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

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Abstract

Stoic philosophy has regained traction in recent years as a prevalent ideology or mindset by which one can live their life, as numerous studies have been conducted on its numerous psychological and behavioural benefits. This study employed a portable EEG device to examine whether these positive effects can be discerned on a neuroscientific level by looking at an individual's neural synchrony and supplementing it with behavioural data. Thirty-two undergraduate students participated in a one-week experiment and were randomly assigned to a Stoicism condition, a journaling-only active control condition, or a passive control condition. Participants completed the Stoic Attitudes and Behaviours Scale (SABS 5.0) and the Rumination-Reflection Questionnaire (RRQ), along with EEG recordings from a Muse portable EEG device, before and after their respective interventions. Results indicated significant decreases in Rumination and increases in Stoic attitudes for the Stoicism condition, but no significant differences in Reflection. EEG analyses yielded mixed outcomes, with non-significant trends leaning toward increased theta-band synchrony at temporal electrode sites (TP9/10) in the Stoicism group, aligning with previous research on emotional regulation and stress reduction. Some limitations, including sample size and uncontrolled external influences (such as a stressful statistics midterm occurring during the participant's interventions), likely affected the results and neural effects. Despite these limitations, this study brings preliminary evidence that even a brief week-long Stoic training can reduce negative cognitive patterns and increase brainwave synchrony. Further research is required to explore the neuroscientific effects more fully, with extended durations and improved experimental control, in order to better understand the neuropsychological mechanisms of Stoicism.

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. Stoicism provides a means to manage negative emotions while maintaining human connections, ensuring that one's reactions remain appropriate (Brown et al., 2022). Still, it is not emotional detachment, suppression, or a lack of motivation to challenge injustices or confront adverse events (Brown et al., 2022). Indeed, Marcus Aurelius, 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). Much research has been conducted regarding the effectiveness of Stoicism, with many researchers finding positive effects associated with benefits to mental and physical health for those who live and abide by the teachings of the Stoics, 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). Practicing Stoicism has even been found to increase adaptability in extreme hypoxic environments (Nöelle-Jorand, Joulia, & Braggard, 2001). Stoicism is also strongly correlated with the personality trait openness to experience (Martin, 2015), 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. Many practical and well-researched psychological therapies, such as Cognitive Behavioural Therapy and Rational Emotive Behavioural Therapy, have solid foundations based on Stoicism (Connery, Cavanna, & Coleman, 2022; Robertson, 2020). Still, it is worth noting that while Stoicism and these schools of therapy share many similarities, they remain independent in their approaches to navigating life's trials (Brown et al., 2022).

Although Stoicism offers numerous benefits across various areas of life, caution must be taken as a misguided interpretation of Stoicism can have detrimental consequences. For instance, some men with cancer who live a misunderstood stoic life may mistakenly believe they must “remain stoic” by not complaining or seeking help (Brown et al., 2022), and this misinterpretation can unfortunately increase their risk of suicide (Witte et al., 2012). 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. Furthermore, such individuals experience cognitive dissonance when told to seek help, as this behaviour conflicts with their identity. Alfons et al. (2022) have also found that a misguided understanding of Stoicism can increase levels of depression and decrease life satisfaction in individuals. This misunderstanding of Stoicism has been called stoic ideology, with traditional Stoicism being capitalized while stoic ideology is not (Alfons et al., 2022). It misrepresents the Stoic philosophy, reducing its intellectual complexity to emotional non-expressiveness and suppression. Essentially, those who wish to live a Stoic life must ensure they have received the proper education to reap the most possible benefits from this philosophy.

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). One interesting case study done by Hequette et al. (2013) followed a man who received an amygdalo-hippocampectomy for the treatment of refractory temporal epilepsy. This man mentioned years after the surgery that he could not feel emotions, and that his family even reported a "change of lifestyle" that occurred after his neurosurgery, and was then "diagnosed" with emotional Stoicism, as other terms were unable to describe their emotional state adequately. They define emotional stoicism as someone who presents a clinical loss of emotional sensitivity and must derive some amount of pleasure from their state of impassiveness, while also having undergone an amygdalohippocampectomy. This also has connections to Stoic ideology, providing further evidence that a misunderstanding of Stoicism can not only negatively impact the individual but also those around them, leading to overall detrimental effects on their quality of life.

