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Mindfulness and Stress - a Randomised Experiment*

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Abstract

We conduct a randomised controlled trial of an online course in mindfulness. Previous research has found evidence that mindfulness reduces stress; however, few studies have been carried out on non-clinical populations that have not self-selected into or paid for treatment. Our sample consists of 139 students with no pre-existing medical conditions and no prior information on the experiment and treatments. Half of them are asked to follow a four-week mindfulness training, while the other half are asked to watch a four-week series of historical documentaries. We follow participants for five consecutive weeks, with an additional post-intervention session five months later. We evaluate the effects of the mindfulness program on measures of chronic stress, and on the response to stressful situations, measured by cortisol and self-reports. We find strong evidence that mindfulness training reduces perceived stress, as measured by the Perceived Stress Scale. However, the physiological responses to an acutely stressful situation do not differ significantly between the treatment and control groups.

JEL Classification: C81, C91, I10

Keywords: Stress, Mindfulness, Experiment.

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1 Introduction

According to a recent OECD report, mental health issues and disorders currently account for one of the largest and fastest growing categories of the burden of disease in OECD countries, with one in five people having a mental disorder. Stress and anxiety, in particular, are widespread. A recent report ([American Psychological Association, 2015](#)) finds that 75% of American adults report feelings of moderate to high-level stress in the past month; 80% of workers feel stress on the job, with 50% expressing interest in guidance on how to manage stress; and about 13.7 million working days are lost annually due to work stress-related illness in the United Kingdom. Younger generations and women in particular consistently have struggled with stress.

Stress has been shown to affect a wide range of cognitive and non-cognitive skills. It has been shown to impair memory ([Wolf, 2009](#); [Kirschbaum et al., 1993](#)), cognitive performance ([Buchanan and Tranel, 2008](#); [Schwabe et al., 2008](#)), and executive functions ([Scholz et al., 2009](#)), and to affect risk-taking behaviour, which in turn impacts important day-to-day decisions ([Buckert et al., 2014](#)). Prolonged stress can lead to both physical health problems (e.g., heart disease, high blood pressure, diabetes) and mental health problems (e.g., depression or anxiety), although the effects are not always clear ([Bosma et al., 1998](#); [Chandola et al., 2008](#); [Cohen et al., 2007](#); [Greenwood et al., 1996](#); [Kivimäki et al., 2006](#); [Pieper and Brosschot, 2005](#)).

We conduct a randomised controlled experiment to measure the impact of a well-known psychological intervention, the Mindfulness Based Stress Reduction (MBSR) program, on stress levels and stress coping response in an adult population in the United Kingdom. Our sample consists of 139 students with no pre-existing medical conditions, who are recruited from the University of Edinburgh to participate in a six-week “lifestyle” study. No information about the training we would offer was provided at the stage of recruitment. This aspect is important, because it reduces the problem of self-selection into the intervention significantly and it enables us to construct an appropriate control group. Students are, however, an interesting population because there is evidence that students suffer from chronic stress ([Galbraith and Brown, 2011](#); [Regehr et al., 2013](#)) and, as mentioned above, younger generations appear to have always been struggling with stress. Therefore, this population is particularly interesting as a possible target group of stress reduction programmes.

Mindfulness, the central principle of the intervention we test in this paper, has recently enjoyed a rise in popularity in many countries (Forbes, 2017; FinancialTimes, 2017). Mindfulness training focuses on attention to moment-by-moment experience (Kabat-Zinn, 1990) and consists of routine exercises such as bringing the mind’s attention to the present (for example, by focusing attention on one’s breathing or on what one is eating). These techniques are seen as ideal training to improve self-control, perhaps because most of the exercises focus on training the ability to inhibit one’s impulses (Friese et al., 2012; Teper and Inzlicht, 2013; Teper et al., 2013; Flook et al., 2010). The direct objective of these techniques is often reducing stress, and there are a number of experimental studies documenting their effectiveness in reducing chronic stress (Tang et al., 2007; Morledge et al., 2013; Caldwell et al., 2012). However, most of the evidence so far has been gathered on individuals who self-select themselves into the interventions. It is therefore unclear whether these techniques are effective or whether the individuals self-selecting into this type of training are particularly receptive to it. Moreover, most previous studies focus on the immediate effects of the mindfulness training. We follow-up on our subjects five months after the interventions and measure the long-run impacts on the outcome variables of interest.

The intervention tested here is an online course in mindfulness called “Be Mindful”.¹ The course is designed as a complete training for mindfulness and is one of the currently most popular online tools for learning mindfulness skills. It is run by the UK Mental Health Foundation.

The students participating in our study were invited to an initial session at the Behavioural Laboratory at the university and allocated (based on the time slot they chose) either to the mindfulness-based stress reduction (MBSR) programme or to a control intervention consisting of a series of documentaries called “BBC Ancient Worlds”. We chose this intervention because it requires a similar degree of time commitment, but involves very different activities. While mindfulness consists of exercises that should help individuals take charge of their thought processes, a TV documentary is more likely to be distracting. Both programmes were to be followed outside the laboratory and lasted for four consecutive weeks, starting in the week immediately after the initial session. Participants were asked to return to the laboratory for five consecutive weeks after the initial session (including one week after the interventions ended) and provide feedback on the previous week (about both their engagement with the intervention

¹See <https://www.bemindfulonline.com/> for a detailed description of the mindfulness-based stress reduction course.

and their well-being and health-related behaviours). We also conducted an additional post-intervention session five months later to document long-term effects.

Our main outcomes of interest are chronic stress and the ability to cope with a stressful situation. Chronic stress is measured with a score on an extended version of the Perceived Stress Scale (PSS). The PSS is a widely used measure of stress, capturing the extent to which an individual perceives events in the previous month as overwhelming and uncontrollable. We also collected information on stressful events that participants encountered in the previous month and evaluated the relationship between the PSS score and these stressful events, for the treated and control groups. The ability to cope with a stressful situation is measured by the cortisol response to a laboratory-induced stressful situation. We also collected a self-reported measure of the degree of stress that the participants experienced during that situation.

We find that the program participants report significantly lower levels of stress than the control group both immediately and five months after the intervention, as measured by the Perceived Stress Scale (PSS). However, their physiological responses to an acutely stressful situation, as measured by cortisol levels, do not differ significantly.

The rest of the paper is structured as follows. Section 2 outlines related literature. Section 3 lays out the experimental design and procedure and describes the participant sample and the recruitment process. Section 4 describes the outcome measures of interest collected during the experiment. In Section 5, we present descriptive statistics on background variables. Section 6 describes the empirical strategy and presents the results, and Section 7 concludes the paper.

2 Related Literature

A growing body of research finds that mindfulness, especially mindfulness-based stress reduction (MBSR) and mindfulness-based cognitive therapy (MBCT), is an effective treatment for health problems such as recurrent depression ([Teasdale et al., 2000](#); [Ma and Teasdale, 2004](#)) and anxiety ([Hofmann et al., 2010](#)). A recent systematic review of meditation programs, including 47 randomized clinical trials with active controls, found moderate evidence that mindfulness meditation programs reduce anxiety, depression and pain, as well as low evidence of stress

reduction (Goyal et al., 2014).

While MBSR has been shown to be an effective treatment for various mental and physical disorders, fewer studies have investigated its possible benefits for “healthy” subjects. A review study by Chiesa and Serretti (2009), which undertook a meta-analysis of mostly less-rigorous studies published prior to 2008, documents that MBSR may be able to reduce stress levels in healthy subjects. However, the review emphasizes the need for further research to demonstrate a robust relationship between MBSR and stress. Several studies since then have found evidence of persistent reductions in perceived stress (i.e., maintained at one- to three-month follow-ups) following participation in a mindfulness intervention (Carmody and Baer, 2008; Carmody et al., 2009; Epel et al., 2009)

Krusche et al. (2013) study the impact of the online mindfulness course we use in the present study and find significant reductions in perceived stress, anxiety and depression at course completion, as well as a further decline at a one-month follow-up. The authors report effects that are comparable to those found in studies using face-to-face mindfulness courses and other types of treatment for stress, such as cognitive behavioural therapy. The amount of (self-reported) meditation practice affected outcomes when the authors controlled for baseline levels of stress, anxiety, and depression. This study, however, has two key limitations: there was no control group, and the sample consisted of self-referred individuals who were willing to pay for and take part in the course, implying a potential sample selection bias.

