The Effects of Stoic Training and Adaptive Working Memory Training on Emotional Vulnerability in High Worriers

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Conflict of Interest

The authors declare that they have no conflict of interest.

Ethical Approval

The study received approval from the Ethics Committee of the Department of Psychological Sciences at Birkbeck College, University of London.

Consent to Participate

Informed consent was obtained from all participants included in the study.

Abstract

Background

Previous research has indicated a causal relationship between attentional control and anxiety with literature finding that attentional control training combined with mindfulness meditation may lead to cognitive improvements in high worriers. The current study investigates whether the practical application of Stoicism, a philosophy originating from the Hellenistic period, will provide similar self-report and cognitive improvement in a sample of high worriers.

Methods

45 high worriers were randomly allocated into one of three training groups: an active control 1-back, a combined adaptive dual n-back and Stoic training and a Stoic training only group. Participants were tested on anxiety and rumination as well as measures of attentional control and a nascent scale to measure Stoic ideation, pre- and post- an 8-session training period.

Results

Results found significant effects of Stoic training on rumination and self-efficacy. Text analyses of the Stoic training found reduced frequencies of anxious and negatively valenced words questions related to self-assessments and planning.

Conclusions

The study provides a positive foundation for the further research and development of Stoic training. The wider implications of these results are discussed.

Introduction

The cost to the global economy of anxiety and depressive disorders is estimated to be $1.15 trillion per year with over 12 billion work days lost (Chisholm et al., 2016). In the UK this figure could be up to £8.9 billion per annum with an estimated 2.56 million people expected to be affected by an anxiety disorder by 2026 (McCrone, Dhanasiri, Patel, Knapp & Lawton-Smith, 2008). Whilst there has been a focus on increasing the availability to psychological therapies to relieve the pressure on services and the economy, there is a strong case to be made for intervention at an earlier stage as certain features of a disorder become apparent.

Features of interest in anxiety and depressive disorders are excessive worry, poor attentional control and dysfunctional emotional regulation. Worry can be defined as an uncontrolled, stream of thoughts and images that predict a negative future for the individual (Sibrava & Borkovec, 2006). Excessive worry is associated with anxiety and negative emotional experience (Andrews & Borkovec, 1988) and often involves events that the individual has little to no control over. This often leads to the individual fixating on their symptoms, preventing them from taking action, i.e. the process of rumination (Cohen, Mor & Henik, 2015). Whilst often described as separate constructs, worry and rumination have been found to be highly similar and potentially affected by the same intervention strategies (Ehring & Watkins, 2008; Topper, Emmelkamp, Watkins & Ehring, 2017). The ruminative process is of particular interest, with previous literature proposing a reciprocal relationship between rumination and negative affect (Moberly & Watkins, 2008). Experimental studies have found that in dysphoric individuals, rumination impairs problem solving behaviour and exacerbates negative affect, self-beliefs and sense of self-efficacy; whereas this effect is not seen in non-dysphoric control individuals (Lyubomirsky & Nolen-Hoeksema, 1995).

This may explain how ruminative thought is also a predictor of future major depressive episodes and anxiety disorders (Ehring & Watkins, 2008).

Cognitive models postulate that the inefficiencies in the individual's cognitive control lead to an increased allocation of attention to threat-related stimuli, such as worrisome thoughts, resulting in an inability to shift to a more goal-driven cognitive process (Eysenck, Derakshan, Santos & Calvo, 2007). Historically, emotional processing was considered automatic yet dependent on attention being directed at the stimulus (Okon-Singer, 2018). The processing and regulation of emotion has been found to involve several prefrontal areas such as the anterior cingulate cortex, ventromedial, dorsolateral prefrontal cortex and the amygdala. These regions are also activated during tasks that require cognitive control (Cohen et al., 2016), suggesting inefficiencies in cognitive control and anxiety can have a causal relationship (Berggren & Derakshan, 2013; Sari, Koster, Pourtois & Derakshan, 2016). With the growing body of research into the efficacy of cognitive control training on improving clinical symptoms of anxiety (e.g. Sari et al., 2016; Cohen et al., 2016) the current study is devised.

It has been proposed that working memory capacity (WMC) is strongly linked with attentional control (Shipstead, Lindsey, Marshall, & Engle, 2014). Susceptibility to worry has been linked with poor WMC and attentional control, as worry reduces the individual's ability to inhibit distracting stimulus under cognitive load (Owens, Derakshan & Richards, 2015; Aue & Okon-Singer, 2015). Training working memory has been found to reduce rumination (Cohen et al., 2015), worry (Course-Choi, Saville & Derakshan, 2017), and improve attentional control in depression (see Koster et al., 2017, for a review), with WM training being a common paradigm in studies into attentional control.