As discussed above, only a handful of neuroimaging studies have examined aspects of Stoicism to date, highlighting a significant gap in the literature. Therefore, 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

Participants

Thirty-four healthy undergraduate students from a Red Deer Polytechnic (RDP) statistics class volunteered for this study. Participants received a one percent bonus mark in their statistics class and were entered into a draw for a $15 gift card as compensation. Students who chose not to participate in the study could complete an alternative assignment to earn the bonus mark. One participant was unable to return for their post-test, while another withdrew from the study entirely, resulting in a total sample size of 32 participants.

This study adhered to all ethical procedures and protocols outlined by the RDP Research Ethics Board (application number 2024-25-13). Informed consent was obtained from all participants at the beginning of their pretest session, with additional informed consent obtained at the start of their posttest session, which took place a week after the initial meeting.

Materials

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 reflects 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 sets 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 (2021, link in references), 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. 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 participate in another EEG recording while being asked to think about a stressful experience that was different than the last one they thought of. 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.

Data Analysis

Each participant's questionnaire data was first summed to obtain a total score, with the RRQ data being split into total scores for the Reflection and Rumination subscales separately. The results from the RRQ questionnaire were analyzed independently for each subscale using a 2 (session/within) × 3 (condition/between) mixed analysis of variance (mixed-ANOVA). Participants' total scores on the SABS 5.0 were analyzed using a similar mixed-ANOVA.

EEG results were analyzed in two ways. The first approach was data-driven, utilizing a series of mixed ANOVAS to identify differences between electrodes within each bandwidth. For example, Delta_TP10_Pre was compared with Delta_TP10_Post, and the same comparison was performed for each bandwidth within TP10 and for each subsequent electrode, resulting in 20 total comparisons. The mean amplitude for each participant across these bandwidths at each electrode was calculated and used in the mixed-ANOVAS. The brainwave values are absolute band powers, based on the logarithm of the EEG data's Power Spectral Density (PSD) for each channel, measured in bels. The frequency spectra of these are: Delta (δ) 1- 4 Hz, Theta (θ) 4- 8 Hz, Alpha (α) 7.5- 13 Hz, Beta (β) 13- 30 Hz, and Gamma (γ) 30- 44 Hz. The EEG PSD values as read from the sensors are in the {-1:+1} range (Clutterbuck, 2015). The second, theory-driven approach to analyzing this data involved examining the Stoicism group alone and performing paired samples *t*-tests within each electrode and bandwidth, as before, but only using theta, beta, and alpha wavelengths. The mean amplitude for each participant across these bandwidths at each electrode was calculated and used for the *t*-tests.

Results

Behavioural Data

A mixed-ANOVA was conducted for each subscale, with intervention as the between-subjects factor and session as the within-subjects factor. Assumptions were met with acceptable skewness/kurtosis (|2| and |7|, respectively; George & Mallery, 2010), and non-significant Levene's tests (all *ps* > .136). 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 increase in journaling, while at the same time, Stoicism decreased after the intervention, which explains 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, $F(2, 29) = 2.506$, $p = .099$ (Fig. 1). 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 ($p = .110$). Descriptive statistics for *Rumination* are shown in Table 1.

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 (Fig. 2). Descriptives for *Reflection* are shown in Table 2.

Descriptive statistics for the SABS 5.0 are found in Table 3. 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 (Fig. 3).

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 the current experiment ($M = 303.546$) and the pre-test scores from the SMRT 2020 course ($M = 291.6$, $SD = 24$), a significant *z* was obtained, $z(N = 11) = 1.65$, $p = .05$ (one-tailed), indicating that this Stoic intervention of only one week was indeed enough to significantly improve an individual's Stoic attitudes and behaviours compared to the general population.

