this study, as participants were concurrently preparing for and taking a statistics midterm exam during the intervention period. This real-world stressor provided a unique context to assess the resilience-building potential of Stoic training. Despite the heightened stress, participants in the Stoicism group demonstrated reduced rumination and improved Stoic attitudes, indicating that even brief exposure to Stoic philosophy can yield measurable psychological benefits under pressure. In contrast, participants in the journaling control condition, who were instructed only to journal daily without specific guidance, showed increased rumination scores post-intervention. This outcome is likely due to the absence of structured prompts, leading to unproductive and stress-amplifying thought patterns during the exam period. These results underscore the value of structured cognitive interventions, such as Stoicism, over unguided self-reflection.

The stark difference in outcomes between the two groups aligns with prior findings that emphasize the importance of guided journaling (Wäschle et al., 2015). Furthermore, the observed benefits of Stoic training, including emotional regulation and resilience (Park & Kim, 2018), suggest that Stoicism promotes more constructive cognitive patterns, even amidst acute stress. Given the minimal time commitment required, Stoic practices may serve as a practical resilience strategy for students in academic settings.

Although it was hypothesized that the Stoicism group would show increased Reflection scores on the RRQ, given Stoicism's emphasis on self-awareness and introspection, no significant changes were observed in any group, including the journaling condition. This result was unexpected, as both Stoic practice and journaling are often linked to enhanced self-reflection in prior research (Whitmore et al., 2019). A likely explanation lies in the limitations of the RRQ Reflection subscale, which may not be sensitive to the specific form of introspection cultivated by Stoic philosophy. Whereas the RRQ emphasizes positively valenced, self-focused reflection, Stoic reflection is more values-driven and centred on virtue, discipline, and emotional regulation (Barrientos-Rastrojo, Saavedra-Macías, & Nardi, 2024). This subtle distinction in measurement may have restricted the scale's capacity to detect significant changes in reflective thinking during the brief intervention period for the Stoic group. Additionally, establishing a reflective mindset, especially one rooted in Stoic philosophical principles, likely requires a more extended period and consistent reinforcement than is feasible within the constraints of this research project. Future research may benefit from employing more targeted reflection measures and lengthier or more immersive interventions that allow Stoic principles to become more fully integrated into an individual's identity.

The EEG data from this study provided limited but potentially meaningful insights. A data-driven analysis revealed statistically significant differences in the delta, theta, and gamma frequency bands, but only within the control group. These frequencies are not typically associated with emotional regulation or cognitive domains central to Stoic practice (Saskia et al., 2024; Smith, Lair, & O'Brien, 2019) and are likely attributable to confounding variables such as bioelectrical noise, uncontrolled environmental factors, or out-of-lab discussions about Stoicism amongst participants. As such, these findings do not offer strong evidence of meaningful cognitive shifts and should be interpreted cautiously.

In contrast, the theory-driven analysis of the Stoicism group targeted the alpha, beta, and theta frequency bands, which are bandwidths previously linked to stress and emotional control. While no statistically significant effects were found, trends toward increased theta activity at TP9/10 (temporal lobe) sites closely mirrored prior research on emotional regulation and neural synchrony (Jung & Lee, 2021; Wheelock et al., 2016). Notably, increased amplitude in theta waves suggests enhanced neuronal synchrony, aligning with findings by Pagnotta, Riddle, and D'Esposito (2024), who demonstrated a correlation between theta synchrony and improved cognitive control. Applying these findings to their study, participants who were asked to recall a recent stressful event during EEG recording, after Stoic training, may have demonstrated improved alignment between external stressors and internal emotional regulation goals. Although these EEG changes were not statistically significant, the trends support the hypothesis that Stoic practice may enhance brain synchrony, particularly in theta activity linked to an adaptive stress response.

In conclusion, this preliminary research provides promising evidence for further investigation into Stoicism using brain imaging techniques. Despite the study's constraints, it has revealed significant changes in participants' mental states and suggests promising directions for identifying the subtle neurological patterns associated with practicing this ancient yet pertinent philosophical mindset. These results lay the foundation for more extensive studies that could deepen our understanding of how Stoic principles influence cognition and behaviour at both psychological and neurological levels.

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