The adaptive dual n-back training (Jaeggi, Buschkuehl, Jonides, & Perrig, 2008) is a common WM training paradigm that has been found to improve cognitive control (Sari et al., 2016). The task

requires participants to simultaneously process two separate streams of information, one visual and one auditory, and determine whether the current visual or auditory stimuli matches that shown a number (*n*) of trials back in the sequence. The level of '*n*' varies depending on the participant's performance, hence an adaptive training. Adaptive n-back training has been found to improve cognitive control in individuals with dysphoria (Owens et al., 2013), high trait anxiety (Sari et al., 2016), high worriers (Course-Choi et al., 2017), reduce longer term emotional vulnerability in women with a history of breast cancer (Swainston & Derakshan, 2018), and protect against vulnerability to anxiety and depression in at risk adolescents (Beloe & Derakshan, 2019). Other adaptive cognitive control trainings found to reduce rumination (Cohen et al., 2015) and improve cognitive control in clinically depressed populations (Siegle et al., 2014). Though there has been some skepticism about these results (Melby-Lervåg, Redick & Hulme, 2016; Kruijt, Parsons & Fox, 2018), the strength of the current literature is compelling. These findings are of great importance, as if sustained benefits are found from cognitive control training, a low cost, easy to implement option is available for individuals struggling with dysphoria, depression or anxiety disorders.

Cognitive control, therefore seems well positioned as the mechanism underlying optimal function and emotional experience. From this position, it is of interest to investigate and interpret how widely used interventions that are not ostensibly cognitive control trainings, such as mindfulness or Cognitive Behaviour Therapy, affect attentional control. If particular interventions are effective at strengthening a particular facet of attentional control such as shifting or inhibition, there may be scope for combining differing interventions to augment one another. Recent studies have found mindfulness-based meditation to have a positive effect on worry, possibly as a result of it recruiting and improving attentional control (Course-Choi et al., 2017). However, whilst there is great enthusiasm about mindfulness, there is concern over the efficacy of mindfulness being particularly sensitive to individual differences (Farias & Wikholm, 2016). Qualitative research

reports individuals can struggle with aspects of mindfulness such as finding the practice 'dull' or that it exacerbates present emotional distress (Lomas, Cartwright, Edington & Ridge, 2015).

Why Stoicism?

Stoicism may provide a solution to this issue, it shares similarities to some mindfulness-based practice, such as neutrality towards negative cognition (Baer, 2003), yet is active in its approach. Stoicism is a philosophy that promotes responsibility and control over one's thoughts and actions. The practice of Stoicism is now beginning to become prevalent in the self-help community, yet there has been little effort to investigate the efficacy of the practice. Findings seem to confirm anecdotal evidence supporting the practice of Stoicism (LeBon, 2018) however, there are concerns over the measures of change chosen, the selection of participants and a weak methodology. Improvements in wellbeing and emotional control have been reported as comments (e.g. "Stoic Week has helped me stay calmer") or as a change in the responses to the Flourishing Scale and the Scale of Positive and Negative Emotions developed by Diener et al. (2009), which show an increase in positive emotion and a decrease in negative emotion after short periods of practice. No work has been carried out with other measures of anxiety, affect or cognitive control.

Stoicism, as a philosophy, has had many contributors over the centuries, yet there seem to be common practices; in addition to the core principle of Stoicism which may be interpreted as only concerning oneself with one's thoughts and actions. This underlying principle, often called the dichotomy of control, aims to provide a reference point when attempting to evaluate themselves or the events of the world around them. Another recurring theme throughout Stoic texts and practice is the contemplation of a fictional ideal in aversive circumstances, often personified and referred to as a "sage".

Individuals with emotion regulation disorders engage in maladaptive, practices of negative rumination (Cohen et al., 2015). The first of the Stoic practices is that of 'premeditatio malorum'. This exercise instructs the individual to mentally consider future difficulties whilst constructing an efficacious statement, train the individual into a practical reflection of their thoughts with the intention of engaging in problem-solving thought patterns and behaviours. This process has been found to have a moderate effect size on disorders such as anxiety and depression where emotional dysregulation is common (Aldao, Nolen-Hoeksema & Schweizer, 2010). The second practice is to examine one's judgements. This is similar to cognitive reappraisal as found in CBT, often facilitated through the use of daily negative thought records (Wells, 2013). The Stoic practice encourages the individual to understand how the negative thought (judgment) came to be, but not reinterpret it, in line with previous research which has raised doubts over the efficacy of attempting to reinterpret negative thoughts (Haeffel, 2010). The Stoic practice instead seeks to train a mindful awareness of the judgement forming process in order for the individual to be able to recognize and halt this process in the future. Whereas traditional reappraisal methods may be conceptualized in the form: event A means outcome B, with the focus on changing the meaning of outcome B to something positive, Stoic appraisal aims to train the recognition of event A and outcome B as valence free.