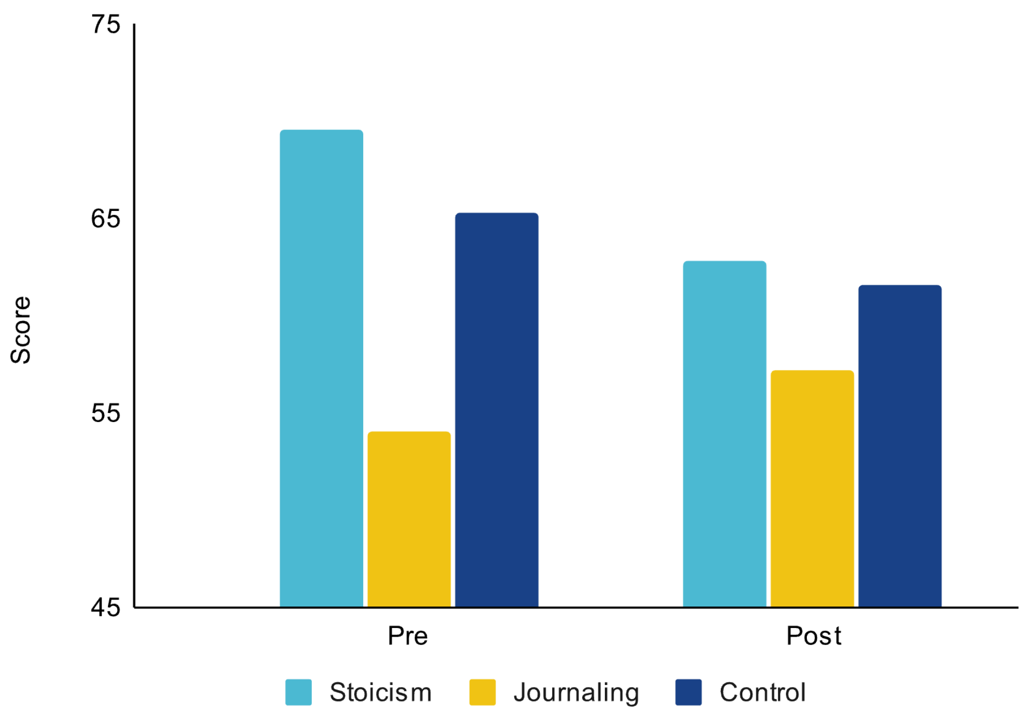
Table 1

Descriptive Statistics for Rumination RRQ Data

Condition	Time	Mean	SD
Stoicism	Pre-test	69.545	9.267
	Post-test	62.818	10.74
Journaling	Pre-test	54	15.29
	Post-test	55.7	15.86
Control	Pre-test	65.273	13.1
	Post-test	61.636	10.278

Figure 1

Rumination RRQ Effects



Note. The Y-axis starts at 45 to better visualize the effects.

