Stress-induced eating and the relaxation response as a potential antidote

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Executive Overview

Stress-induced eating is characterised by the intake of nutrient-poor, energy dense food, in response to stress. This disordered manner of eating is being increasingly recognised as a contributing factor to the current rates of chronic lifestyle diseases prevalent in the world today. What research is yet to establish however, is how best to remedy this problem. Relaxation is the physiological and psychological opposite of stress and may therefore serve as a therapeutic antidote for stress-induced eating. Should relaxation be found to have a role in alleviating stress-induced eating, it would provide a client-centred, cost effective, non-pharmaceutical tool with beneficial side effects. The purpose of this thesis was to examine the effect of the relaxation response on appetite and energy intake after exposure to an acute stressor, and to explore the feasibility and preliminary efficacy of an 8-week relaxation intervention for altering stress and indicators of stress-induced eating.

Before addressing these issues, a preliminary study was conducted, aiming to establish the appropriateness of employing a laboratory stress test in a repeated measures design. Accordingly, the first study presented in this thesis (Chapter 2), is focussed on test-retest validity associated with the laboratory stressor known as the Trier Social Stress Test (TSST). Specifically, previous research has shown that repeated application of the TSST can lead to an attenuated stress response, thereby limiting its use in research where multiple stress exposures are required (i.e. in order to evaluate the effect of an intervention). This study tested the effectiveness of a protocol to reduce habituation to the TSST. Twenty-two healthy men and women undertook the TSST on 2 different occasions separated by ≤ 8 weeks. For the second TSST, participants were informed that their performance during their first TSST was in the lower range of scores, the tasks in the TSST were slightly altered, and

personnel on the judging panel were changed. Cortisol, blood pressure, heart rate, and ratings of perceived stress were compared between exposures. The physiological (cortisol, blood pressure, heart rate) and psychological stress response elicited by the TSST was equivalent between trials ($p > 0.05$). The findings of this study illustrated the effectiveness of small modifications to the TSST to prevent habituation with repeated administration, thus providing a protocol for its use in research where repeated exposure to stress is required (i.e. the studies described in Chapters 3 and 4).

The aim of the second study in this thesis (Chapter 3) was to determine whether relaxation practice in the aftermath of experiencing an acute stressor, or in isolation, can attenuate stress-induced eating. This crossover trial involved 25 men and women that attended the laboratory on four separate occasions, during which time they were administered the following conditions: an acute laboratory stressor (S; TSST), the acute stressor followed by 20 minutes of Abbreviated Progressive Muscle Relaxation (APMR) (SR), APMR alone (R), and a control session (C). Both physiological (heart rate, blood pressure, and cortisol) and psychological (perceived stress and relaxation) responses to stress and relaxation were assessed, as well as the measurement of appetite, appetite hormones, and subsequent energy intake of nutrient poor, energy-dense snack foods from a laboratory test meal. Salivary cortisol, BP, HR, and perceived stress were transiently elevated in response to the laboratory stressor (S and SR compared with R and C; $p < 0.05$); while perceived relaxation was acutely elevated in response to APMR alone (R) compared with S, SR and C ($p < 0.05$), and in SR compared with S immediately after the APMR component ($p < 0.05$). However, no difference in mean total energy intake from the laboratory test meal was observed between the conditions ($p > 0.05$). Likewise, no differences in perceived appetite or the circulating

concentrations of appetite-related hormones ghrelin, leptin and insulin were noted ($p > 0.05$).

Given that a single 20-minute dose of APMR did not significantly alter subsequent energy intake either after an acute stressor, or in isolation, this raised the question of whether regular practice of relaxation may be more potent in overcoming the impetus to stress-induce eat – a possible long ingrained behavioural response. Therefore, the final study of this thesis (Chapter 4) investigated the feasibility and preliminary efficacy of an 8-week, worksite-based, relaxation intervention to address psychological stress and reduce unhealthy food intake. Thirty-six men and women provided baseline data (BMI, general psychological characteristics, palatable food intake, and degree of cravings), and attended a laboratory session in which they were exposed to an acute stressor (TSST) during which physiological and psychological responses were assessed, prior to being offered a laboratory test meal. Participants were then randomised to either a relaxation group (RELAX) (which required attendance to a once-weekly relaxation class, and maintenance of a home-based, daily 20-minute relaxation/mindful meditation practice for 8 weeks), or a waitlist control group (CON). All measures were repeated after the 8-week intervention period. Compliance to the intervention was high (80% ± 19% face-to-face; 79% ± 18% scheduled home practice), with each session acutely reducing perceived stress and increasing relaxation ($p < 0.001$). Relative to the control group, trait mindfulness was increased pre- to post-intervention ($p = 0.025$), and reduced tension ($p = 0.013$) and increased relaxation ($p < 0.05$) was noted during the acute stress exposure in the intervention group after the 8-week program. Other aspects of the acute stress response remained unchanged, and no differences in energy intake, palatable eating, or cravings were observed, across time or between groups, with only small effect sizes noted. This study demonstrated that a daily

20-minute practice of mindful relaxation is feasible, has benefits for mindfulness and stress, but may not exert strong effects on appetite and food intake.

In summary, this thesis represents the first study of the role of relaxation in the alleviation of stress-induced eating, and importantly, considers the practical applicability of implementing a regular relaxation practice. We live in an era where very few are immune to the harmful effects of psychosocial stress, and nutrient-poor, energy-dense foods that are manufactured to appeal to our tastes are highly accessible – a concern for those vulnerable to stress-induced eating. We are therefore in dire need of self-care tools that enhance resilience, yet do not ironically impose time or financial pressure. While eliciting the relaxation response appears to be beneficial for psychological aspects of the stress response, the effects on appetite and energy intake appear to be limited. Nonetheless, this thesis lays the groundwork for further investigation on how best to empower the individual to counteract the harmful dietary effects of psychosocial stress, which are likely contributing to the current global prevalence of preventable lifestyle disease.

Authorship Declaration: Co-authored Publications

This thesis contains work that has been published and prepared for publication:

Masih, T., Dimmock, J. A., Epel, E. S., & Guelfi, K. J. (2017). Stress-induced eating and the relaxation response as a potential antidote: A review and hypothesis. *Appetite, 118*, 136-143. doi: 10.1016/j.appet.2017.08.005.

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This paper appears in Chapter 2

Masih, T., Dimmock, J. A., & Guelfi, K. J. (2017). The effect of a single, brief practice of progressive muscular relaxation after exposure to an acute stressor on subsequent energy intake (*prepared for submission).*

This paper appears in Chapter 3

Masih, T., Dimmock, J. A., Epel, E. S., & Guelfi, K. J. (2017). An 8-week relaxation program to reduce stress, and attenuate stress-driven eating: A randomised feasibility trial (*prepared for submission*).

This paper appears in Chapter 4

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List of Abbreviations

APMR	Abbreviated progressive muscle relaxation
BMI	Body mass index
BP	Blood pressure
bpm	Beats per minute
C	Control session (Chapter 4)
CON	Control group (Chapter 4)
HR	Heart rate
Kcal/d	Kilocalories per day
kJ	Kilojoules
MM	Mindfulness meditation (Chapter 4)
PMR	Progressive muscular relaxation
R	Relaxation session (Chapter 4)
RELAX	Relaxation group (Chapter 4)
S	Stress session (Chapter 4)
SR	Stress – Relaxation session (Chapter 3)
VAS	Visual analogue scale

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I dedicate this thesis to you, my parents, in response to what I have heard you say since I was a little girl: our duty in life is to seek, disseminate knowledge, and to help those in need.

Proclaim! And thy Lord is most bountiful,

He who taught (the use of) the Pen,

Taught man that which he knew not.

(The Holy Qur'an: Sura Iqra 96: 3 – 5)

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Thesis Declaration

I, Tasmiah Masih, certify that:

This thesis has been substantially accomplished during enrolment in the degree.

This thesis does not contain material which has been submitted for the award of any other degree or diploma in my name, in any university or other tertiary institution.

No part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of The University of Western Australia and where applicable, any partner institution responsible for the joint-award of this degree.

This thesis does not contain any material previously published or written by another person, except where due reference has been made in the text and, where relevant, in the Declaration that follows.

The work(s) are not in any way a violation or infringement of any copyright, trademark, patent, or other rights whatsoever of any person.

The research involving human data reported in this thesis was assessed and approved by The University of Western Australia Human Research Ethics Committee. Approval #: RA/4/1/6429.

Written patient consent has been received and archived for the research involving patient data reported in this thesis.

Prior to commencing the relevant work described in this thesis, approvals were obtained from the participating organisations involved in the study described in Chapter 4.

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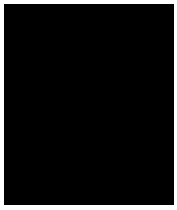
The work involved in the design, implementation and documentation of the research described in this thesis was completed primarily by Tasmiah Masih (the candidate). Under the guidance and support of Dr Kym Guelfi (coordinating supervisor) and Dr James Dimmock (co-supervisor), the candidate, was responsible for the synthesis, planning, and conducting of the experimental protocols, and the analysis and interpretation of data. In addition, original drafting of this thesis and manuscripts (as described on page V) was the responsibility of the candidate. Additional assistance was provided by Professor Elissa Epel in the drafting of the manuscript upon which Chapters 1 and 4 are based. As this thesis contains published work and/or work prepared for publication, some of which has been co-authored, permission has been granted by Dr Kym Guelfi, Dr James Dimmock, and Professor Elissa Epel for inclusion of these papers in this thesis.

Signature:  Date: 20/04/2018

I, Dr Kym Guelfi, certify that the student statements regarding contribution to each of the works presented in this thesis are correct

Coordinating supervisor signature:  Date: 20/04/2018

Chapter 1: Literature Review

As based on a paper *reviewed* and *published* by *Appetite:*

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1.1 Introduction

Stress-induced eating is characterised by an increased intake of energy-dense, highly palatable food when faced with psychological stress (Gibson, 2012; McEwen, 2008). Indeed, numerous studies over the last 20 years have shown that stress leads to a change in eating behavior (Block, He, Zaslavsky, Ding, & Ayanian, 2009; Born et al., 2009; Dallman, 2010; Epel, Lapidus, McEwen, & Brownell, 2001; Kandiah, Yake, Jones, & Meyer, 2006). As a result, research has served to highlight the prevalence of this problem (Diggins, Woods-Giscombe, & Waters, 2015; Mouchacca, Abbott, & Ball, 2013), delineate the underlying physiological and psychological drivers (Merali, Graitson, Mackay, & Kent, 2013; Pool, Delplanque, Coppin, & Sander, 2015; Rower, Maria Teresa, Tonantzin, & Pattussi, 2017), as well as attempt to identify those individuals most vulnerable to stress-induced eating (Darling et al., 2017; Neseliler et al., 2017; Rodrigues et al., 2017). However, potential solutions remain elusive. This literature review explores the proposal that elicitation of the relaxation response, the very opposite of the stress response, may alleviate stress-induced eating. The stress response and the relaxation response will be outlined, followed by an overview of the problem of stress-induced eating, including the possible physiological and psychological drivers involved. The potential role of relaxation in attenuating this issue will then be addressed, along with the mechanism by which this effect may be achieved.

1.2 The stress response versus the relaxation response

Stress is commonly defined as a physiological and psychological state in which the demands upon an individual are perceived as outweighing the resources available to contend with

them (Lazarus & Folkman, 1984). A stressor may be of a physical or psychological nature, or simply the anticipation of such (McEwen, 2008). The acute physiological response to the stressor, or the 'flight or fight' response, sees that energy stores are mobilised and cardiovascular efforts are aimed at the delivery of essential nutrients to areas of high priority (McEwen, 2005). While the primary objective of this acute stress response is to ensure survival of the organism, unnecessary and/or chronic elicitation of the stress response (known as chronic stress) can have deleterious effects on the body (McEwen, 2008). For instance, it is now believed that chronic stress can have a role in the development of coronary heart disease and depression (Glozier et al., 2013; Hammen, 2005; Lagraauw, Kuiper, & Bot, 2015). Stress has also been implicated in the cluster of abnormalities comprising the metabolic syndrome, particularly by way of its involvement with the inflammatory process (Black, 2006; Eckel, Alberti, Grundy, & Zimmet; Rosmond, 2003).

In contrast, the relaxation response is the parasympathetic physiological opposite of the stress response. First defined by Herbert Benson (Benson, Greenwood, & Klemchuk, 1975), the relaxation response involves four basic components including: 1) a mental focus: a repetitive sound, words or visual stimulus such as a symbol by which to minimize distraction, 2) a non-judgmental attitude: to allow the recognition and passing of thoughts, 3) decreased muscular tone: the posture to be held during the practice should be relaxed, 4) a quiet environment: often with the eyes closed (Benson et al., 1975). It is important to note that 'relaxation' is not referred to here as engaging in pleasant activities that are popularly thought of as relaxing, such as occasional hobbies, watching television, or socializing, or even massage. Nor is relaxation considered to refer to all forms of mind-body

practices, such as yoga or tai chi, as it cannot be assumed that all of these practices unequivocally elicit the relaxation response. Furthermore, for those mind-body practices that do elicit the relaxation response, it is unclear whether it is this specific component of the practice that provides benefit, or the holistic effects of such activities on both the body and the mind.

Regardless, it is well established that relaxation reduces general stress (for example, Chellew, Evans, Fornes-Vives, Pérez, & Garcia-Banda, 2015). Indeed, the earliest studies that drew attention to relaxation as a potential healing modality were prompted by 'hypometabolic' changes seen in transcendental meditators. Such changes, distinct from those seen in sleep, included a decrease in oxygen consumption, carbon dioxide production, respiratory rate, and alterations in brainwave activity (Wallace, Benson, & Wilson, 1971). Other studies have reported reduced levels of stress hormones (such as cortisol) and central nervous system arousal in response to relaxation (Chellew et al., 2015; Dolbier & Rush, 2012; Jacobs, 2001), reduced anxiety and depression (Manzoni et al., 2009) , in addition to heightening positive affect (Jain et al., 2007; Unger, Busse, & Yim, 2017). The notion that elicitation of the relaxation response may also attenuate stress-induced eating is discussed below.

One of the oldest and most widely documented relaxation techniques is progressive muscle relaxation (PMR) (Chellew et al., 2015; Dolbier & Rush, 2012; Georgiev et al., 2012). This technique was first proposed by Jacobsen (Jacobsen, 1938), and later modified to a shorter, more practical version known as 'Abbreviated Progressive Muscle Relaxation' (APMR) (Bernstein & Borkovec, 1973). This technique is based on the assumption that psychological stress creates tension in the muscles. It is comprised of the sequential tensing and relaxing

of 16 muscle groups, raising awareness of the opposing feelings of tension versus relaxation, leading to the release of physical tension, and subsequent psychological relaxation (Bernstein & Borkovec, 1973). A review of APMR research published in 1993, which included 29 studies, extracted an effect size of d = 0.9 - indicating that APMR was an effective means by which to clinically treat conditions such as headache, hypertension, and the side-effects of chemotherapy for cancer (Carlson & Hoyle, 1993).

An alternate pathway through which the relaxation response may be achieved is mindfulness meditation (MM) (Benson et al., 1975), defined as the purposeful, non-judgmental focus on the present moment (Kabat-Zinn, 2003). Importantly, the aim of mindfulness meditation is not to evoke the relaxation response, although this may be an unintended consequence (Baer, 2003; Ishii, Suzuki, & Haruki, 2007). For example, Warnecke, Quinn, Ogden, Towle, and Nelson (2011) demonstrated that an 8- week intervention comprised of a daily 30-min guided MM practice for 8 weeks resulted in a reduction in general stress and anxiety, which was sustained 8 weeks post-study completion. However, the degree to which meditation is relaxing may be variable, as argued by Lumma, Kok, and Singer (2015), who found that styles of meditation requiring relatively greater cognitive effort (such as focus on thoughts, or on the cultivation of positive feelings) were less relaxing (both psychologically and physiologically) than a meditation focused on the breath. Therefore, consideration must be given to the method by which relaxation is achieved when testing the hypothesis that relaxation might attenuate stress-induced eating. Others report that both mindfulness practice and an integrated relaxation program (including PMR) have been shown to improve positive states of mind and reduce distress to a similar extent (Agee, Danoff-Burg, & Grant, 2009; Jain et al., 2007).

However, PMR may be more effective in reducing somatic aspects of stress (Matsumoto & Smith, 2001; Rausch, Gramling, & Auerbach, 2006), while mindfulness practice is focused on addressing cognitive components of stress, especially rumination (Jain et al., 2007), automaticity (Fisher, Lattimore, & Malinowski, 2016), and promoting non-judgemental acceptance of the present moment (Alberts, Thewissen, & Raes, 2012). Since both cognitive and physiological elements of stress may play a role in promoting the intake of palatable food (Masih, Dimmock, Epel, & Guelfi, 2017), the combination of PMR and MM in a single intervention may offer a promising approach to reduce stress-induced eating.

1.3 The problem: Stress-induced eating

The phenomenon of stress-induced eating has been previously reviewed (Adam & Epel, 2007; Fink, 2016; Maniam & Morris, 2012; Rabasa, Dickson, Rabasa, & Dickson, 2016; Torres & Nowson, 2007). Indeed, numerous studies have demonstrated that *food choice* is markedly affected by stress (Dallman, 2010; Roberts, Campbell, & Troop, 2014). More specifically, preference for high fat-high sugar foods has been repeatedly documented (Epel et al., 2001; Macht, 2008; Newman, O'Connor, & Conner, 2007; Rutters, Nieuwenhuizen, Lemmens, Born, & Westerterp-plantenga, 2009). In parallel, reductions in the intake of nutritious mealtime foods such as vegetables during times of stress has been reported (Ledoux et al., 2012; Mikolajczyk, El Ansari, & Maxwell, 2009; O'Connor, Jones, Conner, McMillan, & Ferguson, 2008; Unusan, 2006). Stress, therefore, may foster dietary habits that are in conflict with healthy eating guidelines, likely predisposing individuals to increased risk of chronic diseases, particularly the cluster of abnormalities associated with the metabolic syndrome (Mendoza, Drewnowski, & Christakis, 2007; Mikolajczyk et al., 2009). In addition, given that excess energy intake by as little as 50-100 kcal/d can result in

weight gain of clinical concern in the long-term (Mozaffarian, Hao, Rimm, Willett, & Hu, 2011), stress may be an important driver of poor dietary habits leading to weight gain, potentially contributing to the worldwide epidemic of obesity (Jauch-Chara & Oltmanns, 2014; Sinha & Jastreboff, 2013). Of equal relevance, research also highlights the role of stress in the development of diagnosed conditions of uncontrolled eating such as binge-eating disorder and bulimia (Hilbert, Vögele, Tuschen-Caffier, & Hartmann, 2011; Smyth et al., 2007; Sulkowski, Dempsey, & Dempsey, 2011). Notwithstanding these issues, it should be acknowledged that there is significant inter- and intra-individual variation in the precise effect of stress on *total* energy intake (Wallis & Hetherington, 2009; Yeomans & Coughlan, 2009). Admittedly, the dietary response to stress can be subject to a vast array of physiological and psychological factors, including perception of stressor type, length, intensity, and the impact of environment (Adam & Epel, 2007). These factors are discussed later (section 1.6.4).

1.4 The relaxation response – a potential antidote for stress-induced eating?

Stress has the potential to increase the intake of unhealthy energy-dense foods, and relaxation is purported to be the physiological opposite to stress (Adam & Epel, 2007; Wallace et al., 1971). It is therefore reasonable to suggest that elicitation of the relaxation response may be protective in those susceptible to stress-induced eating. Yet, despite a plethora of research devoted to stress-induced eating, the effect of the relaxation response on stress-induced eating has not been directly examined. Nonetheless, there is some evidence to suggest that relaxation can affect appetite. Pawlow and colleagues (2003), for example, reported reduced feelings of evening hunger after one week of daily home-based

guided APMR in individuals suffering from night-eating syndrome. A 3-week practice of APMR was also shown to reduce evening dietary intake amongst individuals with night-eating syndrome in a study by Vander Wal, Maraldo, Vercellone, and Gagne (2015). Meanwhile, others have observed reductions in emotional eating in obese emotional eaters compared with waitlist controls 3 months following a 3-week intervention period consisting of regular relaxation that incorporated PMR in conjunction with exposure to calming visual images (Manzoni et al., 2008; Manzoni et al., 2009). In another study of obese women, Christaki et al. (2013) compared an integrated stress reduction program consisting of dietary and stress management training (including PMR) with a control group that received dietary advice alone. Relaxation participants were required to maintain a twice daily home practice of relaxation for eight weeks. The eight-week program resulted in greater weight loss in the relaxation group compared with the control group. The authors attributed the encouraging results to greater compliance with a dietary regime and higher restrained eating scores due to relaxation training, despite no change in perceived stress levels (Christaki et al., 2013). Similarly, Alert et al. (2013) reported that an integrated mind-body intervention for overweight and obesity (which included relaxation training), led to improvements in awareness and behavior related to eating, as well as weight loss. Also of relevance, based on the understanding that mindfulness practice may include some components of the relaxation response (Benson et al., 1975), an emerging body of research supports a role for mindfulness in the treatment of disordered eating (Haynos, Forman, Butryn, & Lillis, 2016 ; Mason et al., 2016), and the intake of energy dense foods (Fisher et al., 2016). For example, Jordan, Wang, Donatoni, and Meier (2014) demonstrated that a brief 15-minute body scan led to 24% less energy intake in a sham taste test of snack foods relative to a control group amongst male and female university students. Therefore, even if not always necessarily

relaxing, mindfulness practice may therapeutically complement the effect of other relaxation techniques in alleviating dysregulated eating.

Taken together, these findings suggest a potential role for relaxation in the regulation of food intake, although no research has specifically investigated whether relaxation can attenuate stress-induced eating. It is proposed, therefore, that relaxation may provide a simple, cost-efficient, patient-centered approach to disrupt stress-induced eating at two critical points; 1) in ameliorating the stress response itself, and/or 2) intervening at the stage at which the stress response leads to stress-induced eating. Given that stress may affect appetite through both physiological and psychological mechanisms, a discussion of how relaxation may play an equivalent opposing role in both respects follows.

1.5 Physiological mechanisms by which relaxation may attenuate stress-induced eating

Normal appetite (or the desire to eat) is determined by the integration of homeostatic (metabolic requirements of the body) and hedonic control (the body's drive for seeking reward and pleasure) (Begg & Woods, 2013). Research indicates that stress influences the impetus to eat; however, the precise mechanism by which homeostatic and hedonic control of appetite interact during stress is yet to be elucidated. It is evident, however, that a complex interaction of appetite-related neuropeptides and stress hormones are involved, and relaxation may have the potential to influence some of these.

1.5.1 Homeostatic determinants of appetite during stress

1.5.1.a Cortisol

The physiological stress response involves a coordinated neuro-endocrinological cascade of events that involves a number of hormones that may influence subsequent eating. However, cortisol is most commonly implicated in stress-eating, with levels beginning to increase between 15 minutes to 60 minutes after the onset of an acute stressor (Sapolsky, Romero, & Munck, 2000). Experimental evidence for the stimulatory effect of cortisol on appetite has been found in humans, with peak cortisol release (in response to intravenously administered corticotropin-releasing hormone) corresponding with increased ad libitum intake of snack foods in comparison with a placebo infusion (George, Khan, Briggs, & Abelson, 2010). Likewise, daily oral administration of 40 mg of cortisol over four days in healthy males resulted in a significant increase in total daily ad libitum energy intake, compared with a placebo group (Tataranni, Larson, Snitker, & Young, 1996). In relation to an acute stress-induced increase in cortisol, Epel et al. (2001) stratified participants according to a median division of their total cortisol release in response to a laboratory stressor. Those participants with a high cortisol response ate more energy dense foods compared with those participants exhibiting a low cortisol response to stress. In a separate study, participants exhibiting the highest cortisol response to a similar laboratory stressor were more likely to snack in response to daily life hassles compared with those individuals with a low cortisol response (Newman et al., 2007). In contrast, Appelhans and colleagues (2010) found that acute stress-induced intake amongst obese women was inversely related to cortisol response, compared with a healthy weight control group in which dietary intake was unaltered by the magnitude of cortisol response. This inconsistency in past research may be related to variability in individual sensitivity to stress, the ability to adapt, the acute

versus chronic nature of the stressor, and how this is reflected in the cortisol response and consequent dietary intake.

Although no studies have directly examined whether relaxation can reduce stress-induced eating, there is evidence in the literature that relaxation can attenuate the cortisol response to stress. Pawlow and colleagues (2003) found that a 20-minute session of guided relaxation (APMR) - administered before and after a week of daily home-based practice - reduced salivary cortisol levels and subjective reports of stress and anxiety compared with a control group. Chellew et al. (2015) also reported reductions in cortisol levels following a series of five 45-minute sessions of PMR held over a week. Similar findings are reported by others (Krajewski et al., 2011; Pawlow & Jones, 2005); however, the implications of these changes for eating behavior remain to be determined.

1.5.1.b Insulin, ghrelin, and leptin

Other hormones that may play a role in mediating the relationship between stress and energy intake include insulin, ghrelin, and leptin. Although insulin is considered an anorexigenic hormone (Könner, Klöckener, & Brüning, 2009), in tandem with high levels of cortisol, and the presence of energy dense palatable food, insulin may promote consumption, thus acting to palliate the chronic hypothalamic-pituitary axis (HPA) activation associated with prolonged stress (Dallman, 2010). This may occur at the cost of increased risk of abdominal obesity and associated metabolic imbalance. In support of this, Epel et al. (2004) found that in a group of 131 university students, those that were self-reported stress-hyperphagics had higher cortisol and insulin profiles compared with their hypophagic counterparts during periods of high academic stress.

Meanwhile, ghrelin exerts its orexigenic effect through both homeostatic and hedonic pathways, and is known to rise during stress (Rouach et al., 2007). Rouach et al. (2007) undertook one of the first studies in humans to show that the commonly used laboratory stressor, the Trier Social Stress Test, increased the concentration of both cortisol and ghrelin. However, the rise in ghrelin seen by Rouach et al. (2007) was not strongly correlated with the self-reported compulsion to eat, although self-reported measures may not necessarily represent true behavior when actually in the physical presence of palatable food (Adams, Greenway, & Brantley, 2011). This stress-induced rise in ghrelin has been confirmed by others (Jaremka et al., 2014; Monteleone et al., 2012), while some studies have not reported significant alterations in ghrelin with stress (Macedo & Diez-Garcia, 2014; Raspopow, Abizaid, Matheson, & Anisman, 2010). Studies specifically addressing the response of leptin and energy intake to an acute stressor indicate great variation in leptin reactivity, with those individuals with a lower leptin response having greater subsequent food intake. For instance, Appelhans (2010) observed an inverse relationship between stress-induced intake and leptin levels following an acute mental stressor, independent of BMI. A later study by Tomiyama et al. (2012) specifically highlighted increased intake of high energy food being related to lower plasma leptin after exposure to an acute lab-stressor, also independent of BMI.

While there is evidence in the literature that relaxation can attenuate the response of cortisol to stress, no research to date has examined the effect of eliciting the relaxation response on the circulating concentrations of insulin, ghrelin, and leptin, which also appear to have a role in stress-induced eating. Future research is needed to address this issue.

1.5.2 Hedonic influences on appetite during stress

In addition to the above-mentioned pathways through which stress may influence dietary intake, it is acknowledged that the hedonic reward system may also play a significant role in determining dietary intake in response to stress (Yau & Potenza, 2013). For instance, a Brazilian study reported that 77% of women suffering from stress reported having sweet cravings (defined as "a strong desire to eat sweet foods over the last 3 months"), compared with only 31% in individuals assessed as not stressed (Macedo & Diez-Garcia, 2014). Others claim that acute stress can manifest in reduced sensitivity to the perception of sweetness (Al'absi, Nakajima, Hooker, Wittmers, & Cragin, 2012), while Luckett et al. (2015) showed that chronically stressed individuals found the look and taste of low-calorie chips less acceptable compared with less stressed individuals. This finding was in agreement with Born et al. (2009), who reported that acutely stressed participants sought more richness of taste compared with their control counterparts. Thus, stress may alter the reward activation system such that increased dietary intake is necessary to obtain the usual reward (Born et al., 2009).

The manner in which reward, stress, and appetite interact is unclear, although the appetite-related hormones previously discussed may play a role. For instance, the anorexigenic function of insulin may in part be achieved by reducing the rewarding value of food, as evidenced by insulin receptors in the limbic system (Davis, Choi, & Benoit, 2010). In regard to insulin's effect on reward pathways during stress, Jastreboff et al. (2013) found that insulin resistance in a group of obese women was positively correlated with activation in reward centers in the brain after exposure to personalized stressful scenarios and palatable

food prompts. Thus, insulin resistance and sensitivity may play a role in motivating the intake of palatable food when stressed.

Similarly, researchers focusing on the hedonic influence of ghrelin postulate that eating palatable food may ameliorate the stress response via reward pathways that involve the neurotransmitters, serotonin and dopamine (Malik, McGlone, Bedrossian, & Dagher, 2008). Dopamine acts to create the motivation (known as 'incentive salience') to obtain what is desired (such as highly palatable food) (Berridge & Robinson, 2003). Accordingly, during stress, dopamine release may motivate the search for distraction and palatable food, or heightened alertness to unhealthy food cues (Morris, Beilharz, Maniam, Reichelt, & Westbrook, 2015). In support of this notion, intravenous injection of ghrelin in humans undergoing magnetic resonance imaging resulted in activity in brain regions associated with reward (Malik et al., 2008). More specifically, injection of ghrelin into reward areas has been shown to increase dopamine release in rodents, as well as increase subsequent dietary intake (Abizaid et al., 2006). Leptin, on the other hand, has been shown to reduce dopamine action, the hedonic appeal of food, and subsequent urges to eat in rodents (Hommel et al., 2006). However, Burghardt et al. (2012) found that leptin levels were positively associated with dopamine release in reward areas after exposure to a laboratory pain stressor in healthy men and women. The apparent inconsistency demonstrated in this study may reflect the specific changes seen under the influence of stress, and particularly, a physical stress. Alternatively, it may illustrate the diverse action of leptin on functionally distinct groups of dopamine neurons, yet to be identified (Opland, Leinninger, & Myers, 2010).

Research related to stress-eating and reward is still in its infancy; however, there is some evidence that reward areas of the brain are also affected by relaxation (Jastreboff et al., 2011). This suggests the intriguing notion that relaxation may provide a counteracting stimulus for dopamine, thus overriding the need to stress-induce eat. In other research, relaxation meditation (which may also induce the relaxation response) (Esch, Fricchione, & Stefano, 2003) has been shown to produce a 65% increase in dopamine release (a key player of reward) in the ventral tegmental area of the brain (Kjaer et al., 2002). Future research is needed to explore the possibility of whether relaxation–mediated increases in dopamine release influence stress-induced eating.

1.5.3 Interrelationships between physiological mechanisms

In summary, each of the hormones discussed have both a metabolic and hedonic role. As to which component is dominant during times of stress remains unknown. Although research has identified apparent independent roles of cortisol, insulin, ghrelin and leptin (amongst a large number of other polypeptides mediating appetite), this oversimplifies the complexity of the stress-appetite system. It is probably more correct to state that each hormone is subject to the effect of the other components in the system, with varying sensitivity and responses depending on the individual and whether acute or chronic stress is at play. Stress-induced eating can thus be described as a neurobiological interplay of energy homeostasis and brain reward mechanisms falling prey to a maladapted stress response system in an environment that offers symptomatic relief by way of highly palatable, readily available processed food (Jauch-Chara & Oltmanns, 2014). If the stress response is the original impetus for stress-induced eating, intuitively, the effects of relaxation may offer a means by which to reduce stress, and the concomitant desire to stress-induce eat. As to

how these physiological mechanisms manifest in behavior when stressed, or when relaxed, leads to a consideration of the psychological aspect of the stress response.