The third practice included is the process of completing a daily assessment. Stoics recommend reviewing all actions taken that day and assess them, into what has not been done well, what was meant to be done but wasn't, and what has been done well. This practice pairs well with that of assessing judgements and thoughts and brings the individuals focus back to pragmatic action, again prompting the individual to once again take part in problem-solving behaviours which should be of benefit (Aldao et al., 2010).

The present study

The current study attempts to determine if the practice of Stoicism and attentional control training can reduce anxiety and ruminative symptomatology and improve self-efficacy. An online training was devised during which participants would read one or two passages of text from a classic Stoic writing, before summarising their thoughts on the text, and completing the three core practices mentioned previously as a guided online journal. The effects of an 8 session Stoic training were examined across three groups: 1) A non-adaptive dual 1-back active control group; 2) A group combining an adaptive dual n-back WM training with the Stoic training; 3) A group only completing the Stoic online training. An 8-day training was used due to reliable transfer effects being found in studies of similar lengths (Owens et al., 2013; Course-Choi et al., 2017).

Participants were selected to take part in the study based upon their score on the Penn State Worry Questionnaire (PSWQ; Meyer, Miller, Metzger & Borkovec, 1990), which is listed as a clinically relevant outcome measure for patients with anxiety disorders in the National IAPT Programme Handbook detailing guidelines for those recording and monitoring outcomes for clinically relevant, evidence based practice (National IAPT Programme Team, 2011).

Attentional control related training gains were measured using the Flanker task (Cohen et al., 2015) and an emotional Stroop task (Becker, Rinck, Margraf & Roth, 2001). Self-report questionnaires were administered pre- and post- training to measure trait anxiety, emotional vulnerability, self-efficacy and rumination. Trait anxiety, emotional vulnerability and rumination have been found to reduce with WM training in previous research (Sari et al., 2016; Course-Choi et al., 2017) and so further investigated here, with rumination of particular interest as an influential thought process for dysphoric and anxious individuals (Moberly & Watkins, 2008; Topper, Emmelkamp, Watkins & Ehring, 2017). Measures of self-efficacy have rarely been included when examining the transfer of cognitive training benefits, yet as self-efficacy is correlated with subjective wellbeing in

individuals under stress (Schwarzer & Jerusalem, 1995), and may potentially be correlated with Stoic ideals, it was included. To compare with the results found by LeBon (2018), the Stoic Attitudes and Behaviours Scale (SABS), was completed by participants pre- and post-training.

Our primary prediction is that participants undergoing Stoic Training would demonstrate reductions in rumination and improved inhibitory control. In line with previous research (Course-Choi et al., 2017), our second prediction was that these effects would be greater in the Combined Training group. Also, of interest is the relationship between change in Stoic ideation as measured by the SABS scale, and changes in self-efficacy and emotional reactivity. Finally, as the Stoic training component takes the form of a structured journal, the frequency of use of particular word categories was a source of data that we wished to explore. Word categories that express anxieties (e.g. worried, fearful), insight (e.g. think, know) and causation (because, effect) have been found to be indicative of emotional processing in previous studies utilising expressive writing (Park, Ramirez & Beilock, 2014). The change in the frequency of their use whilst journaling therefore may give an insight into the cognitive experience of the participant (Pennebaker et al., 2001; Ramirez & Beilock, 2011; Park et al., 2014).

Method

Participants

High worriers were recruited via advertisements placed around the campus of Birkbeck College, University of London, the college's online recruitment system SONA and via adverts placed on social media platforms. Participants from Birkbeck College were

offered course credits for their participation, amounting to either 5 or 8 experimental hours depending on the condition they were allocated. Non-student participants were not offered any incentive for taking part, and were informed the study was for a university dissertation project. Participants were selected based on their scores on their Penn State Worry Questionnaire (PSWQ; Meyer, Miller, Metzger & Borkovec, 1990). Applicants scoring 45 or above were designated 'high worriers' and thus eligible to take part as set out by the National IAPT Programme Team guidebook (2011). From a total of 93 applicants 78 were invited to take part, of which 60 accepted. 10 were excluded due to lack of response to emails during the study, 2 requested to be withdrawn after the first testing session and 3 were excluded due to not completing the sessions within the required time frame.

The final sample consisted of 45 participants (12 male). Participants were randomly allocated to either the control, combined or training group after grading the PSWQ. Final group numbers were Active Control, n = 13; Combined WM and Stoic Training, n = 16 and Stoic Training, n = 16. These group populations are similar in size to previous research yielding moderate to high effects (e.g. Sari et al., 2016). Groups did not vary significantly on age (Control, M = 28.69, SD = 9.24; Combined, M = 28.69, SD = 5.99; Stoic Training, M = 25.31, SD = 4.91; Welch's F (2,24.853) = 1.748, p = 0.195); had a similar gender distribution (Control, 2 male – 11 females; Combined, 6 males – 10 females; Stoic Training, 4 males – 11 females; Fishers exact test χ^2 = 1.746, p = 0.406); and did not vary significantly on initial PSWQ scores at pre-test (Control, M = 55.92, SD = 9.08; Combined, M = 59.31, SD = 7.49; Stoic Training, M = 59.94, SD = 8.74; Welch's F (2, 26.731) = 0.802, p = 0.459.

