UNIVERSITY OF GOTHENBURG
SCHOOL OF BUSINESS, ECONOMICS AND LAW

WORKING PAPERS IN ECONOMICS

No 663

Mind, Behaviour and Health - a Randomised Experiment

Yonas Alem, Hannah Behrendt, Michele Belot, and Aniko Bíró

June 2016

ISSN 1403-2473 (print)
ISSN 1403-2465 (online)

Department of Economics
School of Business, Economics and Law at University of Gothenburg
Vasagatan 1, PO Box 640, SE 405 30 Göteborg, Sweden
+46 31 786 0000, +46 31 786 1326 (fax)
www.handels.gu.se info@handels.gu.se

EFMD EQUIS ACCREDITED

Mind, Behaviour and Health - a Randomised Experiment*

Yonas Alem† Hannah Behrendt‡ Michele Belot§ Anikó Bíró¶

June 21, 2016

Abstract

Behavioural attitudes toward risk and time, as well as behavioural biases such as present bias, are thought to be important drivers of unhealthy lifestyle choices. This paper makes the first attempt to explore the possibility of training the mind to alter these attitudes and biases, in particular health-related behaviours, using a randomized controlled experiment. The training technique we consider is a well-known psychological technique called "mindfulness", which is believed to improve self-control and reduce stress. We conduct the experiment with 139 participants, half of whom receive a four-week mindfulness training, while the other half are asked to watch a four-week series of historical documentaries. We evaluate the impact of our interventions on risk-taking and inter-temporal decisions, as well as on a range of measures of health-related behaviours. We find evidence that mindfulness training reduces perceived stress, but only weak evidence of its impact on behavioural traits and health-related behaviours. Our findings have significant implications for a new domain of research on training the mind to alter behavioural traits and biases that play important roles in lifestyle.

JEL Classification: C81, C91, D81, I10, I12

Keywords: Health-related behaviours, Behavioural traits, Present Bias, Stress, Experiment.

*We thank participants of the Winter Workshop on Labour Economics at the University of Amsterdam, seminar audiences at CREED (University of Amsterdam), CESS (University of Oxford), NYUAD, Innsbruck and University of Gothenburg for constructive comments. Financial support from the Swedish Research Council, Formas, through the program Human Cooperation to Manage Natural Resources (COMMONS) at the Environmental Economics Unit, Department of Economics, University of Gothenburg is gratefully acknowledged. All errors and omissions are ours.

†Department of Economics, University of Gothenburg, e-mail: yonas.alem@economics.gu.se.

‡Department of Economics, University of Edinburgh, e-mail: H.A.Behrendt@sms.ed.ac.uk.

§Department of Economics, University of Edinburgh, e-mail: Michele.Belot@ed.ac.uk.

¶Department of Economics, University of Edinburgh; Hungarian Academy of Sciences; Corvinus University of Budapest, e-mail: Aniko.Biro@ed.ac.uk.

1 Introduction

The growing prevalence of non-communicable diseases (NCDs), such as cardiovascular diseases, cancer, chronic respiratory diseases and diabetes in both developed and developing countries[1] has triggered significant interest from economists and behavioural economists. These diseases are often referred to as "lifestyle diseases" that is, diseases which are at least in part caused by people's lifestyle. The standard economic approach to lifestyle choices is to portray them as outcomes of a decision process involving a trade-off between immediate benefits (such as eating tasty foods) and long-term consequences (in terms of health in particular). This trade-off involves risks and is intertemporal in nature - the decisions taken today have consequences in the future, which are assumed to be discounted. In this type of model, risk and time preferences play a key role in predicting the extent to which people engage in healthy and unhealthy behaviours. More recently, behavioural economists have shown that people suffer from a range of "behavioural biases" such as biases toward immediate gratification. These biases can explain inconsistencies in people's choices over time, for example choosing to go on a diet and then not sticking to it (Gul and Pesendorfer (2004); DellaVigna and Malmendier (2006)). These theories have received empirical support (Downs et al. (2009)) and the insights are now increasingly used in policy design (Marteau et al., 2012).

Policies inspired by insights from behavioural economics take behavioural traits and biases as given and often propose tools that seek to exploit these behavioural biases to the advantage of individuals. For example, using short-term incentives to encourage healthy behaviours, Charness and Gneezy (2009) exploit the tendency to over-weight present benefits (immediate gratification). There has, however, been relatively little interest in whether one could actually try to correct for these biases or even try to alter the decision-making processes that underpin these behaviours in the first place. The recent literature in Psychology and Economics proposes models of "dual systems"that govern decision-making (see Hofmann et al. (2008), Thaler and Shefrin (1981), Loewenstein and O'Donoghue (2004); and Fudenberg and Levine (2006)). One is an impulsive system that operates effortlessly and automatically, whereas the other is a reflective system that makes reasoned judgments and forms action plans to pursue longer-term goals, overriding the automatic responses that are based on impulse or habit (Strack and

[1] According to WHO (2014), about 38 million (68%) of deaths worldwide in 2012 were associated with NCDs, 40 percent of which were considered preventable.

Deutsch (2004)). Which of the two systems wins and ultimately determines behaviour is an important question. Psychologists (e.g., Hofmann et al. (2008)) have argued that a key determinant of the "bargaining power"between the two is self-control. The key question is whether it is conceivable to train the mind to become more self-controlled, shifting the balance of power between the two systems underlying decision-making and thereby affecting behaviours related to risk and time preferences.

In this paper, we make the first attempt to investigate the possibility of training the mind to alter fundamental cognitive processes underlying decision-making. The idea that the mind can be trained is not new and is in fact at the core of old and traditional activities such as meditation, martial arts and yoga, to cite a few examples (Diamond and Lee (2011)). To achieve this, we select one of the currently most popular techniques based on what is referred to as "mindfulness training". Mindfulness, a practice that combines meditation, breathing and yoga, has recently enjoyed a rise in popularity in many countries (HuffingtonPost (2014)). It has been described as a process of bringing a certain quality of 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)).

Because self-control and stress are believed to play a key role in decision-making in general and health-related behaviours in particular, mindfulness techniques appear to be a promising avenue for affecting fundamental cognitive processes underlying decision-making and, in turn, health-related behaviours. The question of whether it is possible to affect decision-making processes is important and could in principle open a new domain for policy interventions, although the welfare implications of shifting the balance between systems governing decision processes are not clear. In any case, it is an open question whether these processes are malleable or not. We attempt to shed light on this by conducting a randomised controlled experiment where we

expose a sub-group of participants to an online course in mindfulness called "Be Mindful".[2] The course is designed as a complete training for mindfulness and is currently one of the most popular online tools for learning mindfulness skills. It is run by the UK Mental Health Foundation.

We investigate whether the intervention affects risk-taking behaviour, inter-temporal decisions and behavioural "anomalies" such as present bias. We also investigate its effects on both self-reported and revealed measures of health-related behaviours. We invited 139 students from the University of Edinburgh to participate in a six-week study (with a five-month follow-up) on "lifestyle". Students with no pre-existing medical conditions were recruited and were invited to an initial session at the Behavioural Laboratory at the University of Edinburgh. They were allocated randomly either to an 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). They were asked to provide feedback on the previous week (about both their engagement with the intervention and their well-being and health-related behaviours). We also conducted an additional post-intervention session five months later to document their longer-term behaviour and see whether there was evidence of long-term behavioural changes.

We evaluate the effects of the mindfulness programme on a range of outcome variables. The first outcome of interest is to what extent participants are engaging with each of the programmes. Because both programmes require some form of commitment, one might expect, for example, that impulsiveness and present bias could correlate with the ability to complete the programme. We then proceed to evaluate the effects of the programme on three sets of outcome variables. We evaluate effects on measures of chronic stress, as well as on the response to a stressful situation (measured by cortisol and self-reports), because these outcomes are primary targets of the MBSR programme. We then study impacts on risk and inter-temporal attitudes, which

[2]See https://www.bemindfulonline.com/ for detailed description of the mindfulness-based stress reduction.

are believed to play a key role in health-related behaviours. Finally, we evaluate impacts on health-related behaviours, partly self-reported, partly based on an incentivised measure.

Using student subjects to answer these research questions provides more than logistical advantages over other subjects. There is strong evidence that students suffer from chronic stress (Galbraith and Brown (2011); Regehr et al. (2013)) and are particularly prone to engage in unhealthy behaviours such as smoking, drinking and eating unhealthy food ((Dallman et al. (2003), Kandiah et al. (2006), Wansink et al. (2003)).

Around 60% of the participants in the MBSR programme completed the four-week course and 75% of all initial participants attended the session that took place five weeks after the initial session. Program participants report significantly lower levels of stress than the control group, 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. We also find suggestive evidence that participants in the treatment group are more patient, less likely to suffer from present bias and also less likely to engage in "stress-eating", although these effects are not all statistically significant due to large standard errors. We do not find much evidence of effects on other health-related behaviours such as sleep, smoking, alcohol consumption or physical exercise. Overall, our results suggest that mindfulness is effective at reducing stress and there is indicative evidence it may affect time preferences and some health-related behaviours, but few of our results are statistically significant. It could be that our sample size is too small to capture statistically significant effects.

Of course, the intervention we looked at was relatively short in duration (four weeks), and we have post-intervention information only for participants who continued participating in the study. We also targeted a group of adults, for whom such interventions may be less effective than interventions earlier in life. Nevertheless, we believe this is an important research agenda that deserves attention by economists and behavioural economists, and more research is needed to understand the extent to which it is possible to train the mind to overcome behavioural biases.

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, randomization checks and weekly surveys. Section 6 describes the empirical strategy and presents treatment effects on the main outcome variables of interest, and Section 7 concludes the paper.