To summarise, our paper builds on earlier studies that suggest that mindfulness techniques appear effective at reducing stress. We specifically contribute to the literature by using a randomized controlled experiment to identify the impact of a mindfulness training program on a population that has not self-selected or paid for the treatment.

3 Experimental Design

3.1 Sample

We recruited 139 participants² primarily through the database of the Experimental Laboratory of the School of Economics at the University of Edinburgh – called BLUE (Behavioural Laboratory at the University of Edinburgh), as well as through posters and leaflets on campus. The advertisement and recruitment emails are attached in Appendix A.

Participants were required to be at least 18 years old and students at the University of Edinburgh and could not have any pre-existing medical condition. The experiment thus targeted a healthy student population. The study was approved by the School of Economics Ethics Committee at the University of Edinburgh. The slogan used in the advertisements was “Feeling a bit stressed?”, targeting students with relatively high levels of anxiety at the start of the study. This was done in order to maximise the chances of inducing an exogenous difference in chronic stress between the treatment and control groups. However, it is likely that such a slogan would attract the attention of many students, as a recent survey by the National Union of Students (Kerr (2013)) found that 92 percent of respondents reported feelings of mental distress, including feeling down, stressed and demotivated during their time in higher education. Thus, it is likely that most students at the university “feel a bit stressed”.

It is important to point out, however, that, unlike in previous studies, the participants in our experiment have not self-selected into the treatment and are not paying for it, reducing the risk of associated biases. The prospective participants did not know beforehand what the interventions would be.

²We originally intended to have 144 participants (18 participants in 8 groups). We have a smaller sample size because 5 participants did not show up.

3.2 Experimental Interventions

3.2.1 Treatment: Mindfulness Based Stress Reduction Programme

The Stress Management Programme consisted of the “Be Mindful Online” mindfulness course. Combining elements of MBSR and Mindfulness Based Cognitive Therapy (MBCT), the course was developed by leading UK mindfulness instructors and is run by the Mental Health Foundation and Wellmind Media. Participants are given an individual login to the course website (<http://www.bemindfulonline.co.uk>), which provides instructional videos to guide formal meditation. The impact of the course on stress and anxiety has been evaluated by [Krusche et al. \(2013\)](#).

The course is designed to be taken over four weeks, with a total of 10 interactive online sessions lasting 30 minutes each. The course starts with a three-minute introduction video. This is followed by a questionnaire (including the 10-item version of the Perceived Stress Scale (PSS) of [Cohen et al. \(1983\)](#)). It also contains the Patient Health Questionnaire (PHQ-9) and the Generalised Anxiety Disorder Assessment (GAD-7). This is followed by an orientation video, which also prompts participants to write down their intentions. During the course, participants are instructed in both formal (including sitting meditation and body scan) and informal (incorporating mindfulness into daily activities) meditation techniques, through videos, assignments, and reminder emails. Participants are asked to practise exercises for both kinds of techniques each week between online sessions. Upon completing the course, participants are asked to complete the same questionnaire as in the introductory session of the course.

As participants were asked to follow the programme on their own, we could not enforce compliance. However, the online platform includes a web-based administration system to track participants’ activity. In addition, weekly laboratory sessions were held to maintain engagement with the participants and gather self-reported information on their experience of the course (part of the weekly questionnaire, which also included questions about participants’ feelings and health-related behaviours during the previous week). Thus, we are able to study in detail the extent to which participants engage with the programme.

3.2.2 Control Intervention: Historical Documentary Series

The control group was asked to watch the documentary series “BBC Ancient Worlds”, which was provided to them via email link each week after their visit to the laboratory. This activity was chosen because it would require a similar amount of the participants’ time as the MBSR protocol, in order to avoid making the treatment group busier and reducing the time available for health-related activities such as going to the gym. Participants in the control group were also asked to come to the laboratory once a week to fill in a questionnaire and provide feedback on the previous week’s documentary, allowing us to track their degree of engagement with the programme.

It is plausible to be concerned that watching the BBC ancient world series itself might have a stress-reducing effect. In order to explore the possibility of such effects, we asked the participants to evaluate how useful they found the documentary series for relaxation purposes, as part of the weekly feedback. On average, the responses were neutral, indicating slightly lower relaxing effects than reported by the treatment participants for the MBSR intervention (see Appendix B for details). Thus, based on these statistics, we do not see evidence of the control intervention having a stress-reducing effect.

3.3 Experimental Procedure

The experimental sessions were held at the same time and day every week for each participant, with a total of eight groups each week, spread over three different times on three days. In order to minimise the chance that students would find out about the other intervention, randomisation was conducted at the group level. Table 1 presents a summary of the experimental procedure. Sessions 1, 6 and 7 (pre- and two post-intervention sessions) were longer than the sessions that took place during the intervention.

The structure of Sessions 1 and 6 was as follows. Participants were publicly informed about the structure of the session. They then started the computerized survey, beginning with questions relating to their lifestyle and self-reported stress (including the PSS). When all participants had completed this section, the first sample of saliva was collected simultaneously from all

Table 1: Experimental procedure

Session	Date	Content
1	Week of 20/10/2014 Pre-intervention	1. Lifestyle and stress survey 2. Saliva sample I 3. Stressful task 4. Decision making tasks 5. Saliva sample II 6. Further survey questions 7. Picture rating task 8. Saliva sample III
2	Week of 27/10/2014	feedback and short survey
3	Week of 3/11/2014	feedback and short survey
4	Week of 10/11/2014	feedback and short survey
5	Week of 17/11/2014	feedback and short survey
6	Week of 24/11/2014 Post-intervention	same as in Session 1
7	Week of 16/3/2015 5-month follow-up	1. Lifestyle and stress survey 2. Stressful task 3. Decision making tasks 4. Further survey questions 5. Picture rating task

participants in the group. This was followed by the stressful task.³ The task was designed to be new to participants in each session in order to avoid participants getting used to it, which could reduce its effectiveness as a stressor. After completing the task and providing feedback on its difficulty and stressfulness, participants proceeded with survey questions on decision-making and decision-making tasks. The second saliva sample was collected precisely 15 minutes after the end of the stressful task, at a time when a peak in cortisol concentrations in response to the stressful event should be expected. Decision-making tasks aimed at eliciting risk and time preferences followed (the results from these tasks are reported in [Alem et al. \(2017\)](#)), after which participants answered further background questions (including basic demographic questions in Session 1). The third cortisol sample was taken 23-24 minutes after the second one, by which time the recovery of cortisol levels is expected. In order to provide participants with a neutral activity during the remaining time before the final cortisol sample could be taken, participants were asked to view a series of 30 pictures of humans and 30 pictures of wildlife, rating these respectively on attractiveness and how much they liked the pictures. This task was chosen to

³The stressful task involved a combination of testing cognitive ability, time pressure, monetary reward/loss, and social pressure. Section 4.2 presents the task in detail.

fill the time between the two saliva collections in a way that would allow for recovery from the stressful task. Finally, participants were called individually to receive their payments for the session.

Session 7 followed the same procedure as Sessions 1 and 6, but without collection of saliva samples. For Sessions 2-5, participants were asked to complete a short survey asking for feedback about their engagement with the intervention, as well as questions on their health-related behaviours during the previous week.

4 Outcome Variables

Because the mindfulness training aims at both decreasing overall anxiety levels and improving the ability to cope with stressful situations, we are interested in measuring both chronic stress levels and the short-run response to a stressful situation (similar to what a student is likely to encounter in her or his daily life).