Participants gave their consent at pre-screening and pre-training. Participants were able to withdraw and have their data erased at any point during or after the trainings were

completed. The study received approval from the Ethics Committee of the Department of Psychological Sciences at Birkbeck College, University of London.

Materials and tasks

Emotional Stroop Task

The emotional Stroop task was similar to that used in previous research (Becker et al., 2001). 30 words were selected for use: 10 negative (e.g. failure, loser), 10 positive (e.g. happy, winner) and 10 neutral (e.g. wall, door) words describing household objects. Each word was presented once in four colours: red, yellow, blue and green creating 120 trials.

The Stroop was organised as 12 blocks of 10 stimulus words were created with the content randomised, so each word-colour combination would be shown once only. Participants were presented with a 500ms fixation screen before each stimulus screen was presented, and an inter-trial interval screen lasting 1000ms was presented after a response was recorded. Participants had a 6 second break between each block.

Flanker task

A standard arrow Flanker (Eriksen & Eriksen, 1974) task was created, with distractor stimuli as two sets of arrows (<< or >>) with one arrow as a target pointing either left or right in the centre. 2 blocks of 320 trials were created, with 192 congruent trials (e.g. <<<<<) and 128 incongruent trials (e.g. <<><<) in each block. Participants were given a 30 second rest period after the 1st block had been completed.

Self-report questionnaires

Participants completed the Penn State Worry Questionnaire to measure trait worry (Meyer et al., 1990), the State-Trait Anxiety Inventory to measure trait anxiety (STAI-TA; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983), Ruminative Response Scale to measure rumination (RRS; Nolen-Hoeksema & Morrow, 1991), Positive and Negative Affect Schedule to measure emotional vulnerability (PANAS; Watson, Clark & Tellegen, 1988), General Self-Efficacy Scale to measure self-efficacy (GSE; Schwarzer & Jerusalem, 1995), and the Stoic Attitudes and Behaviours Scale to measure Stoic ideation (SABS; LeBon, 2018).

The PSWQ and PANAS present as a 5 point Likert type scale, with the PSWQ containing 16 items and the PANAS containing 20. The STAI, RRS and GSE present as a 4 point Likert type scale with the STAI containing 20 items, the RRS containing 22 items and the GSE containing 10. These scales have all been chosen due to their high levels of reliability. The SABS presents as a 7 point Likert type scale with 37 items.

Adaptive dual n-back training

The adaptive dual n-back training was similar to Sari et al. (2016). Participants were presented with a 3x3 grid, with a fixation cross occupying the central square. In each trial, one of the eight remaining squares would turn green, and a letter (c, h, k, l, q, r, s or t) was spoken by a female automated voice. Participants were instructed to remember both the position of the green square, and the letter spoken, and to respond if either of both the square and letter matched a trial presented *n* trials back (see Figure. 1). If the square position matched, participants were to press the “A” key on their keyboard; if the letter spoken matched, participants were to press the “L” key. If both the letter and the position matched, participants were to press both keys and if neither matched, no response was

necessary. Each block contained four letter matches, four location matches and two simultaneous matches randomly distributed throughout the block. The stimulus was presented for 500ms with a 2500ms inter-stimuli interval, for a total time of 3000ms. Each training session consisted of 15 blocks, with each block containing 20 + *n* trials (e.g. in a 3-back block there were 23 trials). Participants were given a 20 second rest period between each block and the task could not be ended once it had begun. The level of '*n*' increased depending on participant performance. If the accuracy of both stimuli was 95% or above, the level of *n* increased on the subsequent block. If the response accuracy was between 75% and 95% the level of *n* remained the same, and if the accuracy decreased below 75% the level of *n* decreased by 1 in the subsequent block. Participants were informed of the level of *n* prior to the start of each block. Each n-back training session lasted approximately 30 minutes.

INSERT FIGURE 1 HERE

Active control 1-back task

The active control group was a non-adaptive 1-back training identical to the *n*-back training, but without any modification of the difficulty level. Participants would only be tasked with matching stimuli from the previous trial. Each training session consisted of 20 blocks, with 20 trials in each block.

Stoic Training

The Stoic training was created by selecting passages for participants to read from Stoic texts. Participants were presented with passages of Stoic text each day, before being instructed to summarise their thoughts about the passages in a text entry box. Participants were then asked to submit their answers to the three core Stoic practices: predicting misfortune, examining judgments and completing a daily assessment. The Stoic training would take approximately 20 minutes to complete. The selection of texts used in the Stoic training, questions and list of the books referenced can be found in the Supplementary materials.