1.6 Psychological mechanisms by which relaxation may attenuate stress-induced eating

The psychological effects of stress may lead to cognitive, emotional, and behavioral consequences that may impact food choice, either in isolation or through interaction (Kandiah et al., 2006). They may be deliberate and conscious attempts to comfort oneself, or unconscious and driven more by habit for reduction of negative affect. Here, some of the findings from research on psychological factors associated with stress-induced food consumption are reviewed, along with consideration of whether relaxation may play a role in moderating these responses.

1.6.1 Stress, cognition and behavior

Consistent with the strength model of self-control (Muraven & Baumeister, 2000), coping in the face of stress, along with the required regulation of aversive thoughts, emotions, and behaviors, draws on one's finite ability to maintain self-control (Muraven & Baumeister, 2000). Thus, high stress impairs planned behavior and can lead to more automatic and unconscious actions to seek highly palatable food that is easy to access. Cognitive consequences of stress include an inability to focus, ruminative thinking (the dwelling on one's thoughts), and thinking the worst of a situation (Gianferante et al., 2014), all of which may compromise one's ability to make an informed decision regarding food choice (Dallman, 2010). In support of this notion, Kandiah et al. (2006) found that academic stress in female college students was associated with an increase in appetite coupled with less

care for healthy dietary practices. While 80% of the study participants believed they made healthy choices normally, only 33% did so during times of stress imposed by personal, environmental, and academic pressure. Likewise, Sims and colleagues (2008) found that perceived stress was associated with less ordered meal planning and eating in response to emotional cues in a group of African American men and women.

1.6.2 Stress and emotion regulation

Stress leads to a range of negative emotions, and eating may be used, both consciously and unconsciously to down-regulate negative affect. Increased intake of energy-dense foods in response to negative mood states may be related, in part, to the presence of a negative feedback system between mood and food. For example, Macht and Mueller (2007) showed that consumption of palatable chocolate alleviated laboratory induced-negative mood compared with eating less palatable chocolate or eating nothing. The effect was seen instantly but lasted only a few minutes, thus potentially promoting overeating in order to prolong the desirable effect (Macht & Mueller, 2007). The consumption of foods that are perceived as personally enjoyable can be seen, therefore, as a means to avert the negative feelings associated with stress, giving rise to the term 'comfort foods' (Dallman, Pecoraro, & la Fleur, 2005). More recently, however, Wagner, Ahlstrom, Redden, Vickers, and Mann (2014) published findings demonstrating that the intake of comfort foods was no more mood elevating than foods perceived as neutral, or no food at all, after exposure to a negative mood induction, thus, serving to illustrate that mood is yet another variable further complicating our understanding of stress-induced eating.

While the remedial effect of palatable food consumption during stress is the most commonly stated cause of stress-eating, an interesting alternate hypothesis is presented by

Pool et al. (2015). These researchers suggest that stress may actually reduce the enjoyment associated with high energy food (thereby encouraging greater intake to attain the same pleasurable experience), promoting increased awareness of surrounding stimuli (palatable food or food cues), and increased motivation to access high energy foods. This behavior is not motivated by wanting to reduce the initial stressor (as is the motivation purported by some physiologists). Rather, stress may exhaust the ability of the individual to employ goal-driven behavior, leading one to succumb to habit-driven behavior, potentially leading to mindless eating (Neal, Wood, & Drolet, 2013; Pool et al., 2015).

1.6.3 Stress, coping style and drive to eat

A plausible unifying theory that may explain stress-induced eating, whether it be conscious planned behavior or an automatic response, is that proposed by Heatherton and Baumeister (1991). These researchers proposed that a stressful task can heighten one's awareness of his/her inadequacies or inabilities to cope. The resulting aversive state may then prompt the seeking out of an escape/avoidance, or relief from the external environment, in the form of palatable food intake. Thus, stress-induced eating according to this theory allows for a state of reduced self-awareness (Heatherton & Baumeister, 1991). Accordingly, the coping style (involving cognitive and subsequent behavioral responses to stress) of the individual may be an important moderator of the relationship between stress and unhealthy eating (Raspopow et al., 2010). Broadly categorized, individuals may utilise a coping response that involves a problem solving approach (aiming to manage the stressor), an emotion-focused approach (eating to regulate the emotional reaction to the stressor), or an avoidance focused approach (turning to food as a distraction or to seek distance from the stressor) (Raspopow et al., 2010). Expectancies related to reinforcement from eating may

also constitute a mechanism for stress-induced eating. In other words, an individual's drive to eat in response to stress may be influenced by the expectation that such behavior will lead to escape, the ability to cope, provide comfort, or reward, and alleviate negative affect (Combs, Smith, & Simmons, 2011). In support of this mechanism, numerous studies have shown that expectancies for reinforcement from eating predicts disordered eating behavior (e.g., Fischer, Settles, Collins, Gunn, & Smith, 2012; Smith, Simmons, Flory, Annus, & Hill, 2007)

1.6.4 Characteristics of the stressor and individual stress appraisal

In addition to individual attributes that may influence the association between stress and eating, characteristics of the stress stimuli itself are an important consideration. Indeed, the type of stress (psychological versus physical, for instance) can produce varying effects on appetite, with more psychological stressors leading to overeating in contrast with physical stressors (O'Connor et al., 2008). Furthermore, the nature of the psychological stressor and whether an ego-threat is involved may also be of relevance, with ego-threat resulting in increased dietary intake and stress associated with trauma leading to a reduction in energy intake (Jaremka et al., 2014). As previously discussed, the length of exposure to a stressor (acute versus chronic) is also an important factor leading to variation in the stress response (Dallman et al., 2003).

Derived from theories of stress appraisal, more recently, some researchers have posited that it may not be stress, per se, that leads to negative health consequences, but rather one's *perception* of the likely negative consequences of stress (Crum, Salovey, & Achor, 2013; Lazarus & Folkman, 1984). This notion has been identified as one's "stress mindset", which is one's perception of how harmful or beneficial stress is. Hence, re-appraising stress

in a positive way – by focusing on the components of the stress response that allow an individual to survive in the wake of a challenge (increased arousal, sharpness, improved immunity, intellectual growth) may offset the potentially harmful effects of stress on the body by not only influencing behavioral outcomes, but by also influencing hormonal effects leading to health and wellbeing (Crum et al., 2013). Whether this influences the relationship between stress and subsequent energy intake remains to be elucidated.

1.6.5 Effect of the relaxation response on psychological pathways for stress-induced eating

Amongst the limited collection of studies that have explored the influence of relaxation on appetite, the previously mentioned study by Manzoni et al. (2008) compared groups of obese emotional eaters receiving (a) PMR combined with calming visual imagery, (b) a relaxation recording with imagined calming scenarios, and (c) control (neutral) conditions. The relaxation sessions were administered nine times over three weeks and supplemented by regular home-based relaxation practice. These researchers reported a significant reduction in resting heart rate (within single relaxation sessions), and reduced symptoms of anxiety and depression post intervention in both relaxation groups. More importantly, a three month follow-up revealed that participants also reported less emotion-induced eating in contrast with controls, together with an increase in self-efficacy in eating control (a measure of their coping ability when faced with a challenging situation) (Manzoni et al., 2009).

Further evidence of a beneficial effect of relaxation on self-efficacy for healthy eating comes from a study by Katzer et al. (2008), in which a ten-week relaxation intervention that included PMR was followed by eight months of group-support for overweight/obese

women. After 12 months, effect sizes for reduction in symptoms of depression, improvement in stress reduction, reporting of medical symptoms, and self-efficacy for healthy eating were greatest for the relaxation group compared with a non-relaxation control group. A 24-month follow-up of the same cohort found that only the relaxation group participants continued to maintain reduced levels of depression, reduced rate of suffering from general medical symptoms, and improved self-efficacy for healthy eating (Hawley et al., 2008). Similarly, Christaki et al. (2013) provided evidence of the beneficial effect of the addition of PMR to a weight loss intervention by promoting healthier eating, higher restrained eating, and resultant weight loss, though perceived stress remained unchanged. Together, these findings suggest that relaxation may improve behavioral and psychological resources such that individuals can better deal with a perceived stressor instead of resorting to food (Manzoni et al., 2009).

In further support of the notion that relaxation may be of therapeutic benefit in stress-induced eating, studies have shown that mindfulness, which may also contribute to the relaxation response (Benson et al., 1975), may reduce stress by purposefully and non-judgmentally paying attention to the present moment (Kabat-Zinn, 2013), thus detaching from the source of stress. If the psychological effect of relaxation is similar, this creation of distance may lead to less reactive or habitual behavior in relation to food intake. Additionally, the cultivation of awareness of bodily sensations and cues can arise from a relaxation response, especially when practiced in the context of mindfulness training. The focus on sensations within the body cultivated by relaxation techniques may draw one's attention to interoceptive awareness and the distinction between metabolic hunger and hedonic hunger. Beyond this, mindful relaxation may influence how one acts on feelings of

hunger, or cravings for palatable food. For instance, the addition of mindfulness training to a diet and exercise program has been associated with a decreased intake of palatable food (Mason et al., 2016). Further, Marchiori and Papies (2014), reported that a single session of mindful body scanning led to reduced propensity to satisfy hunger with energy dense cookies compared with 'non-mindful' controls. However, to what degree the relaxation component of mindfulness may influence stress-induced eating remains to be determined.

1.7 Statement of the Problem

Despite public health efforts to raise awareness of the link between diet and the risk of lifestyle disease, unhealthy eating continues to be widespread (Popkin, Adair, & Ng, 2012; Swinburn, 2009; World Health Organisation, 2013). Energy dense foods high in saturated fat and sugar contribute up to 36% of daily energy intake in the average Australian diet, almost twice the maximum recommended intake (Rangan, Schindeler, Hector, Gill, & Webb, 2008). This has implications for the risk of weight gain and chronic disease, since excess intake by as little as 50-100 kcal/d can result in weight gain of clinical concern in the long-term (Hill, Peters, & Wyatt, 2009; Mozaffarian et al., 2011). It is therefore apparent that our drive to eat these foods in excess is a function of factors that are being inadequately addressed in the prevention and management of lifestyle disease. One such driver of unhealthy eating is psychosocial stress (Gibson, 2012; McEwen, 2008). In 2015, the Australian Psychological Society reported 75% of Australians eat in response to stress; and of concern, greater than 50% of these individuals found that food consumption is an effective means by which to alleviate stress (Australian Psychological Society, 2015). Feasible and effective interventions are needed to address this issue of great concern.

The relaxation response is the physiological and psychological opposite of stress. This suggests a potential role for relaxation in the regulation of food intake, although no research has specifically investigated whether relaxation can attenuate stress-induced eating. Given that stress may affect appetite through both physiological and psychological mechanisms, relaxation may play an equivalent opposing role in both respects. Research is needed to investigate if the relaxation response alone can reduce stress-eating, both when performed in isolation in a laboratory setting, and when practiced regularly in the long-term. Furthermore, it is important to determine the practical applicability of such interventions under free living conditions. If shown to be effective, regular relaxation practice may provide a convenient, patient-centered, cost and time efficient intervention that could be implemented in a broad range of population groups and settings to enhance the health and wellbeing of our community.

1.8 Research Aims and Hypotheses

The overarching aim of this thesis is to address an increasingly recognised problem - stress-induced eating, for which practical evidence-based solutions are lacking. More specifically the aims of this thesis are:

- To determine whether an isolated brief practice of APMR can elicit the relaxation response following exposure to an acute laboratory stressor, and examine the effect of stress and relaxation on potential drivers of stress-induced appetite, including cortisol and ghrelin.
- To investigate whether a brief practice of APMR following an acute laboratory stressor will reduce intake of energy-dense snack foods, relative to dietary intake after experiencing the acute laboratory stressor alone.

- To determine the feasibility of a worksite-based, 8-week mindful relaxation intervention in terms of recruitment, fidelity, dose, and acceptability.
- To provide preliminary evidence of the efficacy of an 8-week mindful relaxation intervention for managing (a) psychological (perceived acute stress), physiological (cortisol, BP and HR), and appetite (energy intake, self-reported appetite) responses to an acute stressor, and (b) long-term well-being and health behaviours (stress, anxiety, mindfulness, sleep quality, food cravings, and palatable food intake).

The research hypotheses relating to these aims are as follows:

- A brief practice of relaxation following an acute laboratory stressor will elicit the relaxation response, attenuate the stress response and reduce the intake of energy-dense snack foods, relative to dietary intake after experiencing the acute laboratory stressor alone.
- Eight weeks of mindful relaxation practice is a feasible means by which to reduce the acute stress response, attenuate energy intake after exposure to an acute stressor, and improve long-term indicators of wellbeing, including trait mindfulness, sleep quality, stress, anxiety, and degree of craving.

1.9 Organisation and Structure of Thesis

Following this *Literature Review* and *Research Aims and Hypotheses*, Chapters 2, 3 and 4 of this thesis are based on manuscripts prepared for publication. Chapter 2 examines the reproducibility of a commonly used laboratory stressor, known as the Trier Social Stress Test; a core methodological tool employed in the subsequent chapters. Chapters 3 and 4, address the aims of this thesis stated above. The last chapter integrates the findings of this

thesis by providing an overall *General Discussion* (Chapter 5), including implications and directions for future research.

Chapter 2: Using the Trier Social Stress Test twice: a protocol for reducing habituation

As based on a paper under review:

Masih, T., Dimmock, J.A., & Guelfi, K.J. (2018). Using the Trier Social Stress Test twice: a protocol for reducing habituation

2.1 Abstract

Repeated exposure to the laboratory psychosocial stressor, the Trier Social Stress Test (TSST), can lead to an attenuated stress response, thereby limiting its use in research where multiple stress exposures are necessary. This study reports the effectiveness of a protocol to reduce habituation when the TSST is required to be administered a second time. To investigate this issue, twenty-two healthy men and women undertook the TSST on two different occasions separated by 8 weeks. For the second TSST, participants were informed that their performance during their first TSST was in the lower range of scores. Other modifications included varying the test panellists and changing the specific verbal and numerical tasks set. The response of cortisol, blood pressure, heart rate, and ratings of perceived stress were compared between exposures. The physiological (cortisol, blood pressure, heart rate) and psychological stress response elicited by the TSST was equivalent between trials ($p > 0.05$). These findings illustrate the effectiveness of small modifications to the TSST to prevent habituation with repeated administration, thereby confirming a protocol for utilising this laboratory stressor in research where repeated exposure to stress is required within a limited period of time.

2.2 Introduction

The Trier Social Stress Test (TSST) is a laboratory stressor commonly used in research to elicit a stress response under controlled conditions (Allen et al., 2017). Its standardised protocol involves performing a speech to highlight the suitability of one's personal attributes for an imagined job, followed by a reverse counting task, in front of a panel of impassive individuals posing as behavioural analysts. The effects of the stressor are heightened by video-recording the participant's performance and by panellists offering little verbal and non-verbal feedback (Kirschbaum, Pirke, & Hellhammer, 1993). Just as a physical threat stimulates the stress response in order to survive, the lack of control over the situation and the social-evaluative threat posed in the TSST leads to critical self-evaluation which contributes to the stress response (Dickerson & Kemeny, 2004). An important characteristic of an acute stressor, however, is its novelty, and with increasing familiarity of a stressor, the cortisol response is not as pronounced (Dickerson & Kemeny, 2004). Indeed, attenuation of the stress response to second exposures to the TSST, reflected by reduced cortisol release, has been repeatedly demonstrated (for example, Gianferante et al., 2014; Petrowski, Wintermann, & Siepmann, 2012; Schommer, Hellhammer, & Kirschbaum, 2003; Wüst, Federenko, van Rossum, Koper, & Hellhammer, 2005). Hence, it has been suggested that experimental use of the TSST may be limited when multiple stress exposures are necessary (i.e., in within-subject designs) (Allen et al., 2017).

There are recommended strategies to minimise the habituation observed with multiple TSST exposures such as lengthening the time interval between exposures (Foley & Kirschbaum, 2010), and varying the setting, personnel involved (Kirschbaum, 2015), and the specific tasks set (Allen et al., 2017; Kirschbaum, 2015). However, various combinations of these

measures have not fully prevented attenuation of the stress response between first and second exposures (Kirschbaum et al., 1995; Petrowski et al., 2012; Schommer et al., 2003). An additional approach involves informing participants during subsequent exposure to the TSST that their performance during the first TSST was considered to be in the "lower range, and that the second attempt is an opportunity to improve their score" (Hoge et al., 2017). As to whether this approach is effective at attenuating any habituation has not specifically been tested. Accordingly, the purpose of this study was to compare the physiological (heart rate, blood pressure, salivary cortisol) and psychological (perceived stress) responses to repeated TSST administration within an 8 week period (typical of many interventions) with i) variation in the panellists, ii) changes to the specific verbal and numerical tasks set and iii) informing participants their score in the previous TSST was in the lower range. The hypothesis was that these modifications would prevent habituation, and thereby confirm the utility of the TSST in studies in which participants' second exposure to a TSST is desired within a limited period of time (i.e. weeks).

2.3 Research design and Methodology

A subsample of participants from two larger studies utilising the TSST were included in this analysis (Chapters 3 and 4). As part of the parent studies, participants completed two TSSTs on separate occasions. Those completing these two tests within an 8-week period (without intervention in between) were included in the present analyses (n = 22). This sample size is similar to that used by previous research demonstrating habituation to second TSST exposure (Gianferante et al., 2014; Kirschbaum et al., 1995). Participants were healthy men and women aged 18 - 46 years, with no history of chronic disease, or use of prescription

medication. These studies were approved by the University of Western Australia Human Research Ethics Committee and written consent was obtained by all participants.

Each participant attended a familiarisation session during which they were informed that they would be involved in a 'verbal ability task' and familiarised with associated measurements to be used in the experimental sessions such as saliva collection. Experimental session times were standardised for each participant, with sessions commencing at either 0800h or 1330 h with a maximum of 8 weeks (mean = 40 days) between sessions. Participants were required to eat the same standard meals, and abstain from caffeine, alcohol, and exercise for 24 hours prior to each session. Following a 30-minute settling period, baseline blood pressure (BP) and heart rate were recorded using an automatic blood pressure monitor (Omron HEM 7211, Hoofddorp, The Netherlands), followed by the collection of a baseline saliva sample using a salivette (Sarstedt, Numbrecht, Germany). Collected saliva was centrifuged at 4°C for 5 min at 1300 x *g* and frozen at -80°C until analysis (as per Jensen, Hansen, Abrahamsson, & Nørgaard, 2011). Participants were also required to complete a 100 mm Visual Analogue Scale (VAS) in order to gauge perceived level of stress (i.e. 'how stressed do you feel?') (Neseliler et al., 2017).

Following baseline measures, participants were required to complete the TSST (Kirschbaum et al., 1993). Briefly, participants were requested to present a 5-minute talk in order to convince a two-member mock selection panel that they were suitable candidates for a new job of their choice (first TSST), or a promotion within their current position (second TSST) they had applied for (Figure 2.1) (Appendix C). This was followed by a numerical exercise which involved reverse counting. In addition, participants in the TSST were informed that

their performance would be video recorded for later analysis (Kirschbaum et al., 1993). During the second TSST, the mock selection panellists were different individuals compared to their previous attempt, and the numerical task was changed such that they began with a different number and counted backwards by a different increment. In addition, participants were informed that their performance during the first TSST was assessed as "being in the lower range and that this was an opportunity to better their score" (Hoge et al., 2017). Recording of BP, heart rate, and sampling of saliva, along with the administration of the VAS were repeated immediately following the TSST. A full debrief was provided at the completion of the second TSST during which time participants informally met with their panellists and were given the opportunity to ask any questions.

Figure 2.1 Trier Social Stress Test (TSST) mock selection panellists

2.3.1 Statistical Analyses

Data are summarised as means and standard deviations or median and interquartile ranges, as appropriate. The effect of repeated TSST exposure on physiological and psychological responses were assessed using two-way (trial x time) repeated measures ANOVA (cortisol, heart rate, BP, and perceived stress). All analyses were conducted using SPSS software with significance set at $p \leq 0.05$.

2.4 Results

The study sample consisted of healthy men (n = 5) and women (n = 17) (age 25 ± 6 years, BMI 23.4 ± 3.4 kg/m^2). The effect of repeated TSST exposures on physiological and psychological responses are shown in Table 2.1. There was a main effect of time (pre to post TSST) for cortisol, systolic, and diastolic BP, and ratings of perceived stress ($p < 0.01$), with an increase in each of these variables in response to the TSST exposure. The main effect of time was not significant for heart rate ($p = 0.262$). There was no interaction effect of time (pre to post TSST) and trial (TSST 1 and TSST 2) for cortisol ($p = 0.931$); heart rate ($p = 0.853$), or perceived stress ($p = 0.336$). The interaction for time and trial was significant for systolic BP ($p = 0.021$) and diastolic BP ($p = 0.043$); however, post hoc analyses revealed no differences in blood pressure responses to the TSST between conditions (systolic BP post: $p = 0.819$; diastolic BP post: $p = 0.630$).

Table 2.1 Physiological and psychological responses to repeated Trier Social Stress Test (TSST) exposure (n = 22; median (IQR) or mean ± SD)

	First TSST exposure		Second TSST exposure	
	Pre (baseline)	Post	Pre (baseline)	Post
Salivary cortisol (nM)*	3.25 (2.0 – 3.9)	4.4 (3.7 – 7.3)	3.3 (2.8 – 4.7)	4.8 (3.1 – 8.3)
Heart rate (bpm)	67 ± 10	68 ± 10	70 ± 12	71 ± 13
Systolic BP (mm Hg)*	105 ± 9	117 ± 10	109 ± 11	117 ± 10
Diastolic BP (mm Hg)*	64 ± 7	72 ± 9	65 ± 6	71 ± 7
Perceived stress (mm)*	26 (8 – 51)	55 (20 – 68)	28 (11 – 50)	45 (35 – 60)

* indicates a main effect of time (pre to post TSST exposure; $p < 0.01$). No differences between first and second exposures.

2.5 Discussion

The purpose of this study was to test the effectiveness of small modifications to the TSST, including a verbal cue given to participants prior to undergoing the TSST for a second time, in order to prevent stress habituation. In support of the hypothesis, both physiological (cortisol, heart rate), and self-reported (perceived stress) indicators of the stress response were consistent between exposures, suggesting that the second TSST did not result in habituation. Accordingly, these modifications may be useful to apply when multiple exposures to stress are necessary, such as when testing the efficacy of interventions to attenuate the stress response using a repeated measures within-subjects design. As the nature of the stress response is directly related to degree of novelty of a threat (Dickerson &

Kemeny, 2004), subsequent exposure to the TSST often leads to a reduction in amplitude of the stress response (Gianferante et al., 2014; Petrowski et al., 2012; Schommer et al., 2003). Previous recommendations of modifying the specific TSST speech and mental tasks, as well as varying the setting and personnel involved to minimise habituation, have not fully prevented attenuation of the stress response on second TSST exposure (Kirschbaum et al., 1995; Petrowski et al., 2012; Schommer et al., 2003). The additional use of a verbal cue informing participants that performance during their first TSST was in the lower range has been used by others (Hoge et al., 2017); however, this is the first study to specifically compare the consistency of physiological and psychological responses using this approach. The present results indicate that habituation may be prevented in a non-clinical sample, evidenced by both objective physiological results, as well as subjective ratings of stress. This may be related to the social evaluative threat evoked by the TSST, which is associated with perceptions of being judged unfavourably by others (Foley & Kirschbaum, 2010). It is possible that the verbal cue given to participants in this study served to confirm the negative judgement made by the panellists during the first TSST, thereby reducing sense of control and feelings of appeasement due to possible familiarity of the situation on second exposure.

Another recommendation for reducing habituation to repeated TSST exposures is to lengthen the time interval between tests to four months (Foley & Kirschbaum, 2010). Many previous studies demonstrating attenuation of the cortisol response are studies with the TSSTs conducted within days/weeks of each other (Kirschbaum et al., 1995; Petrowski et al., 2012; Schommer et al., 2003; Wüst et al., 2005). Whether the interval between the two TSSTs in the present study (up to 8 weeks) was sufficient to prevent habituation in cortisol

levels, BP, and perceived stress is unclear, but appears unlikely given that habituation of both physiological and self-reported measures of acute stress has also been observed after a 6 month gap between TSSTs (Arvidson, Sjörs, & Jonsdottir, 2017). It must also be acknowledged that although previous research overwhelmingly has observed habituation to a second TSST exposure, some studies have reported the absence of habituation to repeated TSST in sub-sets of participants (Wüst et al., 2005). A lack of habituation in some individuals has been attributed to level of exhaustion (Kudielka et al., 2006), rumination (Gianferante et al., 2014), and negative mood and self-worth (Kirschbaum et al., 1995). Hence, the degree of habituation on multiple exposure of the TSST may be subject to variability. Furthermore, many studies showing habituation between first and second TSST exposures have shown consistent responses between second and third exposures (Kirschbaum et al., 1995; Petrowski et al., 2012), suggesting that an alternative approach when utilising the TSST to assess the effect of an intervention (i.e. pre and post measures) might be to implement a 'familiarisation' TSST prior to any baseline/pre TSST. It should also be acknowledged that the TSST took place at a standardised time of either 0800h or 1330h in the present study. Cortisol levels are subject to a diurnal rhythm, which may potentially impact on the results; however, this is unlikely to have affected the reproducibility of the response given the utilisation of a crossover study design with each individual completing their two TSSTs at the same matched time. Also, related to cortisol response, future studies should aim to extend the observation period both prior to, and post-TSST, in order to provide a more comprehensive picture of TSST-induced cortisol levels. Finally, while this study implemented rigorous experimental protocol with consideration of factors that are known to affect the acute stress response (Dickerson & Kemeny, 2004; Foley & Kirschbaum,

2010), the results are based on a sample of healthy individuals, and therefore, may offer limited capacity to generalise to other populations.

2.6 Conclusion

In conclusion, the present study offers a protocol for utilising the TSST without habituation in research where repeated exposure to stress is required within an 8-week period typical of many interventions. Future research should focus on controlled comparative studies, including TSSTs offered at varying intervals, in order to better understand the nature of habituation and how best to circumvent it.

Chapter 3: The effect of a single, brief practice of progressive muscular relaxation after exposure to an acute stressor on subsequent energy intake.

As based on a paper *prepared for submission:*

Masih, T., Dimmock, J.A., & Guelfi, K.J. (2018). The effect of a single, brief practice of progressive muscular relaxation after exposure to an acute stressor on subsequent energy intake.

3.1 Abstract

Previous research has indicated an association between stress and the intake of energy-dense palatable foods. The aim of this study was to investigate whether relaxation practice, in the aftermath of exposure to a stressor, can attenuate stress-induced eating. To address this issue, 25 men and women were exposed to four different conditions on separate days: an acute laboratory stressor (S), acute stressor followed by 20 minutes of Abbreviated Progressive Muscle Relaxation (APMR) (SR), APMR alone (R), and a control session (C). Both physiological (heart rate, blood pressure, and cortisol) and psychological (perceived stress and relaxation) responses to stress and relaxation were assessed, in addition to measurement of subsequent energy intake of high energy snack foods from a laboratory test meal. Salivary cortisol, BP, HR, and perceived stress were transiently elevated in response to the laboratory stressor (S and SR compared with R and C; $p < 0.05$). Meanwhile, perceived relaxation was acutely enhanced in response to APMR alone (R) compared with S, SR and C ($p < 0.05$) and in SR compared with S immediately after the AMPR component ($p < 0.05$). However, contrary to hypotheses, no difference in mean total energy intake was observed between the conditions ($p > 0.05$). Likewise, no differences in perceived appetite or the circulating concentrations of appetite-related hormones ghrelin, leptin and insulin were noted across sessions ($p > 0.05$). These results suggest great variation in dietary responses to acute stress, and indicate that APMR either after an acute stressor or in isolation may not alter the intake of commonly eaten snack foods. This study adds to our understanding of the complexity of stress-induced eating.

3.2 Introduction

Stress-induced eating is typically described as an increase in the intake of energy-dense, highly palatable food in response to a real or perceived psychological stressor (Gibson, 2012; McEwen, 2008). If undertaken frequently, stress-induced eating can be detrimental to long-term health and well-being (McEwen, 2008; Ozier et al., 2008). Indeed, regular excess intake of as little as 50-100 kcal/d can result in weight gain of clinical concern (Mozaffarian et al., 2011). Moreover, increased intake of unhealthy, energy dense comfort foods high in saturated fat and sugar also has implications for the development of a number of chronic conditions such as cardiovascular disease and diabetes mellitus (McEwen, 2008; Mozaffarian et al., 2011).

Specific dietary responses to stress may vary according to a vast array of personal and environmental variables (Wardle, Chida, Gibson, Whitaker, & Steptoe, 2011), including genetic predisposition, gender, body weight, personality type, and eating style. However, regardless of whether overall energy intake is increased, decreased, or unaffected by stress (Oliver & Wardle, 1999; Ulrich-Lai, Fulton, Wilson, Petrovich, & Rinaman, 2015), a number of studies have shown that, generally speaking, stress leads to an increase in the intake of palatable, energy dense foods, perhaps because the rewarding nature of these foods provides a sense of relief (Habhab, Sheldon, & Loeb, 2009; Ulrich-Lai, 2016). The mechanisms through which this eating response occurs are unclear, although speculation regarding possible drivers of the response has included both physiological and psychological pathways. Among the possible physiological drivers of stress-driven unhealthy eating is the stress hormone, cortisol (Epel et al., 2001; Tataranni et al., 1996), which has been shown to increase ad libitum intake of snack foods when concentrations peak following injection of

corticotropin-releasing hormone, in comparison with a placebo infusion (George et al., 2010). In addition, other appetite-related peptides such as insulin, ghrelin, and leptin may play a role in stress-induced eating by directly affecting appetite, through interaction with cortisol, and/or via influencing reward centres of the brain (Adam & Epel, 2007; Masih et al., 2017). Psychologically, stress may influence cognitive and emotional processes that impact on food choice (Yau & Potenza, 2013). Under conditions of stress, appetite and food choice are more likely to fall prey to impulsive thinking and emotion (Yau & Potenza, 2013), driven by the need to avert the displeasure associated with stress, and a means to cope (Macht, Haupt, & Ellgring, 2005; Macht & Mueller, 2007; Tryon, Carter, DeCant, & Laugero, 2013).

Although it is acknowledged that stress may lead to unhealthy eating, it is yet to be investigated whether relaxation (i.e., the physiological and psychological opposite of stress) (Wallace et al., 1971) can attenuate unhealthy eating in response to exposure to acute stressors. Relaxation may potentially counteract both the physiological and the psychological effects of stress, either by dampening the stress response itself or by intervening at the critical points when stress might affect dietary behaviour (Masih et al., 2017). Progressive muscular relaxation is one of the most widely documented techniques in relaxation research (Jacobsen, 1934), perhaps due to its ease of implementation, low cost, and applicability in both clinical and non-clinical settings (Dolbier & Rush, 2012; Pawlow & Jones, 2005). The sequential tensing and relaxing of muscle groups prescribed by this technique has been adapted to a shortened version known as Abbreviated Progressive Muscle Relaxation (APMR) (Bernstein & Borkovec, 1973), and this technique has been shown to be effective in acutely reducing both perceived stress and cortisol levels (Chellew et al., 2015; Dolbier & Rush, 2012; Pawlow & Jones, 2005; Pawlow et al., 2003).

Whether APMR has efficacy in attenuating unhealthy eating after exposure to an acute stressor is not known; however, there is some evidence to suggest that APMR can influence appetite. More specifically, Pawlow et al. (2003) demonstrated that a 20-minute session of APMR in those suffering from night-eating syndrome reduced feelings of evening hunger, at the same time as reducing salivary cortisol levels and subjective reports of stress and anxiety. Authors of other studies on the effect of relaxation techniques on appetite also indicate that relaxation may reduce cortisol levels, improve dietary habits, and psychologically enable individuals to contend with a stressful situation (as opposed to resorting to palatable food as a means to cope) (Katzer et al., 2008; Manzoni et al., 2009). In light of such evidence, the aim of the present study was to 1) confirm the existence of stress-induced eating by comparing the dietary response after exposure to a stressor relative to a control condition, and 2) test the hypothesis that a brief practice of APMR following an acute laboratory stressor would reduce intake of energy-dense snack foods, relative to dietary intake after experiencing the acute laboratory stressor alone. Secondary aims included verifying that an isolated brief practice of APMR can elicit the relaxation response, and examining the effect of stress and relaxation on potential drivers of stress-induced appetite, including cortisol and ghrelin.