Our hypothesis is that participants in the MBSR programme will be better able to cope with stressful situations. As a consequence, chronic stress should decrease and they should be less affected by and recover faster from stressful events.

4.1 Measures of Chronic Stress

Self-reported measures of stress are included in the survey questions completed by participants prior to beginning the stressful cognitive task. These measurements are based on the Perceived Stress Scale (PSS), using the 10-item version of the PSS ([Cohen et al. \(1983\)](#)). We extend the PSS with two questions that measure academic stress, which can be particularly relevant among university students. The Perceived Stress Scale of [Cohen et al. \(1983\)](#) is a widely used stress measure, capturing the extent to which an individual perceives events in the previous month as overwhelming or uncontrollable. Several studies of mindfulness interventions have reported reductions in PSS scores (see [Krusche et al. \(2013\)](#)). In our analysis, we use as an outcome variable the sum of the scores of the 10-item PSS version.

We also collected information on stressful events to which students may have been exposed. Sources of stress are measured with a substantially shortened version of the Adolescent Perceived Events Scale (APES, based on [Compas \(1987\)](#)), including a selection of questions most relevant to a student population from the 90-item APES. We use a variable indicating the sum of stressful events the participant faced in the previous month, and test whether her response (in terms of PSS score) differed across treatments. Because mindfulness is supposed to improve coping skills, the hypothesis is that participants in the MBSR treatment should respond less to stressful events.

Following most studies in the literature, we also collect self-reported measures of well-being,⁴ asking respondents the following standard questions: “Overall, how satisfied are you with your life nowadays?” (in weekly surveys: the previous week), which we will refer to as “life satisfaction”, and “Overall, how happy are you these days?”, which we will refer to as “happiness”. We also ask how anxious they feel these days (“anxiety these days”) and how anxious they feel right now (“anxiety now”). Participants were asked these questions every week. The answers are scaled from 1 – not at all, to 11 – completely.

4.2 Short-run Response to a Stressful Situation

The second outcome of interest in relation to stress is the ability to cope with a stressful situation. Participants were asked to perform a task aimed at inducing stress through a combination of testing cognitive ability/knowledge, time pressure, monetary rewards/losses, and social pressure/shame.⁵ Because stress responses decline with habituation to a particular stressful situation ([Grissom and Bhatnagar \(2009\)](#)), different stressful tasks were chosen for the pre-and post-intervention sessions.

In the pre-intervention session (Session 1), the task consisted of a computerized cognitive ability and knowledge test, combining numerical, spatial, and verbal reasoning questions with general knowledge questions. Students were informed that the average student would be expected to be

⁴The well-being questions were taken from the UK Labour Force Survey. See <http://www.ons.gov.uk/ons/about-ons/get-involved/taking-part-in-a-survey/information-for-households/a-to-z-of-household-and-individual-surveys/labour-force-survey/index.html>.

⁵See [Dickerson and Kemeny \(2004\)](#) for a synthesis of laboratory research on acute stressors.

able to answer all questions. Each question was presented on a separate page with a 20 second countdown timer ticking in the top right-hand corner of the page. Students were informed of the requirement of answering 70% of questions correctly in order to participate in a lottery to win one of the two £50 prizes.

In the post-intervention session (Session 6), the task consisted of a cognitive ability and knowledge test that was performed publicly in the laboratory. All participants were asked to stand up in the lab and questions were read aloud by the experimenter, as well as being displayed on a large screen. Immediately after reading a question, the experimenters called upon a randomly selected participant to choose the correct answer to the multiple-choice question. If the given answer was incorrect, participants were informed of this and asked to try another answer. This was repeated until the correct answer had been given. The task consisted of 36 questions. Participants were each endowed with £12 at the beginning of the task, losing £1 for every minute expired on the test. This design was chosen to add social pressure to the task, similar to the Trier Social Stress Test of [Kirschbaum et al. \(1993\)](#), but with the additional pressure of joint incentive payment.

Finally, in the five-month follow-up session (Session 7), participants were asked to take a computerized Stroop test ([Stroop \(1935\)](#), [Jensen and Rohwer \(1966\)](#)). Participants were sequentially shown names of four different colours (red, blue, yellow, and green) on the screen, written either in congruent or incongruent colour. They were asked to indicate the colour in which the word was written, by clicking on one of four buttons labelled with the colour names. Upon selecting an answer, the next colour name would immediately appear on the screen. This was repeated 96 times. Participants received one penalty point for each second spent on the task, and one penalty point for each mistake made. They were informed that the two participants with the fewest penalty points would earn a bonus of £50 each.

In each session, directly after completing the task, participants were asked to rate how stressful, difficult, and enjoyable they found the task. This gives us a self-reported measure of the acute stress response. We also asked them to predict their relative performance on the task, before and after having completed it.

In addition, we measured participants' stress response using saliva measurements of cortisol

levels, following a standard protocol.⁶ Increased cortisol levels can be measured in saliva between 10 to 20 minutes after exposure to a stressor. If there are no further stressors, cortisol levels should return to their initial level within a short period (between 20 to 40 minutes). This is called the “recovery period”. If a person experiences stress for a sustained period of time, she could experience what is called “adrenal fatigue”, which leads to low levels of cortisol, a weak response to stressors and a longer recovery period (Nicolson (2008)).

Saliva samples were collected three times during the experimental session using Salivette collection devices. The timing of the saliva measurements is outlined in Section 3.3. The saliva samples were analysed by a professional laboratory (Salimetrics). These samples were collected for the initial session and for the post-intervention session, but not for the follow-up session.

5 Baseline Characteristics

We collected detailed information on several outcome variables of interest during each of the seven sessions. In addition to the outcome variables described above, we also collected background on socio-economic characteristics in the initial session. We use these baseline characteristics to check for balance in randomisation. Alem et al. (2017) also use these indicators to evaluate the implications of attrition and non-random compliance with the interventions, and show detailed evidence that the estimation results on the effects of the MBSR are *not* driven by selection into completing the course.

Table 2 presents summary statistics for our sample of participants at baseline to evaluate balance across treatment and control samples. In each panel, we report summary statistics (for the pooled sample in Column (1), the treatment sample in Column (2), and the control sample in Column (3)). We test whether the difference is statistically significant in Column (4).

Panel A presents basic individual characteristics that will be used in the analysis as control variables. Panel B presents summary statistics for the main outcome variables. Anxiety appears to be a common problem for our sample of student subjects. Providing a more in-depth measure of stress, we also report participants’ Perceived Stress Scale (PSS) score. This is based on

⁶<http://salimetrics.com/collection-system/adult-oral-swab>.

Table 2: Baseline characteristics

Baseline characteristics							
Variables	[1]		[2]		[3]		[4]
	Total	SD	Treatment	SD	Control	SD	Diff
<i>Panel A: Individual Characteristics</i>							
Age	24.36	3.61	23.76	1.92	24.92	4.60	-1.16*
Female	0.65	0.48	0.69	0.47	0.61	0.49	0.08
White	0.65	0.48	0.66	0.48	0.64	0.48	0.02
Weight (kg)	63.81	10.16	64.09	10.57	63.56	9.83	0.53
Body mass index (BMI)	21.83	2.59	22.25	2.73	21.44	2.41	0.81
Undergraduate	0.87	0.34	0.90	0.31	0.85	0.36	0.05
<i>Panel B: Stress and Well-being</i>							
Perceived stress score (scale: 0-40)	17.78	6.00	18.49	5.81	17.11	6.14	1.38
Anxious these days (scale: 1-11)	6.76	2.42	7.10	2.43	6.43	2.39	0.67
Anxious now (scale: 1-11)	5.50	2.43	6.01	2.45	5.03	2.33	0.98
Life satisfaction nowadays (scale: 1-11)	8.02	1.47	8.01	1.32	8.03	1.60	-0.02
Happiness these days (scale: 1-11)	7.86	1.62	7.78	1.60	7.93	1.65	-0.15
Happiness now (scale: 1-11)	7.40	1.61	7.46	1.44	7.35	1.77	0.12
Things worthwhile (scale: 1-11)	8.22	1.61	8.00	1.70	8.42	1.51	-0.42
Observations	139		67		72		

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

10 questions about the frequency of certain thoughts and feelings associated with stress, each answered on a scale from “Never” to “Very Often” (coded as 0-4, with 0 representing “Never” and 4 representing “Very Often”). Thus the highest possible PSS score would be 40. In our baseline sample, the average PSS score is 17.78. This is comparable to PSS scores in similar samples in previous studies. For example, based on samples of university students in the US, [Von Ah et al. \(2004\)](#) report a mean value of 19.56 and [Roberti et al. \(2006\)](#) report a mean of 18.3 on the ten-item PSS. Our average score is lower than the mean scores of 23.04 and 22.4 reported by [Krusche et al. \(2013\)](#) and [Morledge et al. \(2013\)](#), respectively, based on samples of individuals choosing to complete an online mindfulness course.