All experimental tasks and self-report questionnaires, apart from then PSWQ, was created in php and Javascript. All data was stored in a MySQL database, and the program ran on an Ubuntu/apache server. The PSWQ was coded on The Gorilla Online Experiment Builder.

Procedure

Pre-study, the applicants completed the PSWQ online. Eligible participants were allocated to groups using a random number assignment in SPSS and sent a link to their relevant group. Upon logging into the study platform for the first time and registering, participants completed the Emotional Stroop task, Flanker task and self-report questionnaires before being instructed to log back in the next day for the training program to begin. Each training day, participants would log in to complete their training, before being reminded to log back in at the same time the next day. If participants did not log in for two days consecutively, they would be emailed with a reminder to log in to complete a training session. Upon completion of the training period, the participant again completed

tasks and self-report questionnaires administered upon first registering. The mean number of training days participants took to complete the training was 13.31 days, SD = 3.95, with the median number of days being 12 days to complete the training.

Results

Separate mixed ANOVAs for each measure (RRS, STAI-TA, PANAS, GSE, SABS, emotional Stroop and Flanker) were performed, with time (pre-training, post-training) as the within-subjects factor and group (Control, Combined, Stoic Training) as the between-subjects factor; with the results addressed in their relevant sections.

Self-report measures.

Table 1 shows mean and standard deviation scores for all self-report measure pre- and post-training across groups. A univariate ANOVA was conducted on all pre-training scores with none meeting significance, however pre-training rumination scores did display a trend to significance, $F(2,42) = 3.062$, $p = 0.057$; and thus results should be interpreted with caution. Table 2 shows the scores for the 2x3 ANOVA's conducted for all self-report measures.

A significant main effect of time was found for all self-report questionnaires and Group x Time interactions were present for rumination and self-efficacy self-report measures. Follow up analysis, also presented in Table 1, show that after correcting for type 1 errors ($p = 0.025$), both the Combined group and the Stoic training group had a significant change in self-reported rumination compared to the control group. Independent samples t-tests conducted on rumination scores found no significant differences between the groups post-training however, all t's < 1. Post-hoc

G*Power analysis (Faul, Erdfelder, Buchner & Lang, 2009) repeated measures ANOVA (within-between interaction) for an observed effect size calculated from η_p^2 of 0.47, 3 groups, 2 measurements revealed a power of 0.78.

Significant differences are also found when comparing self-efficacy score change between the Stoic training group and control group, t (27) = 2.715, p = 0.011, d = 0.727. The difference between the Combined group and Stoic training group was not significant when correcting for type 1 errors, t (30) = 2.213, p = 0.035, d = 0.892.

Within group t-tests found significant differences in rumination score for the Combined group, t (15) = 2.891, p = 0.011, d = 0.860 and the Stoic Training group, t (15) = 4.267, p = 0.001, d = 0.694. Significant effects were found in the Stoic Training group for self-efficacy score, t (15) = 2.604, p = 0.020, d = 0.564 and SABS score, t (15) = 2.852, p = 0.012, d = 1.073, indicating significantly lower rumination and significantly higher Stoic ideation and self-efficacy.

INSERT TABLE 1 HERE

INSERT TABLE 2 HERE

INSERT FIGURE 2 HERE

Performance in the n-back training

Level of *n* differed significantly on the first day of the n-back training (M = 1.40, SD = 0.35) compared to the last day of training (M = 2.02, SD = 0.60), t (15) = 6.44, p < 0.01, as seen in Figure 3. The accuracy in the active control group did not significantly vary between the first and final day (Day 1, M = 93.65, SD = 2.31; Day 8, M = 96.98, SD = 0.66) t (12) = -1.537, p = 0.150.

INSERT FIGURE 3 HERE

Flanker Task

Data was trimmed to exclude the 5% extreme reaction times, leaving 90% of the available data to be analysed. Similar to Sari et al. (2016) interference scores were calculated by subtracting RT's of compatible trials from RT's of incompatible trials, resulting in a positive figure if the RT was longer on incompatible trials, and negative if it was longer on compatible trials.

A 2 x 3 Mixed ANOVA investigating interference scores found main effects of Time, F (1,40) = 5.568, p = 0.023, η_p^2 = 0.117; and Group F (2,40) = 3.972, p = 0.026, η_p^2 = 0.159. There was no significant Time x Group interaction, F (2,40) = 1.127, p = 0.334, η_p^2 = 0.051. This indicates that post-training reaction times were faster for all groups and groups differed in their change in interference scores. Alpha adjusted (p = 0.025) follow up t-tests found no significant comparisons, however there was a borderline significant trend between Combined and Stoic group at pre-

training, t (30) = 2.048, p = 0.049, d = 0.724. Therefore, an ANCOVA was run on the centred post-training interference scores with centred pre-training interference scores as covariate. There was no main effect of the covariate, F (1,41) < 1, and the corrected model found no Group differences in post-training interference scores when controlling for baseline differences, F (2,41) = 2.108, p = 0.134, η_p^2 = 0.051. Figure 4 shows the differences in interference scores post vs pre training.