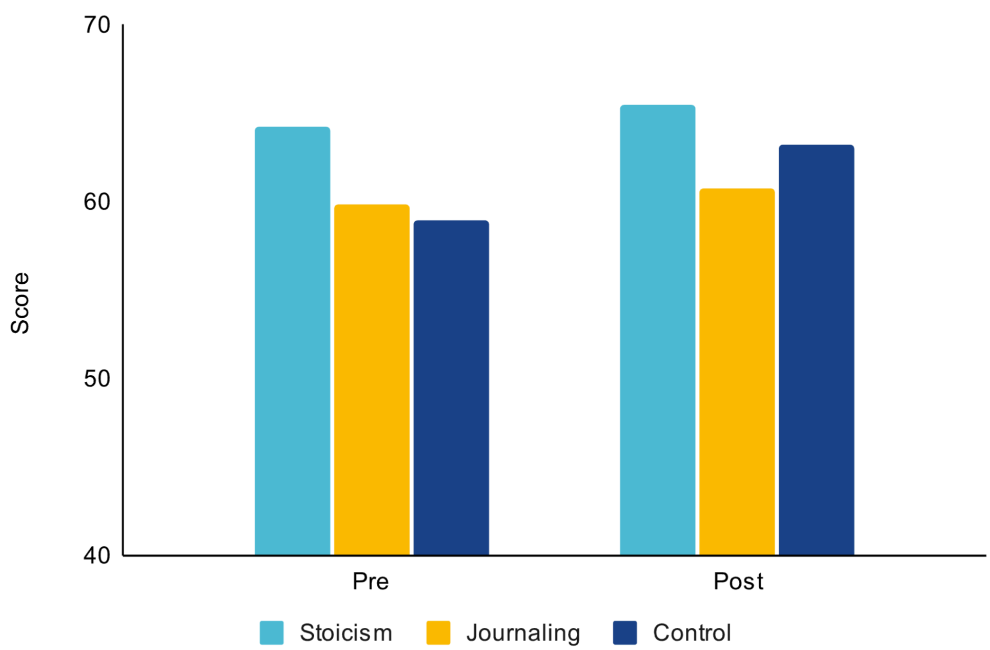
Table 2

Descriptive Statistics for Reflection RRQ Data

Condition	**Time**	**Mean**	**SD**
Stoicism	Pre-test	64.181	12.521
	Post-test	65.454	12.326
Journaling	Pre-test	59.8	17.197
	Post-test	60.7	14.522
Control	Pre-test	58.909	11.47
	Post-test	63.272	8.912

Figure 2

Reflection RRQ Effects



Note. The Y-axis starts at 40 to better visualize the effects.

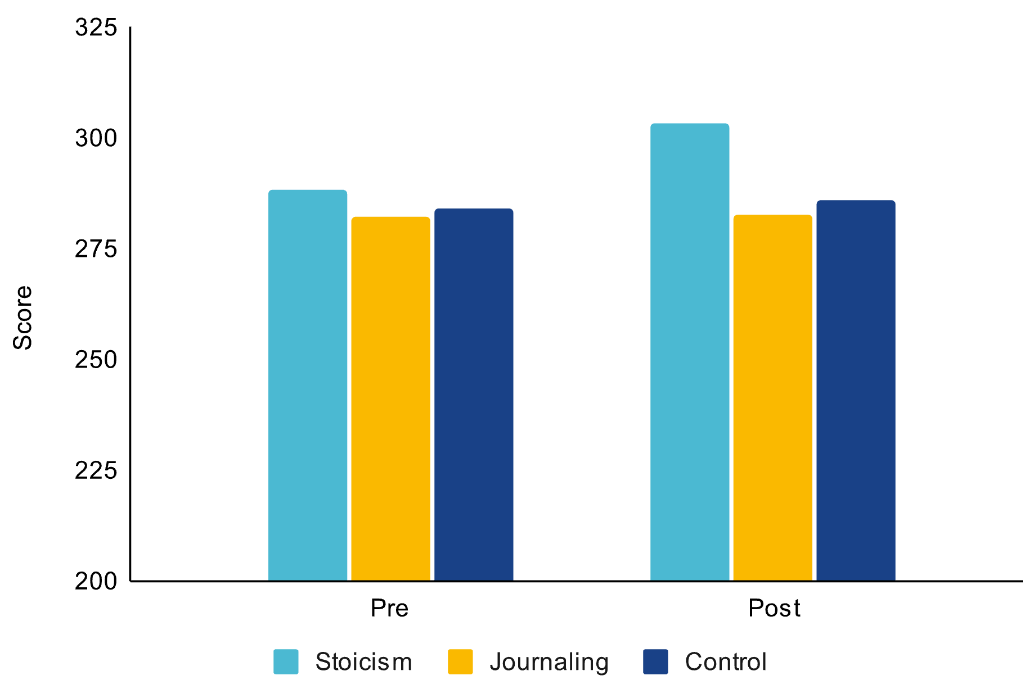
Table 3

Descriptive Statistics for SABS 5.0 Data

Condition	**Time**	**Mean**	**SD**
Stoicism	Pre-test	288.546	22.174
	Post-test	303.546	18.118
Journaling	Pre-test	282	40.901
	Post-test	282.7	39.325
Control	Pre-test	284.182	22.829
	Post-test	286	27.118

Fig 3

SABS 5.0 Effects



Note. The Y-axis starts at 200 to better visualize the effects.

EEG Results

The EEG results were analyzed using both data-driven and theory-driven approaches. A significant improvement in Stoic qualities is hypothesized to be due to be due to the increased synchrony and amplitude within specific wavelengths and electrodes, with a higher mean amplitude indicating more synchrony, as 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 modest statistical power.