3.3 Research Design and Methodology

3.3.1 Study participants

Participants were recruited for the study by flyers and electronic notices distributed around the University of Western Australia (UWA) and the local community. Calls for volunteers stated that healthy men and women aged 18 – 45 years were invited to take part in a

research project investigating the physiological and psychological effects of stress and relaxation. Participants were blinded to the true aims of the study, given that their full awareness may influence their eating behaviour. Volunteers who expressed interest in participating were emailed an information sheet detailing the experimental protocol (Appendix A). A phone interview was then undertaken to confirm suitability based on the following inclusion criteria: a BMI between 20-30kg/m^2, weight stable (no change greater than 2 kg in last six months and currently within 2.5 kg of their maximum adult weight), and no diagnosed medical conditions, or fear of needles. Further exclusion criteria included a history of substance abuse, heavy drinking or smoking, the use of prescription medications, current/recent dieting, previous regular practice of relaxation techniques, excessive exercise (greater than 2 hours/day), an irregular work/sleep schedule, and irregular breakfast intake. Women who were pregnant/lactating or had an irregular menstrual cycle were also excluded (Appendix A). Forty-eight individuals met the study selection criteria; however, only 25 completed all five laboratory sessions. This study was approved by the University of Western Australia Human Research Ethics Committee and written consent was obtained by all participants (Appendix A). Sample size estimation was based on an effect size of 0.4. This was an average derived from results reported by previous research (Habhab et al., 2009; Raspopow et al., 2010; Rutters et al., 2009; Zellner et al., 2006) using G*Power 3.1.9.2 (Faul, Erdfelder, Lang, & Buchner, 2007). Accordingly, it was calculated that 25 participants were required to detect a significant difference in energy intake between conditions with an effect size of 0.4 ($\alpha = 0.05$, power = 0.8). In a within-subject crossover design, participants were required to attend the university laboratory on five separate occasions.

The first was a 1-h familiarisation session and then the following four experimental sessions were undertaken: stress alone (S), relaxation alone (R), stress followed by relaxation (SR),

and control (C). The order of administration of these conditions was counterbalanced, with each new participant assigned their order of condition based on a random sequence.

3.3.2 Familiarisation session

During this session, participants were informed of the pre-experimental protocol they were expected to follow for each subsequent session (Appendix A). They were informed that the stress condition involved a 'verbal ability task' and were provided with a brief overview of the APMR practice. Single blood and saliva samples were also obtained in order to familiarise participants with the intended sampling procedure during the experimental sessions. Additionally, each participant completed the following: a general information questionnaire, in which demographic information was obtained; the Perceived Stress Scale (PSS; Cohen, Kamarck, & Mermelstein, 1983), which is a 14-item questionnaire measuring perception of recent (i.e., over the last week) stress in everyday life, with item scores anchored at 0 (never) and 4 (very often); the trait subscale in the State-Trait Anxiety Inventory (STAI-Trait; Spielberger, 1983), which includes 20 items that measure perceived day to day anxiety on a scale of 1 (almost never) to 4 (almost always); and the Mindfulness Attention Awareness Scale (MAAS; Brown & Ryan, 2003), a 15-item measure of trait mindfulness with response anchors at 1 (almost always) and 6 (almost never). Anthropometric measures that were obtained during this initial session included body weight (assessed with a digital scale; Sauter, Sydney, Australia); height (assessed using a wall mounted height-meter; Seca, Germany), and waist-hip circumference (measured using a commercial tape measure; KDS, Japan). Participants were also provided with diet and behaviour diaries in order to record 24-hour dietary intake, sleep, wake times, and activity level for 24 hours preceding each experimental session (Appendix G).

3.3.3 Experimental sessions

Experimental sessions took place between 1330 and 1600 h with a minimum of 3 days between sessions. For women, testing was standardised to the follicular phase of the menstrual cycle (days one to eleven). Participants were required to eat the same standard meals and snacks, abstain from caffeine, alcohol and exercise for 24 hours prior to each experimental session. They were also instructed to cease consumption of food or drink 1 hour prior to the experimental session. Upon arrival to the laboratory, food and activity diaries were collected. These were later analysed by an Accredited Practicing Dietitian for energy and nutrient intake during the 24 hours preceding the experimental session using nutrient analysis software (FoodWorks; Xyris Software, Kenmore Hills, Qld, Australia) to ensure compliance to pre-trial protocol. Participants initially completed the PSS, and then, following a 30-minute settling period, baseline blood pressure (BP) and heart rate (HR) were recorded using an automatic blood pressure monitor (Omron HEM 7211, Hoofddorp, The Netherlands), followed by the collection of baseline saliva and blood samples. Participants were also required to complete the Profile of Mood States-Adolescents (POMS-A; a 24-item questionnaire assessing the 6 moods of anger, confusion, depression, fatigue, tension, and vigour, with responses on a scale from 0 (not at all) to 4 (extremely) (Terry, Lane, & Fogarty, 2003). Following this, a 100 mm Visual Analogue Scale (VAS) was completed in order to gauge perceived level of hunger, fullness, desire to eat, and prospective food consumption (Flint, Raben, Je, & Astrup, 2000). A similar VAS assessed the level of stress and relaxation felt (i.e. 'how stressed (or relaxed) do you feel?' (Fisher et al., 2016; Neseliler et al., 2017).

Following baseline measures, the stress, relaxation, or control treatment was administered. The stress condition required participants to complete the TRIER Social Stress Test (TSST)

(Kirschbaum et al., 1993), which is a 15-minute laboratory-based stressor comprised of elements that most reliably increase cortisol response: public speaking, a numerical exercise, the presence of spectators, and the threat of a negative outcome. In brief, participants were requested to present a 5-minute talk in order to convince a two-member mock selection panel that they were suitable candidates for a job (or a promotion) they had applied for. This was followed by a numerical exercise which involved reverse counting. In addition, participants in the TSST were informed that their performance would be video recorded for later analysis (Kirschbaum et al., 1993). In order to reduce the stress adaptation likely associated with stressor familiarity during the second TSST, the mock selection panellists were different individuals, and participants were informed that their performance during the first TSST was assessed as "being in the lower range and that this was an opportunity to better their score" (Hoge et al., 2013; Hoge et al., 2017) (the protocol validated in Chapter 2) (Appendix C). The relaxation condition consisted of a 20-minute session of APMR (Bernstein & Borkovec, 1973) (Figure 3.1), with all relaxation sessions conducted by one instructor who used a standard script and took care to maintain consistent pace and tone (Pawlow et al., 2003) (Appendix D). During the control condition, participants viewed a nature documentary on plant life. Recording of BP, HR, samples of saliva and blood, along with the administration of the POMS-A and VAS were repeated at 30, 60, and 90 minutes following commencement of each manipulation. In addition, after administration of stress or relaxation treatments, participants completed the pressure/tension (5 items) and perceived competence (6 items) subscales of the Intrinsic Motivation Inventory (IMI; Ryan, 1982). Scores for items on the IMI are recorded on a scale of 1 (not at all true) to 7 (very true).

Based on previous research (Appelhans et al., 2010; Epel et al., 2001; Raspopow et al., 2010), a time interval of ninety minutes after the onset of stress, relaxation, or control protocols, was imposed before participants were offered pre-weighed portions of potato crisps (150 g) (Smith's Snackfood Company Limited, Chatswood, NSW, Australia), Maltesers (100 g) (Mars, NSW, Australia), Allens Party Mix Lollies (candy) (100 g) (Nestle Australia Limited, Rhodes, NSW, Australia), and three mini donuts (Nana's, Patties Foods Limited, Bairnsdale, VIC, Australia) (Figure. 3.2). This selection was based on a choice of commonly eaten snack foods in Australia (Australian Bureau of Statistics; Roy Morgan Research, 2014). Participants were told that the food offered was in recognition of their time, and because blood was drawn from them four times. Each participant was then left alone to eat as desired for 30 minutes. Following their departure, the remaining food was re-weighed using digital weight scales (Zero Mode, China). Energy and nutrient analysis was performed by an Accredited Practicing Dietitian based on the nutrition information printed on the packaging of each of the food items.

Figure 3.1 Participant undergoing abbreviated progressive muscle relaxation (APMR)

Figure 3.2 Snack food buffet items offered during pre- and post-laboratory sessions

3.3.4 Biochemical measures

Saliva was obtained using salivettes (Sarstedt, Numbrecht, Germany) (Epel et al., 2001). Participants were required to place a cotton swab in their mouth for 90 seconds and then place this into a plastic tube. These were later centrifuged at 4°C for 5 min at 1300 x *g* and frozen at -80°C until assayed for cortisol. Collected saliva (250 µL) was later spiked with 50 ng/mL of labelled cortisol and extracted by vortexing into 1 mL of ethyl acetate prior to being centrifuged, with the supernatant dried down in a centrifugal evaporator. Dried samples were reconstituted in 70 µL of 70% methanol, 30% water, prior to assaying by Liquid Chromatography Mass Spectrometry (Agilent Technologies 2 1290 UPLC series Liquid Chromatography pumps, coupled to a 6460 Triple Quadrupole MS system operating in positive ion multiple reaction monitoring mode). Quality controls were assayed using commercially available serum controls for cortisol (Biorad) and then diluting them x 100 in synthetic saliva.

Blood was drawn from the fingertip using a sterile lancet (Unistik 2 Normal; Owen Mumford, Oxford, UK). From this, blood glucose was determined by a blood gas analyser (35µL; Radiometer, Copenhagen, Denmark), while the remaining sample (500 µL) was placed into EDTA coated microtainer tubes (K2EDTA, BD Microtainer, Franklin Lakes, NJ, USA) with 20 µL of serine protease inhibitor (Pefabloc SC, Roche Diagnostics, Sydney, NSW). This blood was immediately centrifuged for 10 min at 1020 x *g* at 4°C, with the plasma frozen at -80°C for later assay of plasma insulin, active ghrelin, and leptin using the Milliplex Human Gut Hormone Panel (Millipore Corporation, Billerica, USA) according to manufacturer's instructions on a Luminex 200 system (Luminex Corporation, Austin, TX, USA). These specific hormones were selected based on reported associations with stress-induced eating in the literature (Masih et al., 2017; Sominsky & Spencer, 2014).

3.3.5 Post-experimental Debrief Session

On completion of the final experimental session, participants were required to complete the Rumination Response Scale - Trait (RRS; Treynor, Gonzalez, & Nolen-Hoeksema, 2003), which includes 22-items measuring an individual's tendency to ruminate (or dwell on one's thoughts) on a scale of 1(almost never) – 4 (almost always). The Dutch Eating Behaviour Questionnaire (DEBQ; Van Strien, Frijters, Bergers, & Defares, 1986) which consists of 33-items measuring restrained (the tendency to exert control over one's dietary intake, emotional (the tendency to eat in response to emotions felt), and external (the tendency to eat in response to environmental stimuli) eating styles, was also administered at this point. Responses to the DEBQ are made on a scale of 1 (never) – 5 (very often), with the optional 'not relevant' response to a selected few items. In addition to these measures, participants were also asked to complete the 16-item Disinhibition subscale in the Three Factor Eating Questionnaire (TFEQ; Stunkard & Messick, 1985), which assesses the tendency to lose ability to curb one's eating. Responses to this subscale of the TFEQ are based on 13 true/false items and three items on a scale of 1-4 related to eating behaviour. Lastly, degree of self-perceived stress-induced eating was assessed by asking participants to respond to the statement: 'If I am stressed, I eat' on a scale of 1 (less) – 7 (more).

A full debrief was then provided following confirmation by the participants that they were unaware of the true aims of the study (Appendix A).

3.3.6 Statistical Analyses

Twenty-five participants completed all four experimental sessions (SR, S, R, and C), and were therefore included in the final analyses. The effect of the 4 conditions on subsequent energy intake was compared using one-way repeated measures ANOVA. Two-way repeated measures ANOVA (condition (SR, S, R and C) x time-point (0, 30, 60, 90, and 120 min)) were used to examine the effect of condition on psychological and physiological variables over time. Where warranted, post-hoc analyses were then used to identify the nature of any specific significant differences. As a secondary analysis, in order to investigate specific characteristics associated with stress-induced eating, an additional variable was computed by subtracting the energy intake in response to the S condition from the energy intake following the C condition ($EI_S - EI_C$). Correlations were then performed between this measure of stress-induced eating ($EI_S - EI_C$) and trait variables including anxiety, mindfulness, rumination, restraint, disinhibition, emotional or external eating.

3.4 Results

3.4.1 Sample characteristics, physiological, and psychological effects of the stress and relaxation interventions

The background characteristics of the (6 male and 19 female) participants are shown in Table 3.1. Life stress (determined by the PSS) at the commencement of each session was similar between trials ($p = 0.32$). The physiological and psychological responses to the stress and relaxation interventions are displayed in Figure 3.3. Upon arrival to the laboratory sessions, baseline cortisol was similar between conditions ($F_{(1.94,46.56)} = 0.09$, $p = 0.91$). However, there were significant main effects for condition ($F_{(1.84, 44.04)} = 16.05$, $p < 0.001$) and

time ($F_{(2.07, 49.62)} = 28.17$, $p < 0.001$), in addition to an interaction effect for cortisol ($F_{(2.91, 69.81)} = 11.24$, $p < 0.001$), with post-hoc analyses revealing higher cortisol concentrations in S and SR compared with C and R at 30, 60, and 90 min ($p < 0.05$).

Baseline self-perceived stress, relaxation, BP, and HR were similar at baseline between trials ($p > 0.05$). There were significant interaction effects of condition x time for perceived stress ($F_{(12, 276)} = 7.98$, $p < 0.001$), self-reported relaxation, ($F_{(6.24, 149.72)} = 10.10$, $p < 0.001$), systolic BP ($F_{(6.61, 158.71)} = 11.93$, $p < 0.001$), diastolic BP ($F_{(5.14, 123.34)} = 7.30$, $p < 0.001$), and HR ($F_{(6.54, 156.93)} = 3.85$, $p < 0.01$). Post-hoc analyses revealed higher perceived stress, systolic BP, diastolic BP, and HR in SR and S at 30 min compared with conditions R and C ($p < 0.001$), while at 30 min, perceived relaxation was greater for R compared to all other conditions ($p < 0.05$), and higher for C compared to SR and S ($p < 0.001$). Perceived relaxation was also greater at 60 min for SR, compared to S ($p < 0.05$).

Table 3.1 General sample characteristics (n = 25)

	Mean ± SD
Age (yrs)	24.8 ± 7.4
BMI (kg/m^2)	23.7 ± 3.9
Waist:Hip Circumference	0.77 ± 0.07
PSS-baseline	22.00 ± 7.00
MAAS-trait mindfulness	4.06 ± 0.87
STAI-trait anxiety	38.04 ± 8.08
RRS-trait rumination	38.80 ± 9.18
TFEQ-Disinhibition	6.60 ± 3.30
DEBQ-External eating	3.14 ± 0.62
DEBQ-Emotional eating	2.37 ± 0.81
DEBQ-Restrained eating	1.91 ± 0.69
Self-perceived stress-induced eating assessment	5.12 ± 1.48

Note: PSS = Perceived Stress Scale; MAAS = Mindfulness Attention Awareness Scale; STAI-Trait Anxiety = Trait subscale of the State-Trait Anxiety Inventory; RRS-trait rumination = Rumination Response Scale; TFEQ-Disinhibition = Disinhibition subscale of the Three Factor Eating Questionnaire; DEBQ (External eating, Emotional eating, and Restrained Eating) = Dutch Eating Behavior Questionnaire scales for external, emotional, and restrained eating; Self-perceived stress-induced eating assessment = the degree to which one eats in response to stress.

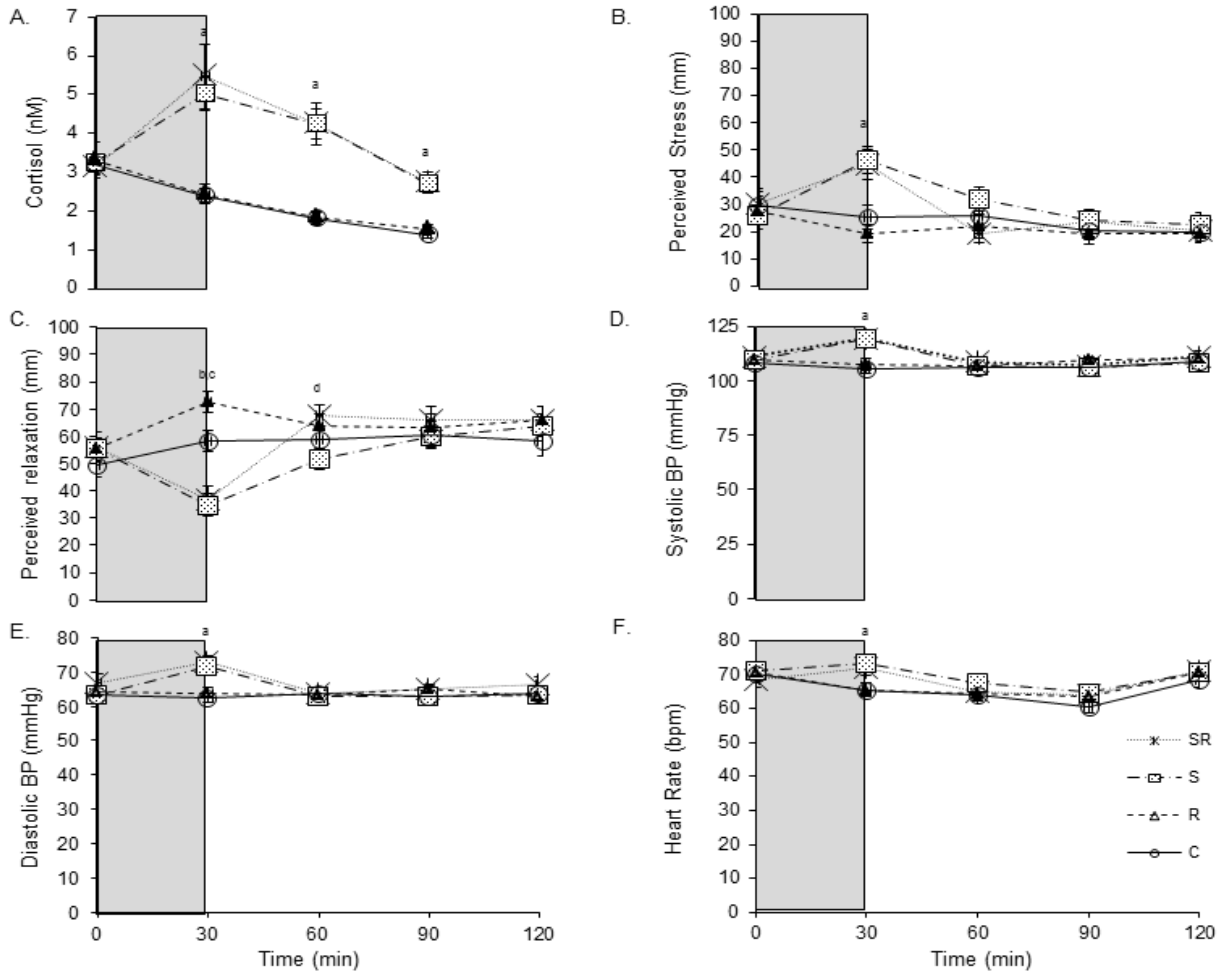

Figure 3.3 The response of (A) salivary cortisol, (B) perceived stress, (C) perceived relaxation, (D) systolic BP, (E) diastolic BP, and (F) heart rate to acute stress (S), relaxation (R), stress followed by relaxation (SR) or a resting control (C) (mean ± SE; n = 25). The grey box represents the period over which the S or R interventions were administered in isolation. For the SR condition, stress was administered in the first 30 min, followed by relaxation in the next 30 min. [a] Indicates significant difference between S and SR compared with R and C. [b] Indicates significant difference between R and all other conditions. [c] Indicates significant difference between C compared with S and SR. [d] Indicates significant difference between S compared with SR ($p < 0.05$).

Mood (anger, confusion, depression, fatigue, tension, and vigour) was similar between trials on commencement of each laboratory session ($p > 0.05$). Significant interaction effects for condition x time were noted for confusion ($F_{(4.93, 118.25)} = 7.41$, $p < 0.001$), tension ($F_{(5.74, 137.77)} = 8.87$, $p < 0.001$), and for vigour ($F_{(12.00, 288.00)} = 3.14$, $p<0.001$), while no interaction effect was found for anger, depression, or fatigue ($p = 0.05$). Post hoc analyses identified significantly more confusion ($p < 0.05$) and tension ($p < 0.05$) at 30 min for SR and S compared with R and C. Vigour was also significantly higher at the same time point for S compared to R ($p < 0.01$). Finally, perceived competence (based on the IMI) reported after both TSST 1 and TSST 2 was similar ($p = 0.14$). Meanwhile, reported levels of pressure/tension was significantly higher after the S condition TSST compared with the SR condition TSST ($p = 0.05$). In contrast, there were no differences in levels of pressure/tension ($p = 0.83$), or perceived competence ($p = 0.74$) post-PMR during the SR and R conditions.

3.4.2 Appetite and energy intake in response to stress and relaxation

There was no difference in energy intake in the 24 hours prior to attending the laboratory sessions between conditions, indicating pre-experimental dietary compliance ($p = 0.43$). Likewise, there were no differences in baseline ratings of hunger ($p = 0.16$), fullness ($p = 0.45$), desire to eat ($p = 0.72$), or prospective food consumption ($p = 0.70$) between conditions. Self-reported hunger, fullness, desire to eat, and prospective food consumption remained similar between trials as the sessions progressed, while there was a main effect for time for each, with increased hunger ($F_{(2.87, 68.86)} = 24.58$, $p < 0.001$), desire to eat ($F_{(2.71, 64.99)} = 29.43$, $p < 0.001$), and prospective food consumption ($F_{(2.33, 55.97)} = 25.64$, $p < 0.001$) and decreased self-reported fullness ($F_{(2.15, 51.54)} = 22.13$, $p < 0.001$) up to 90 min when the

laboratory test meal was administered ($p < 0.05$), as shown in Figure 3.4. Mean energy intake from the laboratory test meal did not differ between conditions ($p = 0.45$), with the control, stress, stress-relaxation, and relaxation conditions resulting in energy intakes of 2827 ± 1383 kJ, 2982 ± 1689 kJ, 2834 ± 1538 kJ, and 2729 ± 1663 kJ, respectively. In addition, associated effect sizes were small, with stress versus control condition: *Cohen's d* = 0.1, and stress versus stress-relaxation condition: *Cohen's d* = 0.09). Order of condition analysis revealed that irrespective of condition, mean energy intake during the second laboratory session was significantly greater in contrast to the first session attended ($F_{(3, 72)} = 3.22$, $p < 0.05$).

3.4.3 Appetite related hormones and metabolites

The circulating concentrations of blood glucose, insulin, ghrelin and leptin in response to the experimental protocol is shown in Figure 3.5. Blood glucose, insulin, ghrelin and leptin were all similar at baseline between conditions ($p > 0.05$), and remained equivalent throughout the experimental protocol in response to each condition ($p > 0.05$). However, there was a main effect for time for glucose ($F_{(1.87, 37.41)} = 17.41$, $p < 0.001$), insulin ($F_{(1.54, 33.80)} = 26.30$, $p < 0.001$), and ghrelin ($F_{(1.53, 33.60)} = 20.95$, $p < 0.001$), with glucose and insulin gradually declining, while ghrelin increased over time in the lead up to the laboratory test meal.

3.4.4 Relationships between trait variables and energy intake

There were no significant correlations between stress-induced eating (EIS – EIC) and trait anxiety, mindfulness, rumination, restrained, disinhibition, emotional or external eating ($p > 0.05$). Likewise, there was no correlation between stress-induced eating and BMI, nor between stress-induced eating and waist-hip circumference ($p > 0.05$).

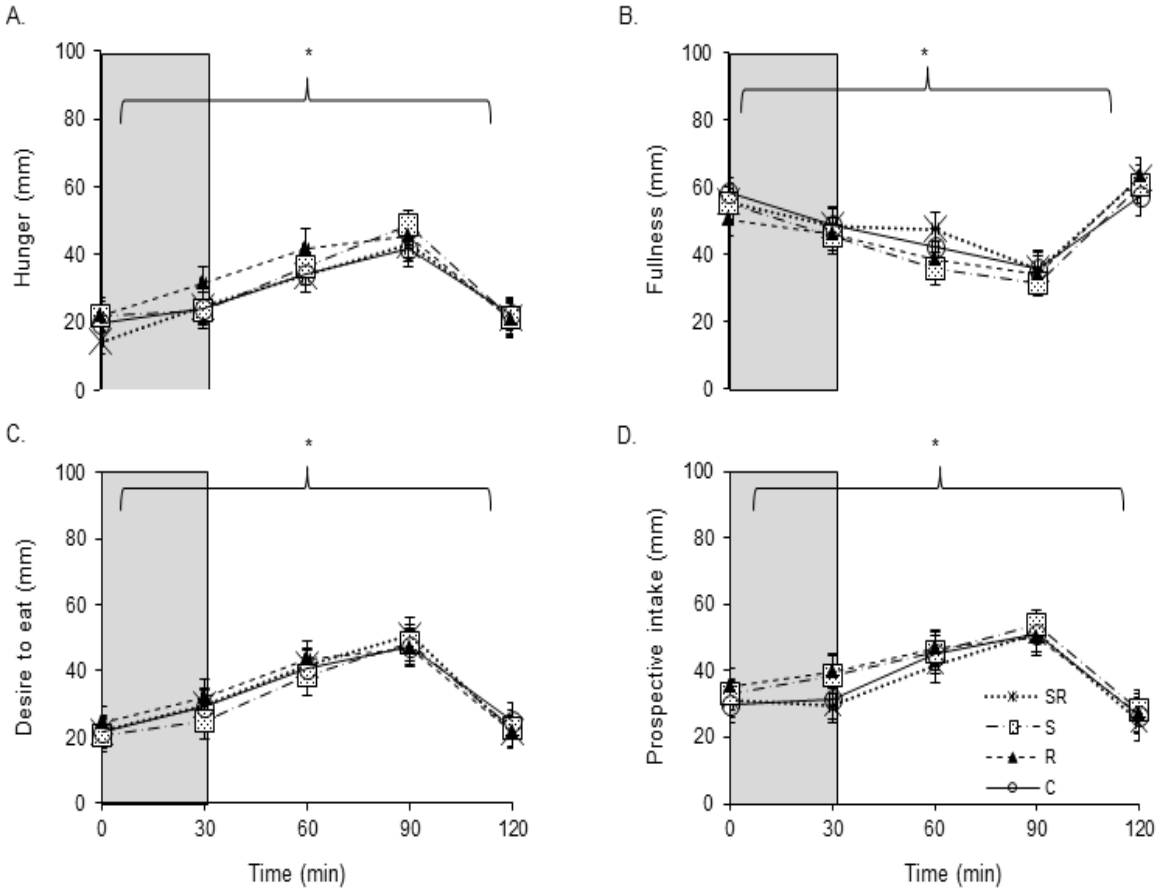

Figure 3.4 The response of self-reported (A) hunger, (B) fullness, (C) desire to eat, and (D) prospective food consumption to acute stress (S), relaxation (R), stress followed by relaxation (SR) or a resting control (C) condition (mean ± SE; n=25). The grey box represents the period over which the S or R interventions were administered in isolation. For the SR condition, stress was administered in the first 30 min, followed by relaxation in the next 30 min. * Indicates a main effect for time ($p < 0.05$).

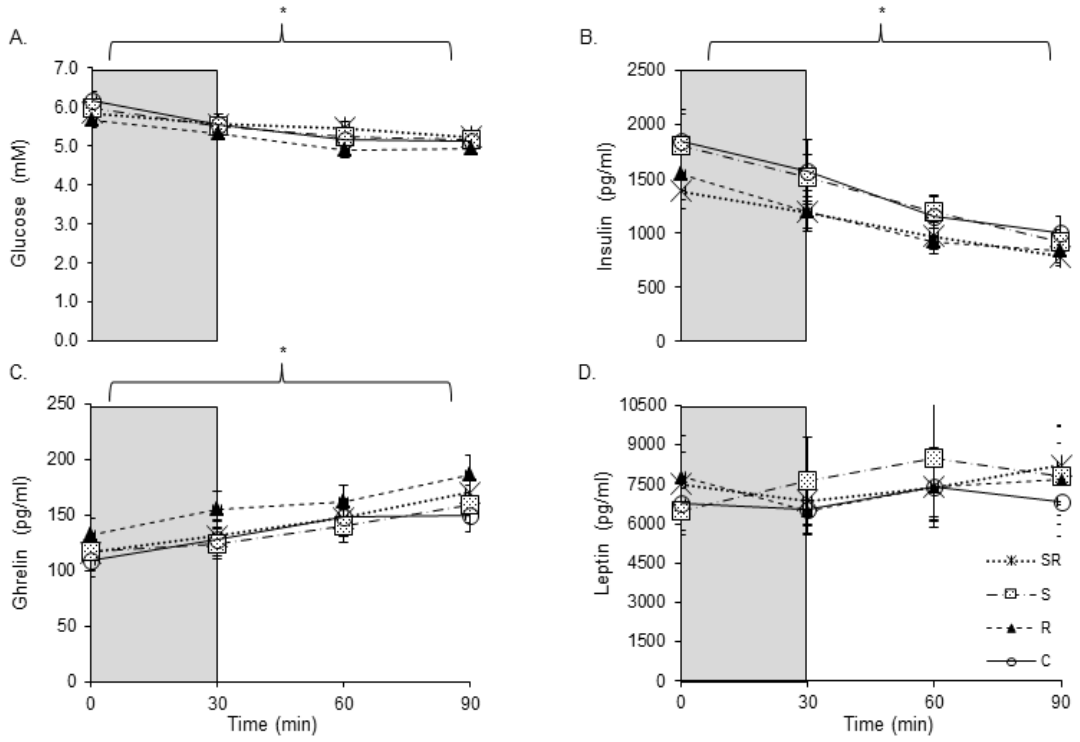

Fig 3.5 The response of (A) blood glucose, (B) insulin, (C), active ghrelin, and (D) leptin in response to acute stress (S), relaxation (R), stress followed by relaxation (SR), or a resting control (C) condition over time (mean ± SE; n = 25). The grey box represents the period over which the S or R interventions were administered in isolation. For the SR condition, stress was administered in the first 30 min, followed by relaxation in the next 30 min. * Indicates a main effect for time ($p < 0.05$).

3.5 Discussion

One of the primary aims of this study was to verify the presence of stress-induced eating amongst a group of healthy adults. A second aim was to test the hypothesis that a brief practice of APMR following an acute laboratory stressor would result in reduced intake of energy-dense snack foods, compared with dietary intake after experiencing the acute laboratory stressor alone. Thirdly, we examined the potential of APMR to evoke physiological and psychological relaxation when practiced in isolation, or immediately post-acute stressor, and lastly, we sought to examine the effect of stress and APMR on hormones that may play a role in stress-induced eating. Contrary to the hypothesis, no difference was found in energy intake between conditions; nor were there differences in self-reported appetite, despite significant alterations in the physiological and psychological indicators of stress including circulating salivary cortisol, HR, BP and self-reported stress and relaxation. However, there was also no difference in energy intake or self-reported appetite between stress and control conditions, suggesting that the phenomenon of stress-induced eating was not evident in the sample of individuals tested here.