2 Related Literature

This paper contributes to a growing literature in economics on decision-making. One way of modelling decision-making that has received a lot of attention in recent years is based on the idea that two separate and independent mental systems may be involved in decision-making (Thaler and Shefrin (1981); Fudenberg and Levine (2006); Loewenstein and O'Donoghue (2004)). The first system is an impulsive system that can trigger rapid decisions; the second system is more reflective and more cognitively based. One can think of them as two participants in the decision-making process that have different (and often conflicting) preferences. Of course, a key question is which system ultimately determines a behaviour. Psychologists (e.g., Hofmann et al. (2008)) attribute a large role to self-control in determining which of these two systems has the most bargaining power. In this context, mindfulness could be seen as a form of training to shift the balance of power between the two systems.

A number of studies in psychology explore the effects of mindfulness on executive function (Friese et al. (2012), Teper and Inzlicht (2013), Teper et al. (2013), Flook et al. (2010)). Because mindfulness consists of exercises that require individuals to focus on something specific for a period of time (one's own breathing, for instance), it could be a good form of training to increase self-control and self-regulation. Some studies have shown that engaging in short-term meditation practice improves executive function, as measured by performance on the Stroop task (Wenk-Sormaz (2005)). Research by Moore and Malinowski (2009) extends this finding by showing that meditators exhibit less Stroop interference than control participants. Using the Attention Network Test (Fan et al. (2002)), a related work by Jha et al. (2007) documents that experienced meditators excel at conflict monitoring. Tang et al. (2007) provide additional evidence on this effect by showing that just five days of brief meditation training improved conflict monitoring on the same test. Finally, related research investigating attentional control has demonstrated that participants who completed a 10-day intensive meditation retreat showed

significant improvements in attentional switching on the Internal Switching Task (Chambers et al. (2008)). Semple (2010) solidified this effect by showing that meditation practice improved sustained attention on the Continuous Performance Test (Rosvold et al. (1956)). All of the above measures capture aspects of executive functioning (Barkley (1997)), thus providing robust evidence on the connection between meditation and executive function. Further, mindfulness shares commonalities with activities such as yoga or martial arts that have been found to improve children's executive function (Diamond and Lee (2011)).

In addition to improving executive function, mindfulness is believed to reduce chronic stress. 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 have since 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. That 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.

By contrast, a recent systematic review (Goyal et al. (2014)) concluded that there is little evidence of the effects of mindfulness on health-related behaviours such as eating habits and sleep, further highlighting that stronger study designs are needed in order to determine the impact of meditation programs on stress-related behaviour.

Because of its potential effect on stress, our work also relates to the literature linking stress and decision-making. Stress triggers a physiological response in the body and neuroscientists typically distinguish between short-run (acute) and long-run (chronic) stress. The effects of acute and chronic exposure to cortisol, the primary stress hormone, can be very different, and are in many cases opposite. Most studies focus on the effects of *acute* stress on decision-making.[3] There are a few studies that look at the effects of chronic stress, indicated by the presence of elevated cortisol levels over longer periods of time. Chronic stress has been found to impair behavioural flexibility and attentional control (McEwen and Morrison (2013); Radley et al. (2004); Liston et al. (2009)). A recent experiment (double-blind and placebo controlled) raised cortisol levels of volunteers over a period of eight days to mimic the biological effects of chronic stress, replicating levels previously observed in real financial traders (Kandasamy et al. (2014)). The study found that raised cortisol levels led volunteers to becoming more risk-averse and that men, relative to women, increasingly over-weighed small probabilities . This suggests that the physiological stress response in humans affects risk-taking behavior.

Similarly, animal studies have found that chronic stress biases rats' behavioural strategies toward habit, making them insensitive to changes in outcome value and compromising their ability to perform actions on the basis of consequences. (Dias-Ferreira et al. (2009)).

To summarise, our paper builds on earlier studies that: (i) model human behaviour as the result of dual processes - one impulsive and automatic, the other reflective and deliberate; and

[3]The evidence on causal effects of acute stress and risk-taking is mixed. A number of studies find that fearful emotions increase risk aversion (Kugler et al. (2012), Guiso et al. (2013)), while other studies find that elevated cortisol is associated with more risk-taking (Putman et al. (2010); van den Bos et al. (2009)). Other studies have found that, in stressful situations, humans are likely to fall back on automatized reactions to risk (Porcelli and Delgado (2009)). Regarding time preferences, a recent study by Cornelisse et al. (2013) finds that temporarily elevated cortisol induces people to prefer more immediate rewards to delayed rewards.

(ii) suggest that mindfulness techniques appear effective at improving executive function and at reducing stress, both of which are believed to play a key role in decision-making and in health-related behaviours. We specifically contribute to the literature by using a randomized controlled experiment to identify the impact of a mind training program on behavioural traits and anomalies that play a key role in decision-making.

3 Experimental Design

3.1 Sample

We recruited 139 participants[4] 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.

[4]We originally intended to have 144 participants (18 participants for 8 sessions), but we have a smaller number because of no-shows.

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 and prompts for 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 technique each week between online sessions. Upon completing the course, participants are asked to complete the same questionnaire as in the introduction session of the course.

During the weekly laboratory session in the lab, students were asked to complete a weekly feedback form on their experience of the mindfulness programme (part of the weekly questionnaire, which also included questions about their feelings and health-related behaviours during the previous week). 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, the weekly laboratory sessions maintain engagement with the participants and provide self-reported information on their experience of the course. 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 gym, etc. 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.

As part of the weekly feedback, we asked the participants to evaluate how useful they found the documentary series for relaxation purposes. On average, the responses were neutral, indicating slightly lower relaxing effects than the treatment participants for the MBSR intervention (see Appendix E for details). Thus, based on these statistics, we do not see evidence that the control intervention itself would have a stress-reducing effect.

3.3 Experimental Procedure

The experimental sessions started in October 2014 and were held at the same time and day every week for each participant, with a total of eight sessions 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 session level.

The experimental procedure is summarised in Table 1. 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

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

Table 1: Experimental procedure

participants in the session. This was followed by the stressful task.[5] 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 (which we will describe below), 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, 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 fill the time between the two saliva

[5]The stressful task involved a combination of testing cognitive ability, time pressure, monetary reward/loss, and social pressure. Section 4.2.1 presents the task in detail.

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 Hypotheses and Outcome Variables

We will now describe the outcome variables in which we are interested, as well as our hypotheses regarding the direction in which these variables could be affected by mindfulness training. These include: (1) measures of engagement and compliance with the programmes, (2) measures of chronic stress and response to a stressful situation, (3) measures of behaviour related to risk and time preferences, as well as a measure of self-reported impulsiveness, (4) measures of health-related behaviours.

4.1 Attrition and Compliance

Compliance and attrition are obvious first key variables of interest. Both interventions require a degree of commitment from the participants. In both cases, they have to watch a video at home and show up to the laboratory every week. We chose the control intervention so that the degree of commitment required would be similar and, therefore, we do not expect compliance and attrition to systematically differ across treatment and control groups. But one could expect, for example, that certain psychological characteristics such as impulsiveness, impatience and present bias may be correlated with the probability of dropping out. Because we collected a large set of variables at baseline, we are able to test this hypothesis directly.

Our first hypothesis is as follows:

Hypothesis 1 - Attrition rates will be similar across interventions and positively correlated with psychological characteristics such as impulsiveness, impatience and present bias.

We construct several measures to gauge the degree of engagement of participants with the programmes. First, we record participants' attendance at each session. Second, we employ three different strategies to measure compliance with the programme. One is based on self-reports of engagement in various leisure activities, which are presented in a list format. Meditation is one of the listed activities and participants are asked to report how frequently they have engaged in each activity during the previous week. Another measure is based on summaries participants are asked to write about the contents of the latest lesson (MBSR intervention) or episode (control intervention) in each weekly session. We create an indicator to reflect accuracy of the report (equal to 1 if what they wrote is correct and 0 otherwise). The last measure is based on records of online activity that we obtained from the organisation running the online MBSR course. We have detailed information about the activity and progress of each participant. We use this information to construct a variable indicating how far the participants have progressed with the course.

4.2 Chronic Stress and Short-Run Response to a Stressful Situation

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).

4.2.1 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 (PSS) 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,[6] 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.

4.2.2 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.[7] 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, the task consisted of a computerized cognitive ability and knowl-

[6]The 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.

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

edge test, combining numerical, spatial, and verbal reasoning questions with general knowledge questions. Students were informed that the average student would be expected to be able to answer all questions. Each question was presented on a separate page with a 20 second count-down 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, 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, 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.[8] 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.

Summarising the expected effects on chronic stress and stress response, our second hypothesis is as follows:

Hypothesis 2 - 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.

4.3 Risk and Time Preferences

Because risk and time preferences potentially play an important role in health-related behaviours, we are interested in evaluating how mindfulness affects risk and inter-temporal attitudes directly. We use standard experimental techniques to elicit measures of risk and time preferences.

[8] http://salimetrics.com/collection-system/adult-oral-swab.

4.3.1 Risk Attitudes

We use the "Bomb Risk Elicitation Task"(BRET), an intuitive procedure aimed at measuring risk attitudes (Crosetto and Filippin (2013)). Subjects decide how many out of 100 boxes to collect, but are informed that one of the boxes contains a bomb. Earnings increase linearly with the number of boxes collected, but participants receive nothing if the boxes they collect include the one that contains the bomb. Essentially, the task presents 100 lotteries which are described fully in terms of outcomes and probabilities by a single parameter (number of boxes collected). In our experiment, earnings per box are £0.05, i.e., participant earnings are equal to the number of boxes collected divided by 20 (unless the bomb is collected). The major advantage of the BRET, compared with other risk elicitation tasks, is that it requires minimal numeracy skills. The task allows estimation of both risk aversion and risk-seeking, and is not affected by the degree of loss aversion.