INSERT FIGURE 4 HERE

Emotional Stroop Task

Reaction times greater than 2.5 standard deviations from the mean were discarded leaving 98.9% of the data available to be analysed. Reaction times for positive, negative and neutral words, pre- and post-training can be found in Table 2. Accuracy scores did not differ between groups, or for word emotion: neutral words F (2,40) = 2.265, p = 0.117, η_p^2 = 0.102; all other F scores < 1.

A 3 (Valence) x 2 (Time) x 3 (Group) mixed ANOVA was performed, with a main effect of Time found, F (1,40) = 26.281, p < 0.001, η_p^2 = 0.397. There were no main effects for Valence or Group, both F's < 1. The three-way interaction was not significant, F < 1. A significant Valence x Time interaction was found to be significant, F (2,40) = 3.424, p = 0.037, η_p^2 = 0.079. Follow up contrasts comparing positive and negative word reaction times to neutral word reaction times across time points found a significant change in reaction time for negative compared to neutral words post-training, F (1,40) = 5.132, p = 0.029, η_p^2 = 0.114; but not for positive compared to neutral words, F < 1. These results indicate reaction times decreased for all word valences post-training compared to pre-training, and the Valence x Time interaction effect is driven by post-

training negative word reaction times being significantly different from positive and neutral word reaction times. Interactions between Valence x Group, F (2,40) = 1.945, p = 0.111, η_p^2 = 0.089; and Time x Group, F (2,40) = 2.261, p = 0.117, η_p^2 = 0.102, were not significant.

INSERT TABLE 3 HERE

Stoic Attitudes and Behaviours Scale Analyses

Correlational analyses of change in SABS score for self-report measures were carried out, producing several significant results. The change in the PANAS-P, r = 0.340, p = 0.022, 95% CI 0.052 to 0.058; and PANAS-N, r = -0.447, p = 0.002, 95% CI -0.655 to -0.178; were significantly correlated with changes in the SABS scale. This indicates that as the SABS score increases, so does self-reported positive affect, with negative affect decreasing. Change in GSE highly correlated with SABS change, r = 0.687, p < 0.001, 95% CI 0.493 to 0.816. This seems to indicate that as SABS score increases, so does self-efficacy.

Stoic Training Text Analysis

The text entries for questions relating to daily planning and self-assessment of participants in the Stoic training groups were analysed using the Linguistic Inquiry and Word Count (LIWC; Pennebaker, Booth, & Francis, 2001) software to determine if the language used by participants differed from the beginning and end of the training period, and if this change correlated with any of the significant reported results. Word categories of interest

were those expressing anxieties (e.g. worried, fearful), insight (e.g. think, know) and causation (because, effect), positive (e.g. love, nice) and negative (e.g. hurt, ugly) emotion. Word frequencies of the relevant categories on the first and last session of the training across the Stoic training groups are presented in Table 3.

INSERT TABLE 4 HERE

A mixed ANOVA for each word category (anxiety, cause, insight, positive, negative) was performed, with time (first session, last session) as the within-subjects factor and group (Combined, Stoic Training) as the between-subjects factor for both questions analysed. Three participants were excluded from analysis due to a technical issue. A main effect of time, $F(1,27) = 5.445$, $p = 0.027$, $\eta_p^2 = 0.168$, was found for the anxiety word category and for the negative emotion category, $F(1,27) = 5.910$, $p = 0.022$, $\eta_p^2 = 0.180$, indicating that post-training participants used less anxious and negatively valenced words (Anxiety M = 0.34, SD = 0.65; Negative Emotion M = 2.05, SD = 2.16) compared to pre-training (Anxiety M = 0.91, SD = 1.25, Negative Emotion M = 2.28, SD = 2.19).

Correlational analyses across the Stoic groups for mean word count, change in anxiety word frequency in the question relating to planning, negatively valenced word frequency in the question relating to self-assessment; and self-report measures were conducted, yielding three significant correlations: between mean word count in the planning question and change in SABS score, $r = 0.434$, $p = 0.017$, 95% CI 0.161 to 0.645; between mean word count in the self-assessment question and change in SABS score, $r = 0.476$, $p = 0.009$, 95% CI 0.212 to 0.675; and between mean word

count in the planning question and change in PANAS-N, r = -0.395, p = 0.031, 95% CI -0.617 to -0.115.