The intention of the present study to test an intervention to alleviate stress-induced eating was based on the premise that stress-induced eating (otherwise known as comfort eating), is a commonly recognised phenomenon. This is supported by numerous studies, both in animals (reviewed by Maniam & Morris, 2012; Ulrich-Lai et al., 2015) as well as in humans (reviewed by Sominsky & Spencer, 2014; Torres & Nowson, 2007), in real life settings (Groesz et al., 2012; Kandiah et al., 2006; O'Connor et al., 2008; Sims et al., 2008), and in laboratory-based studies (Rutters et al., 2009; Sproesser, Schupp, & Renner, 2014; Wingenfeld et al., 2017). However, there appears to be considerable variation in stress-

induced eating between individuals (Campbell & Ehlert, 2012; Ebner & Singewald, 2017) - overall energy intake may increase, decrease, or be unaffected by stress (Oliver & Wardle, 1999; Ulrich-Lai et al., 2015). Nonetheless, it has been repeatedly demonstrated that despite variation in overall energy intake, stress prompts a change of preference favouring the intake of energy dense, palatable foods (Born et al., 2009; Dallman, 2010; Oliver, Wardle, & Gibson, 2000; Zellner et al., 2006). Furthermore, this phenomenon of stress-induced eating has been reported by others specifically employing the TSST (Epel et al., 2001; Newman et al., 2007; Rutters et al., 2009). It is unclear why increased intake of such energy dense comfort foods was not evident in the present study; in fact, both the physiological (HR, BP, cortisol) and psychological (self-reported stress) variables monitored in the study indicated that the TSST successfully elicited the stress response equivalently during both occasions. Furthermore, strict inclusion criteria were applied, such that the study only included weight-stable individuals with a consistent lifestyle, excluding those factors that are likely to interfere with laboratory-based stress studies (Kudielka, Hellhammer, & Wüst, 2009; Kudielka & Wüst, 2010). In regard to sample size (n = 25) of the present study, estimation was based on previous reports of stress-induced intake (Habhab et al., 2009; Raspopow et al., 2010; Rutters et al., 2009; Zellner et al., 2006). Notably, unlike the robust crossover design of this investigation, Habhab et al. (2009) (n = 40), and Zellner et al. (2006) (n = 34), both employed a between-groups experimental design, and detected stress-induced intake in a smaller-scale study. Hence, it is unlikely that the results in this study reflect inadequate power. However, like us, some others have also reported no change in energy intake following a TSST-based lab stressor (Appelhans et al., 2010; Raspopow et al., 2010). These authors suggested that the immediate offering of their test buffet (after the stress test) may have coincided with prevailing levels of appetite-

suppressive corticotropin-releasing hormone, and hence reduced dietary intake. For this reason, participants in the present study were served with the test buffet 90 minutes after the onset of the stressor consistent with others who have demonstrated stress-induced eating (Epel et al., 2001). Others purport that the baseline body weight of an individual may indicate a predisposition for stress-induced eating (Groesz et al., 2012; Rudenga, Sinha, & Small, 2013), while some allude to gender specific differences in how one responds to an acute stress, with women more likely to increase their intake of sweet foods, compared to men (Grunberg & Straub, 1992). Both normal weight and overweight men and women were included in the present study in order to reflect a representative sample; however, a gender specific pattern related to stress eating was not evident. Whether different results would be obtained in a different subset of the population remains to be determined. Regardless, the results of this study suggest that the relationship between stress and eating is not a simple one.

Given that energy intake was not significantly increased following exposure to the TSST, the potential for the relaxation intervention to attenuate energy intake was limited. Nonetheless, the APMR was successful in transiently increasing self-reported feelings of relaxation when performed in isolation, as well as when performed after stress, with significantly higher ratings of relaxation at 60 minutes in the stress followed by relaxation condition compared with the stress alone condition. However, the single, acute practice of APMR was insufficient in counteracting the physiological response evoked by the laboratory stressor, with similar circulating cortisol following the stress alone and stress followed by relaxation condition. It may be that a single bout of relaxation practice may not significantly evoke a reduction in cortisol. For example, although an acute stressor was not involved,

Unger et al. (2017) showed that a once-only 35-minute, guided relaxation (based on progressive muscular relaxation) given to 111 university students led to no change in cortisol levels in comparison with a control group (given a stress management lecture), despite a rise in positive affect. It was surmised that the short-term nature of the intervention may have been responsible for the lack of cortisol response.

The results of the present study indicate that the experience of a single relaxation session for the nascent practitioner may not be sufficiently relaxing in order to palliate the stress response. It is possible that different results may be obtained with individuals well-practised in eliciting the relaxation response. For instance, in a study of different styles of meditation, Lumma et al. (2015) found that the associated effort in meditating decreased, while enjoyment rose, with greater practice of the meditative technique (Lumma et al., 2015). In addition, research on mindfulness meditation suggests that in order to fully operationalize the benefits of this mind-body approach, a sustained practice is essential (Goyal et al., 2014). If stress-induced eating is considered a learned habit (a repeated behaviour perceived to be rewarding to an individual), the practice of APMR may not have the immediacy and potency to counteract the stress response, and thus fail to offset the rewarding appeal of eating palatable food (Lally, Van Jaarsveld, Potts, & Wardle, 2010; Ulrich-Lai et al., 2015). In addition, the study findings may also indicate that relaxation practiced following a stressor may not be as effective as doing so prior to stressor onset. In other words, perhaps relaxation is more effective in preventing the rise of stress, rather than having to counteract the stress response once underway. In support of this point, Gaab et al. (2003) found significantly reduced cortisol levels and subjective reports of stress

in participants that attended a 2-day group stress-management training *prior* to taking part in the TSST, compared to control participants attending the training afterwards.

Given that there was no difference in circulating concentrations of insulin, ghrelin, and leptin between conditions, perhaps it is not surprising that no differences in appetite or energy intake were observed in response to stress or relaxation. Nonetheless, even if appetite hormones had varied across conditions, the downstream impact of these hormones on dietary intake may still not have been substantial. In previous research, relationships between stress, appetite peptides, and dietary intake have been inconsistent, and our understanding of these relationships is still not coherent and fully developed. For instance, Rouach et al. (2007) showed that ghrelin was increased with exposure to the TSST, but this was not associated with a consequent rise in dietary intake. In contrast, Kiessl and Laessle (2017) showed no effect of the TSST on ghrelin levels, nor in response to exam stress (Neseliler et al., 2017). No studies to date have specifically addressed the effects of acute stress on insulin in a non-clinical sample. Animal studies (Dallman et al., 2005), and cross sectional human studies (Epel et al., 2004) have found that in the presence of stress-induced cortisol, high insulin levels have been associated with increased intake of calorie-laden foods. Meanwhile, studies of leptin in relation to stress have also revealed much variability in results (Tomiyama et al., 2012), with some studies demonstrating a rise in plasma leptin following the TSST (Appelhans, 2010; Brydon, 2011; Brydon et al., 2008; Tomiyama et al., 2012) along with a subsequent decrease in snack food consumption (Appelhans, 2010; Tomiyama et al., 2012). Jaremka et al. (2014), however, reported lower leptin levels in individuals specifically experiencing high levels of socially-derived stress. More research is therefore needed to clarify the role of these hormones in stress-induced eating.

As mentioned above, the phenomenon of stress-induced eating was not consistently observed in the present study. Previous literature has documented that there is considerable variation in the stress response across individuals (Campbell & Ehlert, 2012; Ebner & Singewald, 2017), and this includes the subsequent dietary response to an acute stressor (Oliver & Wardle, 1999). Furthermore, there are some individuals who eat more in response to positive situations and compensate by reducing intake during stressful states (Sproesser et al., 2014). It is yet to be established how to identify a stress-induced hyperphagic versus a hypophagic, and what elements may moderate the relationship between stress and eating. Factors that may predispose individuals to stress-induced eating include personality type (Neseliler et al., 2017), genetic factors (Capello & Markus, 2014; Rodrigues et al., 2017), and degree of social support (Darling et al., 2017). In the present study, there were no significant correlations between stress-induced energy intake and trait anxiety, rumination, mindfulness, or eating style.

Other factors that may influence the relationship between stress and subsequent energy intake include the nature of the stressor and individuals' stress-mindset. Stress is a psychological and physiological response to a real or perceived threat, which outweighs the resources one has to cope with it (Lazarus & Folkman, 1984). Stress, however, can also be seen as a challenge that promotes personal growth and development (Aschbacher et al., 2012). One's stress mindset, or the manner in which one perceives stress (through a positive or negative lens), can potentially influence the stress response (Crum et al., 2013), and potentially influence appetitive outcome. Participants in this study were volunteers motivated by an interest in advancing stress research; hence, the laboratory stressor may

not have homogenously induced a negative stress response in all individuals, thus leading to inconsistent measures of post-stress energy intake.

Relevant to variability in stress perception, apart from the laboratory-induced acute stress response, the level of life stress experienced by each participant may also be important. Worthy of note, the mean PSS score of 22.00 ± 7.00 is considerably higher than the average PSS score of 16.43, reported by the average Australian, according to the Australian Psychological Society (Casey, 2013). Although research is yet to establish a definition of what constitutes 'chronic stress', and the impact of this on stress and eating (Rudenga et al., 2013), the higher PSS attained in the present study leads us to consider the differential effects of acute stress superimposed on chronic stress which may have contributed to the unexpected results (Rudenga et al., 2013).

Regarding dietary intake, it also bears mention that if stress-induced eating is considered a habit characterised by automaticity and driven by context, the change in dietary intake we failed to observe may have been due to the lab-based nature of the study (Raspopow et al., 2010; Riet, Sijtsema, Dagevos, & De Bruijn, 2011). The foods offered may also have interfered with demonstration of usual stress-driven eating. Pool et al. (2015) stated that the food eaten in response to stress is largely driven by what one habitually eats in these situations, a concept supported by others (Gibson, 2012; Loxton, Dawe, & Cahill, 2011; Yau & Potenza, 2013). Also, of relevance to context, should the participants in the present study have engaged in stress-eating beyond the 150-min laboratory session in the comfort of their own homes, for instance, this was unaccounted for by the study. In relation to this issue, Liu et al. (2017) found that the experience of work-related stress in the morning resulted in relatively greater unhealthy dietary intake later in the evening. Eating in the absence of

hunger has also been shown to be enhanced in the evening compared to other times of the day (Goldschmidt et al., 2017). Whether alterations in appetite and energy intake occurred later in the evening in the participants is not known, and future studies should seek to extend the time of monitoring to investigate this issue.

The present study included numerous precautions to prevent the influence of confounding variables. First, the crossover study design reduced the inter-individual variability associated with between-group studies. Strict selection criteria were employed in order to account for the multiple external factors that impact on both stress responses and dietary behaviour. The study was executed by one experimenter (with the exception of those involved in the TSST), and all other aspects of the protocol (for example, experimental setting, timing, relaxation script used, and foods served) were standardised. The experimental protocol required that each participant replicated their diet, physical activity, and sleep behaviour 24 hours preceding each of the laboratory sessions, as these factors may have otherwise influenced the stress response (Kudielka et al., 2009; Kudielka & Wüst, 2010). Nonetheless, although verified at the commencement of each laboratory session, compliance to experimental protocol may not have been strictly adhered to by all participants. Results also indicated that possibly due to increased familiarity with the experimental protocol, energy intake was significantly greater during the second laboratory session compared with the first, irrespective of condition. It is likely this will have little impact on the results, given the randomisation protocol strictly adhered to in this study. Another potential limitation of this study is that the snack foods offered as the test meal were composed only of high fat/high sugar options, as previous research has suggested that offering healthy alternatives may serve to prompt individuals to eat 'healthier' options

(Wallis & Hetherington, 2009). In addition, it was believed the foods offered in the buffet reflected the predominance of energy dense snack foods contributing to the 'obesogenic environment' prevalent today (Berthoud, 2011). However, it is possible that limiting the test buffet to solely energy-dense snack foods may have limited a broader understanding of food preferences when under stress (Habhab et al., 2009). In order to account for these potential limitations, future studies may seek to offer an array of both healthy and unhealthy snack options. This approach may better capture habitual response to an acute stressor. In addition, pre-selection of only those individuals that identify themselves as stress-eaters, may help reduce variability in outcome in future studies.

3.6 Conclusion

In summary, the present findings indicate that a brief practice of APMR, either after an acute stressor or in isolation, does not alter the intake of commonly eaten snack foods, in comparison with a control condition. Furthermore, stress-induced eating was not consistently observed in this study. Thus, just as stress and eating behaviour are in themselves complex phenomena, this study highlights the additive complexity of stress-induced eating. The results reflect the variation in individual dietary response to stress, suggesting that while a stress response or a relaxation response may be evoked, it may not necessarily translate to a change in eating behaviour, at least in the short-term. Hence, this study serves to further our understanding of the diversity in dietary response to stress, as well as being one of the first studies to investigate possible methods to manage this increasingly recognised maladaptive dietary behaviour. Future studies should seek to unravel the many factors that predispose one to stress-induce eat. Furthermore, given

stress-induced eating may be a long-established behavioural response, the therapeutic effect of a regular relaxation practice over an extended period of time is worthy of investigation.

Chapter 4: An 8-week, worksite-based relaxation program to reduce stress and attenuate stress-driven eating: A randomised feasibility trial.

As based on a paper *prepared for submission:*

Masih, T., Dimmock, J.A., Epel, E., & Guelfi, K.J. (2018). An 8-week, worksite-based relaxation program to reduce stress and attenuate stress-driven eating: A randomized feasibility trial.

4.1 Abstract

Stress-induced intake of energy-dense palatable foods may be a significant contributor to the current global epidemic of lifestyle disease. As such, interventions aimed at decreasing stress may play an important role in attenuating the harmful effects of stress-induced eating. This trial examined the feasibility and preliminary efficacy of an 8-week worksite-based mindful relaxation intervention to address psychological stress and reduce unhealthy food intake. Thirty-six men and women, recruited from various workplace settings, provided baseline data (BMI, psychometrics, palatable food intake and degree of cravings), and attended a laboratory session in which they were exposed to an acute stressor during which physiological and psychological responses were assessed, prior to being offered a laboratory test meal. Participants were then randomised to either a mindful relaxation group (RELAX) (which required attendance to a once-weekly relaxation class and maintenance of a home-based, daily 20-minute relaxation/mindful meditation practice for 8 weeks), or a waitlist control group (CON). All measures were repeated after the 8-week intervention period. Compliance to the intervention was high (80% ± 19% face-to-face; 79% ± 18% scheduled home practice), with each session acutely reducing perceived stress ($p < 0.001$) and increasing relaxation ($p < 0.001$). Trait mindfulness was increased pre- to post-intervention ($p = 0.025$), and reduced tension ($p = 0.013$) and increased relaxation ($p < 0.05$) were noted during the acute stress exposure in the intervention group, unlike in the control group after the 8-week program. Other aspects of the acute stress response remained unchanged, with no main effects or interaction effects for time and/or group on energy intake, palatable eating, or cravings, with only small associated effect sizes ($d = 0.01 – 0.3$). This study shows that a worksite-based mindful relaxation intervention is feasible, has

benefits for mindfulness and stress, but may not exert strong effects on appetite and food intake.

4.2 Introduction

Psychosocial stress can be a significant driver of unhealthy eating (Gibson, 2012; McEwen, 2008). An extensive body of research based in both laboratory (Rutters et al., 2009; Sproesser et al., 2014; Wingenfeld et al., 2017) and free living settings (Groesz et al., 2012; Kandiah et al., 2006; O'Connor et al., 2008; Sims et al., 2008) has established that stress increases intake of energy-dense highly palatable food. Given the potential for unhealthy eating to contribute to weight gain and related health conditions, including cardiovascular disease, diabetes, stroke, depression, and some cancers (Kopelman, 2007; Luppino, de Wit, Bouvy, & et al., 2010; Tsenkova, Boylan, & Ryff, 2013), it is crucial that we develop strategies to address this disordered dietary behaviour in a manner that is practical and easily incorporated into daily life.

The relaxation response is the physiological and psychological opposite of the stress response (a physiological and psychological state in which the demands upon an individual are perceived as outweighing the resources available to contend with them) (Lazarus & Folkman, 1984; Wallace et al., 1971). Intuitively, therefore, the practice of relaxation may attenuate stress and any subsequent effect on eating behaviour. In support of this notion, Pawlow et al. (2003) demonstrated that progressive muscular relaxation (PMR; or its abbreviated equivalent APMR), which is a somatically-focussed relaxation technique based on successive muscular tension and release (Chellew et al., 2015; Jacobsen, 1934), can reduce appetite associated with night eating syndrome. However, a recent investigation by Masih et al. (Chapter 3) found that a single 20-minute treatment of APMR did not significantly affect the intake of energy-dense snack foods in isolation, or when performed

after exposure to an acute stressor. Although a single relaxation session may result in limited effects on stress-induced eating, this raises the question of whether the *long-term* practice of relaxation techniques may still be a viable approach for reducing stress and associated eating. The regular practice of relaxation, as opposed to the isolated practice examined in this previous study, may be more potent in disrupting any mechanisms associated with stress-induced eating given that stress-eating may be a long-ingrained behavioural response. Also, it is recognised that the skill - and associated beneficial effects - of interoceptive relaxation practice develops with repeated application over time (Lumma et al., 2015).

In attempting to test the hypothesis that regular elicitation of the relaxation response can attenuate stress-induced eating, one must consider that there are many methods by which relaxation can be achieved (Benson et al., 1975). Although PMR is one of the most widely documented techniques in relaxation research (Chellew et al., 2015; Jacobsen, 1934), another method through which the relaxation response may be achieved is mindfulness meditation (MM) (Benson et al., 1975), which involves the cultivation of non-judgmental awareness of the present moment (Kabat-Zinn, 2013). Both mindfulness practice and an integrated relaxation program (including PMR) have been shown to improve positive states of mind and reduce distress to a similar extent (Agee et al., 2009; Jain et al., 2007). However, PMR may be more effective in reducing somatic aspects of stress (Matsumoto & Smith, 2001; Rausch et al., 2006), while mindfulness practice is focused on addressing cognitive components of stress, especially rumination (Jain et al., 2007), automaticity (Fisher et al., 2016), and promoting non-judgemental acceptance of the present moment (Alberts et al., 2012). Since both cognitive and physiological elements of stress may play a role in

promoting the intake of palatable food (Masih et al., 2017), the combination of PMR and MM in a single intervention may offer a promising approach to reducing stress-induced eating.

Like for PMR, there is preliminary evidence that mindfulness approaches can attenuate parameters of stress eating. Corsica, Hood, Katterman, Kleinman, and Ivan (2014) demonstrated reduced self-reported stress-eating amongst overweight volunteers following 6-weeks of Mindfulness-based Stress Reduction and cognitive-behavioural training for stress-eating, which required a once weekly 80-minute class, in addition to daily 30-45-minute home-based activities. In another study, Daubenmier et al. (2011) required overweight/obese women enrolled in a modified Mindfulness-Based Stress Reduction program to attend a weekly 2.5-hour class, supplemented by 30-minutes of daily home practice, and a one-day silent retreat over 4 months, which resulted in a reduction in self-reported anxiety as well as subjective reports of eating in response to external cues. A common feature of these studies is the significant time commitment involved, potentially deterring adoption into daily life. Therefore, the present pilot study aimed to test the feasibility and preliminary efficacy of an 8-week worksite intervention combining brief (20-minute) practice of APMR and MM on stress and stress-induced eating. More specifically, the aim was: 1) To establish the feasibility of such an intervention in terms of recruitment, fidelity, dose, and acceptability, and 2) To provide preliminary evidence of the effect an 8-week mindful relaxation intervention on physiological and psychological features of stress, aspects of wellbeing (i.e. BMI, anxiety, rumination), and indicators of stress-induced eating (i.e. ad libitum intake, craving, circulating concentrations of appetite-related peptides).

4.3 Research Design and Methodology

4.3.1 Study participants

Participants were recruited by distributing flyers and electronic notices to staff and postgraduate students at the University of Western Australia (UWA), by promoting the project to health and wellbeing personnel at 32 corporate organisations, and by liaising with teaching/administrative staff at 3 schools in the city of Perth, Western Australia. Calls for volunteers stated that healthy men and women aged 18 – 60 years were invited to take part in a research project investigating the effect of an 8-week worksite-based mindful relaxation course on the physiological and psychological effects of stress. Volunteers that expressed interest in participating were emailed an information sheet detailing the experimental protocol (Appendix A). This was followed by a phone interview to confirm suitability based on the following inclusion criteria: a BMI between 20-30kg/m^2, weight stable (no change greater than 2 kg in last six months and currently within 2.5 kg of maximum adult weight), no diagnosed medical conditions or fear of needles. Further exclusion criteria included a history of substance abuse, heavy drinking or smoking, the use of prescription medications, current/recent dieting, previous regular practice of relaxation techniques, excessive exercise (greater than 2-hours/day), an irregular work/sleep schedule, and irregular breakfast intake. Women who were pregnant/lactating or had an irregular menstrual cycle were also excluded (Appendix A). Although extensive, these criteria were enforced given the various factors that may influence outcomes of both stress and appetite. This study was approved by the University Human Research Ethics Committee, registered at Australian New Zealand

Clinical Trials Registry (ID number ACTRN12616001337460), and written consent was obtained by all participants (Appendix A). All procedures related to implementation of the study protocol including recruitment, laboratory testing, and guiding of mindful relaxation classes were conducted by the lead author with expertise in relaxation and mindfulness meditation.

4.3.2 Experimental overview

Participants were first required to attend a 90-minute familiarisation session which took place at their workplace (detailed below). They were then scheduled to attend the university laboratory for baseline (pre-intervention) testing at a later date. At the completion of this, participants were randomised to an 8-week mindful relaxation (RELAX) group or a waitlist control (CON) group using sealed envelope randomisation as prescribed by Doig and Simpson (2005). Following the 8-week period, each participant attended the university laboratory for post-intervention assessments.

4.3.3 Familiarisation session

During this session, participants were informed of the pre-experimental protocol they were expected to follow for each subsequent assessment session, and informed that the stress condition involved a 'verbal ability task' (Appendix A). Single blood and saliva samples were also obtained in order to familiarise participants with the intended sampling procedure during the experimental sessions, along with a brief overview of the APMR and the MM practice should they be randomly allocated to the RELAX group. Additionally, each participant completed the following: a general information questionnaire, in which demographic information was obtained; the Perceived Stress Scale (PSS; Cohen, Kamarck, & Mermelstein, 1983), which is a 14-item questionnaire measuring perception of recent stress ('over the last week') in everyday life, with item scores anchored at 0 (never) to 4 (very

often); the trait subscale in the State-Trait Anxiety Inventory (STAI-Trait; Speilberger, Gorsuch, & Lushene, 1970), which includes 20 items measuring perceived anxiety on a scale of 1 (almost never) to 4 (almost always); the Mindfulness Attention Awareness Scale (MAAS; Brown & Ryan, 2003), a 15-item measure of trait mindfulness with response anchors at 1 (almost always) and 6 (almost never); the Rumination Response Scale - Trait (RRS; Treynor et al. (2003), which includes 22-items measuring an individual's tendency to ruminate on a scale of 1 (almost never) – 4 (almost always); The Stress Mindset Measure-General (SMM-G; Crum et al., 2013), an 8-item questionnaire with a response scale ranging from 0 (strongly disagree) to 4 (strongly agree) which assesses the degree to which stress is considered of harm or benefit to one's well-being; the Palatable Eating Motives Scale (PEMS; Burgess, Turan, Lokken, Morse, & Boggiano, 2014), a 20-item questionnaire with responses of 1 (almost never-never) to 5 (almost always-always) indicating motivation for the consumption of palatable foods; the Food Craving Inventory-British (FCI; Nicholls & Hulbert-Williams, 2013) (adapted for suitability for the Australian diet), which assesses the frequency of experiencing particular food cravings, the likelihood of yielding to them (on a scale of 0 (never) to 4 (always, almost every day), and the difficulty associated with resisting the cravings on a scale of 0 (easy) to 4 (so difficult that I gave in). The degree of self-perceived stress-induced eating was assessed by asking participants to respond to the statement: 'If I am stressed, I eat' on a scale of 1 (less) – 7 (more), and finally, an adapted version of the Pittsburgh Sleep Quality Index (PSQI; Buysse, Reynolds, Monk, Berman, & Kupfer, 1989) (self-reported component) was completed in order to gauge the effect of the intervention on sleep quality, by responding to 9 items relating to hours of sleep, and reasons for sleep disturbance. Anthropometric measures that were obtained during this initial session included body weight (assessed with a digital scale; Sauter, Sydney, Australia) and height

(assessed using a wall mounted height-meter; Seca, Germany). Participants were also provided with diet and behaviour diaries in order to record dietary intake, sleep, wake times, and activity level for 24 hours preceding pre- and post-intervention laboratory testing (Appendix G).

4.3.4 Relaxation intervention

Participants assigned to the RELAX group were requested to attend a once-weekly 30-minute, worksite-based class comprised of either a 20-minute guided APMR or MM practice (which were alternated every 2 weeks), and the completion of a brief pre- and post-practice questionnaire. The practice of APMR consists of sequential tensing and relaxing of 16 muscle groups (as described by Bernstein and Borkovec (1973)), in order to release muscular tension and subsequently relieve mental tension. Participants were asked to focus on the contrasting sensations of tension and release as they engaged in the technique (Bernstein & Borkovec, 1973). The MM session was based on a script by Kabat-Zinn (2002), in which participants are asked to draw attention to the present by using the breath as an anchor (Kabat-Zinn, 2002) (Appendix D). In addition to the face-to-face sessions, participants were provided with 20-minute audio recordings of the guided MM and the APMR (performed by *TM*) for maintenance of daily home practice. During the course of the 8 weeks, participants were given reminders to change from the APMR to the MM audio recording every 2 weeks.

4.3.5 Assessment of intervention feasibility

Aspects of recruitment, fidelity, dose, and acceptability of the experimental protocol and intervention were monitored (Saunders, Evans, & Joshi, 2005). Attendance at the weekly sessions was recorded, and each participant was provided with a relaxation log to document

frequency of home practice (Appendix G). In addition, during the weekly face-to-face classes, participants were asked to complete a 100 mm visual analogue scale pre- and post-practice in order to assess state mindfulness, stress, and relaxation (adapted from Fisher et al., 2016). The pre-practice questionnaire consisted of 2 questions: 1. 'How stressed do you feel now?' and 2. 'How relaxed do you feel now?' The post-practice VAS included questions 1) and 2) as above, in addition to 3) 'How demanding was the [relaxation] exercise for you?' and 4) 'How enjoyable was the [relaxation] exercise for you?' In order to specifically address state mindfulness, the post-MM practice questionnaire also asked 5) 'During the guided session, I felt myself getting carried away by my thoughts rather than just noticing them'; 6) 'During the guided session, I paid attention to my thoughts and feelings'; 7) 'During the guided session, I was aware of my thoughts, feelings and bodily sensations'; 8) 'During the guided session, I paid attention to my thoughts and feelings without judging them'; and 9) 'During the guided session, I was aware of my thoughts, feelings and bodily sensations with a sense of acceptance'(adapted from Fisher et al., 2016) (Appendix F).

4.3.6 Assessment of Preliminary Efficacy

Before and after the 8-week intervention period, each participant attended the university laboratory at 0800 h in the fasted state. Participants were required to eat the same standard meals and snacks, and abstain from caffeine, alcohol, and exercise for 24 hours prior to each experimental session (confirmed using nutrient analysis software [FoodWorks; Xyris Software, Kenmore Hills, Qld, Australia]). They were also instructed to commence fasting 12 h prior to attending their scheduled laboratory session. Upon arrival to the laboratory, participants initially completed the PSS, and then, following a 30-minute settling period, baseline blood pressure (BP) and heart rate (HR) were recorded (Omron HEM 7211,

Hoofddorp, The Netherlands), and baseline saliva and blood samples collected. Participants were also required to complete the Profile of Mood States-Adolescence (POMS-A; a 24-item questionnaire assessing the six moods of anger, confusion, depression, fatigue, tension, and vigour, with responses on a scale from 0 (not at all) to 4 (extremely)) (Terry, Lane, & Fogarty, 2003). Following this, a 100 mm Visual Analogue Scale (VAS) was completed in order to gauge perceived level of hunger, fullness, desire to eat, and prospective food consumption (Flint, Raben, Blundell, & Astrup, 2000). A similar VAS assessed the level of stress and relaxation felt (i.e. 'how stressed (or relaxed) do you feel?' (Fisher et al., 2016; Neseliler et al., 2017).

Following baseline measures, participants took part in the TSST (Kirschbaum, Pirke, & Hellhammer, 1993), which is a 15-minute laboratory-based stressor comprised of elements that most reliably increase cortisol response: public speaking, a numerical exercise, the presence of spectators, and the threat of a negative outcome (Kirschbaum et al., 1993). In brief, participants were requested to present a 5-minute talk in order to convince a two-member mock selection panel that they were suitable candidates for a job (or a promotion) they had applied for. This was followed by a numerical exercise that involved reverse counting. In addition, participants in the TSST were informed that their performance would be video recorded for later analysis (Kirschbaum et al., 1993). In order to reduce the stress adaptation likely associated with stressor familiarity during the second (post-intervention) TSST, the mock selection panellists were different individuals, and participants were informed that their performance during the first TSST was assessed as "being in the lower range and that this was an opportunity to better their score" (Hoge et al., 2013; Hoge et al., 2017) (the protocol validated in Chapter 2). After the completion of the TSST, participants

viewed a nature documentary on plant life for the remaining duration of the laboratory session. Recording of BP, HR, samples of saliva and blood, along with the administration of the POMS-A and VAS were repeated at 30, 60, and 90-minute following commencement of the TSST. In addition, after administration of the TSST, participants completed the pressure/tension (5 items) and perceived competence (6 items) subscales of the Intrinsic Motivation Inventory (IMI; Ryan, 1982). Scores for items on the IMI are recorded on a scale of 1 (not at all true) to 7 (very true). Finally, the Stress-Mindset-Specific questionnaire (SMM-S; Crum et al., 2013) was completed in order to assess each participant's perception of the acute stress experience.

Ninety minutes after the onset of TSST, participants were offered a pre-weighed selection of breakfast items. This buffet was based on a choice of commonly eaten healthy and unhealthy breakfast foods in Australia (Australian Bureau of Statistics; Roy Morgan Research, 2014) including breakfast cereal, croissants, toast, a choice of spreads, breakfast biscuits, yoghurt, tea/coffee, a jar of candy, and chocolate (Maltesers, Mars, NSW, Australia) (Figure 4.1). Participants were told that the food offered was in recognition of their time, and because blood was drawn from them four times, while in a fasted state. Each participant was then left alone to eat as desired for 30 minutes. Following their departure, the remaining food was re-weighed, and energy intake determined (FoodWorks; Xyris Software, Kenmore Hills, Qld, Australia).

Figure 4.1 Breakfast buffet items offered during pre- and post-laboratory sessions

(i) Biochemical measures

Saliva was obtained using salivettes (Sarstedt, Numbrecht, Germany) (Epel et al., 2001) placed in the mouth for 90 s. Samples were later centrifuged at 4°C for 5 minutes at 1300 x *g* and frozen at -80°C until assayed for cortisol. Briefly, this involved spiking collected saliva (250 µL) with 50 ng/mL of labelled cortisol and extracting by vortexing into 1 mL of ethyl acetate prior to being centrifuged, with the supernatant dried down in a centrifugal evaporator. Dried samples were reconstituted in 70 µL of 70% methanol, 30% water, prior to assaying by Liquid Chromatography Mass Spectrometry (Agilent Technologies 2 1290 UPLC series Liquid Chromatography pumps, coupled to a 6460 Triple Quadrupole MS system operating in positive ion multiple reaction monitoring mode). Quality controls were assayed using commercially available serum controls for cortisol (Biorad) and then diluting them x 100 in synthetic saliva.