We implemented a static version of the BRET, with participants using a slider to choose how many boxes to collect. In contrast to the dynamic version, in which boxes are collected as time passes and subjects need to decide when to stop collecting boxes, our setup does not introduce any role for time preferences in the decision of how many boxes to collect. Subjects can also revise their decision upward and downward until they are satisfied with their choice. The number of boxes collected is therefore used as the measure of risk aversion. The more risk averse the subject is, the fewer boxes she will collect.

In addition, we construct a non-linear measure of risk aversion, using the approximation of Crosetto and Filippin (2013). Assuming a classic power utility function, the coefficient of relative risk aversion (RRA) can be approximated as $1 - \frac{n}{100 - n}$, where n is the number of boxes collected.

How should we expect mindfulness to affect risk-taking behaviour? There is a theory that risk-taking is linked to executive function. For example, there is evidence that risk-taking observed during adolescence may be due to insufficient prefrontal executive function compared to a more rapidly developing subcortical motivation system (Romer et al. (2011)). Thus, we would expect mindfulness training to decrease risk-taking.

4.3.2 Impulsiveness and Time Preferences

We measure impulsiveness and time preferences using both self-reported and incentivised measures. In order to measure self-reported impulsiveness, we use the Barratt Impulsiveness Scale (Patton et al. (1995)). This is a widely used measure of impulsiveness, including 30 questions assessing various impulsiveness traits (such as self-control, perseverance, and attention). Each item is reported on a four-point scale, with the total score ranging from 30 (low impulsivity) to 120 (high impulsivity).

We also elicit time preferences using an incentivised experiment. Frederick et al. (2002) review various standard methods used to elicit time preferences. This typically involves asking subjects to choose between various monetary amounts in two different time periods. We are interested both in eliciting subjects' discount rates and in testing whether their preferences are time-consistent. A simple way to determine time consistency is to offer individuals the choice between smaller amounts of money in the present and larger amounts in the future (i.e., today versus in one week), and then also offer them the identical choice between these rewards shifted further into the future (i.e., four months versus four months and one week). We follow the literature in asking subjects to make such choices for various different monetary rewards. If a subject chooses the smaller reward in the first scenario, but the larger one in the second (so-called static preference reversal), this reveals the subject's present bias. Tables 2 and 3 display the choice scenarios for Sessions 1, 6 and 7. Participants were informed in each session that one of their decisions would be randomly selected and implemented at the end of the session. While in session 1 the monetary rewards were small and everyone received the selected payments, in sessions 6 and 7 the rewards were higher, but only two randomly selected participants in each session received the payments associated with their decision.

Opting for future payment introduces additional uncertainty and requires subjects to trust the experimenter to pay in the future, introducing variables other than time preference. To keep transaction costs to a minimum, we chose to either provide future payments during pre-scheduled lab-sessions, or give payment via a voucher card, which could be loaded remotely, without the subject having to come to the laboratory. This procedure, combined with the fact that the experimenters are known to use the BLUE lab regularly, should serve to minimize

Question	This Week (£)	Next Week (£)	Question	Next Week (£)	In 2 Weeks (£)
1	3.80	4.00	11	3.80	4.00
2	3.60	4.00	12	3.60	4.00
3	3.40	4.00	13	3.40	4.00
4	3.20	4.00	14	3.20	4.00
5	3.00	4.00	15	3.00	4.00
6	2.80	4.00	16	2.80	4.00
7	2.60	4.00	17	2.60	4.00
8	2.40	4.00	18	2.40	4.00
9	2.20	4.00	19	2.20	4.00
10	2.00	4.00	20	2.00	4.00

Table 2: Time preference measure session 1

potential trust issues in our participants.

Question	This Week (£)	In 2 Weeks (£)	Question	In 4 Months (£)	In 4 M & 2 Wks (£)
1	30	31	6	30	31
2	30	32	7	30	32
3	30	33	8	30	33
4	30	34	9	30	34
5	30	35	10	30	35

Table 3: Time preference measure sessions 6 and 7

We construct two summary measures of time preferences using these incentivised experiments. First, we count the number of times the participant preferred to receive the money on the day of the session rather than later. We call this variable *impatience*. Second, we construct an indicator of whether the participant exhibits time-inconsistent preferences (*present bias*), preferring to receive a smaller amount of money today over a larger sum at a later date, while preferring the greater and later payment when offered a similar choice between payments on two later dates. We call this binary variable *present bias*. [9]

Because mindfulness has been shown to increase executive function, we hypothesize that greater self-control could lead the treatment group to become less present-biased than the control group. Note that, since the core exercises associated with mindfulness involve focusing the mind on the *present,* it is not necessarily obvious that this will be the case. However, there is little

[9]There are three cases of inconsistent choices (i.e., people switching more than once between earlier and later dates), which we exclude from our analysis.

evidence pointing in the direction of this opposite effect. Our experiment is, however, the first to consider the effect of mindfulness on a standard measure of present bias.

Our third hypothesis regarding risk and time attitudes can be summarised as follows:

Hypothesis 3 - The MBSR programme will reduce risk-taking, increase patience and reduce present bias.

4.4 Health-Related Behaviours

The final set of outcomes of interest are health-related behaviours.

4.4.1 Self-reported Measures

We collect self-reported information on smoking, eating, alcohol consumption and sleeping habits of our subjects, and also on their physical activities and overall health. The majority of these questions are included in the weekly survey. The survey also includes questions related to "emotional" or "comfort eating" based on the Compulsive Eating Scale (Kagan and Squires (1983)).

We collect a number of measures related to eating and healthy eating in particular. First, we construct a summary measure of unhealthy food consumption, counting the number of unhealthy items participants report having consumed the previous day (from a list we provided; see Appendix B for details). Second, we focus on two measures of eating behaviour based on survey questions directly related to emotional eating. The first question asks how often participants feel "out of control"when eating; the other asks participants how often they eat too much because they are "upset, nervous or stressed".

Next, we have measures (based on self-reports) of the frequency of smoking and alcohol consumption, as well as the average number of hours slept. In session 1, the respondents were asked generally about their smoking and drinking habits, while, in the other sessions, the questions referred to the previous week. The detailed weekly questions can be found in Appendix B.

4.4.2 Incentivised Measure

We also collected a measure of preferences for "healthy foods", using a revealed preference approach. Participants were asked to make a real choice between a high-calorie and a low-calorie option. Each option is a combination of a snack and a drink. Participants were first asked to choose sequentially among three high-calorie snacks, three high-calorie drinks, three low-calorie snacks and three low-calorie drinks. We then constructed a low-calorie option by combining their preferred low-calorie snack with their preferred low-calorie drink, and a high-calorie option by combining their preferred high-calorie drink and high-calorie snack. Participants were endowed with £4 and asked to pick between the high- and low-calorie options, each of them associated with different prices. The price of the chosen item would be deducted from the £4 endowment. They were asked to choose between their preferred high- and low-calorie options at different prices.[10]

Scenario	Current Choice	Price (£)
1	Option 1: high calorie	2.60
	Option 2: low calorie	2.00
2	Option 1: high calorie	2.40
	Option 2: low calorie	2.00
3	Option 1: high calorie	2.20
	Option 2: low calorie	2.00
4	Option 1: high calorie	2.00
	Option 2: low calorie	2.00
5	Option 1: high calorie	1.80
	Option 2: low calorie	2.00
6	Option 1: high calorie	1.60
	Option 2: low calorie	2.00
7	Option 1: high calorie	1.40
	Option 2: low calorie	2.00

Table 4: Revealed preference measure

We construct a measure of preference for the low-calorie option, which corresponds to the number of times participants choose that option rather than the high-calorie option.

Because of the expected effects of mindfulness on stress, risk and inter-temporal attitudes, the

[10] We also separately asked participants to make decisions involving receiving the snack and drink immediately, but paying later. Unfortunately, these measures cannot be used in the analysis due to an error in programming.

hypothesis regarding health-related-behaviours follows naturally:

Hypothesis 4 - Participants in the MBSR programme will engage more in health-promoting behaviours (such as healthy eating and sleep) and less in health-harming behaviours (such as smoking, unhealthy eating and drinking alcohol).

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 and, later on, for evaluating the implications of attrition.

Table 5 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. The average subject in the whole sample is 24.36 years old. About 65 percent of our subjects are female and a similar proportion are white. The average subject weighs about 63.8 kilograms and has a body mass index (BMI) of 21.83. Around 87 percent of our subjects are undergraduate students, while the remaining 13 percent are graduate students.