Fig 4

Bilateral Temporal Lobe Theta Wave Mean Absolute Amplitude

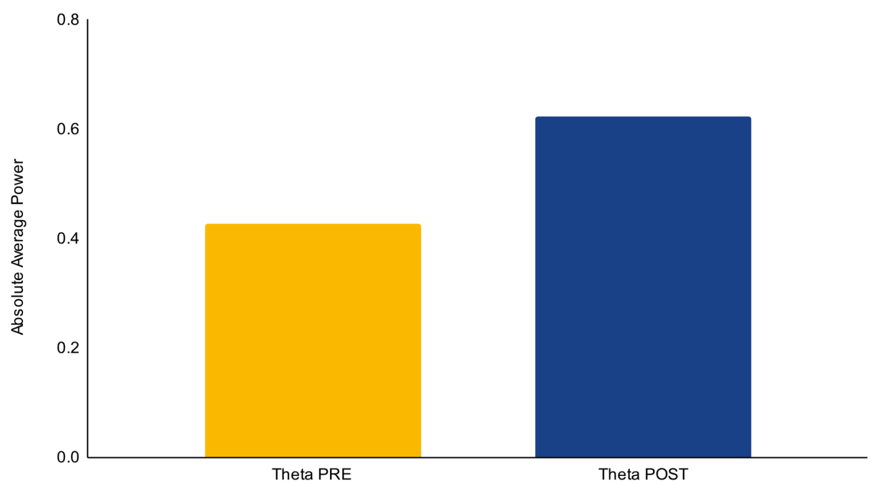
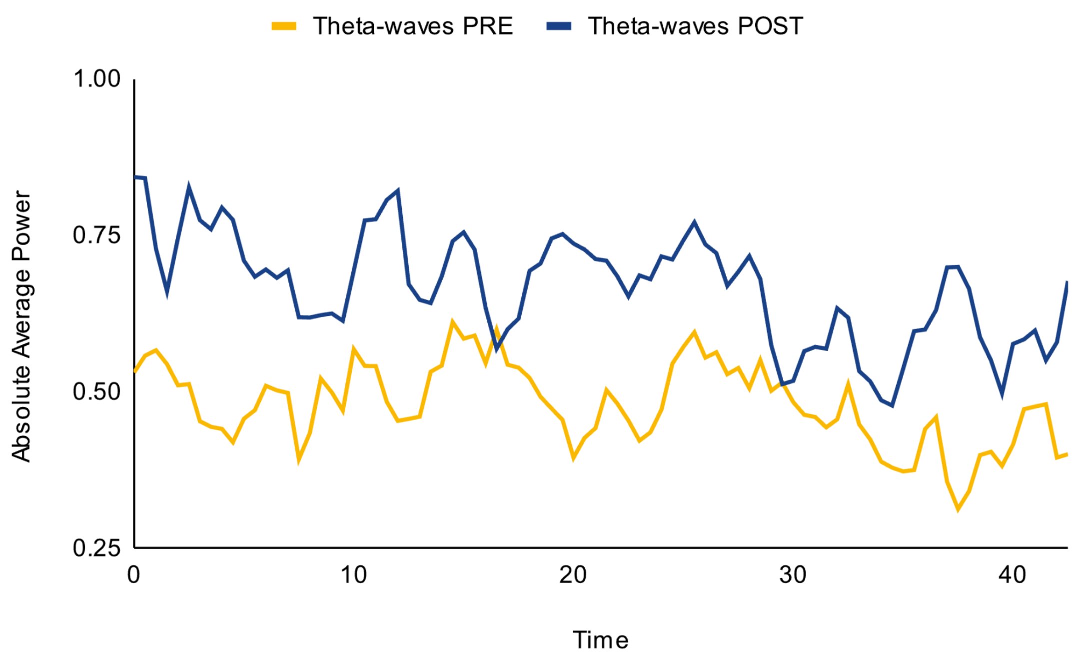


Fig 5

Bilateral Temporal Lobe Theta Wave Amplitude Over Time



Discussion

This study employed a portable EEG device and self-report questionnaires to investigate the impact of a week-long Stoic intervention on brainwave synchrony, rumination levels, reflective tendencies, and Stoic attitudes and beliefs. The results have revealed that a week-long Stoic intervention was sufficient to achieve statistically significant decreases in rumination levels, as measured by the RRQ. However, the reflection subscale did not yield any significant changes. There were also significant improvements in Stoic attitudes and behaviour from the SABS 5.0. Regarding the EEG data, no meaningful statistically significant effects were found; however, noteworthy trends were observed bilaterally in the temporal lobe, indicating increases in neural synchrony associated with coherent theta wave oscillations.