Discussion

This study attempted to investigate the findings of the Modern Stoicism team (LeBon, 2018) and determine if the practice of Stoicism has an effect on mechanisms of anxiety, as determined by attentional control and self-report measures; and augment a well-established cognitive control training. Training related gains in attentional control were examined via a Flanker task and attentional bias was examined via an emotional Stroop task. Self-report measures of rumination, trait anxiety, positive and negative affect and self-efficacy were used to measure subjective correlates of anxiety.

The behavioural measures yielded no significant findings. The Combined training group showed non-significant trends indicating benefits of adaptive dual n-back training to improve attentional control as measured by the Flanker task, with a similar pattern of results found in the emotional Stroop task, with no significant interactions rendering interpretation difficult.

The results of the self-report measures are clearer, with experimental groups found to have significantly reduced scores in ruminative thinking, in line with our primary prediction, which may have practical implications. Interestingly, significant correlations between increase in Stoic ideation and reductions in negative affect, and increases in positive affect and self-efficacy were found, and whilst the sensitivity of the SABS may be in question, this seems to indicate a relationship between Stoic ideation and subjective emotional wellbeing.

Self-report measures

All groups recorded improvements in self-report measures, consistent with previous literature (Course-Choi et al., 2017) however there is tentative cause for optimism. The improvements in rumination scores pre- to post-training in the combined group compare favourably with previous research investigating the efficacy of n-back training on ruminative thinking and anxiety (Sari et al., 2016; Course-Choi et al., 2017). As rumination is a hallmark of anxiety (Andrews & Borkovec, 1988) and depression (Watkins & Ehring, 2008) this finding is encouraging, as is the result of the Stoic Training group producing a similar significant result. Also of interest is the improving GSE scores in the Stoic Training group and its correlation with increasing SABS score. As this has been seldom included in studies, yet seemingly correlated with wellbeing under stress (Schwarzer & Jerusalem, 1995), this seems to lend support to Stoic practice as a method of building resilience, and more commonly used measures of resilience should be included in future studies.

Three 'core' Stoic practices were described with potential mechanisms for their potential efficacy proposed. The increased sense of self-efficacy and decreased ruminative worry in the Stoic groups may be the result of the participants shifting to more problem-solving thought patterns, as has previously been found beneficial (Aldao et al., 2010). As ruminative thinking may be thought of as a distracting stimulus (Cohen et al., 2015), it may be that the Stoic practices of 'premeditatio malorum' and daily assessments train the inhibition of such stimulus and shift attention away from them, potentially explaining how the Stoic only group matched the group with adaptive n-back training, in line with successes in previous attentional control training studies (Course-Choi et al., 2017).

Text Analysis

The results of the text analysis do not provide much material for interpretation due to the paucity of data collected and a lack of control exercise for comparison. However, the analysis carried out reveals two findings of interest. The significant reduction in 'anxious' words used in the question instructing participants to predict future problems is an encouraging sign, indicating less anxious language used and so less anxious cognition (Pennebaker et al., 2001; Ramirez & Beilock, 2011; Park et al., 2014). Equally, the significant reduction in negative word frequency used in the question relating to daily assessments, indicating fewer negative words used in participant's self-assessment is encouraging and warrants further investigation.

Also of interest was the correlation between mean word count of both questions analysed, and change in SABS score, and the correlation between mean word count of the planning question and change in PANAS-N score. If the mean number of words written may be taken to be an indicator of level of engagement with the training, then this suggests a positive relationship between the level of engagement and the changes in self-report scores. These interpretations are deliberately tentative, and future studies should seek to increase the material available for analysis and further investigate these correlations by collecting similar data for all groups to allow proper comparison.

Behavioural measures

Training related gains in working memory capacity are demonstrated in the Combined group due to the significant increase in n-back level across the training period. However, transfer effects to attentional control are not apparent from either training group, and yields no support to the notion of supplementing n-back training with Stoic training, if

the goal is to improve inhibitory function. One might argue that due to differences in the pre-training scores, the effect is largely driven by regression towards the mean, however the magnitude of change in interference scores was greater in the Combined group as compared to the other groups who are either not expected to demonstrate improvements in inhibitory control from previous findings in the literature (the control group) or practicing a novel task (the Stoic group). Tentatively we may argue this supports our hypothesis that the adaptive n-back training would improve attentional control, however we did not observe a significant difference between the Stoic only group and the control group, against our predictions.

Reaction times for emotional words, regardless of valence, were longer than those for neutral words, consistent with previous literature (Dresler et al., 2009) and all participants experienced a reduction in reaction time, possibly indicating practice effects post-training. Negative word reaction times did differ from both positive and neutral word reaction times post-training, however the absence of a main effect of group prevents further interpretation.