Taken together, the results suggest the prevalence of a high degree of anxiety among the student population participating in our experiment.

6 Evaluation of the MBSR Intervention

6.1 Empirical strategy

We estimate the reduced form effect of participating in the MBSR intervention on the outcome variables described above using the following differences-in-differences specifications. Specification (1) is used for outcome measures taken only at the baseline and Sessions 6 and 7, while specification (2) is used for outcome measures that are measured at each session.

$$Y_{it} = \alpha + \beta MBSR_i + \gamma_1 MBSR_i \times Session6_t + \gamma_2 MBSR_i \times Session7_t + \delta_t week_t + \phi X_i + \eta_i + \epsilon_{it} \quad (1)$$

$$\begin{aligned} Y_{it} = & \alpha + \beta MBSR_i + \gamma_1 MBSR_i \times Session2_t + \gamma_2 MBSR_i \times Session3_t \\ & + \gamma_3 MBSR_i \times Session4_t + \gamma_4 MBSR_i \times Session5_t + \gamma_5 MBSR_i \times Session6_t \\ & + \gamma_6 MBSR_i \times Session7_t + \delta_t week_t + \phi X_i + \eta_i + \epsilon_{it} \end{aligned} \quad (2)$$

where Y_{it} is an outcome variable measured for individual i in week t . $MBSR$ is a dummy variable equal to 1 for individuals in the MBSR treatment. The $Session$ variables are dummy variables that equal 1 if the outcome is measured in that particular session, where $Session7$ corresponds to the five-month follow-up session. X_i is a vector of individual characteristics such as gender, age, ethnicity, a dummy for being an undergraduate student and Body Mass Index at baseline (i.e., week 1). η_i is an individual-specific random effect and ϵ_{it} is a white noise error term. We check robustness of our results to the exclusion of the control variables (X_i). We also perform the Hausman test, which tests the null hypothesis of orthogonality (no correlation between the regressors and the individual fixed effects η_i). The test results do not reject the null, implying that our parameter estimates are consistent when estimated using the random effects specification.

6.2 Effects on Chronic Stress and Stress Response

We use three different sources to construct a measure of chronic stress. The first is based on the total score of the Perceived Stress Scale (measured in the initial session and in the two post-intervention sessions). The second and third are based on responses to weekly questions about how anxious the participants feel “now” and “these days”, both on a scale from 1 – 11. Table 3 reports the treatment effects of the intervention on these three measures from a difference-in-differences estimator (MBSR & Session 6, and MBSR & Session 7 show the post-intervention estimates of the treatment effect).

Table 3: The Impact of MBSR on Perceived Stress Score (PSS) and Anxiety Measures

	[1]		[2]		[3]	
	PSS		Anxiety Now		Anxiety These Days	
	Coeff.	95% CI	Coeff.	95% CI	Coeff.	95% CI
MBSR	1.463	(-0.460,3.386)	1.256***	(0.459,2.052)	0.878**	(0.078,1.677)
Session 2	.		0.531	(-0.147,1.209)	0.273	(-0.385,0.932)
Session 3	.		0.918***	(0.278,1.559)	0.302	(-0.237,0.841)
Session 4	.		0.227	(-0.499,0.954)	-0.095	(-0.692,0.501)
Session 5	.		0.344	(-0.344,1.032)	-0.141	(-0.740,0.458)
Session 6	0.999*	(-0.002,1.999)	0.279	(-0.395,0.953)	-0.131	(-0.669,0.408)
Session 7	2.205***	(0.529,3.881)	0.747*	(-0.012,1.506)	0.344	(-0.352,1.040)
MBSR & Session 2	.		-0.857*	(-1.847,0.132)	-0.454	(-1.337,0.429)
MBSR & Session 3	.		-1.163**	(-2.182,-0.144)	-0.882*	(-1.780,0.016)
MBSR & Session 4	.		-0.402	(-1.438,0.635)	-0.387	(-1.259,0.484)
MBSR & Session 5	.		-0.360	(-1.362,0.643)	-0.296	(-1.265,0.674)
MBSR & Session 6	-1.809*	(-3.625,0.006)	-0.068	(-1.129,0.994)	-0.069	(-0.959,0.820)
MBSR & Session 7	-2.464*	(-5.051,0.123)	-1.095*	(-2.369,0.179)	-0.765	(-1.906,0.376)
Intercept	17.363**	(3.519,31.206)	6.982***	(3.044,10.919)	8.575***	(4.428,12.722)
Individual random effects	Yes		Yes		Yes	
Control variables	Yes		Yes		Yes	
No. of individuals	138		138		138	

Notes: Robust standard errors; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Results show that the MBSR intervention leads to a significant decrease in participants’ PSS scores, both in the week immediately following completion of the course (session 6) and at the five-month follow-up (session 7). The decrease is on the order of 10 percent (compared to the baseline average PSS score). The estimated treatment effect resulted from both decreasing levels of stress among the treatment group and increasing levels of stress among the control group. The effect is comparable to the effect found by [Morledge et al. \(2013\)](#) after 8 and 12 weeks of an internet-based mindfulness program, but smaller than the effect found by [Krusche](#)

et al. (2013). Krusche et al. (2013) estimate that the online mindfulness course reduces the average PSS score by around 8 points and by a further 1.5 points a month later; however, these estimates are based on a sample of self-selected individuals, without the inclusion of a control group in their analysis. The MBSR intervention also appears to reduce reported anxiety throughout sessions 2 to 7, but these estimates are mostly not statistically significant. The results indicate that the treatment is more effective in reducing the current level of anxiety (anxiety “now”) than the general level of anxiety (anxiety “these days”). We do not find any significant treatment effects on other measures of subjective well-being, including measures of life satisfaction, happiness and “considering things worthwhile”.⁷

Next, we examine how the intervention affected the response to a stressful situation. Appendix E (Table 6) summarises how stressful, not enjoyable and difficult the participants found each task. We also present an indicator of over-confidence.⁸ Based on these indicators, while the stressfulness of all three tasks was rated around 6-7 on average on a 10-point scale, the computerised ability and knowledge test was considered on average less enjoyable and more difficult than the post-intervention tasks. Over-confidence was also more prevalent in the first session. Apart from over-confidence in Session 7, there was no statistically significant difference between the treatment and control groups with respect to the evaluation of the stressful tasks. In the final session, over-confidence was 14.5 percentage points more prevalent within the treatment group than the control group.

Considering the salivary cortisol measurements, we do not find evidence that the MBSR intervention significantly affected the objective measures of stress levels and stress responses. The average levels of the three cortisol measurements by session and by treatment are displayed in Figure 1. These cortisol levels are within the normal ranges of cortisol concentration.