Unfortunately, during the study, an unexpected but ultimately beneficial confounding variable arose, as participants were simultaneously preparing for and taking a statistics midterm during their intervention period. This unplanned academic event provided a unique opportunity to assess the resilience-building potential of Stoic practices in a real-world setting. As several students briefly mentioned during the post-test session, the exam was very stressful and would likely be the focus of their thinking about a stressful event for their second EEG recording. Despite this increased stress, the behavioural data still showed significant results, as the Stoicism group displayed a significant decrease in Rumination and increased Stoic attitudes and behaviours. These findings suggest that even brief exposure to Stoic philosophy can yield measurable psychological benefits, particularly in reducing negative thought patterns, such as rumination. The fact that these improvements occurred during a stressful academic week adds more credibility to Stoic training as an effective resilience intervention. This is especially meaningful, considering participants had only one week to learn and apply Stoic principles, and suggests that Stoic practices are valuable for managing stress and improving mental well-being, even with minimal practice as brief as one week.

However, an unexpected outcome was found, as participants in the journaling group experienced increased Rumination scores. This contrast with the Stoicism group's results may be attributed to the absence of guidance in the journaling condition, as they were merely told to journal about whatever they wanted during the week, but to ensure that they did indeed journal every day. Lacking direction on effective journaling techniques, these participants resorted to counterproductive thought patterns, which increased their stress as they studied for and wrote their exam. This distinction highlights the significant impact of Stoicism on an individual's negative reflective tendencies, as evidenced by the fact that, after just one week, the Stoic participants showed decreased Rumination scores, despite also undergoing the same stress of the same exam. Unfortunately, though, the unguided nature of the journaling condition led participants to engage in negative thought patterns, only intensifying their Rumination. This provides further evidence of why a prompt is beneficial to individuals when they journal (Wäschle et al., 2015). That being said, however, the Stoic principles learned in the Stoicism condition, such as managing emotions and developing resilience, had a positive impact on the students studying for and performing the exam (Park & Kim, 2018). Not only did the principles reduce anxiety and stress, as reflected in the SABS 5.0, but they also appeared to promote more constructive thought patterns among the participants, as indicated by their decreased Rumination scores in the RRQ. This is particularly encouraging, considering the brief, week-long nature of the Stoic training provided, which suggests that the benefits of incorporating Stoic techniques into stress management and emotional coping strategies at colleges and universities, such as wellness activities or resilience training, may be substantial. Given its simple nature, Stoic exercises could become a powerful tool for helping students navigate the pressures of academic life without letting the stress and anxiety caused by simply being a student become too overwhelming.

While it was hypothesized that the Stoicism group would demonstrate increased levels of Reflection on the RRQ, given the Stoic philosophy's emphasis on self-awareness, introspection, and examining one's thoughts and actions, no significant changes were observed across any group, including the journaling group. This outcome was also unexpected, as Stoic practice and journaling are both commonly associated with enhanced self-reflection in the existing literature (Whitmore et al., 2019). One possible explanation lies in the Reflection subscale used in the RRQ, as it may not have been sensitive enough to detect the type of introspection required by living a Stoic lifestyle, let alone only a week of it. The RRQ primarily captures positively valenced self-focused Reflection, but Stoicism fosters a more deliberate, values-centred Reflection focused 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.

On the other hand, in addition to what was previously said about the lack of guidance for the journaling condition, those who only journaled may not have been reflective enough. Instead, they were more concerned for the future, particularly their upcoming exam. This limitation suggests that future studies investigating these effects use a scale specifically designed to assess the Stoic values related to reflective abilities. Additionally, the brief one-week intervention may not have provided adequate time for participants to develop these deep reflective behaviours, despite still being enough time to decrease Rumination and increase Stoic attitudes and behaviours. 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 more fully become integrated into an individual's identity.