Panels B, C and D of Table 5 present summary statistics for the main outcome variables. We start with self-reports of chronic stress, as well as subjective and emotional well-being. In terms of life satisfaction, Panel B shows that the average respondent scores 8.02 on a 11 point Likert scale, with a score of 7.86 in terms of being "happy these days". While students seem to be relatively satisfied with their lives, they still report a high level of anxiety. On an 11 point Likert scale, where 1 represents least anxious and 11 represents most anxious, on average, subjects in our experiments score around 6.7. This highlights that anxiety is a common problem for

Baseline characteristics

	[1]		[2]		[3]		[4]
	Total		**Treatment**		**Control**		**Diff**
Variables	Mean	SD	Mean	SD	Mean	SD	Mean
Panel A: Individual Characteristics							
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
Panel B: Stress and Wellbeing							
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	-0.99
Life satisfaction nowadays (scale: 1-11)	8.02	1.47	8.01	1.32	8.03	1.60	0.01
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
Panel C: Behavioural measures							
Present bias (0/1)	0.08	0.27	0.07	0.26	0.08	0.28	0.01
BIS total score (30 to 120)	64.34	9.47	65.01	10.25	63.71	8.70	1.31
# boxes collected (BRET)	45.65	20.19	48.01	22.36	43.44	17.81	4.57
Impatience (0 to 10)	0.48	1.10	0.42	1.03	0.54	1.16	-0.12
Panel D: Health related behaviours							
Unhealthy food items eaten yesterday	3.94	3.33	3.72	3.06	4.14	3.57	0.42
Avoid fat	0.48	0.50	0.51	0.50	0.46	0.50	0.05
Eat high fibre food	0.37	0.49	0.42	0.50	0.33	0.47	0.08
Eat at regular times (1-always to 4-never)	2.10	0.82	2.13	0.81	2.07	0.83	0.06
Eat high-calorie snack while studying (0-no, 1-yes)	0.53	0.50	0.52	0.50	0.53	0.50	-0.01
Eat more than usual while preparing for exam (0-no, 1-yes)	0.45	0.50	0.46	0.50	0.43	0.50	0.03
Out of control with food (0-never to 4-always)	1.22	0.93	1.34	0.93	1.10	0.92	0.25
Eat because upset, nervous (0-never to 4-always)	1.39	1.12	1.49	1.15	1.29	1.09	0.20
Eat because bored, lonely (0-never to 4-always)	1.40	1.10	1.34	1.14	1.46	1.07	-0.12
Eat much too fast (0-never to 4-always)	0.89	1.03	1.00	1.03	0.79	1.03	0.21
Average hours of sleep/day	7.62	0.99	7.60	1.03	7.63	0.96	0.03
Suffer from a health problem leading to a doctoral visit in past 4 weeks	0.15	0.36	0.16	0.37	0.14	0.35	0.03
Frequency of alcohol consumption (1-almost every day to 5-never)	3.40	0.84	3.48	0.73	3.32	0.93	0.16
Smoking (1-none to 4-(10-20) cigarettes per day)	1.29	0.66	1.30	0.65	1.28	0.68	0.02
Observations	139		67		72		

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

Table 5: Baseline characteristics

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 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 literature. 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.

Panel C reports the measures of behavioural attitudes at baseline. Only a small proportion of participants are present-biased (8%) at baseline, which is surprisingly low. The average value of impulsivity is in the lower half of the impulsivity scale and is comparable to other recent studies involving students in the UK (see Caswell et al. (2016)). In terms of patience, the majority of the students prefer all of the later options to the earlier ones, thus the indicator of impatience at Session 1 is on average very low. Note, that impatience becomes more common at Sessions 6 and 7, when the monetary rewards are higher. Finally, the mean value of our measure of risk aversion, corresponding to the number of boxes collected in the BRET, is 46, which is very close to the mean observed in Crosetto and Filippin (2013).

Descriptive statistics on health-related behaviours are presented in Panel D of Table 5.[11] On average, the participants in our experiment consumed about four unhealthy food items during the day before the baseline survey; eating high-calorie snacks when studying or preparing for exams seems to be common. Taken together, the results suggest the prevalence of a high degree of anxiety and health-compromising lifestyles among the student population participating in our experiment.

[11] While the table includes all the variables, in the rest of the main text we focus on a representative set of indicators of health-related behaviours. Results relating to the remaining variables are presented in Appendix D.

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.

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

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

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 in 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.

Note that attrition can potentially play an important role in the analysis of all outcome variables. Similarly, we cannot be sure that all students have fully complied with the protocol to

which they were assigned. So our estimates will always be Intention-To-Treat estimates. We first discuss attrition and compliance, and then move to the other outcome variables.

6.2 Attrition and Compliance

We now turn to testing *Hypothesis 1.* Both interventions require some degree of commitment from the participants. Our data allow us to study the determinants of continued participation in the study and, in particular, engagement with the mindfulness protocol. One would expect that certain behavioural characteristics such as impulsiveness, impatience and present bias may be correlated with the likelihood of attrition. Because we have collected a large set of variables at baseline, we are able to test this hypothesis directly.

We start with the information on attendance. The number of subjects in both the treatment and control groups declined over time due to attrition. In Session 6, 17 of the 67 original subjects in the treatment group (representing 25%) and 11 of the original 72 subjects in the control group (representing 15.3%) did not attend the experimental session. The non-attendance rate in Session 7 was 41.8% in the treatment group and 29.2% in the control group. Concern about bias in the estimation results due to attrition thus seems justified.

First, we conduct an analysis of the determinants of attrition using attrition probits (Fitzgerald et al. (1998)). Attrition probits consist of estimates of binary-choice models for the determinants of attrition in later periods as a function of base year characteristics. We estimate separate attrition probit models for the treatment and control groups. We include a rich set of baseline characteristics in the models, but have to exclude some variables to avoid strong multicollinearity (anxiety now, happiness now) and perfect prediction (present bias).We will come back to the latter, since it is a variable we thought could be correlated with engagement. The dependent variable is a binary indicator of being present at Session 6 or 7.

The results presented in Table 6 show that, although there are some significant coefficients in the attrition probit models, there is no systematic relation between the baseline characteristics and attrition. The personal characteristics that are significantly related to attrition are those characteristics for which we control in our estimations. We also see that anxiety these days

significantly reduces the probability of remaining in the sample within the treatment group. If the MBSR program is more effective among the subjects who report anxiety, then this selectivity can lead to underestimation of the beneficial effect of the program on anxiety. Six individuals in the control group, coded as present-biased in Session 1, have to be excluded due to perfect prediction of non-attrition by present bias. To gauge the effects of present bias on attrition, we tested for a simple mean difference in present bias as measured in Session 1 between the original sample and the sample present in Sessions 6 and 7. We found no significant differences.

Table 6: Attrition probits (marginal effects on non-attrition)

	Treatment Session 6		Control Session 6		Treatment Session 7		Control Session 7	
	Marginal effect	SE	Marginal effect	SE	Marginal effect	SE	Marginal effect	SE
Personal characteristics								
Age	-0.039*	0.022	0.007*	0.005	-0.062*	0.034	0.048***	0.015
Female	0.082	0.117	-0.049	0.043	0.518***	0.161	-0.130	0.102
White	-0.058	0.109	0.409***	0.143	-0.024	0.172	0.479***	0.157
BMI	0.022	0.016	-0.011	0.010	0.058**	0.026	-0.002	0.020
Stress and subjective well-being								
PSS	0.008	0.011	-0.001	0.005	0.010	0.018	-0.015	0.011
Anxious these days	-0.060*	0.033	0.022*	0.011	-0.128***	0.048	0.020	0.030
Anxious now	-0.018	0.027	-0.034**	0.015	0.016	0.038	-0.008	0.029
Life satisfaction nowadays	0.070	0.054	-0.038**	0.024	-0.033	0.073	-0.062	0.044
Happiness these days	0.006	0.044	0.019	0.020	0.033	0.058	-0.032	0.043
Behavioural measures								
Risk aversion (BRET)	0.003	0.002	0.002*	0.001	0.003	0.004	0.004	0.003
Impulsivity (BIS)	-0.003	0.005	-0.003	0.003	0.000	0.007	0.006	0.006
Impatience	-0.049	0.046	0.076**	0.049	0.018	0.084	0.027	0.074
Present bias	-0.264	0.403			-0.213	0.385	0.161	0.084
Health-related behaviours								
Unhealthy food items eaten yesterday	0.018	0.016	-0.001	0.007	0.044*	0.024	0.006	0.014
Out of control with food	0.086	0.069	0.002	0.034	-0.041	0.101	0.136*	0.074
Eat because upset, nervous	-0.035	0.062	0.033	0.027	-0.013	0.097	-0.031	0.060
Average hours of sleep/day	0.023	0.044	-0.056***	0.028	0.068	0.072	-0.053	0.049
Smoking	-0.146**	0.069	-0.096***	0.044	-0.017	0.124	-0.274***	0.082
Frequency of alcohol consumption	0.023	0.060	-0.001	0.028	0.257***	0.110	-0.006	0.064
Low calorie option chosen	0.017	0.012	-0.001	0.007	-0.014	0.020	0.015	0.014
No. of individuals	67		65		67		71	

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

As the second test of attrition, we look at whether the treatment and control samples that are present in Sessions 6 and 7 are still comparable in terms of their baseline characteristics. This check can reveal whether there is asymmetric attrition between the treatment and the control groups (on observable characteristics). We test for equality of the same set of baseline characteristics that we used in the attrition probit models. The results are presented in Table 7. There are statistically significant differences in age, gender and BMI between the treated and control individuals at the baseline, but these are relatively small. These are also characteristics that we control for in the empirical specifications. More importantly, we do not see significant differences in terms of risk attitudes, patience or impulsiveness. One variable for which we observe significant differences is stress-related eating, which is significantly more prevalent within the treatment group. We do not see evidence of significant differences for the other

behavioural measures and health-related behaviours. Thus, Hypothesis 1 is not supported by the data. We do not see that engagement with the protocols is correlated with psychological traits or behavioural measures such as impulsiveness and impatience. This reduces concerns about the analysis of behavioural measures and health-related behaviours suffering from bias due to attrition. We provide a further check of the importance of attrition in Section 6.3, where we re-estimate the results on PSS and anxiety measures using the non-attriting sub-sample.