⁷We conducted a series of specification checks to investigate further the impact of the MBSR intervention on PSS score and anxiety. First, to check for the importance of attrition, we re-estimated the treatment effects using the sub-sample of individuals who were present at Session 6 or 7. Although the precision of the estimated treatment effects declines, the main conclusions remain robust. These results are reported in Table 5 in Appendix D. Next, we estimated the effect of MBSR on the sum of the two indicators of academic stress (worries about grades in the current semester and in the future). We find no significant treatment effects. Finally, while we see that stressful events (measured by the modified Adolescent Perceived Events Scale, APES) increase the PSS score, we do not see evidence that the PSS score of the treatment group responds less to such stressful events.

⁸In our setting, the binary indicator capturing over-confidence equals one if, before the task, a participant thinks she would perform among the best three or best six people in the room, but, after the task, she does not think she performed among the best three or six. Thus it is based on the comparison of individual judgment before versus after the task, and not based on the comparison of individual judgment versus the actual outcome.

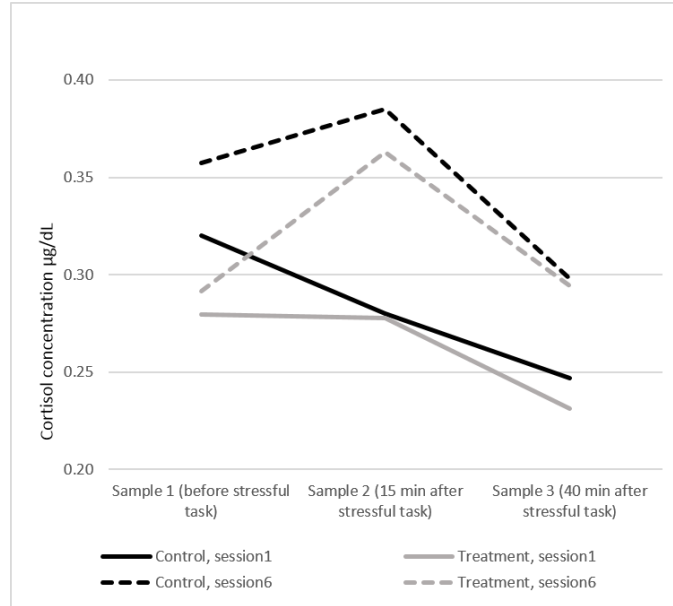


Figure 1: Salivary cortisol concentration averages by session and by treatment

Summarizing, these results show little difference in the ability to cope with a stressful situation induced in the laboratory.

7 Conclusions

We conducted a randomised field experiment on 139 participants to investigate the effects of mindfulness training on stress, risk-taking and time preferences, as well as health-related behaviours. Half of the participants were assigned to a “Mindfulness Based Stress Reduction” programme while the other half were asked to watch a documentary series called “BBC Ancient Worlds”. Both interventions ran for four consecutive weeks, and, to measure their long-term impact on behaviour, we conducted a post-intervention session five months later. Importantly, our participants did not self-select into the programmes.

We find that the mindfulness intervention significantly reduces perceived chronic stress, but no evidence on the ability to cope with a laboratory-induced stressful situation. Overall, we conclude that such interventions appear to be effective at reducing “feelings of chronic stress”. These findings are in line with other studies that find discrepancies between stress and cortisol measures (Hjortskov et al., 2004).

References

- Y. Alem, B. Hannah, M. Belot, and A. Bíró. Mind, behaviour and health - a randomised experiment. Unpublished manuscript, 2017.
- American Psychological Association. 2015 Stress in America. <http://www.apa.org/news/press/releases/stress/2015/snapshot.aspx>, 2015. Accessed: 2018-02-07.
- H. Bosma, R. Peter, J. Siegrist, and M. Marmot. Two alternative job stress models and the risk of coronary heart disease. *American Journal of Public Health*, 88(1):68–74, 1998.
- T. W. Buchanan and D. Tranel. Stress and emotional memory retrieval: Effects of sex and cortisol response. *Neurobiology of Learning and Memory*, 89:134–141, 2008.
- M. Buckert, C. Schwieren, B. M. Kudielka, and C. J. Fiebach. Acute stress affects risk taking but not ambiguity aversion. *Frontiers in Neuroscience*, 8(82):1–11, 2014.
- K. Caldwell, M. Baime, and R. Wolever. Mindfulness based approaches to obesity and weight loss maintenance. *Journal of Mental Health Counseling*, 34(3):269–282, 2012.
- J. Carmody and R. A. Baer. Relationships between mindfulness practice and levels of mindfulness, medical and psychological symptoms and well-being in a mindfulness-based stress reduction program. *Journal of Behavioral Medicine*, 31:23–33, 2008.
- J. Carmody, R. A. Baer, E. L B Lykins, and N. Olendzki. An empirical study of the mechanisms of mindfulness in a mindfulness-based stress reduction program. *Journal of Clinical Psychology*, 65:613–626, 2009.
- T. Chandola, A. Britton, E. Brunner, H. Hemingway, M. Malik, M. Kumari, E. Badrick, M. Kivimaki, and M. Marmot. Work stress and coronary heart disease: what are the mechanisms? *European Heart Journal*, 29(5):640–648, 2008.
- A. Chiesa and A. Serretti. Mindfulness-based stress reduction for stress management in healthy people: a review and meta-analysis. *Journal of Alternative and Complementary Medicine (New York, N.Y.)*, 15:593–600, 2009. ISSN 1557-7708. doi: 10.1089/acm.2008.0495.
- S. Cohen, T. Kamarck, and R. Mermelstein. A global measure of perceived stress. *Journal of Health and Social Behavior*, pages 385–396, 1983.

- S. Cohen, D. Janicki-Deverts, and G. E. Miller. Psychological stress and disease. *JAMA*, 298(14):1685–1687, 2007.
- B. E. Compas. Stress and life events during childhood and adolescence. *Clinical Psychology Review*, 7(3):275–302, 1987.
- S. S. Dickerson and M. E. Kemeny. Acute stressors and cortisol responses: a theoretical integration and synthesis of laboratory research. *Psychological Bulletin*, 130(3):355, 2004.
- E. Epel, J. Daubenmier, J. T. Moskowitz, S. Folkman, and E. Blackburn. Can meditation slow rate of cellular aging? Cognitive stress, mindfulness, and telomeres. In *Annals of the New York Academy of Sciences*, volume 1172, pages 34–53, 2009.
- FinancialTimes. The madness of mindfulness. <https://www.ft.com/content/9b8c0c6e-e805-11e6-967b-c88452263daf>, 2017. Accessed: 2017-09-18.
- L. Flook, S. L. Smalley, M. J. Kitil, B. M. Galla, S. Kaiser-Greenland, J. Locke, E. Ishijima, and C. Kasari. Effects of mindful awareness practices on executive functions in elementary school children. *Journal of Applied School Psychology*, 26(1):70–95, 2010.
- Forbes. How generations meditate on mindfulness. <https://www.forbes.com/sites/neilhowe/2017/03/17/how-generations-meditate-on-mindfulness/>, 2017. Accessed: 2017-09-18.
- M. Friese, C. Messner, and Y. Schaffner. Mindfulness meditation counteracts self-control depletion. *Consciousness and Cognition*, 21(2):1016–1022, 2012.
- N. D. Galbraith and K. E. Brown. Assessing intervention effectiveness for reducing stress in student nurses: quantitative systematic review. *Journal of Advanced Nursing*, 67(4):709–721, 2011.
- M. Goyal, S. Singh, E. M. S. Sibinga, N. F. Gould, A. Rowland-Seymour, R. Sharma, Z. Berger, D. Sleicher, D. D. Maron, H. M. Shihab, P. D. Ranasinghe, S. Linn, S. Saha, E. B. Bass, and J. a. Haythornthwaite. Meditation programs for psychological stress and well-being: a systematic review and meta-analysis. *JAMA Internal Medicine*, 174(3):357–68, Mar. 2014.
- D. Greenwood, K. Muir, C. Packham, and R. Madeley. Coronary heart disease: a review of the role of psychosocial stress and social support. *Journal of Public Health*, 18(2):221–231, 1996.