Blood was drawn from the fingertip using a sterile lancet (Unistik 2 Normal; Owen Mumford, Oxford, UK), and 500 µL was placed into EDTA coated microtainer tubes (K2EDTA, BD Microtainer, Franklin Lakes, NJ, USA) with 20 µL of serine protease inhibitor (Pefabloc SC, Roche Diagnostics, Sydney, NSW). This blood was immediately centrifuged for 10 minutes at 1020 x *g* at 4°C, with the plasma frozen at -80°C for later assay of plasma insulin, active ghrelin, and leptin using the Milliplex Human Gut Hormone Panel (Millipore Corporation, Billerica, USA) according to manufacturer's instructions on a Milliplex MAGPIX system (EMD-Millipore/Merck KGaA, Darmstadt, Germany). These specific hormones were selected based on reported associations with stress-induced eating in the literature (Masih et al., 2017; Sominsky & Spencer, 2014).

4.3.7 Post-experimental Debrief Session

On completion of post-intervention testing, participants were required to repeat all questionnaires presented during the familiarisation session, in addition to the Dutch Eating Behaviour Questionnaire (DEBQ; van Strien, Frijters, Bergers, & Defares, 1986) and the 16-item Disinhibition subscale in the Three Factor Eating Questionnaire (TFEQ; Stunkard & Messick, 1985). A full debrief was then provided following confirmation by the participants that they were unaware of the true aims of the study.

4.3.8 Statistical Analyses

The feasibility and acceptability of the intervention was assessed based on compliance, enjoyment, and acute outcomes of the mindful relaxation classes. A comparison of the observations from each RELAX participant's initial and final class was carried out using a two-way ANOVA (session (initial session versus final)) x time (pre-class versus post-class)), for perceived stress and relaxation. Single post-practice outcomes (e.g. degree of

enjoyment, perception of demand, and levels of mindfulness achieved), were analysed using one-way ANOVA between the first and final session. To compare aspects of APMR versus MM, three-way (practice type (MM vs APMR) x session (initial versus final) x time (pre-class versus post-class) ANOVA was conducted for stress and relaxation, while a two-way ANOVA (practice type x session) was conducted for enjoyment and demand.

To assess the preliminary efficacy of the intervention, variables with a single value measured pre and post-intervention (i.e. BMI, life stress, stress mindset, trait anxiety, rumination, and mindfulness, along with sleep quality) were compared using two-way (group (RELAX vs CON) x time (pre-post)) repeated measures ANOVA. Variables with multiple measures over time within the pre- and post-intervention laboratory session (e.g. BP, HR, mood, perceived stress) were compared using three-way (group (RELAX vs CON) x time (pre-post) x time (within the session)) repeated measures ANOVA. In addition, Cohen's d effect sizes were determined to assess the practical significance of changes as a result of the intervention. Effect sizes were interpreted as < 0.5 small, 0.5-0.8 moderate and > 0.8 large (Lakens, 2013). Finally, bivariate correlation analysis was performed between trait mindfulness and parameters of appetite, including self-reported palatable food intake and craving in order to explore relationships between mindfulness and characteristics that may influence stress-induced eating

4.4 Results

4.4.1 Study Feasibility

(i) Recruitment

A total of 172 individuals were formally assessed for eligibility for the study between October 2016 and July 2017, with 28% (n = 48) meeting the criteria for inclusion. Of these, 37 completed baseline assessments and were randomised (Figure 4.2), with the remaining 11 declining to participate due to a lack of time. Following baseline assessment, one participant was found to no longer meet the inclusion criteria (due to the commencement of medication), leaving 36 individuals randomised to the intervention or control. A further 2 participants in the RELAX group were unable to attend the post-intervention assessment after completion of the 8-week trial. Based on the study selection criteria, the most common reasons for exclusion included maintenance of a special diet (13.6%), weight instability (10.4%), irregular menstrual cycle (10.4%), and psychopathology (9.6%). The final sample comprised employees from two large corporations (n = 16) and university students (n = 20). Baseline characteristics are shown in Table 4.1. The groups were well matched at baseline, with no differences in characteristics such as age, BMI, and psychometric variables.

Figure. 4.2 Consolidated Standards of Reporting Trials (CONSORT) flow diagram (Schulz, Altman, & Moher, 2010).

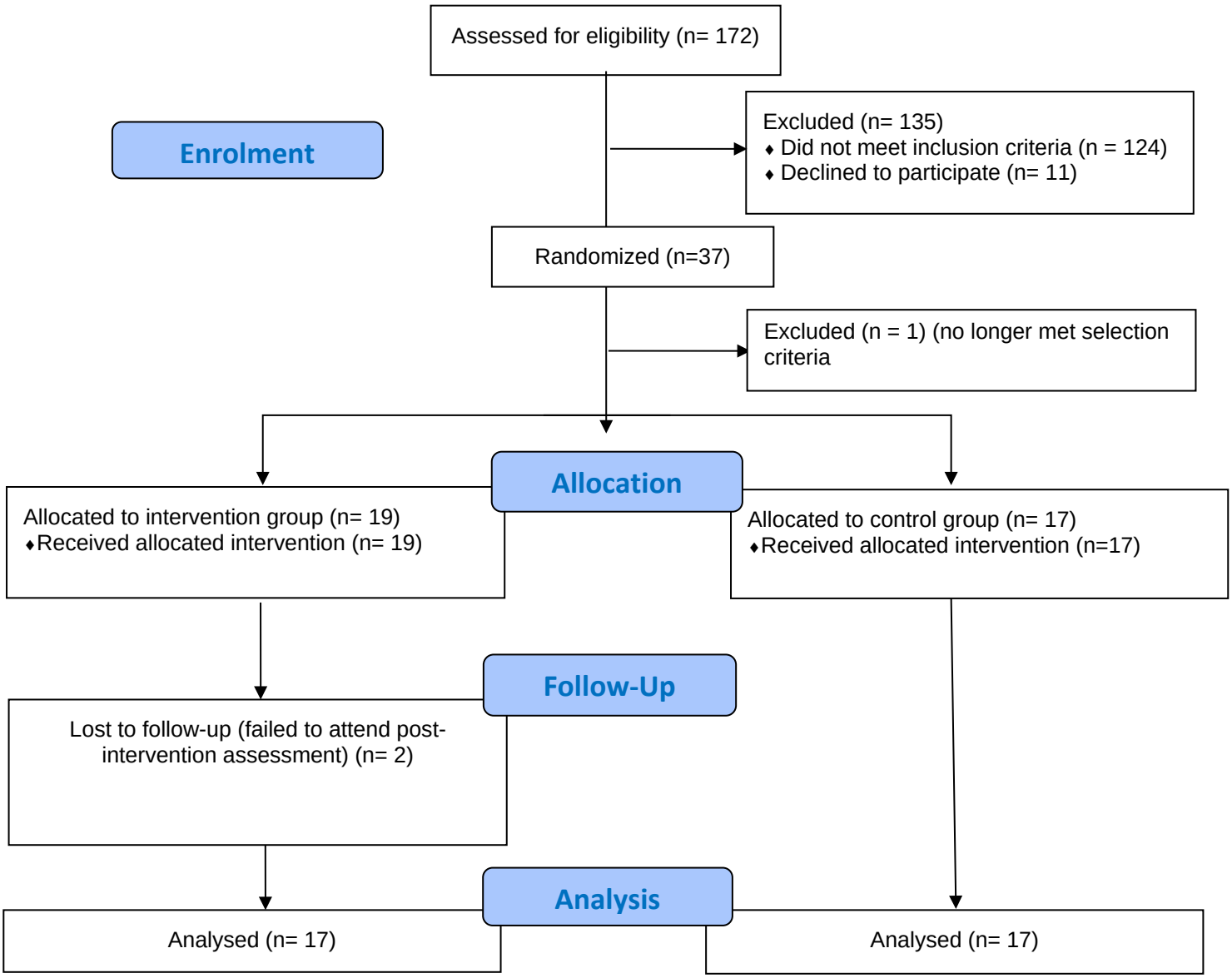

Table 4.1 Baseline characteristics of participants allocated to a wait-list control (CON) or mindful relaxation group (RELAX) (mean ± SD).

	CON group (n = 17)	RELAX group (n = 19)	p-value
Age (yrs)	33 ± 12	39 ± 10	P = 0.08
Sex	M (35%), F (65%)	M (32%), F (68%)	P = 0.81
BMI (kg/m^2)	24.4 ± 3.3	26.1 ± 4.3	P = 0.20
Perceived Stress Scale	25.24 ± 7.5	23.42 ± 14	P = 0.51
General stress mindset	1.90 ± 0.81	2.02 ± 0.72	P = 0.63
Trait anxiety	43.00 ± 10.16	40.63 ± 8.41	P = 0.45
Trait Rumination	40.41 ± 10.81	38.95 ± 8.25	P = 0.65
Trait mindfulness	3.60 ± 0.83	3.55 ± 0.90	P = 0.87
Stress-eating	4.59 ± 1.91	3.79 ± 2.02	P = 0.23
Restrained eating	2.48 ± 0.75	2.35 ± 0.82	P = 0.62
Emotional eating	2.48 ± 0.84	2.00 ± 0.62	P = 0.07
External eating	3.2 ± 0.7	2.99 ± 0.61	P = 0.40
Disinhibition	6.29 ± 3.31	5.88 ± 3.57	P = 0.73

(ii) Intervention Fidelity

Overall, the 8-week mindful relaxation intervention was implemented as intended. All components of the experimental protocol were conducted by a single researcher (an Accredited Practicing Dietitian, a qualified mindfulness meditation and yoga teacher), with the exception of panellists required to conduct the TSST. The setting, timing, relaxation script used, equipment used, and foods served, were standardised for all participants. The

replication of diet, sleep, and physical activity 24 hours preceding the pre- and post-intervention assessment session was also verified. There was no difference in energy intake in the 24 hours preceding the laboratory session (across groups and over time), indicative of dietary compliance ($p = 0.43$). The debrief provided to participants after completion of the post-intervention laboratory session indicated that the blinding of participants to the appetite component of the investigation was successful (Appendix A).

(iii) Dose and acceptability

Delivery of the once-weekly classes were completed as planned. Compliance to the face-to-face classes was 80% ± 19%, while participants completed 79% ± 18% of the home-practice sessions. The face-to-face sessions acutely reduced perceived stress and increased relaxation based on the pre-post session measures obtained at each class, with a main effect for time (pre-post session) for stress ($F = 41.18_{(1, 16)}$, $p < 0.001$), and relaxation ($F = 30.39_{(1, 16)}$, $p < 0.001$). There was also indication that the degree of relaxation achieved during the classes increased over the course of the 8 weeks, with the main effect for time approaching significance, from the initial to final class ($F = 4.34_{(1, 16)}$, $p = 0.056$). When the AMPR and MM classes were compared, both were effective for acutely reducing stress $F_{(1, 16)} = 63.77$, $p < 0.001$, and increasing perceived relaxation ($F_{(1, 16)} = 85.62$, $p < 0.001$), with APMR inducing a greater level of relaxation ($F_{(1, 16)} = 7.02$, $p < 0.05$) (Table 4.2). Measures of state mindfulness obtained after the face-to-face MM sessions remained constant over the course of the 8 weeks, except for item: '*During the guided session, I paid attention to my thoughts and feelings without judging them,'* which increased in rating over time from the first class (M = 64 ± 20 mm) to the final class (M = 72 ± 16 mm, $p = 0.049$) and item: *'During the guided session, I was aware of my thoughts, feelings, and bodily sensations with a sense of acceptance,'* which also increased in rating between first and final classes (63 ± 20 versus

76 ± 16 mm, p = 0.003), indicating that the repeated practise of MM positively affected elements of state mindfulness. The degree of enjoyment derived from the face-to-face practice was high (M = 86 ± 14 (APMR); 80 ± 20 (MM)), similar between session types, and did not change over the course of the 8 weeks (p = 0.59). How demanding the APMR (M = 15 ± 19) or MM (M = 29 ± 31) practice felt also did not change over the course of the 8 weeks; however, a main effect of practice type ($F = 8.42_{(1, 16)}$, p = 0.010) distinguished MM as more demanding than APMR. Associated effect sizes are shown in Table 4.2. For those randomised to the control group, 41% took up the option to complete the 8-week program after completion of the study.

Table 4.2 Perceived stress, relaxation, enjoyment, and demand of an-8-week mindful relaxation intervention consisting of abbreviated progressive muscle relaxation (APMR) and mindfulness mediation (MM) face to face sessions (mean ± SD)

	APMR						MM					
	Initial session		*Cohen's d*	Final session		*Cohen's d*	Initial session		*Cohen's d*	Final session		*Cohen's d*
	pre	post		pre	post		pre	post		pre	post	
Perceived stress (mm)	38 ± 28	13 ± 13*	***-1.15***	33 ± 24	13 ± 13*	***-1.04***	45 ± 29	22 ± 18*	***-0.95***	32 ± 18	15 ± 19*	***-0.92***
Perceived relaxation (mm)	47 ± 26	82 ± 11*	***1.75***	55 ± 20	83 ± 13*	***1.66***	47 ± 26	68 ± 29*	***0.76***	58 ± 24	79 ± 22*	***0.91***
Enjoyment (mm)	-	86 ± 14	-	-	86 ± 14	*0*	-	77 ± 22	-	-	80 ± 20	*0.14*
Demand (mm)	-	12 ± 13	-	-	15 ± 19	*0.09*	-	32 ± 28	-	-	29 ± 31	*-0.10*

*Indicates significant difference pre to post session ($p < 0.05$)

Moderate-large effect sizes are denoted in bold.

4.4.2 Study Efficacy

(i) Effect on BMI, psychometrics, and sleep quality

The preliminary efficacy of the intervention for altering BMI, self-reported psychological variables (including stress, stress mindset, trait anxiety, rumination, and mindfulness), and sleep quality are summarised in Table 4.3. There was no significant main effect for time or significant interaction of group and time, and the associated effect sizes were small, for BMI, trait rumination, trait anxiety, and sleep quality ($p > 0.05$). For trait mindfulness, there was a main effect for time ($F = 4.85_{(1,32),}$ $p = 0.035$), and an interaction effect approaching significance ($F = 3.97_{(1, 32)}$, $p = 0.055$), with post hoc analyses revealing a significant increase in trait mindfulness within the intervention group over the 8-week intervention ($T = -2.48_{(16),}$ $p = 0.025$; $d = 0.53$), but no change in the control group ($T = -0.20_{(16)}$, $p = 0.85$). Life stress (based on the perceived stress scale) decreased over the experimental period, ($F = 4.31_{(1),}$ $p = 0.046$), with a main effect for time but no difference between groups. Likewise, there was a main effect for time on general stress mindset ($F = 11.88_{(1,32)} = 0.002$), indicating a parallel increase (across both groups) in the degree to which stress was viewed as health-enhancing. Only the increase in stress mindset in the intervention group was supported by a moderate effect size ($d = 0.68$).

Table 4.3 Effect of an-8-week mindful relaxation intervention or wait-list control on BMI, psychometrics, and sleep quality (mean ± SD)

	CON (n = 17)			RELAX (n = 17)		
	Pre	Post	*Cohen's d*	Pre	Post	*Cohen's d*
BMI (kg/m^2)	24.4 ± 3.3	24.6 ± 3.2	*0.06*	25.7 ± 4.3	25.9 ± 4.1	*0.05*
Perceived stress scale*	25.23 ± 7.50	23.53 ± 5.28	*-0.30*	23.00 ± 9.24	19.47 ± 8.25	*-0.40*
General stress mindset*	1.90 ± 0.81	2.16 ± 0.87	*0.30*	2.07 ± 0.71	2.55 ± 0.70	***0.68***
Trait anxiety	43.00 ± 10.16	42.41 ± 7.10	*-0.07*	41.00 ± 8.44	39.65 ± 8.99	*-0.15*
Trait rumination	40.41 ± 10.81	40.53 ± 11.28	*0.01*	38.18 ± 8.25	37.00 ± 9.11	*-0.14*
Trait mindfulness	3.60 ± 0.83	3.62 ± 0.70	*0.03*	3.51 ± 0.93	3.98 ± 0.83†	***0.53***
Sleep quality	5.65 ± 2.52	5.29 ± 2.14	*-0.15*	4.71 ± 2.71	4.06 ± 1.39	*-0.30*

*indicates a main effect for time ($p < 0.05$)

†indicates significant difference from pre- to post-intervention ($p < 0.05$)

Moderate-large effect sizes are denoted in bold.

(ii) Effect on the acute stress response

The acute stress response was elicited pre- and post-intervention by the laboratory stressor (TSST), as evidenced by a main effect of time (within each laboratory session) for perceived stress ($F = 18.83_{(4, 128)}$, $p < 0.001$), cortisol ($F = 19.15_{(1.66, 49.90)}$, $p < 0.001$), systolic BP ($F = 28.64_{(4, 128)}$, $p < 0.001$), diastolic BP ($F = 26.85_{(4, 128)}$, $p < 0.001$), and HR ($F = 29.02_{(3.25, 103.94)}$, $p < 0.001$), all of which consistently increased in response to the TSST (Figure 4.3). Meanwhile, a time (pre- to post-intervention) x group interaction ($F = 4.39_{(1, 31)}$, $p = 0.045$) was obtained for self-reported relaxation in response to the Trier. Post hoc analysis indicated that, unlike the CON group, the RELAX group reported greater levels of relaxation within the post-intervention laboratory session (immediately, 60 minutes, and 90 minutes post-stressor) compared to pre-intervention ($p < 0.05$).

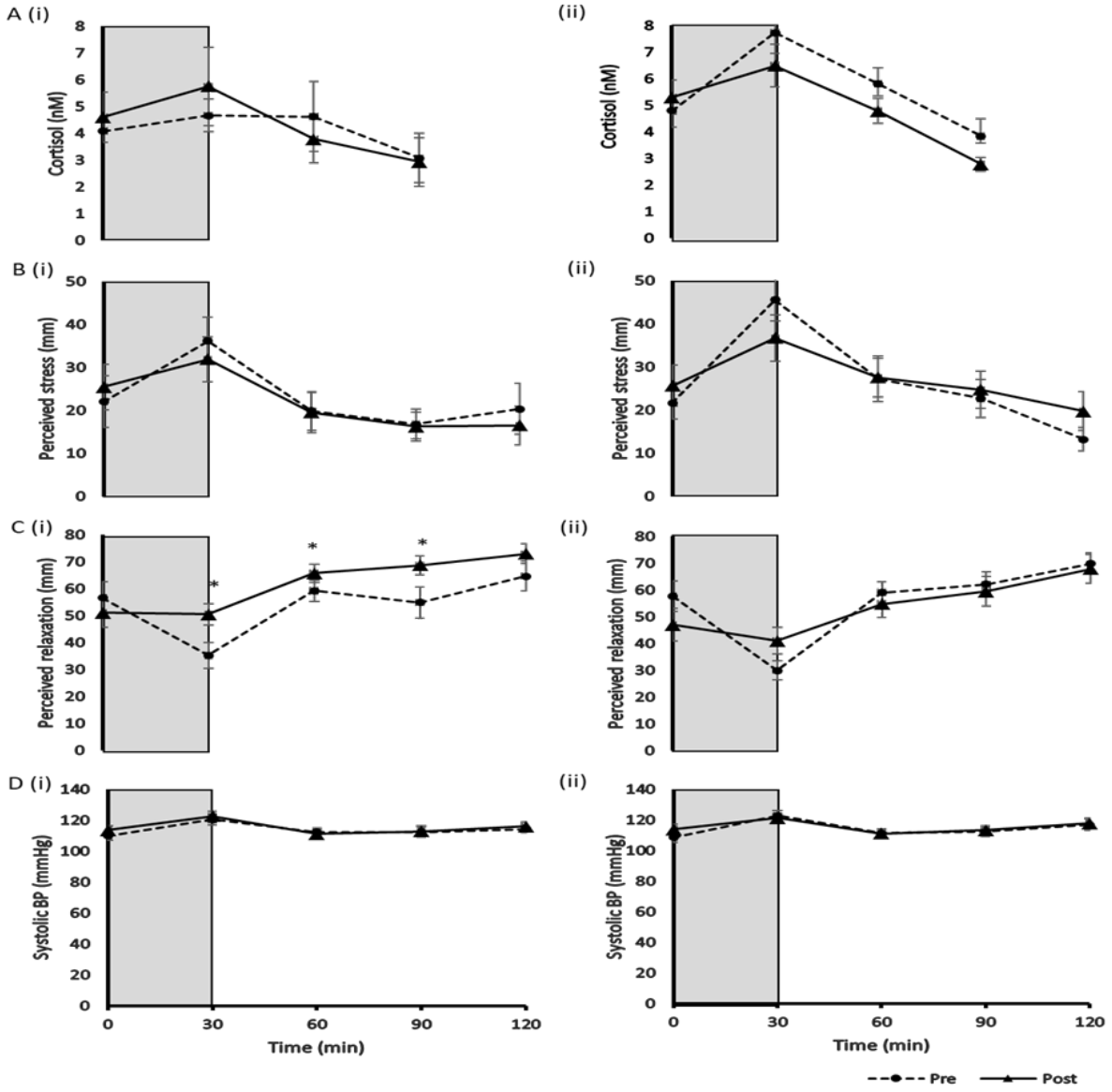

Figure 4.3 The pre- and post-intervention response of (A) salivary cortisol, (B) perceived stress, (C) perceived relaxation, and (D) systolic BP to acute stress over time in (i) RELAX and (ii) CON groups (mean ± SE). The grey box represents the period over which the TSST was administered. A main effect of time was evident for perceived stress, cortisol, and systolic BP ($p < 0.001$). * Indicates a significant difference pre- to post intervention ($p < 0.05$).

Anger, ($F = 5.87_{(2.40, 76.86)}$, $p = 0.002$), depression ($F = 6.43_{(2.43, 77.66)}$, $p = 0.001$), confusion ($F = 17.41_{(2.28, 72.83)}$, $p < 0.001$), tension ($F = 27.54_{(2.22, 71.18)}$, $p < 0.001$), and vigour ($F = 7.95$, (3.00, 96.27), $p < 0.001$), increased in response to the TSST, based on a main effect of time (within the laboratory sessions), followed by a gradual decline. This pattern of response was consistent pre- to post-intervention for all, but for tension, where the interaction effect of the intervention (pre to post) x time (within the laboratory session) x group approached significance ($F = 2.44_{(2.90, 92.92)}$, $p = 0.07$). Post hoc analyses indicated that the RELAX group reported less tension immediately following the post-intervention TSST ($M = 1.82 \pm 2.01$), compared to pre-intervention ($M = 3.65 \pm 2.69$; $T = 2.79_{(16)}$, $p = 0.013$), a result not demonstrated in the CON group ($T = 1.67_{(16)}$, $p = 0.114$).

In addition, reported levels of pressure/tension, perceived competence, degree of rumination evoked by the TSST, and the extent to which the TSST was considered health-enhancing (according to the Stress Mindset Measure specific to the TSST (SMM-specific) did not differ between pre- and post-intervention trials for either group, ($p > 0.05$), and were associated with small effect sizes (Table 4.4).

Table 4.4 Effect of an-8-week mindful relaxation intervention or wait-list control on the acute stress response (mean ± SD)

	CON (n = 17)			RELAX (n = 17)		
	Pre	Post	*Cohen's d*	Pre	Post	*Cohen's d*
Pressure/tension	5.18 ± 1.14	5.00 ± 0.79	*0.18*	4.75 ± 1.31	4.18 ± 1.74	*0.37*
Perceived competence	3.08 ± 1.54	2.94 ± 1.43	*0.09*	3.28 ± 1.19	3.29 ± 1.42	*0.01*
TSST-induced rumination	7.18 ± 1.88	7.12 ± 2.20	*0.03*	6.88 ± 2.32	6.41 ± 2.18	*0.21*
TSST-specific stress mindset	2.26 ± 0.88	2.38 ± 0.77	*-0.15*	2.63 ± 0.61	2.70 ± 0.88	*-0.09*

(iii) Effect on appetite-related measures

There was no change over time or differences between groups in the frequency of self-reported palatable food intake based on the PEMS, nor the self-perceived level of stress-induced eating ($p > 0.05$), and associated effect sizes were small. Likewise, there were no differences in the degree of craving, the frequency of giving in, and the difficulty associated with resisting craving of fast foods, sweet foods, high fat foods, and carbohydrate foods between groups over the 8-week period ($p > 0.05$) and only small effect sizes were noted (Table 4.5).

Table 4.5 Effect of an 8-week mindful relaxation intervention (RELAX) or wait-list control (CON) on appetite-related outcomes (mean ± SD)

	CON group (n = 17)			RELAX group (n = 17)		
	Pre	Post	*Cohen's d*	Pre	Post	*Cohen's d*
Palatable food intake	8.72 ± 1.99	8.41 ± 2.39	*-0.14*	8.12 ± 2.21	7.71 ± 2.80	*-0.16*
Stress-eating measure	4.59 ± 1.91	4.65 ± 1.58	*0.03*	3.94 ± 2.01	3.41 ± 2.12	*-0.26*
Craving						
Fast food						
Craving	5.47 ± 3.61	5.71 ± 2.85	*0.07*	5.53 ± 3.28	4.65 ± 4.20	*-0.23*
Giving in	5.18 ± 3.78	5.47 ± 3.66	*0.08*	5.41 ± 3.64	4.65 ± 3.98	*0.20*
Difficulty in resisting	3.82 ± 3.99	4.41 ± 3.79	*0.15*	4.24 ± 3.75	3.59 ± 3.87	*-0.17*
Sweet food						
Craving	7.59 ± 4.85	7.24 ± 4.40	*-0.08*	7.41 ± 6.13	6.00 ± 5.05	*-0.25*
Giving in	6.88 ± 4.30	6.94 ± 3.73	*0.01*	7.76 ± 6.64	6.53 ± 4.16	*-0.22*
Difficulty in resisting	5.47 ± 4.65	5.65 ± 3.69	*0.04*	5.41 ± 5.77	4.53 ± 3.99	*-0.18*

	CON group (n = 17)			RELAX group (n = 17)		
	Pre	Post	*Cohen's d*	Pre	Post	*Cohen's d*
High fat food						
Craving	4.47 ± 2.98	3.88 ± 3.08	*-0.19*	4.53 ± 2.72	4.18 ± 2.72	*-0.13*
Giving in	4.65 ± 2.91	4.18 ± 3.57	*-0.14*	4.94 ± 3.05	4.71 ± 3.00	*-0.08*
Difficulty in resisting	3.12 ± 2.67	2.65 ± 2.42	*-0.18*	3.18 ± 3.30	3.53 ± 2.21	*0.12*
Carbohydrate food						
Craving	8.41 ± 4.39	7.18 ± 4.07	*-0.30*	6.77 ± 6.02	6.94 ± 5.78	*0.03*
Giving in	8.00 ± 4.50	6.76 ± 4.47	*-0.30*	7.88 ± 7.04	7.29 ± 5.13	*-0.10*
Difficulty in resisting	4.94 ± 3.61	4.76 ± 3.83	*-0.05*	5.12 ± 5.93	4.94 ± 5.02	*-0.03*
Overall						
Craving	25.94 ± 10.54	24.00 ± 10.28	*-0.19*	24.23 ± 15.02	21.76 ± 14.55	*-0.17*
Giving in	24.71 ± 10.66	23.35 ± 12.66	*-0.12*	26.00 ± 16.04	23.18 ± 12.46	*-0.20*
Difficulty in resisting	17.35 ± 10.61	17.47 ± 10.34	*0.01*	17.94 ± 14.37	16.59 ± 12.13	*-0.10*

The acute appetite responses to the laboratory stressor (TSST) are shown in Figure 4.4. There was a main effect for time within each session for hunger ($F = 72.39_{(2.37, 75.79)}$, $p < 0.001$), desire to eat ($F = 79.24_{(2.47, 79.06)}$, $p < 0.001$), and prospective food consumption ($F = 104.01_{(2.73, 87.44)}$, $p < 0.001$), all of which gradually rose over the course of the laboratory session until the test meal was consumed. With respect to the appetite-related hormones, there were no interaction effects for ghrelin, insulin, or leptin ($p > 0.05$), suggesting a similar response between groups pre- and post-intervention. A main effect for time was detected for insulin ($F = 21.63_{(2.35, 65.83)}$, $p < 0.001$), with levels peaking immediately post-TSST before decreasing. Meanwhile, leptin concentrations (main effect for time; $F = 52.73_{(1.55, 49.74)}$, $p < 0.001$) saw a gradual decline over the laboratory session, until the test meal was served.

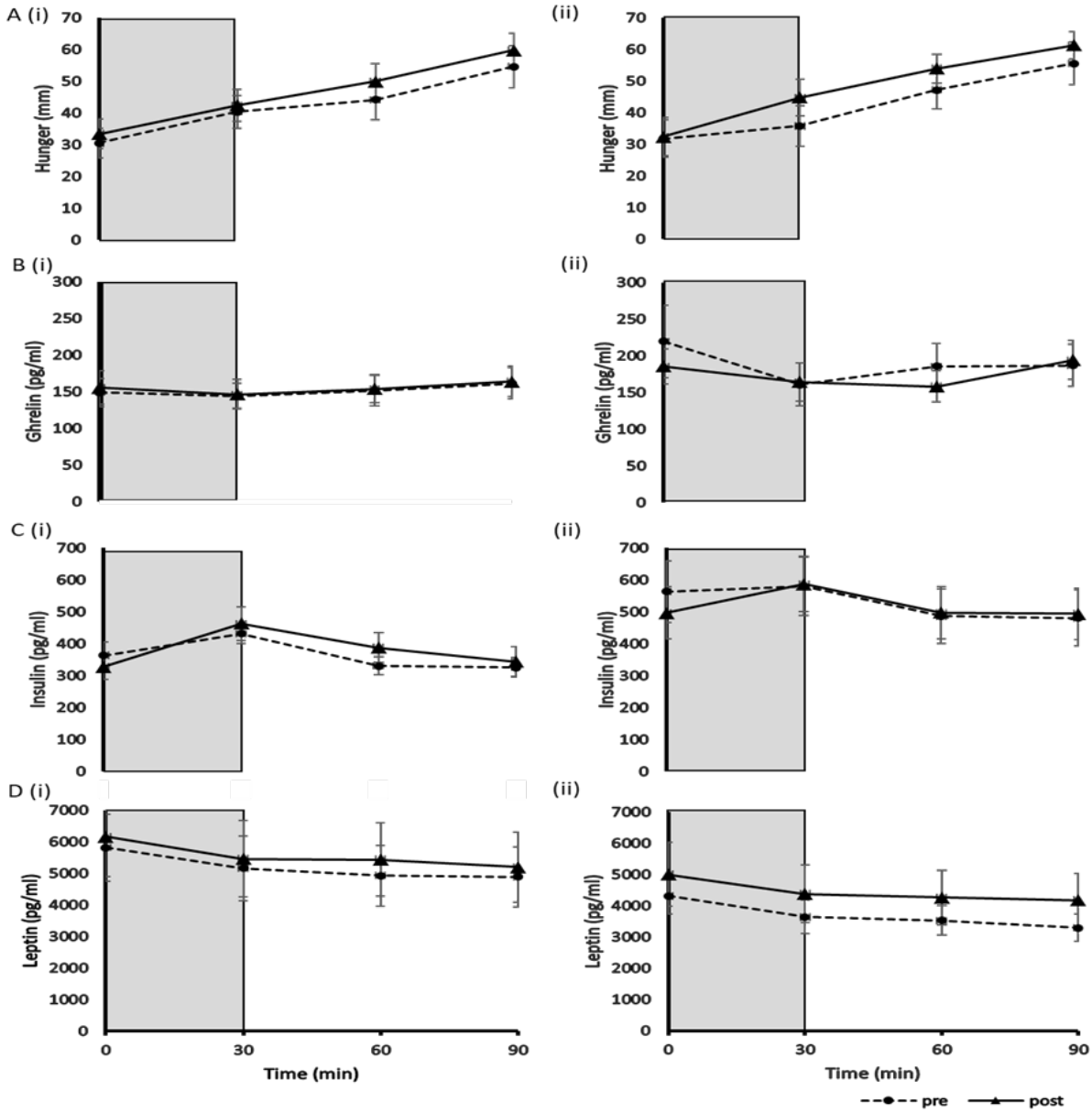

Figure 4.4 The response of self-reported (A) hunger, (B) active ghrelin, (C) insulin, (D) leptin in response to acute stress over time in (i) RELAX and (ii) CON groups (mean ± SE). The grey box represents the period over which the TSST was administered. A main effect of time was evident for hunger, insulin, and leptin levels ($p < 0.001$).