Table 7: Comparison of Baseline Means of the Non-attrited Subsamples of Treatment and Control Groups

	Present at session 6, treatment-control		Present at session 7, treatment-control	
	Diff.	SE	Diff.	SE
Personal characteristics				
Age	-1.478**	0.732	-1.991**	0.874
Female	0.097	0.09	0.252**	0.097
White	-0.032	0.091	-0.045	0.101
BMI	1.269**	0.498	-1.356**	0.579
Stress and subjective well-being				
PSS	0.992	1.165	1.148	1.35
Anxious these days	0.192	0.456	-0.062	0.533
Anxious now	0.724	0.458	0.297	0.525
Life satisfaction nowadays	0.233	0.273	0.299	0.312
Happiness these days	-0.034	0.319	0.056	0.370
Behavioural measures				
Impulisivity (BIS)	1.412	1.881	1.090	2.033
Risk aversion (BRET)	3.081	3.831	2.428	4.004
Impatience	-0.343	0.213	-0.268	0.241
Present bias	-0.058	0.049	-0.047	0.057
Health-related behaviours				
Unhealthy food items	-0.258	0.673	-0.208	0.762
Out of control with food	0.358**	0.180	0.351*	0.203
Eat because upset, nervous	0.221	0.217	0.407*	0.236
Average hours of sleep/day	0.036	0.191	0.069	0.211
Smoking	0.007	0.108	0.106	0.123
Frequency of alcohol consumption	0.196	0.164	0.237	0.186
Low calorie option chosen	1.025	0.654	0.520	0.719

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

The next variables of interest are the degree of engagement and compliance with the interventions. We have designed three strategies to measure these. First, we asked participants to report every week to what extent they engaged in various activities to relax, such as meeting with friends, going to the theatre, etc. (see Appendix B for full questionnaire). Meditating is one of the activities they were asked about. Figure 1 shows the average report on the extent to which participants meditate, with 0 being never or less than once a week and 3 being almost every day. We report the difference-in-difference analysis in Table 8. We find a significantly positive treatment effect during Sessions 2-6. The effect remains positive but becomes statistically not significant during the follow-up session five months later.

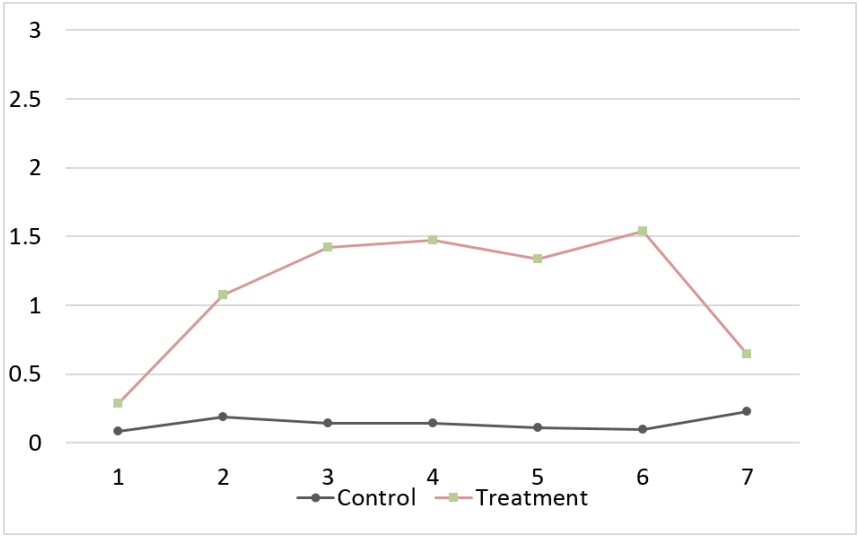

Figure 1: Average frequency of meditation (0-less than once a week or never to 3-almost every day), by session and treatment

Second, we asked participants to describe the contents of the weekly mindfulness lesson (in at least 100 words). We also asked the participants in the neutral intervention to describe the documentary episode they were asked to watch. We constructed a dummy variable indicating whether the text was indeed an accurate description of the lesson/episode.[12] Participants complied to a large extent with the interventions. Based on this binary indicator of compliance, more than 90% of the subjects in the control group followed the control intervention every week. Compliance also exceeded 90% in the treatment group every week, except for the first week, when 82% of the subjects followed the MBSR program (this statistic is based on the survey during Session 2). Of course it is worth noting that the number of participants falls over time, and attriting participants are unlikely to still be engaged with the intervention.

Finally, the last strategy to check for engagement and compliance with the interventions involves using data from the website, which tracked participants' activities during the online sessions. The website tracks when participants logged in and completed the various stages of the intervention. By Session 6, 36% of the non-attrited individuals in the treatment group had fully completed the online mindfulness course (while 72% had reached at least Week 4 of the course by this point). By Session 7, the completion rate increased to 59%. The estimated marginal effects on the probability of completing the course (based on probit models) are reported in

[12]We also coded the response as a zero if the description was generic and did not demonstrate that they engaged with the intervention or if they mention not having done the activity at all.

Table 8: Effect of MBSR on the frequency of meditation (0-less than once a week to 3-almost every day)

	Coeff.	SE
MBSR	0.178**	0.088
Session 2	0.103	0.063
Session 3	0.060	0.059
Session 4	0.060	0.041
Session 5	0.022	0.047
Session 6	0.012	0.041
Session 7	0.165*	0.090
MBSR & Session 2	0.694***	0.138
MBSR & Session 3	1.076***	0.123
MBSR & Session 4	1.145***	0.122
MBSR & Session 5	1.032***	0.116
MBSR & Session 6	1.212***	0.114
MBSR & Session 7	0.113	0.152
Intercept	0.099	0.369
Individual random effects	Yes	
Control variables	Yes	
No. of individuals	138	

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

Table 9. According to these results, indicators of stress, behavioural preferences and health behaviours are not systematically related to the probability of completing the mindfulness course. Therefore, it does not seem likely that our estimation results on the effects of the MBSR would be driven by selection into completing the course.

6.3 Effects on Chronic Stress and Stress Response

We now turn to *Hypothesis 2,* which relates to the impact of the MBSR intervention on chronic stress and on the response to a stressful situation. These outcomes are primary targets of the programme.

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

Table 9: Probability of completing the course

	Marginal effect	SE	Marginal effect	SE
Personal characteristics				
Age	0.086*	0.046	0.046	0.040
Female	0.244	0.148	0.315	0.209
White	-0.051	0.140	0.047	0.177
BMI	0.035	0.026	0.027	0.030
Stress and subjective well-being				
PSS	0.007	0.014	0.014	0.014
Anxious these days	-0.068*	0.039	-0.104**	0.043
Anxious now	0.036	0.035	0.070*	0.041
Life satisfaction nowadays	0.005	0.060	-0.003	0.075
Happiness these days	0.007	0.053	0.016	0.062
Behavioural measures				
Impulisivity (BIS)	-0.001	0.006	0.008	0.007
Risk aversion (BRET)	0.000	0.003	-0.001	0.003
Impatience	-0.034	0.090	-0.074	0.082
Present bias	-0.073	0.346	-0.112	0.406
Health-related behaviours				
Unhealthy food items			0.010	0.022
Out of control with food			-0.147	0.124
Eat because upset, nervous			0.048	0.095
Average hours of sleep/day			-0.133**	0.067
Smoking			0.086	0.117
Frequency of alcohol consumption			0.237**	0.121
Low calorie option chosen			-0.016	0.019
No. of individuals	65		65	

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

10 reports the treatment effects of the intervention on these three measures from a difference-in-differences estimator.

Table 10: The Impact of MBSR on Perceived Stress Score (PSS) and Anxiety Measures

	[1]		[2]		[3]	
	PSS		Anxiety Now		Anxiety These Days	
	Coeff.	SE	Coeff.	SE	Coeff.	SE
MBSR	1.463	0.981	1.256***	0.407	0.878**	0.408
Session 2	.	.	0.531	0.346	0.273	0.336
Session 3	.	.	0.918***	0.327	0.302	0.275
Session 4	.	.	0.227	0.371	-0.095	0.304
Session 5	.	.	0.344	0.351	-0.141	0.306
Session 6	0.999*	0.511	0.279	0.344	-0.131	0.245
Session 7	2.205***	0.855	0.747*	0.387	0.344	0.355
MBSR & Session 2	.	.	-0.857*	0.505	-0.454	0.450
MBSR & Session 3	.	.	-1.163**	0.520	-0.882*	0.458
MBSR & Session 4	.	.	-0.402	0.529	-0.387	0.445
MBSR & Session 5	.	.	-0.360	0.511	-0.296	0.495
MBSR & Session 6	-1.809*	0.926	-0.068	0.542	-0.069	0.454
MBSR & Session 7	-2.464*	1.320	-1.095*	0.650	-0.765	0.582
Intercept	17.363**	7.063	6.982***	2.009	8.575***	2.116
Individual random effects	Yes		Yes		Yes	
Control variables	Yes		Yes		Yes	
No. of individuals	138		138		138	

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

Regression results show that the PSS score significantly decreases in the two weeks post-intervention. The fall is of 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, 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".[13]

Next, we examine how the intervention affected the response to a stressful situation. Table 11 summarises how stressful, not enjoyable and difficult the participants found each task on a scale of 1 (least stressful/most enjoyable/least difficult) to 10 (most stressful/least enjoyable/most difficult). We also present an indicator of over-confidence.[14] 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 group 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 2. These cortisol levels are within the normal ranges of cortisol concentration.

Summarising, the evidence based on self-reported measures is supportive of *Hypothesis 2,* but the evidence based on physiological measurements is inconclusive.

6.4 Effects on Risk Attitudes, Time Preferences and Impulsiveness

We now turn to investigating the effects of the intervention on risk attitudes and time preferences of the program participants (*Hypothesis 3*). The impulsivity and risk measures are identical

[13]We conducted a series of specifications checks to investigate further the results on PSS score and anxiety measures. First, to check the importance of attrition, we re-estimated the models 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 are not affected. These results are reported in a table in Appendix C. 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 (based on the abbreviated APES) increase the PSS score, we do not see evidence that the PSS score of the treatment group would respond less to such stressful events.