In contrast, the EEG data in this study offered limited but potentially meaningful insights. The data-driven approach revealed statistically significant differences, but only within the control group, specifically in the delta, theta, and gamma frequency bands. However, these particular brainwave frequencies are not typically associated with the domains of emotional regulation central to Stoic practice and are likely not indicative of genuine cognitive shifts (Saskia et al., 2024; Smith, Lair, & O'Brien, 2019). Instead, they may be attributed to various confounding factors such as bioelectrical noise during the recordings or external influences that were not adequately controlled for during the experiment, or inter-participant dialogue about Stoicism. Therefore, drawing firm conclusions about cognitive changes based on these findings alone would be premature.

On the other hand, the theory-driven analysis focused exclusively on the Stoicism group and targeted the alpha, beta, and theta frequency bands, which have been previously associated with regulating stress, emotional control, and introspection, among other things. Though no statistically significant effects were found, emerging trends in increased Theta activity at the TP9/10 (temporal lobe) sites were close to being significant and mirrored patterns reported in past research on emotional regulation and neuronal synchrony (Jung & Lee, 2021; Wheelock et al., 2016). Examining the increased amplitude alone (Fig. 4), it is evident that Stoicism indeed enhanced neuronal synchrony in individuals in the Stoicism condition, although the increase was not statistically significant. To further this, Pagnotta, Riddle, and D'Esposito (2024) have uncovered, in a recent study examining theta and delta wave synchrony, that increased synchrony in theta waves (i.e., higher mean amplitudes in theta waves) is correlated with increased cognitive control. Specifically, when individuals adjust their behaviour in response to shifting environmental demands and personal goals, there is an increase in theta wave activity. To apply these findings to the results of this experiment, when participants were asked to relive a recent stressful experience for their EEG recordings, they did experience some minor stress. So, for the Stoic group, after their week-long training, when they were thinking of a stressful experience again, their training in resilience and emotional control enabled them to be better able to align the environmental demand of thinking of a stressful experience and adapt their internal goals of feeling less stressed from that external demand. This ultimately led to them feeling less stressed, supporting the hypothesis that Stoicism can indeed increase synchrony in the brain, specifically in the temporal lobe for theta waves. That being said, however, it is worth reiterating that these differences were not statistically significant.

Indeed, it is essential to recognize that the lack of significant findings in the theory-driven EEG data may be due more to methodological constraints than to the absence of a real effect. The sample size was adequate, but of course, there could have been more statistical power had it been larger, and both the Muse EEG and Mind Monitor mobile app have inherent limitations in what they can offer for a cheaper and easier alternative to traditional EEGs. This includes having fewer electrodes, as well as the lag introduced by the Bluetooth connection. If future researchers choose to explore the neurological effects of Stoicism, these limitations must be addressed. Additionally, to improve the quality of the data collected and avoid potential confounds, enhancing environmental control in the research room, limiting discussion about the experiment outside the lab, and using consistent and validated stress-inducing stimuli would be greatly beneficial. Alternatively, using a traditional EEG with more electrodes and a wired connection could provide more meaningful and reliable results, enabling researchers to draw more detailed neurophysiological conclusions from the increased neural synchrony. The brief duration of the intervention may also have limited the Muse EEG's capacity to detect neurological changes. Furthermore, the commonly used p-value threshold of 0.05 for statistical significance, which has long been a standard in scientific research, is not an absolute cutoff for interpreting meaningful results, but rather an arbitrary tradition within scientific research (Cowells & Davis, 1982).

A final point worth considering is the control group's overall performance, which demonstrated an unexpected considerable reduction in Rumination and an increase in Reflection, which is expected for intervention conditions but not the control, as well as random significant increases and decreases in gamma, theta, and delta wave activity. The control group was not given any intervention or materials related to Stoicism or journaling, yet the results were mirrored in those of the Stoicism group. This suggests the presence of an uncontrolled confounding variable, potentially arising from informal peer dialogue about the study, since all participants were from the same cohort/class. Alternatively, it may be more likely that simple test anxiety resulted in a confound, either from preparing for their statistics exam or from the exam itself being over. It would be premature to make definitive statements regarding the reason for the abnormal results from the control condition; however, it is sufficient to say that future studies should minimize external influences and account for the natural changes people make when they are aware of being observed.

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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