There were no differences in total energy intake from the laboratory test meal pre- to post-intervention or between groups (RELAX group; 2753 ± 1045 kJ (pre-intervention) and 3190 ± 1359kJ (post-intervention); (CON group 3036 ± 1264 kJ (pre-intervention) and 3104 ± 1291 kJ (post-intervention) ($F = 1.48_{(1,32)}$, $p = 0.233$). Further analysis indicated no differences between groups in the energy intake derived from unhealthy foods: RELAX group: 1476 ± 804 kJ (pre-intervention) and 1765 ± 1087 kJ (post-intervention); CON group: 1570 ± 883 kJ (pre-intervention) and 1757 ± 1028 kJ (post-intervention) ($F = 0.19_{(1,32)}$, $p = 0.67$), with small associated effects sizes (RELAX: $d = 0.30$, and CON: $d = 0.20$). Correlational analyses between trait mindfulness and appetite parameters revealed a significant negative correlation between trait mindfulness and both palatable food intake ($r = -0.490$, $p = 0.003$) and overall craving ($r = -0.404$, $p = 0.018$) after the 8-week intervention. No other significant correlations were noted.

4.5 Discussion

This study examined the feasibility and preliminary efficacy of an 8-week work-based mindful relaxation intervention for reducing stress, enhancing aspects of health (i.e. BMI, sleep quality, anxiety), and reducing indicators of stress-induced eating. Overall, we have shown that an 8-week work-based relaxation intervention is practically viable in terms of recruitment, fidelity, dose, and acceptability. Furthermore, the 8-week mindful relaxation intervention was effective for altering state and trait mindfulness, as well as perceived levels of tension and relaxation when faced with an acute stressor; however, the effect on appetite and food intake variables appeared limited.

4.5.1 Study Feasibility

Recruitment was an onerous process that lasted 8.5 months. This was likely attributed to a number of factors. First, there was substantial time commitment involved in participation of the study, particularly the lengthy (3-hour) pre- and post-intervention assessments. These assessments required full-time employees to take two half days off work in order to attend the university laboratory. As a result, a frequently quoted reason for the unwillingness of corporate companies to participate was the financial loss associated with staff absence, despite verbal recognition by company representatives that employee mental health is important. Second, although the intervention was designed for broad application in workplace contexts, only a small sample could be included due to resource constraints associated with the research component of the intervention. That being the case, we imposed numerous selection criteria for recruitment to ensure that the control and intervention groups were similar on key variables (focusing on both stress and dietary behaviour). This resulted in only 28% of those expressing interest in the study meeting the strict criteria for inclusion. Future studies may consider including individuals with co-morbidities for whom a study focused on stress management may be of particular benefit such as mental health conditions.

Despite a large proportion of volunteers being excluded from participation, once randomised, study attrition was low with only 2 participants being lost to follow-up, compared with other workplace-based stress management interventions reporting 34% attrition in the control group Bartlett, Lovell, Otahal, & Sanderson, 2017),. These 2 individuals completed the 8-week intervention, but were unable to attend the post-intervention assessment due to lack of time. Notably, there was no attrition in the control

group, although they did not immediately receive the treatment for which they were likely drawn to participate in the study, with 41% opting to complete the 8-week course after completion of the study. Furthermore, compliance to the intervention itself was excellent, with 80% of scheduled face-to-face sessions attended, and 79% of daily home-practise adhered to, which is comparable to the high rates of compliance reported by others (Bartlett et al., 2017; Corsica et al., 2014). While the face-to-face sessions were conducted in the workplace in an attempt to maximise convenience, the high compliance to the home-based sessions may be attributed to the high ratings of enjoyment (Lehrer, 1996), together with the minimal time commitment compared with other interventions of this nature with session durations > 60 minutes (Corsica et al., 2014; Daubenmier et al., 2011). The mindful relaxation program in the present study was specifically designed to optimise the potential benefit of interoceptive practice, yet minimise the time commitment, and thereby encourage compliance and integration into day-to-day life. This is important given that interoceptive practice is considered to be the honing of a mental skill with cumulative benefits (Conrad & Roth, 2007), and an intervention of greater length may be required to address long-standing, habit-driven behaviours (such as stress-induced eating).

Another aspect of feasibility to note is that the multiple components of the experimental protocol in this study (including recruitment, pre- and post-laboratory assessment, and weekly worksite-based classes), were conducted by a single researcher (with the exception of panellists required to conduct the Trier). Hence, despite being a laborious study protocol, it was completed with minimal manpower. The coordination and implementation of the study by a single researcher also likely facilitated the building of rapport between experimenter and participant, possibly minimising attrition. Overall, the demonstrated

acceptability and feasibility of the worksite-based aspect of this intervention underscores the potential of relaxation programs implemented in the workplace benefitting employee wellbeing, whilst causing minimal disruption to the working day as also demonstrated by previous research (Krajewski et al., 2011; Melville, Chang, Colagiuri, Marshall, & Cheema, 2012; Ponce et al., 2008).

In regard to levels of perceived stress and relaxation following an isolated practice, the pre- and post-class measures of the once-weekly class reflected a consistent decrease of perceived stress, and increase of perceived relaxation and enjoyment, despite MM being considered a more demanding task than APMR, as also found by Lumma et al. (2015). The immediate calming effect of a single dose of relaxation (Dolbier & Rush, 2012; Krajewski et al., 2011; Rausch et al., 2006) and mindfulness meditation (Creswell, Pacilio, Lindsay, & Brown, 2014; Rausch et al., 2006) techniques have been reported previously.

4.5.2 Study efficacy

The secondary aim of this study was to explore the preliminary efficacy of the intervention for altering stress, general wellbeing, and outcomes related to appetite. Despite the excellent compliance to the intervention, and the consistent reduction of stress experienced during the face-to-face classes, the reported reduction in general life stress was equivalent in both groups. Likewise, the degree to which participants felt stress was life-enhancing (according to the SMM-G) rose in both groups over the course of the 8 weeks, although only the increase in the RELAX group was supported by a moderate effect size, compared to a small effect size in the CON group. The reason for these changes in both groups is unclear. It is possible that merely taking part in the study (irrespective of group assignment) may have induced a change in participants' general perceptions of stress, which may then have influenced their stress responses. Alternatively, a greater duration or potency of

intervention may be needed to elicit differences between groups, particularly when stress is high. The baseline stress level (PSS) in both groups (CON: 25.24 ± 7.5 and RELAX: 23.42 ± 14) was considerably higher than the average PSS score reported by the average Australian (~16; Casey, 2013). What constitutes 'chronic stress' and the degree to which it interacts with the acute stress response is still to be defined (Hammen, Kim, Eberhart, & Brennan, 2009). However, it is conceivable that the high PSS attained in the present study may have mitigated the potential stress-alleviating effects of a mindful relaxation course limited to 8 weeks. Meanwhile, trait mindfulness was increased in the intervention group, which is encouraging given the brief nature of the daily practice. In support of the present results, Zeidan and colleagues (2010) also found improvements in trait mindfulness with as little as daily 20-minute mindfulness training over 4 days.

In relation to the effect of the 8-week intervention on the acute stress response, the majority of physiological (cortisol, BP and HR) and psychological (perceived stress) variables examined were unchanged from pre- to post-intervention. However, 8 weeks of mindful relaxation practice appeared to reduce the level of tension felt and increase the relative degree of relaxation in response to the acute stressor. These beneficial changes suggest that further research should delineate the incongruency between the physiological and psychological findings. Interestingly, Lumma et al. (2015) suggest that consistency of physiological and self-report measures after interoceptive practice increases with greater practice. Accordingly, future research should focus on longitudinal effects of practice.

The preliminary efficacy of the intervention for altering stress-driven eating was also examined. Associated effect sizes were small for the effect of the intervention on self-

reported palatable food intake, cravings, and ad libitum intake after an acute exposure to stress. Although previous research has demonstrated efficacy for regular APMR (Pawlow et al., 2003) and for mindfulness practice (Jordan et al., 2014) to reduce appetite, no studies have been focused on the effects of relaxation practice on energy intake directly after an acute stress induction. The observation of a lack of alteration in appetite-related variables occurred despite an increase in trait mindfulness with the present intervention. This finding may reinforce the notion that general mindfulness training may not be as potent in affecting disordered eating due to stress, compared with programs specifically focussed on dietary behaviour, as exemplified by others (Arch et al., 2016; Fisher et al., 2016). However, it is interesting to note that trait mindfulness was negatively correlated with reported palatable food intake ($r = -0.490$, $p = 0.003$), and with overall craving ($r = -0.404$, $p = 0.018$) after the present intervention, suggesting trends worthy of investigation in future trials.

4.6 Conclusion

In summary, this randomised controlled pilot study has demonstrated the feasibility of a worksite-based, 8-week relaxation intervention in terms of fidelity, dose, and acceptability. In addition, we provide evidence of the potential efficacy of such an intervention on parameters of wellbeing, the acute stress response, and subsequent energy intake and appetite. Future research should consider the limitations imposed by the laboratory-based pre- and post-assessments of this pilot study. Choice of foods eaten, timing, and setting of stress-eating can be specific for an individual (Liu et al., 2017; Pool et al., 2015; Wallis & Hetherington, 2009); hence the recording of dietary intake 24 hours beyond the assessment session may also be warranted in future studies. Furthermore, a follow-up of overall

acceptability of the 8-week course, and likelihood of long-term practice, would inform the planning of future research. Nonetheless, the preliminary findings of this study underscore the feasibility of investigating abbreviated practice regimes of relaxation in the context of general wellbeing in the workplace, and lay preliminary foundation for investigating its impact on stress-induced appetite.

Chapter 5: General discussion

5.1 Summary

While a growing body of evidence indicates that stress-induced eating contributes to the global prevalence of lifestyle disease, strategies by which to tackle this issue are lacking. Relaxation is the physiological and psychological opposite of the stress response, yet few studies have tested the effectiveness of relaxation therapy in the alleviation of stress-induced eating. Hence, the goals of this thesis were to (a) examine whether an isolated practice of relaxation following an acute laboratory stressor would affect energy intake, and (b) determine the practical viability of administering an 8-week worksite-based relaxation intervention, together with providing preliminary evidence of the effect of such an intervention on health, wellbeing and appetite-related parameters. An integral component of the research in this thesis was the elicitation of the stress response, which involved the commonly used Trier Social Stress Test. Given that a limitation of this laboratory stressor is habituation when multiple exposures are necessary (Allen et al., 2017), a precursory study was conducted in order to establish a protocol by which the test could be used repeatedly without habituation.

5.2 Conclusions

Overall, the key findings from studies in this thesis were that:

- Minor modifications to the TSST protocol were effective in preventing habituation associated with repeated exposures to the test within an 8-week period.
- A single, brief practice of relaxation, either after an acute stressor or in isolation, did not alter the intake of commonly eaten snack foods, in comparison with a control condition.

- Stress-induced eating was subject to great individual variation, and elicitation of the stress response, or a relaxation response, may not necessarily translate to a change in eating behaviour.
- An 8-week work-based relaxation intervention was found to be feasible and an acceptable means by which to incorporate relaxation practice into the lives of employees.
- Guided relaxation sessions as part of an 8-week relaxation intervention benefitted acute levels of stress and relaxation.
- An 8-week relaxation intervention enhanced trait mindfulness, reduced perceived levels of tension, and increased relaxation when faced with an acute stressor.
- An 8-week relaxation intervention did not appear to affect food cravings, or measures of appetite and energy intake in response to an acute stressor.

5.3 Limitations

Although the findings from this research provide valuable insight into an area of human science that requires further investigation, the following limitations should be considered;

- The premise of the study in presented in Chapter 3 was that stress-induced eating is common. There was no evidence of stress-induced eating found in the study sample; hence, the capacity to evaluate the potential of relaxation to alleviate it, was limited.
- The results from the study presented in Chapter 3 were specific to a young adult population, the majority of whom were tertiary students and of a healthy BMI. Similarly, Chapter 4 was based on a study sample composed of postgraduate

students and corporate employees with an average BMI of 25 kg/m^2. The findings, therefore, cannot be generalised to individuals of different ages, educational levels, socioeconomic status, BMI, or those with comorbidities (such as anxiety, and depression).

- Both studies presented in Chapters 3 and 4 were based on a group of altruistic volunteers with a desire to assist scientific research, possibly with a belief in the potential benefit of relaxation; hence, participants may not have been representative of the larger population.
- Given the variability in the prevalence of stress-induced eating demonstrated by the work in this thesis, whether a larger sample size would have provided a more representative sample remains to be determined.
- While the TSST evokes the stress response, the acute study did not discern participants' perception of the type of stress experienced, i.e. eustress (denoting a feeling of challenge and subsequent growth) versus distress (indicating mental strain and lack of control). Distinction of each participant's stress mindset related to the laboratory stressor (whether a positive or negative stress) may have better identified those individuals more susceptible to stress-eating.
- As with any laboratory-based research, the findings of this study must be interpreted in light of the artificial conditions imposed upon the participants and the applicability of these findings to real life. This is particularly relevant given that the observed dietary intake was limited only to the duration of the laboratory session, and to the choice of test foods offered. As to whether this was a true reflection of each individual's habitual stress-induced intake remains a question.

- The rigorous crossover design of the study in Chapter 3 required limiting laboratory testing within the follicular phase of the menstrual cycle. This may have lengthened the interval of time between laboratory sessions for some participants; thus, increasing variability within results of an individual
- The study presented in Chapter 4 consisted of a combination of PMR and MM, in contrast with a control group. The combination of PMR and MM precluded the ability to investigate the differential effects of each type of practice. In addition, the incorporation of weekly face-to-face contact between each participant in the control group and the chief investigator over the intervention period may have accounted for any social interaction effects imposed by the weekly relaxation sessions offered to participants assigned to the intervention group.

5.4 Directions for future research

In the future, researchers interested in the management of stress-induced eating by relaxation interventions may consider the following recommendations:

- Future research should focus on establishing a clearer understanding of the phenomenon of stress-induced eating; including the individual, and the circumstantial factors that predispose one to unhealthy eating in response to stress.
- Future studies should seek to elucidate the influence of time interval between TSST exposures on habituation to the stress response, and to what degree different strategies may overcome habituation effects.
- Given the study in Chapter 3 involved an investigation of the effect of 20 minutes of acute relaxation, an examination of the effect of varying time lengths of acute

practice may provide a more definitive answer as to whether acute bouts of relaxation practice in novice practitioners can counteract stress-induced eating.

- Comparative studies of different forms of relaxation may lend credence to the notion that relaxation should be tailored to the specific preferences and/or needs of an individual, in order to affect downstream impact on stress-driven eating.
- Future research should focus on the benefits of relaxation in alleviating stress-induced eating in population groups that may be particularly vulnerable to psychosocial stress including overweight/obese populations, children and adolescents, care-givers, those from low socioeconomic backgrounds, and those suffering from mental disorders.
- Given that stress and appetite are subject to intra- and inter-individual variability, there is likely to be great value in qualitative research in which underlying mechanisms driving eating behaviour, and factors that influence one's likelihood and quantity to eat due to stress (including timing, choice of food eaten, and individual stress coping mechanisms), are investigated. Specific to laboratory-based studies of stress-induced eating, a follow-up assessment to identify the reasons for the choice and quantity of food eaten during the trial that were unrelated to stress, would allow further validation of the energy intake observed.
- In order to account for individual timing and setting for stress-induced eating, laboratory measures of appetite and energy intake in response to an acute stressor should extend beyond the duration of the laboratory session and include the maintenance of a diet and activity diary upon leaving the laboratory.

- Based on the feasibility of the 8-week pilot study (Chapter 4), future studies should extend the intervention period in order to determine long-term effects on appetite and wellbeing, including follow-up beyond the duration of the study.
- A qualitative assessment after a relaxation intervention may also help identify barriers to maintenance of practice, preference of practice type (if any), suggestions for improvement of the execution of a relaxation intervention, and participants' willingness to continue a practice beyond the study period, which could better inform the planning of future studies of this type.
- Future research should also focus on incorporating different methods of relaxation in the workplace. While financial considerations may deter authorities from implementing such programs related to stress-induced eating, the inclusion of work productivity outcomes may provide further incentive.

5.5 Implications

Stress-induced eating involves the intake of energy-dense, nutrient poor foods in response to acute or chronic stress. Given the important role diet plays in the aetiology of numerous health conditions such as obesity, cardiovascular disease, and diabetes mellitus, stress-induced eating of highly palatable foods is an area in need of therapeutic attention. The rising costs of healthcare, however, require us to seek strategies that place the onus of healthcare upon the individual. Strategies must be affordable, time-efficient, and achievable given the maintenance of a healthy lifestyle is considered a major stress in itself (Australian Psychological Society, 2015).

The practice of relaxation has been shown to reduce appetite in previous studies (Pawlow et al., 2003), yet its direct application to stress-induced eating has never been investigated. However, research investigating the acute effectiveness of interventions to attenuate stress-induced eating requires the repeated administration of laboratory stressors, such as the TSST. Although the TSST is a well-validated stress test, administration on repeated occasions is known to result in habituation (Allen et al., 2017). Demonstration that modifications of the TSST protocol can effectively reduce habituation - despite repeated TSST exposure - is important for future studies that necessitate pre- and post-intervention acute stress assessment.

With this in mind, the second study of this thesis demonstrated that acute elicitation of the relaxation response does not affect energy intake, whether practiced in isolation, or directly after an acute stressor. More importantly, we provide evidence that there is great variation in individual eating behaviour in response to acute stress. Hence, elicitation of acute stress may not clearly or immediately affect dietary intake of palatable foods as other research has indicated. Therefore, more research is needed to understand and to clarify the phenomenon of stress-induced eating itself in order to subsequently attempt to therapeutically address the issue.

Furthermore, if stress-induced eating represents a long-established behavioural response, that is subject to individual variability, investigation of the effect of a *sustained* practice of relaxation is indicated. Accordingly, an 8-week relaxation intervention was implemented, which served to illustrate that such an intervention, despite its multi-faceted design, is feasible in terms of recruitment and retention. This research demonstrated outstanding

compliance both in terms of home practice, and attendance to weekly relaxation sessions, even though the latter necessitated a change in the usual working day. This study also provided evidence that a relaxation practice of only 20 min duration results in an immediate decrease in stress, increase in perceived relaxation, and aspects of state mindfulness.

The preliminary efficacy of a regular practice of relaxation is also demonstrated by this research with the reduction of perceived levels of tension and increased relaxation when faced with an acute laboratory stressor. Furthermore, this thesis provides evidence that a dispositional characteristic such as trait mindfulness can be enhanced by the simple incorporation of 20 min of relaxation practice into daily life. Although relaxation practice did not appear to change appetite-related variables in response to acute stress, or across the 8-week intervention as a whole, the notion that relaxation and/or mindfulness may be of benefit for stress-induced eating should not yet be ruled out, particularly in light of the significant correlation between trait mindfulness and palatable food intake and cravings observed post-intervention.

Overall, on the basis of the research presented in this thesis, the practice of relaxation seems to be a convenient, cost effective, patient-centred prophylactic practice that can be incorporated into daily life in order to alleviate acute stress, and increase one's awareness of the present moment. However, larger-scale studies are required to further investigate the potential for a long-term practice of relaxation (of brief duration) to reduce the intake of unhealthy foods in response to stress.

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Appendix A

Participant Information Sheets and Consent Forms (Chapter 3)

Participant Information Sheets and Consent Forms (Chapter 4)

Participant screening interview script (Chapters 3, & 4)

Familiarisation session script (Chapter 3)

Familiarisation session script (Chapter 4)

Debrief Session Script (Chapter 3)

Debrief Session Script (Chapter 4)

Participant Information Sheets and Consent Forms (Chapter 3)

The Physiological and Psychological Effect of Acute Stress and Relaxation: A Comparative Study

- Participant Information Sheet-

Purpose of this study:

The increasing prevalence of stress is of great concern in the world today and its effective management is an area urgently requiring more research. This study aims to compare the physiological and psychological effect of the stress response to the relaxation response as reflected by blood and saliva hormone levels, blood pressure, heart rate and self-reported questionnaires.

Procedures:

You will be required to attend 5 laboratory sessions at the School of Sport Science, Exercise and Health. The first is a 2-hour familiarisation session in which you will be informed about the study and what will be required of you. During this session we will also ask that you complete questionnaires related to your general health and we will also take measures of your weight, height and waist-hip circumference. The four laboratory sessions following this, will be on the same day of the week, at least one-week apart. Each session will begin between 2.30 – 5.00pm and last two and a half hours. We will require you to record your behavior related to sleep, physical activity, food and drink consumed on the day of the laboratory session in a diary and to maintain the same behavior before each subsequent laboratory session.

On your arrival to the laboratory at each session, you will be requested to complete a questionnaire as you settle in and then take part in one of the following conditions at each visit;

- a 20-minute verbal ability exercise (which can be quite stressful),
- a 20-minute relaxation session (which involves comfortably lying back and being directed to sequentially tense and relax muscle groups).
- a period of quiet sitting or,
- a combination of the verbal ability exercise and the relaxation session.

During the course of each laboratory session we will take three small capillary blood samples taken from your fingertip (equivalent to half of a milliliter). In short, this involves a small prick on the fingertip with a sterile lancet device. You may experience slight discomfort with the procedure, however this is only temporary. In addition, a sample of saliva will be collected at the same time points by placing a cotton swab in your mouth for 2 minutes, after which the cotton swab will be placed in a tube for later analysis of cortisol levels (a marker of stress levels in the body). We will also ask that you complete various questionnaires in order for us to gauge your thoughts and feelings throughout the course of each session.

Risks:
The blood sampling procedure may cause some mild discomfort and may leave a small bruise at the sampling site. This procedure in commonly performed in our laboratory and causes no long-term harm.

The verbal ability task may be mentally challenging but will cause no long-lasting negative effect. Please be assured all of the procedures we employ in this study have been commonly used in past research studies and are completely safe to be used with human participants.

Confidentiality:
Your confidentiality will be maintained throughout the study through random assignment of a number to de-identify your data. All data collected will be securely stored in a locked filing cabinet and password-protected computer assessable only to the chief investigator and PhD student (Tasmiah Masih). The findings of this study may be published, however all information used will be non-identifiable.

Your Rights:
Participation in this research is voluntary and you are free to withdraw from the study at any time without prejudice. You can withdraw for any reason and you do not need to justify your decision. If you withdraw from the study and you are an employee or student at the University of Western Australia (UWA) this will not prejudice your status and rights as employee or student of UWA. If you do withdraw we may wish to retain the data that we have recorded from you but only if you agree, otherwise your records will be destroyed.

Your participation in this study does not prejudice any right to compensation that you may have under statute of common law. If you have any questions concerning the research at any time please feel free to ask the researcher who has contacted you about your concerns. Further information regarding this study may be obtained from Dr Kym Guelfi on 6488 2602, Dr James Dimmock on 6488 1384 or Tasmiah Masih on 0421 130222 or 21287209@student.uwa.edu.au

The Human Research Ethics Committee at the University of Western Australia requires that all participants are informed that, if they have any complaint regarding the manner, in which a research project is conducted, it may be given to the researcher or, alternatively to the Secretary, Human Research Ethics Committee, Registrar's Office, University of Western Australia, 35 Stirling Highway, Crawley, WA 6009 (telephone number 6488-3703). All study participants will be provided with a copy of the Information Sheet and Consent Form for their personal records.

The Physiological and Psychological Effect of Stress and Relaxation: A Comparative Study

— Consent Form —

I _____ have read the information provided and any questions I have asked have been answered to my satisfaction. I agree to participate in this activity, realising that I may withdraw at any time without reason and without prejudice.

I understand that all information provided is treated as strictly confidential and will not be released by the investigator unless required to by law. I have been advised as to what data is being collected, what the purpose is, and what will be done with the data upon completion of the research.

I agree that research data gathered for the study may be published provided my name or other identifying information is not used.

_____ _____

Participant Date

The Human Research Ethics Committee at the University of Western Australia requires that all participants are informed that, if they have any complaint regarding the manner, in which a research project is conducted, it may be given to the researcher or, alternatively to the Secretary, Human Research Ethics Committee, Registrar's Office, University of Western Australia, 35 Stirling Highway, Crawley, WA 6009 (telephone number 6488-3703). All study participants will be provided with a copy of the Information Sheet and Consent Form for their personal records.

Participant Information Sheets and Consent Forms (Chapter 4)

The Physiological and Psychological Effect of Stress and Relaxation: A Comparative Intervention Study

- Participant Information Sheet-

Purpose of this study:

The increasing prevalence of stress is of great concern in the world today and its effective management is an area urgently requiring more research. This study aims to compare the physiological and psychological effect of the stress response to the relaxation response as reflected by hair, blood, and saliva hormone levels, blood pressure, heart rate and self-reported questionnaires.

Procedures:

Based on your responses during the phone interview if you are selected to participate in this study, you will first attend a 1-hour familiarisation session which will be conducted at your workplace. This will be followed by two laboratory sessions at the School of Sport Science, Exercise and Health at the University of Western Australia. The initial laboratory session will be followed by, an 8-week study period and then a second laboratory session identical to the first.

During the familiarisation session, you will be informed about the study and what will be required of you. You will also be requested to complete questionnaires related to your general health and perception of stress. Additionally, we will measure your weight, height and waist-hip circumference. In order to measure the impact of the study on your stress levels we will measure the level of the stress hormone, cortisol, in your hair before and after the 8-week study period. This component of the study is entirely optional, and you may wish to decline this component of the study. Should you provide your consent during the familiarisation session; the investigator will cut a small amount of hair (less than 100 strands) from your head for measurement. The hair will be cut as close to the scalp as possible and using care to ensure there is no visible sign of hair removal. We will follow the same procedure to take a sample at the completion of the study also. This will provide us with an understanding of your stress levels for 2 months before the study and for the 2-month study period.

The two laboratory sessions will be held on the same day of the week eight weeks apart. Each of these sessions will begin at 8.00am and last two and a half hours. We will require you to describe your behavior related to sleep, physical activity, food and drink consumed on the day of the laboratory session and to maintain the same behavior before the next laboratory session. In addition, we require that you arrive at the laboratory after having fasted from 10pm, the night before.

On your arrival to the laboratory, you will be requested to complete a questionnaire as you settle in and then asked to take part in a 20-minute cognitive-ability exercise followed by a period of quiet sitting. During the course of each laboratory session we will take four small capillary blood samples taken from your fingertip (approximately 7 drops of blood per sample equivalent to less than one fifth of a milliliter). In short, this involves a small prick on the fingertip with a sterile lancet device. You may experience slight discomfort with the procedure, however this is only temporary. We will

also ask that you complete various questionnaires in order for us to gauge your thoughts and feelings throughout the course of each session.
For the eight-week study period you will be randomly allocated to either a wait-list relaxation group or a mindfulness-based relaxation group. If you are placed in the relaxation group, you will be given a once-weekly group relaxation class at your worksite (on the same day of the week) for eight weeks. You will also be required to maintain a daily home-based relaxation practice for 20 minutes, for which you will be provided an MP3-recording of your live class. If you are placed in the wait-list relaxation group, you will carry on your normal activities for the initial 8-week period. Following the second laboratory session, you will be given the same, once-weekly group relaxation class at the worksite (on the same day of the week) for eight weeks.

Risks:
The blood sampling procedure may cause some mild discomfort and may leave a small bruise at the sampling site. This procedure in commonly performed in our laboratory and causes no long-term harm. The verbal ability task may be mentally challenging but will cause no long-lasting negative effect. Please be assured all of the procedures we employ in this study have been commonly used in past research studies and are completely safe to be used with human participants.

Confidentiality:
Your confidentiality will be maintained throughout the study through random assignment of a number to de-identify your data. All data collected will be securely stored in a locked filing cabinet and password-protected computer assessable only to the chief investigator and PhD student (Tasmiah Masih). The findings of this study may be published, however all information used will be non-identifiable.

Your Rights:
Participation in this research is voluntary and you are free to withdraw from the study at any time without prejudice. You can withdraw for any reason and you do not need to justify your decision. If you withdraw from the study and you are an employee or student at the University of Western Australia (UWA) this will not
prejudice your status and rights as employee or student of UWA. If you do withdraw we may wish to retain the data that we have recorded from you but only if you agree, otherwise your records will be destroyed.

Your participation in this study does not prejudice any right to compensation that you may have under statute of common law. If you have any questions concerning the research at any time, please feel free to ask the researcher who has contacted you about your concerns. Further information regarding this study may be obtained from Dr Kym Guelfi on 6488 2602, Dr James Dimmock on 6488 1384 or Tasmiah Masih on 0421 130 222, or email
tasmiah.masih@research.uwa.edu.au

Approval to conduct this research has been provided by the University of Western Australia with reference number RA/4/1/6429, in accordance with its ethics review and approval procedures. Any person considering participation in this research project, or agreeing to participate, may raise any questions or issues with the researchers at any time. In addition, any person not satisfied with the response of researchers may raise ethics issues or concerns and may make any complaints about this research project by contacting the Human Ethics office at UWA on (08) 6488 4703 or by emailing to

humanethics@uwa.edu.au. All research participants are entitled to retain a copy of any Participant Information Form and/or Participant Consent Form relating to this research project

The Physiological and Psychological Effect of Stress and Relaxation: A Comparative Study

— Consent Form —

I _____ have read the information provided and any questions I have asked have been answered to my satisfaction. I agree to participate in this activity, realising that I may withdraw at any time without reason and without prejudice.

I agree / I do not agree (please circle) to take part in the component of the study that requires that I provide a sample of hair at the commencement and completion of the study.

I understand that all information provided is treated as strictly confidential and will not be released by the investigator unless required to by law. I have been advised as to what data is being collected, what the purpose is, and what will be done with the data upon completion of the research.

I agree that research data gathered for the study may be published provided my name or other identifying information is not used.

_____ _____

Participant Date

The Human Research Ethics Committee at the University of Western Australia requires that all participants are informed that, if they have any complaint regarding the manner, in which a research project is conducted, it may be given to the researcher or, alternatively to the Secretary, Human Research Ethics Committee, Registrar's Office, University of Western Australia, 35 Stirling Highway, Crawley, WA 6009 (telephone number 6488-3703). All study participants will be provided with a copy of the Information Sheet and Consent Form for their personal records.

Participant screening interview script (Chapters 3 & 4)

Participant Screening Interview Script Date:

Thank you for your interest in participating in my study. My study is about comparing the physiological and psychological effect of stress and relaxation. In order for you to participate you need to satisfy certain study criteria. Would you mind if I asked you a few questions?

1) Name: Contact number:

2) Age

3) Body weight

i. Current weight? _____
ii. Maximum adult weight? _____
iii. Has your weight been stable over the last 6 months (gain/loss no more than 2.5kg) Y / N

iv. Height _____ BMI _____

4) Do you have any diagnosed medical conditions including allergies?

_____

5) Any conditions that cause you pain? Y / N

6) Females-

i. Pregnant/lactating? Y / N
ii. Given birth in the last 6 months? Y / N
iii. Irregular menstrual cycle (can you predict day 1 with some accuracy?) Y / N

7) Any periodontal disease/bleeding of gums? Y / N

8) Fear of needles or blood collection problems? Y / N

9) Use of drugs –

i. Have you used recreational drugs over the past 6 months? Y / N
ii. Do you use prescription meds? Y / N
iii. Do you use the contraceptive pill or an IUD? Y / N
iv. Do you smoke? Y / N
v. How often do you drink alcohol? _____

10) Lifestyle related-

i. Are you currently or have you been recently on a diet? Y / N
ii. Have you ever had a regular practice of relaxation? Y / N
iii. Do ever do excessive exercise? (> 2hr/d) Y / N
iv. Do you have a regular work schedule? Y / N
v. Do you have a regular sleep schedule? Y / N
vi. Are you a regular breakfast eater? Y / N

What is your typical breakfast?
What is a treat food? A breakfast treat food?