[14]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.

Table 11: 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*

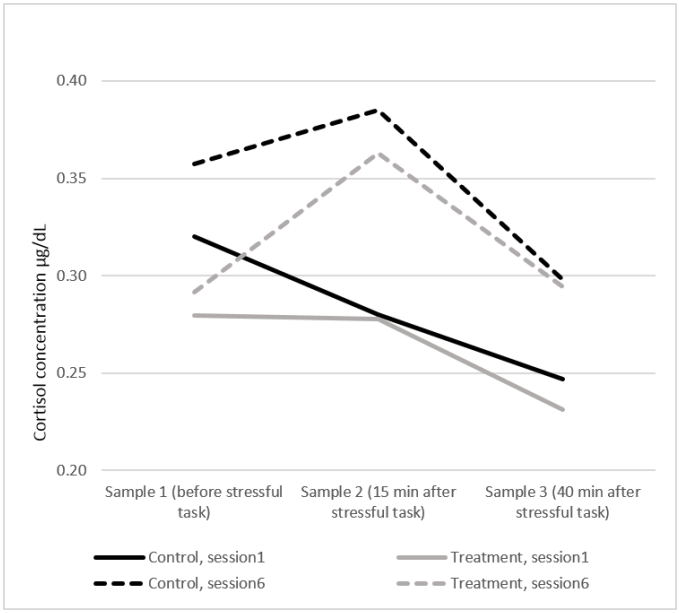

Figure 2: Salivary cortisol concentration averages by session and by treatment

across Sessions 1, 6 and 7. The time preferences measure differs slightly across the three sessions. The exact choice scenarios are described in Section 4.3.2.

Table 12 presents difference-in-differences regression results on the impact of our MBSR intervention on risk preferences. Results in Column [1] show that the number of boxes collected decreases in the treatment group relative to the control group (which is indicative of a decrease in risk-taking), but only in Session 7, and the effect is not statistically significant at conventional levels. Using the approximated coefficient of relative risk aversion (Column [2]), the estimated treatment effects are more robust and statistically significant in Session 7. As the coefficient "MBSR"indicates, subjects in the treatment group were initially significantly less risk-averse than those in the control group, as measured by the coefficient of relative risk aversion. The gap between the two groups appears to be eliminated by the MBSR treatment. This effect is in line with *Hypothesis 3*.

Table 12: The Impact of MBSR on risk aversion

	[1]		[2]	
	Risk aversion (BRET) Number of boxes		Risk aversion (BRET) RRA coefficient	
	Coeff.	SE	Coeff.	SE
MBSR	5.04	3.453	-0.733**	0.362
Session 6	-4.081	2.693	0.138	0.111
Session 7	2.844	2.87	-0.047	0.096
MBSR Session 6	0.407	4.378	0.431	0.414
MBSR Session 7	-4.522	3.987	0.779**	0.398
Intercept	63.203***	13.99	-1.560**	0.757
Individual RE	Yes		Yes	
Control variables	Yes		Yes	
No. of individuals	138		138	

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

Because the measure of time preferences was not identical across sessions, we conduct a simple difference analysis on patience and present-bias between treatment and control groups for Sessions 1, 6 and 7 separately and report the results in Tables 13 and 14 respectively. Results in Table 13 show that participants in the treatment group became more patient after the in-

tervention, but the effects are not statistically significant. The point estimates and standard errors are quite large, however, so there is a possible issue of statistical power. In Table 14, we show that participants have a similar propensity of being present-biased in Session 1, but the treatment group appears less present-biased immediately after the intervention, although the effects are again not statistically significant. We find no significant difference in Session 7 either. However, it is useful to point out that the baseline measure of present-bias was very low (with only 8% of the participants categorised as present-biased). Overall, we take our results as somewhat indicative that patience may have increased and the propensity to be present-biased decreased, but these results are not statistically significant at conventional levels. Thus, we do not find strong support for *Hypothesis 3*.

Table 13: The Impact of MBSR on Impatience

	Impatience, session 1		Impatience, session 6		Impatience, session 7	
	Coeff.	SE	Coeff.	SE	Coeff.	SE
MBSR	-0.018	0.178	-0.179	0.411	-0.12	0.486
Intercept	3.002**	1.294	5.184***	1.891	-3.571	2.501
Individual RE	No		No		No	
Control variables	Yes		Yes		Yes	
No. of individuals	136		112		80	

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

Table 14: The Impact of MBSR on present bias

	Present bias session 1		Present bias session 6		Present bias session 7	
	Coeff.	SE	Coeff.	SE	Coeff.	SE
MBSR	0.016	0.033	-0.113	0.101	0.026	0.121
Individual RE	No		No		No	
Control variables	Yes		Yes		Yes	
No. of individuals	136		112		80	

Notes: Probit estimates (marginal effects reported).
, **, * indicate significance levels at 10%, 5% and 1% respectively*

Finally, we look at how mindfulness affects the scores on the Barratt Impulsiveness Scale (BIS). We conduct a difference-in-differences analysis and report the results in Table 15. Here, we document a significant effect in Session 6, but we find that participants in the treatment group increased their average score on the BIS relative to the participants in the control group; that is, if anything, mindfulness appears to have increased impulsiveness rather than decreased it.

These survey-based results go in the opposite direction to those we found for patience and present-bias using revealed preference methods.[15]

Table 15: The Impact of MBSR on Impulsivity

	Coeff.	SE
MBSR	0.809	1.589
Session 6	-0.11	0.735
Session 7	0.217	0.756
MBSR Session 6	2.229*	1.174
MBSR Session 7	0.983	1.298
Intercept	59.199***	9.135
Individual RE	Yes	
Control variables	Yes	
No. of individuals	138	

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

6.5 Effects on Health-related Behaviours

We finally investigate the impact of the MBSR intervention on health-related behaviours (*Hypothesis 4*). First, we look at our three main measures of eating behaviour: the number of unhealthy food items eaten the day before, and two measures related to emotional eating (how often participants feel out of control while eating and how often they eat too much because of being upset or nervous). The results are reported in Table 16. (We document effects on additional variables related to eating behaviour in Appendix D.) Overall, participants in the MBSR programme appear to adopt somewhat healthier eating habits, but the effects are only significant for one variable, which is the second measure of emotional eating. We estimate a significant treatment effect in Session 7, with an estimated effect of -0.417. While this effect is quite substantial (the indicator ranges from 0-never to 4-always, with baseline mean of 1.4), it has to be kept in mind that Table 7 indicates non-random attrition related to this particular indicator. Thus, this result might partly be driven by the self-selection of participants with emotional eating problems.

[15] This result seems to be driven by the sub-category of questions related to "Self-control" and, more specifically, four of the 30 questions that make up the Barratt Impulsiveness Scale. In Session 6, participants in the treatment group are statistically significantly more likely to describe themselves as "I am happy-go-lucky" (Barratt item 4) and significantly less likely to say "I am self-controlled" (item 8), "I am a careful thinker" (item 12), or "I am a steady thinker" (item 20). The effect on "I am happy-go-lucky" (Barratt item 4) persists to Session 7 five months later. Given that these are self-reported measures, it is of course possible that doing the mindfulness course has simply made participants think of themselves differently (and possibly more critically, in terms of self-control).

Table 16: The Impact of MBSR on eating habits

	Unhealthy food items yesterday		Out of control with food		Eat because upset, nervous	
	Coeff.	SE	Coeff.	SE	Coeff.	SE
MBSR	-0.267	0.593	0.126	0.156	0.086	0.176
Session 2	-0.245	0.429	-0.274***	0.101	-0.386***	0.139
Session 3	-0.152	0.389	-0.275**	0.111	-0.431***	0.138
Session 4	0.142	0.496	-0.246**	0.123	-0.549***	0.135
Session 5	0.127	0.455	-0.306***	0.115	-0.530***	0.143
Session 6	-0.236	0.492	-0.16	0.108	-0.379***	0.14
Session 7	-0.226	0.55	0.015	0.131	0.076	0.145
MBSR S2	0.355	0.588	0.167	-0.007	0.178	-0.066
MBSR S3	0.235	0.501	0.035	0.186	0.025	0.195
MBSR S4	-0.246	0.618	-0.223	0.185	-0.041	0.191
MBSR S5	-0.405	0.559	-0.045	0.168	0.057	0.202
MBSR S6	-0.488	0.647	-0.195	0.162	-0.038	0.191
MBSR S7	-0.791	0.7	-0.094	0.207	-0.417*	0.228
Intercept	5.910*	3.201	1.458**	0.688	0.628	0.78
Ind. RE	Yes		Yes		Yes	
Control var.	Yes		Yes		Yes	
No. of ind.	138		138		138	

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

Next, we look at number of hours of sleep, alcohol consumption and smoking, all self-reported as well. The results are presented in Table 17. We do not find any consistent pattern here - there is little evidence that these behaviours were affected in one direction or the other.