Limitations and directions for future research

The primary limitation and cause for concern in the reported results are the trends to a priori group differences in both pre-training rumination and Flanker interference scores, thus any effects found may be as a result of regression towards the mean. A secondary limitation may be the lack of a group with participants undertaking n-back training alone. Such a group was not included as the efficacy of n-back training has already been established, with the focus of interest being on the potential efficacy of Stoic Training.

The second major limitation is the narrow selection of task choice to measure attentional control. With both the flanker and Stroop tasks primarily measurements of inhibitory function it may be potential benefits to other executive functions such as shifting or updating have been missed entirely. Future studies should seek to include measures of several facets of attentional control.

The study was designed and conducted online in order to maximise participation, however this led to lack of control over experimental setting and may be partially responsible for the variability. Participants were accepted and randomly allocated based on PSWQ scores and no group differences were found pre-study on this measure, however the trend to baseline group differences still occurred. As participants determined when they sat each testing and training session, testing environments pre- and post-training may have been significantly different for each participant. Whilst this does lend the study ecological validity, it is less than ideal. In addition, participants were emailed after two days of inaction, with these reminders potentially adding stress and anxiety.

Though the online nature of the training and testing may be responsible for variable engagement and the trend to group differences at baseline, the benefits of creating low-cost, easily accessible paradigms should not be discounted (Birnbaum, 2004). It is therefore recommended that future studies investigating Stoic practice should ideally involve lab-based testing with online home-based training, as in previous literature. Also of consideration are the doubts raised as to the reliability of the emotional Stroop task itself. (Eide, Kemp, Silberstein, Nathan & Stough, 2002; Strauss, Allen, Jorgensen & Cramer, 2005).

As mentioned previously, the Stoic Attitudes and Behaviours scale appears to measure Stoic thinking to some degree, however the sensitivity of it is in question, due to the overall non-significant differences between groups. Of great interest is the correlation in

SABS change to PANAS scores and self-efficacy measures. Future research into Stoic practice should endeavour to confirm and investigate these initial correlations, and to seek to refine the sensitivity of the scale (LeBon, 2018). As this is the initial exploration into the nascent field of practical modern Stoicism, the content of the training provided will undoubtedly be in need of refinement, yet the method of data collection, online journals with guided questions, is a robust one that additionally yields qualitative data for analysis. Future research would be remiss to alter the structure and lose a valuable method of tracking engagement and participant experience.

The question of whether Stoicism correlates with attentional control and attentional bias remains unanswered. For the reasons stated previously, interpreting this data must be done with caution. Taking advantage of in lab experimental testing would allow more sensitive investigation into WMC changes, possibly by use of a change detection task, alongside a more diverse set of measurements of attentional control. It would be of value to attempt to replicate the patterns found in the emotional Stroop task, however adding an additional measure of interpretative bias such as the scrambled sentence task (Grol et al., 2018), would lead to more confidence in any patterns found.

Finally, whilst we have conducted post-hoc power analyses to lend confidence in the results found, our sample size is relatively small, and as such a larger sample size would be desirable in future studies.

Clinical Implications

These findings of the current study are of interest, as it has been found that individuals displaying high levels of ruminative thought and worry take longer to improve when undergoing standard CBT, when compared to individuals with lower levels of ruminative thinking (Jones et al.,

2008; Price & Anderson, 2011). With recent studies showing the benefits of preventative approaches targeting ruminative thinking (Topper, Emmelkamp, Watkins & Ehring, 2017), the results found in this study are encouraging.

The implementation of Stoic practice and n-back training as a preventative intervention may solve another issue. The IAPT model proposes stepped care in the following manner: at step 1 the individual's symptoms are recognised and primary care teams engage in 'watchful waiting' to determine if further action is required. At step 2 individuals are engaged in low intensity CBT often self-administered or delivered online. At step 3 individuals are progressed to a high intensity service, often with weekly meetings with a trained therapist (NCCMH, 2018). This process leaves much to the discretion of the primary care team, with GP's found to not refer certain individuals, such as those over the age of 65, due to the perception of IAPT assessment being distressing and preferring to treat with medication and watchful waiting (Collins & Corna, 2018). The trainings, as delivered in this study has the advantage of not only being accessible to many due to its online delivery, but also may be more easily received and delivered by primary care teams who might be more wary of referring potentially resistant patients to IAPT services. Should future studies build on these findings, these interventions may emerge to provide a low cost, simple, easy to implement approaches targeting rumination as a risk factor to prevent future instances of depression or anxiety.

Conclusion

This study set out to investigate the practice of Stoicism combined with n-back training. Results added to the literature surrounding the efficacy of adaptive dual n-back training as a method of improving attentional control. The reduction in rumination in both

groups is of interest when considering the implications for emotional dysregulation disorders. These results must be taken with caution, but are encouraging with potential to develop or augment existing interventions to target rumination as risk factor for future episodes of anxiety and depressive disorders.

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