Familiarisation session script (Chapter 3)

Script for Participant Familiarisation Session:

Welcome participant. My study is in partial fulfilment of a PhD, so I am very grateful for your volunteering to take part.

My 2-hour session today is to give you an overview of:

1. The purpose of my study
2. What you need to do in preparation for the study
3. What will happen during the experimental days including
    - Going through the blood sampling procedure i.e. I will take some blood so that you are fully aware of the procedure
    - Briefly going through the relaxation procedure
4. I will then have some forms and questionnaires for you to fill out (which will take about 30 minutes)

    The consent form including a summary of this session
    A general health and demographic form
    A form that is a dietary diary that asks that you record what you have eaten for the 24 hrs prior to your attending each experimental session.
    A series of questionnaires that asks about stress in your life.
    I will need to take your body weight, height and your waist and hip circumference as well.

5. If you give your consent to participate, I will then schedule you for the four lab sessions. Females will be tested during day 3-9 of the menstrual cycle.

The purpose of my study

My study aims to compare the physiological and psychological effect of the stress response to the relaxation response. I will be doing this by looking at blood and saliva hormone levels, blood pressure, heart rate and self-reported questionnaires. Participation in this study will require a total of 12 hours of your time.

General Procedure

Should you wish to go ahead, I will need you to attend 4 laboratory sessions at the School of Sport Science, Exercise and Health. (*mention specific location in the building*)

The four laboratory sessions following this, will be on the same day of the week (appointed by you), at least one-week apart.

Each session will begin between 1.30 – 4.00pm and last two and a half hours.

Your Preparation

For 24 hours before each of the four experimental sessions please do **not** have:

Any caffeine (in any form i.e. tea, coffee, Coke, Red Bull), for example),

Alcohol, other drugs/medications

Or take part in any exercise

I will require you to record your behaviour related to sleep, physical activity, food and drink consumed on the day of the laboratory session in a diary and to maintain the same behaviour before each subsequent laboratory session. If this is not possible on a particular day – I need you to inform me.

Meaning, I ask that you have the same breakfast, lunch and snacks and maintain the same level of physical activity **24 hours before** the experimental days

Also, please have lunch at midday on experimental days so that we can ensure you have fully digested your meal prior to the first blood sample we take on arrival.

We require you to strictly follow the preparation protocol so that your blood chemistry remains the same for all 4 experimental sessions.

What happens on the experimental days?

On your arrival to the laboratory at each session, you will be requested to complete a questionnaire as you settle in. I will then ask you to take part in one of the following conditions at each visit;

- a 20-minute verbal ability exercise (which can be stressful),
- a 20-minute relaxation session (which involves comfortably lying back and being directed to sequentially tense and relax muscle groups).
- a period of quiet sitting or,
- a combination of the verbal ability exercise and the relaxation session.

The details of the verbal ability task will be given on the day of testing. A total of approximately 30 minutes will be assigned to the completion of questionnaires throughout each laboratory session.

During the course of each laboratory session we will take three small capillary blood samples taken from your fingertip (equivalent to half of a millilitre). In short, this involves a small prick on the fingertip with a sterile lancet device. You may experience slight discomfort with the procedure, however this is only temporary. In addition, a sample of saliva will be collected at the same time points by placing a cotton swab in your mouth for 2 minutes, after which the cotton swab will be placed in a tube for later analysis of cortisol levels (a marker of stress levels in the body). We will also ask that you complete various questionnaires in order for us to gauge your thoughts and feelings throughout the course of each session.

Risks:

The blood sampling procedure may cause some mild discomfort and may leave a small bruise at the sampling site. This procedure in commonly performed in our laboratory and causes no long-term harm. The verbal ability task may be mentally challenging but will cause no long-lasting negative effect. Please be assured all of the procedures we employ in this study have been commonly used in past research studies and are completely safe to be used with human participants.

Confidentiality:

Your confidentiality will be maintained throughout the study through random assignment of a number to de-identify your data. All data collected will be securely stored in a locked filing cabinet and password-protected computer assessable only to the chief investigator and PhD student (Tasmiah Masih). The findings of this study may be published, however all information used will be non-identifiable.

Your Rights:

Participation in this research is voluntary and you are free to withdraw from the study at any time without prejudice. You can withdraw for any reason and you do not need to justify your decision. If you withdraw from the study and you are an employee or student at the University of Western Australia (UWA) this will not prejudice your status and rights as employee or student of UWA. If you do withdraw we may wish to retain the data that we have recorded from you but only if you agree, otherwise your records will be destroyed.

Your participation in this study does not prejudice any right to compensation that you may have under statute of common law. If you have any questions concerning the research at any time please feel free to ask the researcher who has contacted you about your concerns. Further information regarding this study may be obtained from Dr Kym Guelfi on 6488 2602, Dr James Dimmock on 6488 1384 or Tasmiah Masih on 0421 130222 or 21287209@student.uwa.edu.au

The Human Research Ethics Committee at the University of Western Australia requires that all participants are informed that, if they have any complaint regarding the manner, in which a research project is conducted, it may be given to the researcher or, alternatively to the Secretary, Human Research Ethics Committee, Registrar's Office, University of Western Australia, 35 Stirling Highway, Crawley, WA 6009 (telephone number 6488-3703). All study participants will be provided with a copy of the Information Sheet and Consent Form for their personal records.

Take blood to familiarise participant with procedure

Participant Familiarisation Session: Script for Progressive Muscle Relaxation

The process of progressive muscle relaxation session consists of sequentially tensing and relaxing muscle groups throughout the body. At the same time, I ask you to focus on the feeling of tension in contrast to relaxation. Our goal is for you to release muscular tension and thereby release mental tension. The most effective way to do this is to purposely create a good degree of tension (by for example, making a fist) so that you have added momentum as you release into relaxation. It is similar to how you would get a pendulum moving from a still point. We could push it with effort to the right from its vertical position to begin the swing or more easily, we could pull it in the opposite direction and then let it go allowing it to swing past the vertical point and carry on to the right.

Creating more tension beforehand also allows you to clearly distinguish tension from relaxation in each muscle group and make you more aware of the unnecessary tension you carry with you without even noticing.

My purpose today is to familiarise you with the sixteen muscle groups we will be working with during the relaxation sessions you will attend.

Just to repeat - other important points

Try to remain focussed on the muscle group we are working on, as you create tension in it and as you relax it.

Release tension immediately on cue, rather than slowly and in your own time. For example, when I ask you to create tension in the hand and lower arm, when you are asked to relax do not slowly open the hand - allow the tension to release immediately.

Once you have relaxed a muscle group, try to keep that part still.

Do not speak to me during the session.

REFER TO TABLE over the page

#	Muscle group	Instruction	Alternative Tensing Strategies
	Arms and hands		
1	Dominant hand and lower arm	Make a tight fist (you should be able to feel tension in the hand, over the knuckles and in the lower arm)	
2	Dominant upper arm	Press elbow against floor (you should be able to get a feeling of tension in the biceps without involving the lower arm and hand)	Press the elbow down and simultaneously, pull elbow toward inward toward the body. Still problems → reverse order and tense biceps by lifting lower arm off floor and bending the elbow. → then relax hand and lower arm by tight fist
3	Non-dominant hand and lower arm	Make fist	
4	Non-dominant upper arm	Press elbow against floor	Press the elbow down and simultaneously, pull elbow toward inward toward the body. Still problems → reverse order and tense biceps by lifting lower arm off floor and bending the elbow. → then relax hand and lower arm by tight fist
	Face and neck (model face-making) The facial muscles are divided into three: upper (forehead), central (upper part of cheeks) and the lower part of the face (lower part of cheeks and jaw).		
5	Forehead	Lift eyebrows as high as possible (you should be able to feel tension in the forehead and scalp)	Make an exaggerated frown (knitting the eyebrows)
6	Central face	Squint eyes tightly, simultaneously and wrinkle nose (you should be able to feel tension in the upper cheeks and around the eyes)	
7	Lower face and jaw	Bite hard and pull back corners of mouth	
8	Neck	Pull chin toward chest and simultaneously keep from touching chest (might feel some shaking in these muscles)	Press the head back against the floor by using the neck muscles to press (doesn't use counterpoising muscles but better than nothing)
	Chest and abdomen		
9	Chest, shoulders and upper back	Tense these muscles by breathing in, holding and pulling shoulder blades together. I.e. pull shoulders back and try to get the shoulder blades to touch. You should feel tension in the chest, shoulders and upper back region	Imagine that 2 strings hanging from the ceiling are attached to the shoulders and are being pulled upward (causing a shrugging of the shoulders)
#	**Muscle group**	**Instruction**	**Alternative Tensing Strategies**
10	Abdomen	Make your belly hard (as if about to hit yourself) You should feel tension and tightness in the abdomen.	Pull abdomen in as far as you can OR push the abdomen out.
	Legs and feet		
11	Dominant upper leg	Tense muscles in upper leg y counterpoising the muscle on top with the 2 smaller ones underneath. The top one should feel quite hard.	Lift leg very slightly - this produces tension in the upper leg.
12	Dominant calf	Pull toes toward head to create tension in the calf	Point toes away from the head
13	Dominant foot	Point & curl toes, turn foot inward. Do not tense too hard just enough to feel tightness under the arch and in the ball of the foot	
14	Non- Dominant upper leg	Counter pose top and bottom muscles	Lift leg very slightly - this produces tension in the upper leg.
15	Non-Dominant calf	Pull toes toward head	Point toes away from the head
16	Non-Dominant foot	Point & curl toes, turn foot inward	

Hand out forms and Questionnaires and tick off according to Participant Familiarisation checklist

Familiarisation session script (Chapter 4)

Script for Participant Familiarisation Session:

Welcome participant. My study is in partial fulfilment of a PhD, so I am very grateful for your volunteering to take part.

My 1-hour session today is to give you an overview of:

5. The purpose of my study
6. What you need to do in preparation for the study
7. Going through the hair sampling procedure
8. What will happen during the experimental days including;

    - Going through the blood sampling procedure i.e. I will take some blood so that you are fully aware of the procedure
    - Briefly going through the relaxation procedure

9. I will then have some forms and questionnaires for you to fill out (which will take about 30 minutes)

    - The consent form including a summary of this session
    - A general health and demographic form
    - A series of questionnaires that asks about stress in your life, and your general lifestyle.
    - I will need to take your body weight, height and your waist and hip circumference as well.

10. If you give your consent to participate, I will then schedule you for the 2 lab sessions. Females will be tested during day 2-11 of the menstrual cycle.

11. I will give you a form that is a dietary diary that asks that you record what you have eaten for the 24 hrs prior to and after your attending each experimental session and a second form that is a diary of your home relaxation practice sessions

The purpose of my study

My study aims to compare the physiological and psychological effect of the stress response to the relaxation response. I will be doing this by looking at hair, blood and saliva hormone levels, blood pressure, heart rate and self-reported questionnaires. Participation in this study will require a total of 10 contact hours (including 1 HOUR FAM + 2 X 2.5 HOUR LAB + 8 X 30 min (CLASS), in addition to a daily 20-min home practice (6 X 20 mins = 120 mins/wk. (total 16 HOURS FOR 8 WEEKS)).

General Procedure

Should you wish to go ahead, I will need you to attend 2 laboratory sessions at the School of Sport Science, Exercise and Health. (*mention specific location in the building*). I can arrange free parking also.

The two laboratory sessions following this, will be on the same day of the week (appointed by you), 8 weeks apart.

Each session will begin between 8.00 – 10.30am and last two and a half hours. The last session could last an extra 15 mins

Your Preparation

For 24 hours before each of the four experimental sessions please do **not** have:

Any caffeine (in any form i.e. tea, coffee, Coke, Red Bull), for example),

Alcohol, other drugs/medications

Or take part in any exercise

I will require you to record your behaviour related to sleep, physical activity, food and drink 24 hours prior to, and after your laboratory session in a diary and to maintain the same behaviour before the next laboratory session 8 weeks later. If this is not possible on a particular day – I need you to inform me.

Show example

- cups and spoons
- diary

Meaning, I ask that you have the same breakfast, lunch and snacks and maintain the same level of physical activity **24 hours before** the experimental days

We require you to strictly follow the preparation protocol so that your blood chemistry remains the same for both laboratory sessions.

We require that you arrive at the laboratory after having fasted from 10pm, the night before.

Hair cortisol measurement

In order to measure the impact of the study on your stress levels we will measure the level of the stress hormone, cortisol, in your hair before and after the 8-week study period. This component of the study is entirely optional, and you may wish to decline this component of the study. Should you provide your consent during the familiarisation session, the investigator will cut a small amount of hair (less than 100 strands) (PASS AROUND SAMPLE) from your head for measurement. The hair will be cut as close to the scalp as possible and using care to ensure there is no visible sign of hair removal. We will follow the same procedure to take a sample at the completion of the study also.

This will provide us with an understanding of your stress levels for 2 months before the study and for the 2-month study period.

What happens on the experimental days?

On your arrival to the laboratory at each session, you will be requested to complete a questionnaire as you settle in. I will then ask you to take part in a 20-minute verbal ability exercise (which can be stressful) followed by a period of quiet sitting.

The details of the verbal ability task will be given on the day of testing. A total of approximately 30 minutes will be assigned to the completion of questionnaires throughout each laboratory session.

During the course of each laboratory session we will take four small capillary blood samples taken from your fingertip (equivalent to half of a millilitre). In short, this involves a small prick on the fingertip with a sterile lancet device. You may experience slight discomfort with the procedure, however this is only temporary. In addition, a sample of saliva will be collected at the same time points by placing a cotton swab in your mouth for 2 minutes, after which the cotton swab will be placed in a tube for later analysis of cortisol levels (a marker of stress levels in the body). We will also ask that you complete various questionnaires in order for us to gauge your thoughts and feelings throughout the course of each session.

Risks:

The blood sampling procedure may cause some mild discomfort and may leave a small bruise at the sampling site. This procedure in commonly performed in our laboratory and causes no long-term harm. The verbal ability task may be mentally challenging but will cause no long-lasting negative effect. Please be assured all the procedures we employ in this study have been commonly used in past research studies and are completely safe to be used with human participants.

Confidentiality:

Your confidentiality will be maintained throughout the study through random assignment of a number to de-identify your data. All data collected will be securely stored in a locked filing cabinet and password-protected computer assessable only to the chief investigator and PhD student (Tasmiah Masih). The findings of this study may be published, however all information used will be non-identifiable.

Your Rights:

Participation in this research is voluntary and you are free to withdraw from the study at any time without prejudice. You can withdraw for any reason and you do not need to justify your decision. If you withdraw from the study and you are an employee or student at the University of Western Australia (UWA) this will not prejudice your status and rights as employee or student of UWA. If you do withdraw we may wish to retain the data that we have recorded from you but only if you agree, otherwise your records will be destroyed.

Your participation in this study does not prejudice any right to compensation that you may have under statute of common law. If you have any questions concerning the research at any time, please feel free to ask the researcher who has contacted you about your concerns. Further information

regarding this study may be obtained from Dr Kym Guelfi on 6488 2602, Dr James Dimmock on 6488 1384 or Tasmiah Masih on 0421 130222 or 21287209@student.uwa.edu.au

The Human Research Ethics Committee at the University of Western Australia requires that all participants are informed that, if they have any complaint regarding the manner, in which a research project is conducted, it may be given to the researcher or, alternatively to the Secretary, Human Research Ethics Committee, Registrar's Office, University of Western Australia, 35 Stirling Highway, Crawley, WA 6009 (telephone number 6488-3703). All study participants will be provided with a copy of the Information Sheet and Consent Form for their personal records.

What's in it for you?

Participation in this study allows you to have a snapshot of how your body responds to stress, physiologically and psychologically. All your results will be sent to you as soon as all analysis is complete. You also play a major role in actively contributing to research at the University of Western Australia in an area of scientific research that is important for all individuals, young and old.

Take blood to familiarise participant with procedure.

Please note you will be randomly assigned to either the waitlist control or to the mindful relaxation group. Those in the waitlist group will be offered the full 8-week course after the study period.

Participant Familiarisation Session Script for Progressive Muscle Relaxation (as outlined in Appendix A, pp 165-166).

Participant Familiarisation Session Script for Mindfulness meditation

Mindfulness is the practice of focussing your attention on the present moment, in a non-judgemental, accepting manner as you experience passing thoughts, feelings and sensations, or whatever else the present moment brings you.

A brief taster:

Adapted from Kabat Zinn Full Catastrophe Living 2013p. 52-

Assume a comfortable lying posture lying on your back or sitting.

If sitting, as best you can lengthen the spine toward the sky and allow your shoulders to relax.

If you are comfortable to do so, close your eyes.

Allow your attention to gently arrive at your belly. Feel your belly gently rise or expand on the inhale and fall or recede on the exhale.

As best you can, focus on the various sensations that tell you that you are breathing, being with the full duration of the inhale and being with the full duration of the exhale, as if you are riding the waves of your own breathing.

Every time you notice your mind drifting off to something other than the breath, notice what it was that carried you away (such as a thought, emotion, or sensation), observe it with kindness, without judgement, and then gently bring your attention back to your belly and the sensations of the inhale and the exhale.

Even if your mind wanders off away from the breath another few hundred times, simply notice what is on your mind at the moment you realise you are no longer focussed on your breath, and then gently bring your attention back to your breath.

As best you can rest in the awareness of the feeling of the breath entering and leaving the body, coming back to the breath every time it wonders off to something else.

Our sessions will last 30 mins of which 20 minutes will be devoted to the guided practice. This may seem longer, but please be assured that I will only take this time.

You will receive the guided script on MP3 by email after your first lab if you are randomly placed in the mindful relaxation group. In order for you to most benefit from this course, and for my research results to truly reflect the effect of 8 weeks of mindful-relaxation, I request that you commit to a daily practice, and that you truthfully document your practice in the log you will be provided (show log). The time you are required to devote to the practice has been made as brief as possible so that it is do-able, yet still hopefully convey benefit to your lives. Because the practice is so brief, it is important that you do practice it on a daily practice.

If you do provide your consent to participate, please understand you will be randomly allocated to the intervention group (and receive the 8-week mindful relaxation course first). But those of you that are allocated to the waitlist control group will be offered the 8-week course after I complete the study.

I will now collect hair

Take ht. wt., and waist and hip circumference

Hand out forms and questionnaires - inform that there are a number of questionnaires

Tick off according to Participant Familiarisation checklist

Debrief Session Script (Chapter 3)

The Physiological and Psychological Effect of Acute Stress and Relaxation: A Comparative Study

- Participant Debrief Sheet-

The following protocol was used by the researcher in debriefing participants after the completion of the study. The debriefing was provided individually after the completion of data collection.

1. Opening briefing to participants

1.1 The researcher will thank each participant for their time in participating in the study and proceed to explain that this session will be used to clarify any queries the participants may have and explain, in greater detail the objectives of the study.

2. Probing questions with participants

2.1 The researcher will proceed to ask the following questions to each participant.

a) Was everything about this study clear to you?

b) Different people respond to things in different ways, and it's useful to hear your feelings about and reactions to this study. Did you find any aspect of the study odd or confusing?

c) Were you suspicious about anything?

d) What do you think we were looking for in this study?

e) Do you have any further questions about the study?

3. Explanation of experiment

3.1 The researcher will explain that each participant was led to believe that the study was solely about the physiological and psychological aspects of stress and relaxation.

3.2 The researcher will then provide the following clarifying statements:

a) In fact, what we were really interested in this study was the effect of stress and relaxation on dietary intake of high-energy snack foods.

b) The main hypothesis for this study was that people who are exposed to an acute stress eat more high-energy snack foods compared to when they have been relaxed.

3.3 The researcher will then ask the participants for any more clarifying questions they may have before moving to part 4.

Rationale for withholding information about the experiment

4.1 The researcher will explain that the participants were not explicitly told about the nature of the study because it may have led some participants to shape their behaviour and beliefs in such a way that may render the research findings invalid.

4.2 However, the researcher will emphasise to the participants that all assurances of confidentiality, as described on the consent form, are true and will be maintained.

5. Assess participant's state of mind

5.1 As the study used some form of deception, the researcher will invite participants to share any personal concerns with any member of the research team or with a counseling officer.

6. Enquiry of pre-study knowledge

7.1 The researcher will then ask the participants if they had heard about the procedures or objectives of this study before participating in it.

7. Closing Notes

8.1 The researcher will open up any remaining questions to the participants before thanking all participants once again for their time in the study.

This concludes the debriefing protocol, and the entire session is expected to last approximately 15 minutes.

Debrief Session Script (Chapter 4)

The Physiological and Psychological Effect of Acute Stress and Relaxation: A Comparative Study

- Participant Debrief Sheet-

Protocol used by the researcher in debriefing participants after the completion of the study. The debriefing was provided individually after the completion of data collection.

1. Opening briefing to participants

1.1 The researcher will thank each participant for their time in participating in the study and proceed to explain that this session will be used to clarify any queries the participants may have and explain, in greater detail the objectives of the study.

2. Probing questions with participants

2.1 The researcher will proceed to ask the following questions to each participant.

f) Was everything about this study clear to you?

g) Different people respond to things in different ways, and it's useful to hear your feelings about and reactions to this study. Did you find any aspect of the study odd or confusing?

h) Were you suspicious about anything?

i) What do you think we were looking for in this study?

j) Do you have any further questions about the study?

3. Explanation of experiment

3.1 The researcher will explain that each participant was led to believe that the study was solely about the physiological and psychological aspects of stress and relaxation.

3.2 The researcher will then provide the following clarifying statements:

c) In fact, what we were really interested in this study was the effect of stress and relaxation on dietary intake of high-energy snack foods.

d) The main hypothesis for this study was that people who are exposed to an acute stress eat more high-energy snack foods compared to that after completing a course of relaxation.

3.3 The researcher will then ask the participants for any more clarifying questions they may have before moving to part 4.

4. Rationale for withholding information about the experiment

4.1 The researcher will explain that the participants were not explicitly told about the nature of the study because it may have led some participants to shape their behaviour and beliefs in such a way that may render the research findings invalid.

4.2 However, the researcher will emphasise to the participants that all assurances of confidentiality, as described on the consent form, are true and will be maintained.

5. Assess participant's state of mind

5.1 As the study used some form of deception, the researcher will invite participants to share any personal concerns with any member of the research team or with a counseling officer.

6. Enquiry of pre-study knowledge

7.1 The researcher will then ask the participants if they had heard about the procedures or objectives of this study before participating in it.

7. Closing Notes

8.1 The researcher will open up any remaining questions to the participants before thanking all participants once again for their time in the study.

This concludes the debriefing protocol, and the entire session is expected to last approximately 15 minutes.

Appendix B

Food intake data collection sheet (Chapter 3)

Food intake data collection sheet (Chapter 4)

General data collection sheet (Chapters 3 & 4)

Food intake data collection sheet (Chapter 3)

Name: Date: Exp ID:

SF Data Sheet

SF	Wt (g)	Wt remaining (g)	Wt I (g)	Comments (request for 2nds?)
M	150			
L	150			
D	3 x 25			
C	100			
W	250ml			

Food intake data collection sheet (Chapter 4)

Name: Date: Exp ID:

Breakfast Intake Data Sheet

B/f food Item	Wt (g)	Wt remaining (g)	Wt I (g)	Comments (request for 2nds?)
Weetbix				
Nutrigrain				
Hilo Milk				
Yoghurt				
Bread				
Croissant				
Margarine				
Vegemite				
Marmalade				
Nutella				
Cheese				
Belvita breakfast biscuits				
Lollies				
Maltesers				
Water				
Tea				
Coffee				

General data collection sheet (Chapters 3 & 4)

TIME POINT 60 MINS Rlxn / Control start time: _____ pm Rlxn / Control completion time:

TIME POINT: 80 MINS Time scheduled: _____ pm Actual time: _____ pm

BP 3 Systolic _____ Diastolic _____ HR 3 _____ beats /min

SALIVA SAMPLE 3 Time commenced: _____ pm Time completed: _____ pm

ID Code: _____ Cortisol sample 3 ☐

BLOOD SAMPLE 3 Time commenced: _____ pm Time completed: _____ pm

ID Code: _____ Hormones 3 ☐ BGL3 _____ (mmol/l)

POMS-A 3 ☐ VAS 3 ☐ IMI 2 ☐

TIME POINT 90 MINS Control start time: _____ pm Control completion time:

TIME POINT: 110 MINS Time scheduled: _____ pm Actual time: _____ pm

BP 4 Systolic _____ Diastolic _____ HR 4 _____ beats /min

SALIVA SAMPLE 4 Time commenced: _____ pm Time completed: _____ pm

ID Code: _____ Cortisol sample 4 ☐

BLOOD SAMPLE 4 Time commenced: _____ pm Time completed: _____ pm

ID Code: _____ Hormones 4 ☐ BGL4 _____ (mmol/l)

POMS-A 4 ☐ VAS 4 ☐ Rumin 1 ☐

TIME POINT 120 MINS SF start time: _____ pm SF completion time:

TIME POINT: 150 MINS Time scheduled: _____ pm Actual time: _____ pm

BP 5 Systolic _____ Diastolic _____ HR 5 _____ beats /min

POMS-A 5 ☐ VAS 5 ☐ Behaviour diary 1 copy + blank diary given ☐

Remind re confidentiality

TIME POINT 60 MINS Rlxn / Control start time: _____ pm Rlxn / Control completion time:

TIME POINT: 80 MINS Time scheduled: _____ pm Actual time: _____ pm

BP 3 Systolic _____ Diastolic _____ HR 3 _____ beats /min

SALIVA SAMPLE 3 Time commenced: _____ pm Time completed: _____ pm
ID Code: _____ Cortisol sample 3 ☐

BLOOD SAMPLE 3 Time commenced: _____ pm Time completed: _____ pm
ID Code: _____ Hormones 3 ☐ BGL3 _____ (mmol/l)

POMS-A 3 ☐ VAS 3 ☐ IMI 2 ☐

TIME POINT 90 MINS Control start time: _____ pm Control completion time:

TIME POINT: 110 MINS Time scheduled: _____ pm Actual time: _____ pm

BP 4 Systolic _____ Diastolic _____ HR 4 _____ beats /min

SALIVA SAMPLE 4 Time commenced: _____ pm Time completed: _____ pm
ID Code: _____ Cortisol sample 4 ☐

BLOOD SAMPLE 4 Time commenced: _____ pm Time completed: _____ pm
ID Code: _____ Hormones 4 ☐ BGL4 _____ (mmol/l)

POMS-A 4 ☐ VAS 4 ☐ Rumin 1 ☐

TIME POINT 120 MINS SF start time: _____ pm SF completion time:

TIME POINT: 150 MINS Time scheduled: _____ pm Actual time: _____ pm

BP 5 Systolic _____ Diastolic _____ HR 5 _____ beats /min

POMS-A 5 ☐ VAS 5 ☐ Behaviour diary 1 copy + blank diary given ☐
Remind re confidentiality

Appendix C

TSST Experimenter's script

TSST Instructions for panel members

TSST Participant Assessment Sheet

TSST Experimenter's Script

It is important not to say too much about the TSST. Any questions related to the test should be answered with a general statement about a psychological stress situation explaining a proper introduction will follow. The experimenter can explain about the need for the rest period being a time to get used to the surroundings and feel comfortable.

Note exact time of arrival and beginning of rest period.

After the 30 min rest period and collection of blood and saliva 2 minutes before the TSST, lead the participant into Experimental room # 2.

Thank you for participating in my study. You have been assigned the verbal ability task for today. For this I need you to take part in a role play.

Your job will be to present an introductory talk in front of a committee.

TSST 1

Please imagine that you have applied for a job and have been invited for an interview. In contrast to a real interview, you will give a 5-minute talk in which you have to convince the committee that represents the company's staff managers, why you think you are the best candidate for the vacant position.

TSST 2 (Your performance was assessed as being in the lower range the first time you did this, and so this is a second chance to improve your score)

Please imagine that you have applied for a promotion within the company that you work. In contrast to a real interview, you will give a 5-minute talk in which you have to convince the committee that represents the company's staff managers, why you think you are the best candidate for the promotion.

The committee that assesses your performance consists of behavioural analysts. They will be assessing your talk including non-verbal behaviour and will be taking notes during your talk. You will also be recorded by video camera for later analysis.

You should leave the best possible impression and assume the role of the applicant for the entire 5-minute presentation.

The committee may ask you follow-up questions in case they need to clarify something you have said.

Following the 5-minute talk, you will be asked to complete a second task which will only be explained to you by the committee.

You will be allowed to take notes now which cannot be used during the talk. When asked to step up to the microphone, introduce yourself and begin your talk.

Do you have any questions?

Any questions should be directly answered.

Briefly introduce the participant to the committee members

Experimenter leaves Experimental room # 2.

Take note of time of post-test assessments

TSST instructions for panel members

Thank you for agreeing to help me with my study. You are an essential component of my experimental protocol leading to my PhD degree, so your time and effort are sincerely appreciated.

For future reference here are my contact details: Tasmiah (Tas) Masih

Email address: tasmiah.masih@research.uwa.edu.au

Mobile: 0421 130 222

In preparation for each of the TSST sessions you will be panelling:

- Dress professionally (preferably a tailored jacket and pants). You will be given a name tag.
- Please read this handout so that you are familiar with the TSST protocol and your role appears spontaneous and not rehearsed.
- Arrive at the time requested. When a participant is booked for his/her TSST sessions, I will notify you by email immediately.

The TSST sessions will require you to be seated, waiting for arrival of the participant at 8.30am. Arrival a few minutes before is advised. Please enter G.05 and take the door to your immediate right (into the TSST room). If this is locked exit G.05 and enter Lab G.02 (Research Lab 4). Once in this lab there is another door leading into G.02A (Research Lab 5) from which you can enter the TSST room.

The Trier Social Stress Test (TSST)

Background

The Trier Social Stress Test (TSST) is a well-tested laboratory stressor that has been used in a multitude of studies worldwide. Its aim is to induce the psychological and physiological changes associated with the stress response. Conducted according to standard protocol, it is known to increase stress hormone levels two-three fold in the majority of participants.

Your Role

You will be part of facilitating this stress response in the participants. It is therefore very important that you maintain serious countenance throughout each session, in no way revealing the trivial, humorous or artificial nature of the situation.

The participant will be asked to take part in a role play. My study requires each participant to undergo the TSST twice (on 2 different days, 8 weeks apart).

- For the first TSST session, they will be asked to assume the role of a job applicant attending a personal interview with the company's management committee of which

you are a member. The participant will be asked to convince the committee that they are the best candidate for the position. Following the speech, they will be asked to take part in a numerical exercise.

- For the second TSST session, the same participant will be asked to imagine they are applying for a promotion within a company of their choice. As for the first TSST, the numerical exercise will follow, though slightly modified.

Before the second TSST, they will also be told that their performance in the first interview was assessed as being in the low range and that the second TSST is a chance to improve their score. You will be introduced as one of two interview panel members. The participants will be informed that you are both specialists in assessing non-verbal behaviour. You will also be given a form to fill out (and additional note paper) on which you will record/comment on the participant's performance. It should appear to the participant that you are taking notes and that he or she is being evaluated.

Participants will also be informed that their performance will be filmed and audio recorded for post-interview analysis (the equipment however, will not be turned on and this is stated only to heighten the stress response)

You will be one of 2 panel members and have had no previous acquaintance with the participants. It is required that none of the committee members engage in any discussion about the situation that has been created. Should the participant address the committee, you can return the greeting politely. If the participant asks you any questions, direct them to ask the experimenter.

You are required to communicate with the participant in a neutral manner and not offer any verbal on non-verbal feedback at any point (no nodding or smiling, for instance). At the same time we do not want to harass or evoke anger or shame.

Should a participant become overly upset, please try to maintain a neutral manner and encourage him/her to continue with the assigned task. Should it appear, he/she is becoming e.g. overly distressed/looking faint please ask the participant to discontinue and take a seat and record the reason for discontinuation.

One of the 2 of you must be appointed the chair of the committee who will be the speaker.