Table 17: The Impact of MBSR on Health-related Behaviours

	Average hours of sleep/day		Smoking		Frequency of alcohol consumption	
	Coeff.	SE	Coeff.	SE	Coeff.	SE
MBSR	-0.028	0.192	0.025	0.120	0.180	0.130
Session 2	0.055	0.347	0.038	0.033	0.052	0.109
Session 3	-0.264**	0.112	-0.049	0.057	0.200*	0.108
Session 4	-0.176*	0.098	-0.049	0.061	0.479***	0.111
Session 5	-0.241**	0.121	-0.081	0.052	0.355***	0.120
Session 6	-0.583***	0.143	-0.002	0.044	-0.195**	0.098
Session 7	0.029	0.487	0.047	0.051	-0.295***	0.084
MBSR S2	1.436	1.205	0.040	0.064	0.076	0.159
MBSR S3	0.049	0.191	0.065	0.071	0.177	0.150
MBSR S4	-0.325*	0.185	0.086	0.073	-0.171	0.167
MBSR S5	-0.214	0.223	0.071	0.070	-0.179	0.182
MBSR S6	0.140	0.198	0.002	0.069	0.096	0.138
MBSR S7	-0.378	0.520	-0.044	0.090	0.072	0.127
Intercept	9.452***	1.578	1.513***	0.490	5.003***	1.009
Ind. RE	Yes		Yes		Yes	
Control var.	Yes		Yes		Yes	
No. of ind.	138		138		138	

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

Finally, we look at the revealed preference measure of healthy eating based on real choices between a low-calorie and a high-calorie option. We counted the number of times participants preferred the low calorie option over the high calorie option, which is a direct indicator of their relative preferences. Table 18 reports the difference-in-differences estimates on the effect of the intervention. We find no evidence that participants changed their choices significantly. They all appear to value the low calorie option less in the later sessions, but this effect is not significantly different across treatment and control groups.

Summarising, we find indicative evidence for *Hypothesis 4*, that is, eating habits may have improved a bit, particularly stress-related eating; but all other measures of health-related behaviours appear unaffected by the intervention.

Table 18: Effects on Food Choices (# of low calorie options chosen, 0 to 10)

	Coeff.	SE
MBSR	0.596	0.714
Session 6	-1.812***	0.420
Session 7	-1.451***	0.471
MBSR & Session 6	-1.008	0.671
MBSR & Session 7	-0.994	0.737
Intercept	3.980	2.482
Random effects	Yes	
Control variables	Yes	
No. of individuals	132	

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

7 Discussion and Conclusions

Lifestyle choices are thought to be factors central to explaining the increasing prevalence of non-communicable diseases around the world. This paper makes the first attempt to explore the possibility of training the mind to alter fundamental cognitive processes underlying decision-making using a series of novel experiments. 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 was 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 stress, but the evidence based on physiological measures of stress (cortisol) is less conclusive. We find indicative evidence that participants may have become more risk averse, as well as more patient and less present-biased, but these results are not statistically significant. On the other hand, participants in the MBSR treatment score higher on the Barratt Impulsiveness Scale based on survey questions. Finally, we find that participants in the MBSR treatment are less likely to engage in stress-related eating, and the point estimates relating to other variables are also suggestive that eating habits may have improved overall, although again the results are not statistically significant. We fail to find any evidence - even suggestive - of changes in other health-related behaviours

such as sleep, alcohol consumption and smoking.

Overall, we conclude that such interventions appear to be effective at reducing "feelings of stress", but the effects on decision-making and health-related behaviours are not entirely clear. It could be that our sample is too small to capture the effects. Looking at the set of point estimates we have, we cannot reject the hypothesis that mindfulness may have in fact increased patience and risk aversion, reduced present-bias and encouraged healthier eating habits, by a significant magnitude. The effects of mindfulness on such outcomes may be more diffuse, specifically because we are considering a population of healthy subjects. We believe that further research is needed to obtain more robust evidence of the effects of such techniques on decision-making.

•

References

R. A. Barkley. Behavioral inhibition, sustained attention, and executive functions: constructing a unifying theory of adhd. *Psychological Bulletin*, 121(1):65, 1997.

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.

A. J. Caswell, M. A. Celio, M. M. J, and D. T. Impulsivity as a multifaceted construct related to excessive drinking among uk students. *Alcohol and Alcoholism*, 51(1):77–83, 2016.

R. Chambers, B. C. Y. Lo, and N. B. Allen. The impact of intensive mindfulness training on attentional control, cognitive style, and affect. *Cognitive Therapy and Research*, 32(3): 303–322, 2008.

G. Charness and U. Gneezy. Incentives to exercise. *Econometrica*, 77(3):909–931, 2009.

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.

B. E. Compas. Stress and life events during childhood and adolescence. *Clinical Psychology Review*, 7(3):275–302, 1987.

S. Cornelisse, V. Van Ast, J. Haushofer, M. Seinstra, and M. Joels. Time-dependent effect of hydrocortisone administration on intertemporal choice. *Available at SSRN*, (2294189), 2013.

P. Crosetto and A. Filippin. The bomb risk elicitation task. *Journal of risk and uncertainty*, 47(1):31–65, 2013.

M. F. Dallman, N. Pecoraro, S. F. Akana, et al. Chronic stress and obesity: a new view of comfort food. *Proceedings of the National Academy of Sciences*, 100(20):11696–11701, 2003.

S. DellaVigna and U. Malmendier. Paying not to go to the gym. *The American Economic Review*, pages 694–719, 2006.

A. Diamond and K. Lee. Interventions shown to aid executive function development in children 4 to 12 years old. *Science*, 333(6045):959–964, 2011.

E. Dias-Ferreira, J. a. C. Sousa, I. Melo, P. Morgado, A. R. Mesquita, J. a. J. Cerqueira, R. M. Costa, and N. Sousa. Chronic Stress Causes Frontostriatal Reorganization and Affects Decision-Making. *Science*, 325(5940):621–625, July 2009.

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.

J. S. Downs, G. Loewenstein, and J. Wisdom. Strategies for promoting healthier food choices. *The American Economic Review*, pages 159–164, 2009.

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.

J. Fan, B. D. McCandliss, T. Sommer, A. Raz, and M. I. Posner. Testing the efficiency and independence of attentional networks. *Journal of Cognitive Neuroscience*, 14(3):340–347, 2002.

J. Fitzgerald, P. Gottschalk, and R. Moffitt. The impact of attrition in the panel study of income dynamics on intergenerational analysis. *Journal of Human Resources*, 33(2):123–134, 1998.

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.

S. Frederick, G. Loewenstein, and T. ODonoghue. Time discounting and time preference: a critical review. *Journal of Economic Literature*, 40(2):351–401, 2002.

M. Friese, C. Messner, and Y. Schaffner. Mindfulness meditation counteracts self-control depletion. *Consciousness and Cognition*, 21(2):1016–1022, 2012.

D. Fudenberg and D. K. Levine. A dual-self model of impulse control. *The American Economic Review*, pages 1449–1476, 2006.

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.

N. Grissom and S. Bhatnagar. Habituation to repeated stress: get used to it. *Neurobiology of Learning and Memory*, 92(2):215–224, 2009.

L. Guiso, P. Sapienza, and L. Zingales. Time varying risk aversion. *NBER Working Paper*, (19284), 2013.

F. Gul and W. Pesendorfer. Self-control and the theory of consumption. *Econometrica*, pages 119–158, 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.

W. Hofmann, M. Friese, and R. W. Wiers. Impulsive versus reflective influences on health behavior: A theoretical framework and empirical review. *Health Psychology Review*, 2(2): 111–137, 2008.

HuffingtonPost. Why 2014 will be the year of mindful living. http://www.huffingtonpost.com/2014/01/02/will-2014-be-the-year-of-_0_n_4523975.html, 2014. Accessed: 2016-04-12.

A. R. Jensen and W. D. Rohwer. The stroop color-word test: A review. *Acta psychologica*, 25: 36–93, 1966.

A. P. Jha, J. Krompinger, and M. J. Baime. Mindfulness training modifies subsystems of attention. *Cognitive, Affective, & Behavioral Neuroscience*, 7(2):109–119, 2007.

J. Kabat-Zinn. Full catastrophe living: The program of the stress reduction clinic at the university of massachusetts medical center. *New York: Delta*, 1990.

D. M. Kagan and R. L. Squires. Dieting, compulsive eating, and feelings of failure among adolescents. *International Journal of Eating Disorders*, 3(1):15–26, 1983.

N. Kandasamy, B. Hardy, L. Page, M. Schaffner, J. Graggaber, A. S. Powlson, P. C. Fletcher, M. Gurnell, and J. Coates. Cortisol shifts financial risk preferences. *Proceedings of the National Academy of Sciences*, 111(9):3608–3613, Mar. 2014.

J. Kandiah, Y. Melissa, J. Jones, et al. Stress influences appetite and comfort food preferences in college women. *Nutrition Research*, 26(3):118–123, 2006.

H. Kerr. National union of students: Mental distress survey overview. http://www.nus.org.uk/Global/Campaigns/20130517%20Mental%20Distress%20Survey%20%20Overview. 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.

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.

T. Kugler, T. Connolly, and L. D. Ordóñez. Emotion, decision, and risk: Betting on gambles versus betting on people. *Journal of Behavioral Decision Making*, 25(2):123–134, 2012.

C. Liston, B. S. McEwen, and B. J. Casey. Psychosocial stress reversibly disrupts prefrontal processing and attentional control. *Proceedings of the National Academy of Sciences of the United States of America*, 106:912–917, 2009. ISSN 0027-8424. doi: 10.1073/pnas.0807041106.

G. Loewenstein and T. O'Donoghue. Animal spirits: Affective and deliberative processes in economic behavior. *Available at SSRN 539843*, 2004.

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. M. Marteau, G. J. Hollands, and P. C. Fletcher. Changing human behavior to prevent disease: the importance of targeting automatic processes. *science*, 337(6101):1492–1495, 2012.

B. McEwen and J. Morrison. The Brain on Stress: Vulnerability and Plasticity of the Prefrontal Cortex over the Life Course, 2013.

A. Moore and P. Malinowski. Meditation, mindfulness and cognitive flexibility. *Consciousness and Cognition*, 18(1):176–186, 2009.

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 managementa 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.