- N. Grissom and S. Bhatnagar. Habituation to repeated stress: get used to it. *Neurobiology of Learning and Memory*, 92(2):215–224, 2009.
- N. Hjortskov, A. H. Garde, P. Ørbæk, and Å. M. Hansen. Evaluation of salivary cortisol as a biomarker of self-reported mental stress in field studies. *Stress and Health*, 20(2):91–98, 2004.
- S. G. Hofmann, A. T. Sawyer, A. A. Witt, and D. Oh. The effect of mindfulness-based therapy on anxiety and depression: A meta-analytic review. *Journal of Consulting and Clinical Psychology*, 78:169–183, 2010.
- A. R. Jensen and W. D. Rohwer. The stroop color-word test: A review. *Acta Psychologica*, 25: 36–93, 1966.
- J. Kabat-Zinn. Full catastrophe living: The program of the stress reduction clinic at the university of massachusetts medical center. *New York: Delta*, 1990.
- H. Kerr. National union of students: Mental distress survey overview. <http://www.nus.org.uk/Global/Campaigns/20130517%20Mental%20Distress%20Survey%20%20overview.pdf>, 2013. Accessed: 2016-04-12.
- C. Kirschbaum, K.-M. Pirke, and D. H. Hellhammer. The ‘trier social stress test’—a tool for investigating psychobiological stress responses in a laboratory setting. *Neuropsychobiology*, 28(1-2):76–81, 1993.
- M. Kivimäki, M. Virtanen, M. Elovainio, A. Kouvonen, A. Väänänen, and J. Vahtera. Work stress in the etiology of coronary heart disease—a meta-analysis. *Scandinavian Journal of Work, Environment & Health*, pages 431–442, 2006.
- A. Krusche, E. Cyhlarova, and J. M. G. Williams. Mindfulness online: an evaluation of the feasibility of a web-based mindfulness course for stress, anxiety and depression. *BMJ open*, 3(11):e003498, Jan. 2013.
- S. H. Ma and J. D. Teasdale. Mindfulness-based cognitive therapy for depression: replication and exploration of differential relapse prevention effects. Technical report, 2004.
- T. J. Morledge, D. Allexandre, E. Fox, A. Z. Fu, M. K. Higashi, D. T. Kruzikas, S. V. Pham, and P. R. Reese. Feasibility of an online mindfulness program for stress management—a randomized, controlled trial. *Annals of Behavioral Medicine*, 46(2):137–148, 2013.

- N. A. Nicolson. Measurement of cortisol. *Handbook of physiological research methods in health psychology*, pages 37–74, 2008.
- S. Pieper and J. F. Brosschot. Prolonged stress-related cardiovascular activation: is there any? *Annals of Behavioral Medicine*, 30(2):91–103, 2005.
- C. Regehr, D. Glancy, and A. Pitts. Interventions to reduce stress in university students: A review and meta-analysis. *Journal of Affective Disorders*, 148(1):1–11, 2013.
- J. W. Roberti, L. N. Harrington, and E. A. Storch. Further psychometric support for the 10-item version of the perceived stress scale. *Journal of College Counseling*, 9(2):135–147, 2006.
- U. Scholz, R. L. Marca, U. M. Nater, I. Aberle, U. Ehlert, R. Hornung, M. Martin, and M. Kliegel. Go no-go performance under psychosocial stress: Beneficial effects of implementation intentions. *Neurobiology of Learning and Memory*, 91:89–92, 2009.
- L. Schwabe, A. Bohringer, M. Chatterjee, and H. Schachinger. Effects of pre-learning stress on memory for neutral, positive and negative words: Different roles of cortisol and autonomic arousal. *Neurobiology of Learning and Memory*, 90:44–53, 2008.
- J. R. Stroop. Studies of interference in serial verbal reactions. *Journal of Experimental Psychology*, 18(6):643, 1935.
- Y.-Y. Tang, Y. Ma, J. Wang, Y. Fan, S. Feng, Q. Lu, Q. Yu, D. Sui, M. K. Rothbart, M. Fan, et al. Short-term meditation training improves attention and self-regulation. *Proceedings of the National Academy of Sciences*, 104(43):17152–17156, 2007.
- J. D. Teasdale, Z. V. Segal, J. M. Williams, V. A. Ridgeway, J. M. Soulsby, and M. A. Lau. Prevention of relapse/recurrence in major depression by mindfulness-based cognitive therapy. Technical report, 2000.
- R. Teper and M. Inzlicht. Meditation, mindfulness and executive control: the importance of emotional acceptance and brain-based performance monitoring. *Social Cognitive and Affective Neuroscience*, 8(1):85–92, 2013.
- R. Teper, Z. V. Segal, and M. Inzlicht. Inside the mindful mind how mindfulness enhances

emotion regulation through improvements in executive control. *Current Directions in Psychological Science*, 22(6):449–454, 2013.

D. Von Ah, S. Ebert, A. Ngamvitroj, N. Park, and D.-H. Kang. Predictors of health behaviours in college students. *Journal of Advanced Nursing*, 48(5):463–474, 2004.

O. T. Wolf. Stress and memory in humans: Twelve years of progress. *Brain Research*, 1293: 142–154, 2009.

Appendix for Online Publication

Appendix A: Recruitment Poster and Email



Participate in a LIFESTYLE study!

The School of Economics at the University of Edinburgh is currently seeking

150 HEALTHY individuals

Do you sometimes feel stressed? Want to participate in a scientific study and earn a bit of money?

Are you available for a couple of hours a week (at a time of your choice) between mid-October and mid-November?

GOAL OF THE STUDY

The goal of this study is to look at stress and lifestyle among university students. If you decide to participate, you will be given a specific protocol that you will be kindly requested to follow for four consecutive weeks. These protocols are non-invasive and will include requests to undertake certain activities during the week, for a period of four weeks starting immediately after the initial session.

Note: you must be **at least 18 years old**, a **student** at the University of Edinburgh, and have **NO pre-existing medical conditions**

INTERESTED? WANT MORE INFORMATION?

E-mail: blue@ed.ac.uk

FEELING A BIT STRESSED? WANT TO EARN SOME MONEY? HAVE A COUPLE OF HOURS PER WEEK TO SPARE IN THE COMING TWO MONTHS?

Participate to our study on “Stress and Lifestyle among University Students”.

The Behavioural Laboratory at the University of Edinburgh is currently seeking 150 HEALTHY individuals for a scientific study on stress and lifestyle among university students.

- You will be asked to come every week to our laboratory at a specific timeslot (the same day and same time every week) for a period of 6 weeks (starting in the week of October 22d) and another time 4 months later (in March 2015).
- You will be asked to follow a specific protocol in between (more information below).

Please read on before signing up.

DESCRIPTION OF THE STUDY

The goal of this study is to look at stress and lifestyle among university students. If you decide to participate, you will be given a specific protocol that you will be kindly requested to follow for **four consecutive weeks**. These protocols are non-invasive and will include requests to undertake certain activities during the week, for a period of four weeks starting immediately after the initial session. **It is very important for our study that you agree to follow the protocol’s instructions.** These activities should not take more than 2 hours a week and **we will pay all costs involved.**

The study will take place over the course of 6 weeks and an additional follow-up in six months. You will be asked to come to our experimental laboratory (situated at the) every week (6 times in total including the 6 months follow up). You will be asked to come every week on the same day and same time slot (this is VERY important for our analysis, so please do pick your timeslot carefully and make sure you can come every week).

Each time, you will be asked to answer basic survey questions (including basic background information), questions about your lifestyle and health, feedback on the protocol you have been asked to follow and you will be asked to take decisions that will involve monetary rewards (you can only earn positive amounts). You should expect to receive between £3 and £10 in each session (the exact amount will depend on your decisions). The sessions in weeks 1 and 6 (and in March 2015) will last about an hour and a half. The other sessions will take less than half an hour each.

Note that in sessions 1 and 6, we will collect saliva samples using a standard scientific protocol. The protocol is non invasive and completely safe. The goal is to measure cortisol concentration (as an indicator of stress levels). We kindly ask you not to drink or eat anything one hour prior to the session.

Eligibility criteria:

- You must be older than 18 years old, student at the University of Edinburgh, with NO medical condition

Possible time slot options (you can only choose one option and are asked to stick to the days and times once you have picked that option)

	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Week 1 Initial session (1 hour 30 min) Pay: £3-10	Tue 21/10 10 am	Tue 21/10 12.30 pm	Tue 21/10 3 pm	Wed 22/10 10 am	Wed 22/10 12.30 pm	Wed 22/10 3.30 pm
Week 2 (30 min) Pay: £7.50	Tue 28/10 10 am	Tue 28/10 12.30 pm	Tue 28/10 3 pm	Wed 29/10 10 am	Wed 29/10 12.30 pm	Wed 29/10 3.30 pm
Week 3 (30 min) Pay: £7.50	Tue 4/11 10 am	Tue 4/11 12.30 pm	Tue 4/11 3 pm	Wed 5/11 10 am	Wed 5/11 12.30 pm	Wed 5/11 3.30 pm
Week 4 (30 min) Pay: £7.50	Tue 11/11 10 am	Tue 11/11 12.30 pm	Tue 11/11 3 pm	Wed 12/11 10 am	Wed 12/11 12.30 pm	Wed 12/11 3.30 pm
Week 5 (30 min) Pay: £7.50	Tue 18/11 10 am	Tue 18/11 12.30 pm	Tue 18/11 3 pm	Wed 19/11 10 am	Wed 19/11 12.30 pm	Wed 19/11 3.30 pm
Week 6 (1 hour 30 min) Pay: £3-£10	Tue 25/11 10 am	Tue 25/11 12.30 pm	Tue 25/11 3 pm	Wed 26/11 10 am	Wed 26/11 12.30 pm	Wed 26/11 3.30 pm
4 months later (1 hour 30 min) Pay: £3-£10	Tue 18/3 10 am	Tue 18/3 12.30 pm	Tue 18/3 3 pm	Wed 19/3 10 am	Wed 19/3 12.30 pm	Wed 19/3 3.30 pm

Location of the sessions: Behavioural Laboratory at the University of Edinburgh, School of Economics, 31 Buccleuch Place, 4th floor

Ethical issues and Informed consent

Note that the study is conducted with ethical approval of the School of Economics at the University of Edinburgh. All the data will be anonymised and treated with confidentiality, in accordance with the ethical guidelines.

You will be asked to sign an informed consent form at the beginning of the initial session. Although we emphasize the importance of participating to all sessions, you will be free to withdraw from the study at any point in time.

Interested? Please e-mail blue@ed.ac.uk and indicate which option you would prefer.

Appendix B: Evaluation of the Treatment and Control Intervention for Relaxation Purposes

How useful was the program (control: BBC Ancient Worlds; treatment: Mindfulness) for relaxation purposes? 1-very useful, 2-somewhat useful, 3-not useful at all.

Session		Control, previous week	Control, overall	Treatment, previous week	Treatment, overall
2	mean (sd)	2.00 (0.54)		2.05 (0.57)	
	median	2		2	
3	mean (sd)	2.10 (0.65)		1.92 (0.65)	
	median	2		2	
4	mean (sd)	1.97 (0.54)		1.97 (0.60)	
	median	2		2	
5	mean (sd)	2.03 (0.57)		1.86 (0.52)	
	median	2		2	
6	mean (sd)	2.10 (0.61)	2.13 (0.55)	1.98 (0.51)	2.02 (0.51)
	median	2	2	2	2

Table 4: Evaluation of the Treatment and Control Intervention for Relaxation Purposes

Appendix C: Weekly Survey

you feel these days? (6) Overall, how anxious do you feel right now? (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
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Q97 How many hours did you spend studying the previous week? Do NOT include hours spent in classes, but DO include hours spent studying alone, in the library or with classmates.

Q98 Did you have any midterm exams in the previous week?

- Yes (1)
- No (2)

Q99 Did you have to submit any assignments in the previous week?

- Yes (1)
- No (2)

Q100 Did anything unusually upsetting or stressful happen to you in the previous week?

- Yes (1)
- No (2)

Answer If Did anything unusually upsetting or stressful happen to you in the previous week?

Yes Is Selected

Q101 Please provide some details.

Q5 The next questions are about your health behaviours during the PREVIOUS WEEK.

Q102 Please read all the following statements carefully and tick the box next to the one that best describes you. During the previous week:

- I did not smoke any cigarette, not even a puff (1)
- I smoked cigarettes, but fewer than one per day (2)
- I smoked between 1 and 10 cigarettes per day (3)
- I smoked between 10 and 20 cigarettes per day (4)
- I smoked more than 20 cigarettes per day (5)

Q8 How often did you eat breakfast in the previous week?

- Almost every day (1)
- Most days a week (2)
- About once a week (3)
- Never (5)

Q9 How often did you eat lunch in the previous week?

- Almost every day (1)
- Most days a week (2)
- About once a week (3)
- Never (5)

Q10 How often did you eat dinner in the previous week?

- Almost every day (1)
- Most days a week (2)
- About once a week (3)
- Never (5)

Q11 Did you eat at regular times of the day during the previous week?

- Almost always (1)
- Most days (2)
- Sometimes (3)
- Never (4)

Q12 On average, how many meals did you eat each day during the previous week?

Q13 On average, how many between-meal snacks did you eat each day during the previous week?

Q16 These questions ask about what you ate or drank YESTERDAY. Tick all relevant boxes for each item (you can tick more than once as you could have the same type of meal for example for lunch and for dinner as well). There are no right or wrong answers. Did you eat (drink)...

	For breakfast (1)	For lunch (2)	For dinner (3)	Between main meals (4)	Not at all (5)
Processed meats like bacon, ham, sausage, or processed lunchmeats (1)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Deep fried food, e.g. chips, onion rings, fried chicken, battered fish (2)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Burgers, hot dog, pizza, sausage rolls (3)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Potato crisps (4)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Vegetable crisps (5)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Popcorn, salted peanuts (6)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Unsalted nuts, seeds (e.g. sunflower, pumpkin) (7)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Pretzels, crackers, e.g. Ritz (8)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Pies (savoury or sweet) (9)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cakes, muffins, brownies, cookies (10)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Doughnut, pastry, e.g. Danish pastry, croissant, pain chocolat (11)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Chocolate, candy bars, candies (12)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ice cream (13)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Energy bar, high protein bar, e.g. Zone, PowerBar (14)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Breakfast bar, e.g. Nutri-Grain (15)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Soft drinks, e.g. Coke, Fanta, sugared sweetened fruit juices (16)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Energy drinks, e.g. RedBull (17)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Q17 How many servings of fruit did you eat yesterday? One serving is about one cup of chopped or sliced fruits, or one medium sized apple or banana.

Q18 Not counting potatoes, how many servings of vegetables did you eat yesterday? One serving is about one cup of chopped or sliced vegetables.

Q19 How often did you drink coffee, latte or cappuccino (not decaf) in the previous week?

- Never (1)
- About once a week (3)
- Every 2 or 3 days (4)
- Once a day (5)
- Twice a day (6)
- At least three times a day (7)

Q25 The next questions are about drinking alcohol, including beer, wine, spirits and any other alcoholic drink.

Q26 How many days over the previous week did you have an alcoholic drink?

- Almost every day (1)
- Most days a week (2)
- About once or twice (3)
- Never (5)

Q27 On the days that you did drink during the previous week, how many drinks did you have, on average? One drink is a glass of wine, or a pint of beer or cider, or 25 ml of spirits.

Q28 How often did each of the following happen to you during the previous week?