J. H. Patton, M. S. Stanford, et al. Factor structure of the barratt impulsiveness scale. *Journal of clinical psychology*, 51(6):768–774, 1995.

A. J. Porcelli and M. R. Delgado. Acute Stress Modulates Risk Taking in Financial Decision Making. *Psychological Science*, 20(3):278–283, Mar. 2009.

P. Putman, N. Antypa, P. Crysovergi, and W. A. J. Van Der Does. Exogenous cortisol acutely influences motivated decision making in healthy young men. *Psychopharmacology*, 208:257–263, 2010.

J. J. Radley, H. M. Sisti, J. Hao, A. B. Rocher, T. McCall, P. R. Hof, B. S. McEwen, and J. H. Morrison. Chronic behavioral stress induces apical dendritic reorganization in pyramidal neurons of the medial prefrontal cortex. *Neuroscience*, 125:1–6, 2004.

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.

D. Romer, L. M. Betancourt, N. L. Brodsky, et al. Does adolescent risk taking imply weak executive function? a prospective study of relations between working memory performance, impulsivity, and risk taking in early adolescence. *Developmental Science*, 14(5):1119–1133, 2011.

H. E. Rosvold, A. F. Mirsky, I. Sarason, E. D. Bransome Jr, and L. H. Beck. A continuous performance test of brain damage. *Journal of Consulting Psychology*, 20(5):343, 1956.

R. J. Semple. Does mindfulness meditation enhance attention? a randomized controlled trial. *Mindfulness*, 1(2):121–130, 2010.

F. Strack and R. Deutsch. Reflective and impulsive determinants of social behavior. *Personality and Social Psychology Review*, 8(3):220–247, 2004.

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.

R. H. Thaler and H. Shefrin. An economic theory of self-control. *Journal of Political Economy*, 89(2):392–406, 1981.

R. van den Bos, M. Harteveld, and H. Stoop. Stress and decision-making in humans: Performance is related to cortisol reactivity, albeit differently in men and women. *Psychoneuroendocrinology*, 34(10):1449–1458, Nov. 2009.

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.

B. Wansink, M. M. Cheney, and N. Chan. Exploring comfort food preferences across age and gender. *Physiology and Behavior*, 79(4):739–747, 2003.

H. Wenk-Sormaz. Meditation can reduce habitual responding. *Alternative Therapies in Health and Medicine*, 11(2):42, 2005.

WHO. *World Health Organisation: Global Status Report on Noncommunicable Diseases*. 2014.

Appendix for Online Publication

Appendix A: Recruitment Poster and Email

BEHAVIOURAL LABORATORY AT THE UNIVERSITY OF EDINBURGH

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.auk and indicate which option you would prefer.

Appendix B: Weekly Survey

Weekly survey

Q1 Please enter your desk number.

Q2 This survey aims to collect information on various aspects of your lifestyle and activities in the previous week. The survey takes around 30 minutes to complete. All data collected in this survey will be held anonymously and securely, and will be used for research purposes only. Please click next to continue.

Q3 Please enter your participant ID. This is the code consisting of letters and numbers on the card you were given at registration. Please don't put any spaces between the letters and numbers.

Q4 We would like to ask you some questions about your feelings on aspects of your life. There are no right or wrong answers. For each of these questions we'd like you to give an answer on a scale of 0 to 10, where 0 is 'not at all' and 10 is 'completely'.

	0 (1)	1 (2)	2 (3)	3 (4)	4 (5)	5 (6)	6 (7)	7 (8)	8 (9)	9 (10)	10 (11)
Overall, how satisfied were you with your life in the previous week? (1)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Overall, to what extent do you feel that the things you did the previous week were worthwhile? (2)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Overall, how happy are you these days? (3)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Overall, how happy are you right now? (5)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Overall, how anxious do	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍

you feel these days? (6)											
Overall, how anxious do you feel right now? (4)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍

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)	❑	❑	❑	❑	❑
Deep fried food, e.g. chips, onion rings, fried chicken, battered fish (2)	❑	❑	❑	❑	❑
Burgers, hot dog, pizza, sausage rolls (3)	❑	❑	❑	❑	❑
Potato crisps (4)	❑	❑	❑	❑	❑
Vegetable crisps (5)	❑	❑	❑	❑	❑
Popcorn, salted peanuts (6)	❑	❑	❑	❑	❑
Unsalted nuts, seeds (e.g. sunflower, pumpkin) (7)	❑	❑	❑	❑	❑
Pretzels, crackers, e.g. Ritz (8)	❑	❑	❑	❑	❑
Pies (savoury or sweet) (9)	❑	❑	❑	❑	❑
Cakes, muffins, brownies, cookies (10)	❑	❑	❑	❑	❑
Doughnut, pastry, e.g. Danish pastry, croissant, pain chocolat (11)	❑	❑	❑	❑	❑

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

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 of 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)	❍	❍	❍	❍	❍
Ate too much because you were upset, nervous or stressed. (2)	❍	❍	❍	❍	❍
Ate too much because you were bored or felt lonely. (3)	❍	❍	❍	❍	❍
Ate so much food so fast that you didn't know how much you ate or how it tasted. (4)	❍	❍	❍	❍	❍
Ate more than usual while preparing for an exam or working on an assignment. (5)	❍	❍	❍	❍	❍
Ate high calorie snacks while studying or working on assignments. (6)	❍	❍	❍	❍	❍

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)	❍	❍	❍	❍
Go to the cinema / theatre / concert (2)	❍	❍	❍	❍
Meet with friends (3)	❍	❍	❍	❍
Yoga / pilates / tai chi / chi gong or similar exercises (4)	❍	❍	❍	❍
Meditate / do breathing exercises / practice mindfulness (5)	❍	❍	❍	❍
Do sport activities (6)	❍	❍	❍	❍
Other (7)	❍	❍	❍	❍

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

Table 19: 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.	SE	Coeff.	SE	Coeff.	SE
MBSR	1.057	1.109	1.094**	0.467	0.462	0.462
Session 2	0.000	.	0.624	0.382	0.298	0.357
Session 3	0.000	.	1.066***	0.359	0.377	0.304
Session 4	0.000	.	0.213	0.387	-0.049	0.323
Session 5	0.000	.	0.457	0.371	-0.073	0.312
Session 6	1.156**	0.505	0.382	0.359	-0.084	0.282
Session 7	2.321***	0.873	0.839**	0.402	0.387	0.365
MBSR & Session 2	0.000	.	-0.844	0.593	-0.278	0.494
MBSR & Session 3	0.000	.	-0.926	0.595	-0.557	0.517
MBSR & Session 4	0.000	.	-0.153	0.576	-0.131	0.484
MBSR & Session 5	0.000	.	-0.164	0.554	0.130	0.490
MBSR & Session 6	-1.796*	0.951	0.038	0.585	0.184	0.474
MBSR & Session 7	-2.417*	1.344	-0.986	0.690	-0.510	0.604
Intercept	16.162**	7.253	6.546***	2.070	8.145***	2.205
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 D: The Impact of MBSR on Eating Habits (measures not reported in main text)

Table 20: The Impact of MBSR on Eating Habits (measures not reported in main text)

	Avoid fat		Eat high fibre		Eat regular (1 always to 4 never)		Snack, studying (0 never to 4 always)		Eat more while studying (0 to 4)		Eat because bored (0 to 4)		Eat much fast (0 to 4)	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
MBSR	-0.04	0.087	-0.082	0.083	0.028	0.14	0.17	0.244	-0.102	0.25	-0.21	0.168	0.161	0.18
Session 2		.		.	-0.086	0.079	-0.145	0.179	-0.441**	0.183	-0.516***	0.144	-0.197*	0.111
Session 3		.		.	-0.166*	0.096	-0.269	0.176	-0.617***	0.179	-0.596***	0.133	-0.373***	0.102
Session 4		.		.	-0.078	0.088	-0.401**	0.157	-0.793***	0.158	-0.758***	0.129	-0.270**	0.118
Session 5		.		.	-0.208**	0.085	-0.325**	0.158	-0.702***	0.182	-0.752***	0.135	-0.294**	0.119
Session 6	0.079*	0.048	-0.046	0.058	-0.183*	0.098	-0.125	0.167	-0.432**	0.171	-0.616***	0.126	-0.216*	0.119
Session 7	-0.005	0.064	-0.1	0.069	-0.051	0.106	.		.		-0.336**	0.144	-0.185	0.136
MBSR S2	.		.	0.062	0.124	0.206	0.269	0.391	0.272	-0.128	0	0.179	-0.133	0.167
MBSR S3		.		.	0.04	0.14	0.101	0.25	0.214	0.257	0.232	0.182	0.015	0.176
MBSR S4		.		.	-0.078	0.136	0.234	0.252	0.385*	0.227	0.241	0.185	0.058	0.168
MBSR S5		.		.	0.143	0.138	-0.149	0.261	0.354	0.254	0.201	0.196	-0.021	0.166
MBSR S6	-0.005	0.067	0.014	0.09	0.145	0.144	-0.101	0.26	0.198	0.246	0.084	0.189	-0.142	0.191
MBSR S7	0.08	0.08	0.135	0.093	-0.056	0.177	.		.		0.222	0.222	0.086	0.202
Intercept	1.848***	0.455	1.573***	0.412	1.868**	0.9	1.269	0.935	1.485	1.065	0.222	0.962	1.714**	0.723
Ind. RE	Yes		Yes		Yes		Yes		Yes		Yes		Yes	
Control var.	Yes		Yes		Yes		Yes		Yes		Yes		Yes	
No. of ind.	138		138		138		134		134		138		138	

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

Appendix E: 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 21: Evaluation of the Treatment and Control Intervention for Relaxation Purposes