	All of the time (1)	Often (2)	Sometimes (3)	Rarely (4)	Never (5)
Felt completely out of control when it came to food. (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ate too much because you were upset, nervous or stressed. (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ate too much because you were bored or felt lonely. (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ate so much food so fast that you didn't know how much you ate or how it tasted. (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ate more than usual while preparing for an exam or working on an assignment. (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ate high calorie snacks while studying or working on assignments. (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q33 At what time did you go to sleep most days during the previous week?

- before 8pm (1)
- 8-9pm (2)
- 9-10pm (3)
- 10-11pm (4)
- 11pm-midnight (5)
- midnight-1am (6)
- 1am-2am (7)
- after 2am (8)

Q34 On average, how many hours of sleep did you get in a 24 hour period during the previous week?

Q35 How did you relax during the previous week?

	Almost every day (1)	Most days a week (2)	About once a week (3)	Never (5)
Watch movies / read books / listen to music (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Go to the cinema / theatre / concert (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Meet with friends (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Yoga / pilates / tai chi / chi gong or similar exercises (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Meditate / do breathing exercises / practice mindfulness (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Do sport activities (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other (7)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Answer If How do you relax? Other - Almost every day Is Selected Or How do you relax? Other - About once or twice a week Is Selected Or How do you relax? Other - About once or twice a month Is Selected

Q36 What other activities did you do to relax, not listed above?

Q75 What time did you get up today?

Q76 What time did you go to sleep last night?

Q47 Please enter the code announced by the experimenters to continue.

Answer If Please enter the code announced by the experimenters to continue. Text
Response Is Equal to AW37

Q103 Please summarize in at least 100 words the episode of the Ancient Worlds series you watched the previous week. You might add some of the following details: What were the main locations and topics? What did you learn from the documentary? Which parts did you find the most interesting or stunning?

Answer If Please enter the code announced by the experimenters to continue. Text
Response Is Equal to AW37

Q104 Please provide a critical review of at least 50 words of the Ancient Worlds episode you watched the previous week. Feel free to add positive and negative remarks as well.

Answer If Please enter the code announced by the experimenters to continue. Text
Response Is Equal to AW37

Q105 Did you find watching the Ancient Worlds episode useful for relaxation purposes?

- Very useful (1)
- Somewhat useful (2)
- Not useful at all (3)

Answer If Please enter the code announced by the experimenters to continue. Text
Response Is Equal to AW37

Q106 Overall, how would you rate the Ancient Worlds episode you watched during the previous week?

- Excellent (1)
- Very good (2)
- Fair (3)
- Poor (4)

Answer If Please enter the code announced by the experimenters to continue. Text
Response Is Equal to AW37

Q107 Would you recommend the Ancient Worlds documentary series to a friend?

- Yes (1)
- No (2)

Answer If Please enter the code announced by the experimenters to continue. Text
Response Is Equal to MI28

Q108 How many days of the previous week did you practice mindfulness?

Answer If Please enter the code announced by the experimenters to continue. Text
Response Is Equal to MI28

Q109 Overall, how many hours did you spend with learning and practicing mindfulness during the previous week?

Answer If Please enter the code announced by the experimenters to continue. Text
Response Is Equal to MI28

Q110 Please describe in at least 100 words the mindfulness exercises you did the previous week.

Answer If Please enter the code announced by the experimenters to continue. Text
Response Is Equal to MI28

Q111 What did you gain from the mindfulness course during the previous week? Please describe in at least 50 words. Feel free to add critical remarks as well.

Answer If Please enter the code announced by the experimenters to continue. Text
Response Is Equal to MI28

Q112 How difficult/easy did you find practising mindfulness during the previous week?

- Very difficult (1)
- Difficult (2)
- Neither difficult nor easy (3)
- Easy (4)
- Very easy (5)

Answer If Please enter the code announced by the experimenters to continue. Text
Response Is Equal to MI28

Q113 How useful did you find mindfulness for relaxation purposes during the previous week?

- Very useful (1)
- Somewhat useful (2)
- Not useful at all (3)

Answer If Please enter the code announced by the experimenters to continue. Text
Response Is Equal to MI28

Q114 Overall, how would you rate the previous week's mindfulness instruction?

- Excellent (1)
- Very good (2)
- Good (3)
- Fair (4)
- Poor (5)

Answer If Please enter the code announced by the experimenters to continue. Text
Response Is Equal to MI28

Q115 Would you recommend the mindfulness course to a friend?

- Yes (1)
- No (2)

Appendix D: The Impact of MBSR on Perceived Stress Score (PSS) and Anxiety Measures, Sample of Individuals Present at Session 6 or 7

Table 5: The Impact of MBSR on PSS and Anxiety, Individuals Present at Session 6 or 7

	[1]		[2]		[3]	
	PSS		Anxiety Now		Anxiety These Days	
	Coeff.	95% CI	Coeff.	95% CI	Coeff.	95% CI
MBSR	1.057	(-1.118,3.232)	1.094**	(0.179,2.008)	0.462	(-0.444,1.368)
Session 2	.		0.624	(-0.124,1.372)	0.298	(-0.401,0.997)
Session 3	.		1.066***	(0.362,1.769)	0.377	(-0.218,0.973)
Session 4	.		0.213	(-0.546,0.972)	-0.049	(-0.682,0.583)
Session 5	.		0.457	(-0.269,1.184)	-0.073	(-0.685,0.539)
Session 6	1.156**	(0.166,2.147)	0.382	(-0.321,1.084)	-0.084	(-0.638,0.469)
Session 7	2.321***	(0.609,4.032)	0.839**	(0.050,1.628)	0.387	(-0.328,1.102)
MBSR & Session 2	.		-0.844	(-2.005,0.318)	-0.278	(-1.247,0.691)
MBSR & Session 3	.		-0.926	(-2.093,0.242)	-0.557	(-1.571,0.456)
MBSR & Session 4	.		-0.153	(-1.282,0.975)	-0.131	(-1.080,0.818)
MBSR & Session 5	.		-0.164	(-1.249,0.922)	0.130	(-0.830,1.090)
MBSR & Session 6	-1.796*	(-3.661,0.068)	0.038	(-1.108,1.185)	0.184	(-0.744,1.113)
MBSR & Session 7	-2.417*	(-5.052,0.218)	-0.986	(-2.338,0.366)	-0.510	(-1.694,0.674)
Intercept	16.162**	(1.947,30.377)	6.546***	(2.488,10.603)	8.145***	(3.823,12.466)
Individual random effects	Yes		Yes		Yes	
Control variables	Yes		Yes		Yes	
No. of individuals	112		112		112	

Notes: Robust standard errors; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Appendix E: Summary Statistics of the Stressful Tasks

Table 6: Summary Statistics of the Stressful Tasks

Session 1: Computerised cognitive ability and knowledge test					
	Treatment		Control		Diff
	Mean	SD	Mean	SD	
Task stressful (0-10)	7.373	0.204	7.611	0.166	-0.238
Task not enjoyable (0-10)	6.373	0.284	6.069	0.279	0.304
Task difficult (0-10)	7.179	0.187	6.917	0.192	0.262
Over-confident (0/1)	0.209	0.05	0.155	0.043	0.054

Session 6: Publicly performed cognitive ability and knowledge test					
	Treatment		Control		Diff
	Mean	SD	Mean	SD	
Task stressful (0-10)	6.36	0.282	6.746	0.235	-0.386
Task not enjoyable (0-10)	4.68	0.376	5.206	0.307	-0.526
Task difficult (0-10)	5.16	0.272	5.016	0.234	0.144
Over-confident (0/1)	0	0	0.048	0.027	-0.048

Session 7: Computerised Stroop test					
	Treatment		Control		Diff
	Mean	SD	Mean	SD	
Task stressful (0-10)	6.524	0.311	6.151	0.226	0.373
Task not enjoyable (0-10)	4.762	0.381	4.623	0.285	0.139
Task difficult (0-10)	4.714	0.296	4.642	0.264	0.073
Over-confident (0/1)	0.167	0.063	0.021	0.021	0.145**

, **, * indicate significance levels at 10%, 5% and 1% respectively*