The TSST procedure

You and your colleague will already be seated behind a table as the participant arrives into the room. The table will already be equipped with:

2 x notepads

2 x pens

2 x TSST protocol sheets

2 x Participant Performance Evaluation sheets

1 x timer

I will give the participant the instructions regarding the role play and introduce him/her to you before I leave the room.

You will then ask the participant to sit down at a small table (with paper and pen) and prepare their talk. Set the timer for 3 minutes

After 3 minutes, the participant will be asked to leave the preparation notes on the table and step forward to the marked line in front of a microphone (1-3m distance from the panel) and begin their talk.

At this point you must turn on the video camera by hand/remote and the audio recorder (making this an obvious action for the participant to notice)

Set the timer for 5 minutes and ask the participant to begin

Both committee members must maintain eye contact with the participant throughout the duration of the talk with the occasional exchange of looks between panel members. Only the chairperson addresses the participant.

If a subject completes the speech before 5 minutes, you must wait 20 seconds as you maintain focus on the subject. If the participant continues to be silent, the standard responses are the following:

'You still have some time left, please continue'

If the subject stops a second time, wait for 20 seconds and then ask the following questions:

<u>Questions to prompt participant to continue talking</u>

What are your personal strengths?

What are your shortcomings?

Do you have enemies? Why?

What do you think about teamwork?

Why do you think you are especially well-qualified for this task?

Why do you think you are better qualified then the other applicants?

What do your family/friends especially appreciate about you?

What do you appreciate about your friends?

What do you appreciate about colleagues?

You just pointed out that you were especially good at…, what other characteristics qualify you?

You just mentioned your qualities in respect to…, what do you in particular think about...?

You just spoke about…, what exactly do you then think about…?

Please complete the following sentence: "I am the best at/in…"

Please list your strengths!

Please list your weaknesses!

What kind of leading qualities do you have?

What do you think about teamwork?

Where do you see your position in a team?

What can you constructively add to a team?

You just mentioned that you really appreciate teamwork, what do you think about lone fighters?

Would you lie in order to gain an advantage?

What do you think about the saying "Everybody determines his own luck"

<u>Specifically, relevant to the job application TSST</u>

What do you think about job interviews?

What do your employees appreciate about you most?

Would you be willing to work overtime without compensation?

Would you be willing to work on the weekends if this be deemed necessary?

What kind of leading qualities do you expect from your employees?

What kind of qualities to you expect from your co-workers?

Under what circumstances would you be willing to compensate for the mistakes your co-workers make?

Usually, participants end their talk early, in rare cases they may continue to speak for the entire 5 minutes. It is left up to the discretion of the chair as to whether he/she should be left to continue or whether interrupted during the 3rd-5th minute to ask questions.

The object of the speech is to speak of their own attributes. If the participant begins to speak in great detail about their knowledge on a particular subject, the chair should intervene with the following:

'We believe that you know how to execute a …… (eg market anlaysis) but we are more interested in why you were so involved in or drawn to this area.'

After 5 minutes, the chair must intervene and inform the participant about the second task. Please make clear it is a second task (unrelated to the speech) as some participants have become annoyed that maths had nothing to do with a job application.

Then say, **(FOR TSST 1)**;

"Thank you, that is enough for now. We now want you to work on a numerical task. Please count aloud backwards from 2023 to zero by 17 as fast and as accurately as possible. If an error is made, you will be asked to begin from the first number. Do you have any questions?

Direct the participant to begin and set the timer to 5 minutes

When the participant makes a mistake say

'Stop – error-start at 2023 again please. After 5 minutes this task is complete.

Please note the number of errors made and the number reached as a performance measure.

The numerical task should only last 5 minutes, ending a total of 13 minutes. The chair should then thank the participant and ask him/her to wait for Tas. Please maintain a serious look as you exit the room - so that I know to enter. Your role for the TSST is then complete for that session ☺

2023	1649	1275	901	527	153
2006	1632	1258	884	510	136
1989	1615	1241	867	493	119
1972	1598	1224	850	476	102
1955	1581	1207	833	459	85
1938	1564	1190	816	442	68
1921	1547	1173	799	425	51
1904	1530	1156	782	408	34
1887	1513	1139	765	391	17
1870	1496	1122	748	374	0
1853	1479	1105	731	357	
1836	1462	1088	714	340	
1819	1445	1071	697	323	
1802	1428	1054	680	306	
1785	1411	1037	663	289	
1768	1394	1020	646	272	
1751	1377	1003	629	255	
1734	1360	986	612	238	
1717	1343	969	595	221	
1700	1326	952	578	204	
1683	1309	935	561	187	
1666	1292	918	544	170	

Then say, **(FOR TSST 2)**;

"Thank you, that is enough for now. We now want you to work on a numerical task. Please count aloud backwards from 1521 to zero by 13 as fast and as accurately as possible. If an error is made, you will be asked to begin from the first number. Do you have any questions?

Direct the participant to begin and set the timer to 5 minutes

When the participant makes a mistake say

'Stop – error-start at 1521 again please. After 5 minutes this task is complete.

Please note the number of errors made and the number reached as a performance measure.

The numerical task should only last 5 minutes, ending a total of 13 minutes. The chair should then thank the participant and ask him/her to wait for Tas. Please maintain a serious look as you exit the room - so that I know to enter. Your role for the TSST is then complete for that session ☺ but as this is the second TSST I will request that you return for the debriefing 1½ hours later.

1521	1261	1001	741	481	221
1508	1248	988	728	468	208
1495	1235	975	715	455	195
1482	1222	962	702	442	182
1469	1209	949	689	429	169
1456	1196	936	676	416	156
1443	1183	923	663	403	143
1430	1170	910	650	390	130
1417	1157	897	637	377	117
1404	1144	884	624	364	104
1391	1131	871	611	351	91
1378	1118	858	598	338	78
1365	1105	845	585	325	65
1352	1092	832	572	312	52
1339	1079	819	559	299	39
1326	1066	806	546	286	26
1313	1053	793	533	273	13
1300	1040	780	520	260	0
1287	1027	767	507	247	
1274	1014	754	494	234	

Debriefing

It is important that participants are debriefed regarding the TSST protocol including why the TSST was employed for the research question being addressed, that the audio and video recording will be deleted, and no analysis will be done of their performance.

As each participant in my study will be administered the TSST twice, this debriefing session must take place following the completion of the **lab session** in which the second TSST was administered. At this time, I will ask you to introduce yourselves to the participants (without your name tags) explaining that the experimental protocol required you to maintain a serious, unfriendly manner throughout the sessions.

References

Kudielka, B.M. (2013). The Trier Social Stress Test (TSST) Protocol. Sent via email by the author 24/10/2013.

Kirschbaum, C. (2013). Trier Social Stress Test. From http://p113367.typo3server.info/index.php?id=27&L=1 (Retrieved August 2013).

Kirschabum, C. & Hellhammer, D. (2000). Salivary Cortisol and Challenge Tests.

From http://www.macses.ucsf.edu/research/allostatic/challenge.php Retrieved 13/08/13

TSST Participant Assessment Sheet

(To be filled out by panel members during the speech and numerical exercise)

Participant Name _____ Date: / /

ID: _____

Gender: _____

Panel member name:

1 _____

2. _____

1) General appearance of participant:

a) Happy

b) Neutral

c) Tense

Comments

_____
_____
_____

2) Participant's response to interview:

a) Confident with minimal prompting required

b) Some prompting required to complete interview

c) Much prompting required to complete interview

c) Non-cooperative and not responsive to interview questions

3) Participant's response to the numerical challenge:

a) Willing to complete the task

b) Mildly anxious while completing the task

c) Became anxious/frustrated after incorrect answers

d) Non-cooperative and refused to complete the task

Did the participant require the alternate challenge of subtracting 7 (instead of 17)? Y / N

Number of errors made _____

Final number reached after serial subtraction _____

Additional comments?

Appendix D

Progressive Muscular Relaxation Script (Chapters 3 & 4)

Mindfulness Meditation Script (Chapter 4)

Progressive Muscular Relaxation Script (Chapters 3 & 4)

Before commencement check that;

Contact lenses removed

Watch / jewellery /belt removed if desired

Phone switched off

APMR Script

The procedure we are going to do today in order to reduce your tension is Abbreviated Progressive Muscle Relaxation. Basically, this means learning to sequentially tense and relax various groups of muscles all through the body, while at the same time, paying close attention to the feelings associated with both tension and relaxation. The goal is for you to learn to produce larger and very much more noticeable reductions in tension, and the best way to do this is by first producing a good deal of tension in the muscle group. And tensing muscle groups in this way prior to letting them relax is like giving yourself a running start toward deep relaxation through the momentum created by the tension release.

When I say the word 'tense' that is your specific signal to tense the muscles in the group we are working as tightly and as immediately as possible. You will be holding the tension for 7 seconds. Do not begin tensing until you hear this cue. Likewise, when I say the word 'release' that is your specific relaxation signal to immediately release the tension. Do not let the tension dissipate gradually, and do not release the tension until I give the cue. I will give you specific instructions on what muscle group to tense, as well as general guidelines on how to tense it. Please do not move unnecessarily, but feel free to move in any way that helps you maintain a comfortable position at all times. Also, there can be no unnecessary talking.

DOM-HAND

When I say 'tense, 'I want you to tense the muscles in your dominant hand by making a tight fist. Ready? Tense. (Hold for 7 secs). Feel the muscles pull. Notice the tension in these muscles as they pull and remain hard and tight. Release. (Relax for 30 secs). Just let the tension go, notice the difference between tension and relaxation, focus on the feeling of relaxation within the muscles as they loosen up, and relax more and more deeply. Pay attention only to the sensation of relaxation as the relaxation process takes place. 1

DOM UPPER ARM

When I say 'tense, 'I want you to tense the muscles in your dominant upper arm by pushing your elbow down against the armrest of the chair. Ready? Tense. (Hold for 7 secs). Feel the muscles pull. Notice what it's like to feel tension in these muscles as they pull and remain hard and tight. Release. (Relax for 30 secs). Just let the muscles go, take note of the difference between tension and relaxation, focus on the feeling in the muscle as it becomes more and more relaxed. Nowhere to go, nothing to do but just focus all your attention on the feeling of relaxation flowing into these muscles. 2

NON-DOM-HAND

When I say 'tense, 'I want you to tense the muscles in your non-dominant hand by making a tight fist. Ready? Tense. (Hold for 7 secs). Feel the muscles pull. Notice what it's like to feel tension in these muscles as they pull and remain hard and tight. Release. (Relax for 30 secs). Just let the tension go, notice the difference between tension and relaxation, focus on the feeling of relaxation within the muscles as they loosen up, and relax more and more deeply. Pay attention only to the sensation of relaxation as the relaxation process takes place. 1

NON-DOM UPPER ARM

When I say 'tense, 'I want you to tense the muscles in your non-upper arm by pushing your elbow down against the armrest of the chair. Ready? Tense. (Hold for 7 secs). Feel the muscles pull. Notice what it's like to feel tension in these muscles as they pull and remain hard and tight. Release. (Relax for 30 secs). Just let the muscles go, notice the difference between tension and relaxation, focus on the feeling in the muscle as it becomes more and more relaxed. Nowhere to go, nothing to do but just focus all your attention on the feeling of relaxation flowing into these muscles. 2

UPPER FACE

When I say 'tense' I want you to tense the muscles in the upper part of your face by lifting the eyebrows as high as you can and getting tension in the forehead and scalp region. Ready? Tense. (Hold for 7 secs). Feel the muscles pull. Notice what it's like to feel tension in these muscles as they pull and remain hard and tight. Release (Relax for 30 secs). Just let the muscles go. Compare the feeling of tension and relaxation. Experiencing the feeling of the muscles unwinding, smoothening out and letting go. Pay attention to the sensation of deep, complete relaxation in the muscles. 3

CENTRAL FACE

When I say 'tense' I want you to tense the muscles in the central part of your face by squinting your eyes very tightly and at the same time, wrinkling up your nose to feel the tension in the upper cheeks and eyes. Ready? Tense. (Hold for 7 secs). Feel the muscles pull. Notice what it's like to feel tension in these muscles as they pull and remain hard and tight. Release (Relax for 30 secs). Just let the muscles go and notice how they feel now as compared to before. Feeling the process of becoming calm, peaceful and relaxed. Focus only on the feeling of deep, complete relaxation. 4

LOWER FACE

When I say 'tense, 'I want you to tense the muscles in the lower part of your face by biting your teeth together and pulling the corners of your mouth back to feel the tension in the jaw. Ready? Tense. (Hold for 7 secs). Feel the muscles pull. Notice what it's like to feel tension in these muscles as they pull and remain hard and tight. Release. (Relax for 30 secs). Just let the tension go, notice the difference between tension and relaxation, focus on the feeling of relaxation within the muscles as they loosen up, and relax more and more deeply. Pay attention only to the sensation of relaxation as the relaxation process takes place. 1

NECK

When I say 'tense, 'I want you to tense the muscles in your neck by pulling your chin downward toward your chest and at the same time preventing it from actually touching your chest. Ready? Tense. (Hold for 7 secs). Feel the muscles pull. Notice what it's like to feel tension in these muscles as they pull and remain hard and tight. Release. (Relax for 30 secs). Just let the muscles go, notice the difference between tension and relaxation, focus on the feeling in the area as it becomes more and more relaxed. Nowhere to go, nothing to do but just focus all your attention on the feeling of relaxation flowing into these muscles. 2

CHEST, SHOULDERS AND UPPER BACK

When I say 'tense, ' I want you to tense the muscles in your chest, shoulders and upper back by taking a deep breath, holding it and at the same time pulling the shoulder blades together to try and make them touch. Ready? Tense. (Hold for 7 secs). Feel the muscles pull. Notice what it's like to feel tension in these muscles as they pull and remain hard and tight. Release (Relax for 30 secs). Just let the muscles go and notice how they feel now as compared to before. Feeling the process of becoming calm, peaceful and relaxed. Focus only on the feeling of being completely relaxed. 4

ABDOMEN

When I say 'tense, 'I want you to tense the muscles in your abdomen by making your belly hard, that is, just tense it up so that it feels firm. Ready? Tense. (Hold for 7 secs). Feel the muscles pull. Notice what it's like to feel tension in these muscles as they pull and remain hard and tight. Release (Relax for 30 secs). Just let the muscles go. Compare the feeling of tension and relaxation. Experiencing the feeling of the muscles unwinding, smoothening out and letting go. Pay attention to the pleasant sensation of deep, complete relaxation in the muscles. 3

DOM-THIGH

When I say 'tense, 'I want you to tense the muscles in your dominant thigh by squeezing the muscle as hard as you can and feeling it get hard. Ready? Tense. (Hold for 7 secs). Feel the muscles pull. Notice what it's like to feel tension in these muscles as they pull and remain hard and tight. Release. (Relax for 30 secs). Just let the tension go, notice the difference between tension and relaxation, focus on the feeling of relaxation within the muscles as they loosen up, and relax more and more deeply. Pay attention only to the sensation of relaxation as the relaxation process takes place. 1

DOM-CALF

When I say 'tense, 'I want you to tense the muscles in your dominant calf by pulling the toes upward toward your head. Ready? Tense. (Hold for 7 secs). Feel the muscles pull. Notice what it's like to feel tension in these muscles as they pull and remain hard and tight. Release. (Relax for 30 secs). Just let the muscles go, notice the difference between tension and relaxation, focus on the feeling in the muscle as it becomes more and more relaxed. Nowhere to go, nothing to do but just focus all your attention on the feeling of relaxation flowing into these muscles. 2

DOM FOOT

When I say 'tense, 'I want you to tense the muscles in your dominant foot by pointing the toe, turning the foot inward and curling the toes. Ready? Tense. (Hold for 7 secs). Feel the muscles pull. Notice what it's like to feel tension in these muscles as they pull and remain hard and tight. Release (Relax for 30 secs). Just let the muscles go and notice how they feel now as compared to before. Feeling the process of becoming calm peaceful and relaxed. Focus only on the feeling of complete relaxation. 4

NON_DOM THIGH

When I say 'tense, 'I want you to tense the muscles in your non-dominant thigh by squeezing the muscle as hard as you can and feeling it get hard. Ready? Tense. (Hold for 7 secs). Feel the muscles pull. Notice what it's like to feel tension in these muscles as they pull and remain hard and tight. Release. (Relax for 30 secs). Just let the tension go, notice the difference between tension and relaxation, focus on the feeling of relaxation within the muscles as they loosen up, and relax more and more deeply. Pay attention only to the sensation of relaxation as the relaxation process takes place. 1

NON-DOM-CALF

When I say 'tense, 'I want you to tense the muscles in your non-dominant calf by pulling the toes upward toward your head. Ready? Tense. (Hold for 7 secs). Feel the muscles pull. Notice what it's like to feel tension in these muscles as they pull and remain hard and tight. Release. (Relax for 30 secs). Just let the muscles go, notice the difference between tension and relaxation, focus on the feeling in the muscle as it becomes more and more relaxed. Nowhere to go, nothing to do but just focus all your attention on the feeling of relaxation flowing into these muscles. 2

NON-DOM FOOT

When I say 'tense, 'I want you to tense the muscles in your non-dominant foot by pointing the toe, turning the foot inward and curling the toes. Ready? Tense. (Hold for 7 secs). Feel the muscles pull. Notice what it's like to feel tension in these muscles as they pull and remain hard and tight. Release (Relax for 30 secs). Just let the muscles go and notice how they feel now as compared to before. Feeling the process of becoming calm peaceful and relaxed. Focus only on the feeling of complete relaxation. 4

Bernstein, A.D., & Borkovec, T.D. (1973). Progressive Relaxation Training. Research Press: Champagne, IL.

Mindfulness Meditation Script (Chapter 4)

Kabat Zinn, Guided Mindfulness Meditation Series 2, sitting meditation 20 mins

Coming into this seated meditation practice with the firm intention to bring mindfulness and discernment to each moment.

Sitting in a posture which for you in this moment, embodies feelings of dignity, self-reliance and wakefulness, stillness and stability

And when you are ready, bringing your attention to settle on your breath as you feel it flowing in and out of your body.

Focusing on feeling your belly as it expands gently on the in-breath and recedes gently on the out-breath, or on the feeling of the air as it flows past your nostrils, or on being in touch with your breathing, wherever you find it most vivid.

15 secs

And just keeping your attention on the breath for the full duration of each in-breath and the full duration of each out-breath. Riding the waves of your own breathing as a raft would ride up and down on the waves of the ocean. Fully in touch with the sensations in the belly or at the nostrils or wherever else you are following it, breath by breath, moment by moment.

Allowing your breath to remind you over and over again to be fully present, to be right here, right now.

40 secs

If at any time you find that your attention has waned, or has wondered off the breath entirely, noting where your mind has gone and what it is preoccupied with, once you come to notice it.

And then gently, and without condemning yourself for it, and without either clinging to the content of your thoughts and feelings or rejecting and supressing it, just letting go, and bringing your attention back to the breath, and doing this over and over again each time the mind loses its focus momentarily and moves away from the breath.

1.15secs

Staying fully in touch, just this breath coming in, just this breath going out. Using your breath as an anchor to keep your attention right here in the present moment.

2.35secs

And if you feel comfortable with it, at a certain point, expanding the field of your awareness around the breath until it includes a sense of the body as a whole, sitting here, breathing.

Opening to the full spectrum of feelings associated with your body as you sit here, awareness filling the body

Allowing whatever sensations that arise, to be held in awareness moment by moment, watching them come and go without reacting to the them as best you can just observing the play of any and all perceptions, sensations, thoughts and feelings along with your breath as you sit here, fully in touch with this moment.

60 secs

And here too, continually bringing your focus back to the body as a whole, sitting and breathing, each time it fades or is carried off by the stream of thoughts or feelings or sensations that runs through the mind.

2.30 secs

Perhaps reminding yourself from time to time, that you are not trying to get anywhere, or feel anything special. You are simply allowing yourself to be where you already are, and to feel whatever is here to be felt in this moment, observing and accepting whatever is here simply because it is already here – a part of your experience in this moment, regardless of whether it feels pleasant, unpleasant or neutral.

2.00 secs

Giving full care and attention to each moment – a continual seeing and letting be - seeing and letting go.

1.20 secs

And in the last few moments of this sitting, recommitting yourself to being fully awake and focussed, fully in your body. Sitting with the majesty, the beauty, the stability of a mountain. And perhaps committing yourself to bringing mindfulness to the various situations and activities that you will encounter today, so that you can respond consciously, rather than automatically to the various events and occurrences in your life. And perhaps find a way to live all your moments with greater harmony and effectiveness, including those in which you are faced with obstacles and challenges.

And as this guidance draws to an end, you might also want to thank yourself for the discipline and effort it takes to practice in this way, and for your commitment to devote some time each day to nourishing your own being through no-doing and wakeful stillness.

Kabat-Zinn, J. (2002). 20-minute seated meditation. Guided mindfulness meditation: series two. USA, University of Massachusetts Centre for Mindfulness.

Appendix E

Questionnaires (Chapters 3 & 4)

[Study ID:] (office use only)

Participant General Information Sheet

Name _____

Gender M F

Date of birth / /

Ethnic background:

Contact Details ph. _____ (mobile)

_____ (alternate number if available)

Email address _____

Degree major/occupation _____

(Office use only)

Body wt: _____ kg

Ht: _____m

D1 MC: _____

Waist: _____cm

Hip: _____cm

C/P: _____

Name: Date: Exp ID: PSS

The statements in this scale ask you about your general thoughts and feelings. In each case please indicate how often you feel or think a certain way. The best approach is to answer each question fairly quickly, based on how you feel/think **right now**. Be aware that there are no right or wrong answers.

	never	almost never	sometimes	fairly often	very often
1. In the last month, how often have you been upset because of something that happened unexpectedly?	0	1	2	3	4
2. In the last month, how often have you felt that you were unable to control the important things in your life?	0	1	2	3	4
3. In the last month, how often have you felt nervous and "stressed"?	0	1	2	3	4
4. In the last month, how often have you dealt successfully with irritating life hassles?	0	1	2	3	4
5. In the last month, how often have you felt that you were effectively coping with important changes that were occurring in your life?	0	1	2	3	4
6. In the last month, how often have you felt confident about your ability to handle your personal problems?	0	1	2	3	4
7. In the last month, how often have you felt that things were going your way?	0	1	2	3	4
8. In the last month, how often have you found that you could not cope with all the things that you had to do?	0	1	2	3	4
9. In the last month, how often have you been able to control irritations in your life?	0	1	2	3	4
10. In the last month, how often have you felt that you were on top of things?	0	1	2	3	4
11. In the last month, how often have you been angered because of things that happened that were outside of your control?	0	1	2	3	4
12. In the last month, how often have you found yourself thinking about things that you have to accomplish?	0	1	2	3	4
13. In the last month, how often have you been able to control the way you spend your time?	0	1	2	3	4
14. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?	0	1	2	3	4

Name: Date: Exp ID: STAI-trait

The statements in this scale ask you about your general thoughts and feelings. In each case please indicate how often you feel or think a certain way. The best approach is to answer each question fairly quickly, based on how you feel/think **right now**. Be aware that there are no right or wrong answers.

	almost never	sometimes	often	almost always
1. I feel pleasant	1	2	3	4
2. I feel nervous and restless	1	2	3	4
3. I feel satisfied with myself	1	2	3	4
4. I wish I could be as happy as others seem to be	1	2	3	4
5. I feel like a failure	1	2	3	4
6. I feel rested	1	2	3	4
7. I am “calm, cool and collected"	1	2	3	4
8. I feel that difficulties are piling up so that I can’t overcome them	1	2	3	4
9. I worry too much over something that really doesn’t matter	1	2	3	4
10. I am happy	1	2	3	4
11. I have disturbing thoughts	1	2	3	4
12. I lack self confidence	1	2	3	4
13. I feel secure	1	2	3	4
14. I make decisions easily	1	2	3	4
15. I feel inadequate	1	2	3	4
16. I am content	1	2	3	4
17. Some unimportant thought runs through my mind and bothers me	1	2	3	4
18. I take disappointments so keenly that I can’t put them out of my mind	1	2	3	4
19. I am a steady person	1	2	3	4
20. I get in a state of tension or turmoil as I think over my recent concerns and interests	1	2	3	4

Name: Date: Exp ID: MAAS

Below is a collection of statements about your everyday experience. Using the scale of 1-6 below, please indicate how frequently or infrequently you currently have each experience. Please answer according to what really reflects your experience rather than what you think your experience should be. Please treat each item separately from every other item.

	almost always	very frequently	somewhat frequently	somewhat infrequently	very infrequently	almost never
1. I could be experiencing some emotion and not be conscious of it until some time later.	1	2	3	4	5	6
2. I break or spill things because of carelessness, not paying attention, or thinking of something else.	1	2	3	4	5	6
3. I find it difficult to stay focused on what's happening in the present	1	2	3	4	5	6
4. I tend to walk quickly to get where I'm going without paying attention to what I experience along the way.	1	2	3	4	5	6
5. I tend not to notice feelings of physical tension or discomfort until they really grab my attention.	1	2	3	4	5	6
6. I forget a person's name almost as soon as I've been told it for the first time.	1	2	3	4	5	6
7. It seems I am "running on automatic" without much awareness of what I'm doing.	1	2	3	4	5	6
8. I rush through activities without being really attentive to them.	1	2	3	4	5	6
9. I get so focused on the goal I want to achieve that I lose touch with what I'm doing right now to get there.	1	2	3	4	5	6
10. I do jobs or tasks automatically, without being aware of what I'm doing.	1	2	3	4	5	6
11. I find myself listening to someone with one ear, doing something else at the same time.	1	2	3	4	5	6
12. I drive places on "automatic pilot" and then wonder why I went there.	1	2	3	4	5	6
13. I find myself preoccupied with the future or the past.	1	2	3	4	5	6
14. I find myself doing things without paying attention	1	2	3	4	5	6
15. I snack without being aware that I'm eating.	1	2	3	4	5	6

Name: Date: Exp ID: RRS

Please read each of the items below and indicate whether or how often you think or do each one. Please indicate what you generally do, not what you think you should do.

	almost never	sometimes	often	almost always
1. Think about how alone you feel	1	2	3	4
2. Think "I won't be able to do my job if I don't snap out of this"	1	2	3	4
3. Think about your feelings of fatigue and achiness	1	2	3	4
4. Think about how hard it is to concentrate	1	2	3	4
5. Think "What am I doing to deserve this?"	1	2	3	4
6. Think about how passive and unmotivated you feel.	1	2	3	4
7. Analyse recent events to try to understand why you are depressed	1	2	3	4
8. Think about how you don't seem to feel anything anymore	1	2	3	4
9. Think "Why can't I get going?"	1	2	3	4
10. Think "Why do I always react this way?"	1	2	3	4
11. Go away by yourself and think about why you feel this way	1	2	3	4
12. Write down what you are thinking about and analyse it	1	2	3	4
13. Think about a recent situation, wishing it had gone better	1	2	3	4
14. Think "I won't be able to concentrate if I keep feeling this way."	1	2	3	4
15. Think "Why do I have problems other people don't have?"	1	2	3	4
16. Think "Why can't I handle things better?"	1	2	3	4
17. Think about how sad you feel.	1	2	3	4
18. Think about all your shortcomings, failings, faults, mistakes	1	2	3	4
19. Think about how you don't feel up to doing anything	1	2	3	4
20. Analyse your personality to try to understand why you are depressed	1	2	3	4
21. Go someplace alone to think about your feelings	1	2	3	4
22. Think about how angry you are with yourself	1	2	3	4

Name _____ Date / / Study ID:

Experimental protocol compliance

24-hour behaviour diary submitted ☐

1. Approximately at what time did you last eat?

(If this has not been recorded in your diary, please ask for a diary sheet and record what you have eaten over the past 24 hours).

_____

_____

2. When was the last time you took a caffeine containing beverage (e.g tea/coffee/Coke/Red Bull) ?

_____

_____

3. When was the last time you had alcohol?

_____

_____

4. At what time did you:

(a) Sleep last night? _____ pm

(b) Awake this morning? _____ am

5. When was the last time you did exercise?

_____

_____

6. Have you taken any medication over the past 24 hours (including any medicated creams, drops, herbal or vitamin supplements)? If so, please record type and dosage taken.

_____

_____

7. Have the last 24 hours been unusual for this day of the week in any way?

_____

_____

_____

Name: Date: Exp ID: POMS

Below is a list of words that describe feelings that people have. Please read each one carefully. Then circle the answer which best describes **HOW YOU FEEL RIGHT NOW**. Make sure you answer every question.

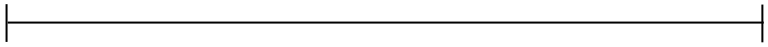
	not at all	a little	moderately	quite a bit	extremely
1. Panicky	0	1	2	3	4
2. Lively	0	1	2	3	4
3. Confused	0	1	2	3	4
4. Worn out	0	1	2	3	4
5. Depressed	0	1	2	3	4
6. Downhearted	0	1	2	3	4
7. Annoyed	0	1	2	3	4
8. Exhausted	0	1	2	3	4
9. Mixed up	0	1	2	3	4
10. Sleepy	0	1	2	3	4
11. Bitter	0	1	2	3	4
12. Unhappy	0	1	2	3	4
13. Anxious	0	1	2	3	4
14. Worried	0	1	2	3	4
15. Energetic	0	1	2	3	4
16. Miserable	0	1	2	3	4
17. Muddled	0	1	2	3	4
18. Nervous	0	1	2	3	4
19. Angry	0	1	2	3	4
20. Active	0	1	2	3	4
21. Tired	0	1	2	3	4
22. Bad tempered	0	1	2	3	4
23. Alert	0	1	2	3	4
24. Uncertain	0	1	2	3	4

Name: Date: Exp ID: VAS

For each of the scales below place a vertical stroke at the pint which best describes how you feel right now.

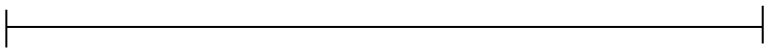
1. How tired do you feel?

Not tired at all As tired as I have ever felt



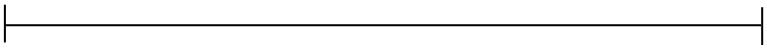
2. How sleepy do you feel?

Not sleepy at all As sleepy as I have ever felt



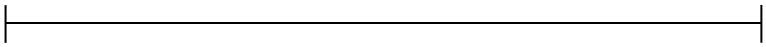
3. How hungry do you feel?

Not hungry at all As hungry as I have ever felt



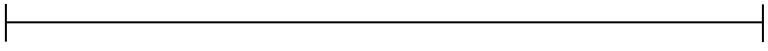
4. How full do you feel?

Not full at all As full as I have ever felt



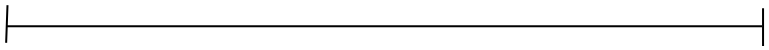
5. How energetic do you feel?

Not energetic at all As energetic as I have ever felt



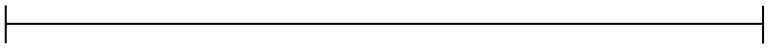
6. How strong is your desire to eat right now?

Very weak Very strong



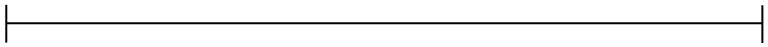
7. How stressed do you feel?

Not stressed at all As stressed as I have ever felt



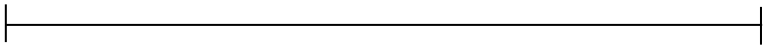
8. How much do you think you could eat right now?

Nothing at all A large amount



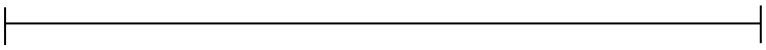
9. How relaxed do you feel?

Not relaxed at all As relaxed as I have ever been



10. How strong is your desire to drink alcohol right now?

Very weak Very strong



Name: Date: Exp ID IMI - post TSST

Below is a collection of statements about how you feel. Using the scale of 1-7 below, please indicate, in relation to the verbal ability task, how true each statement is for you **RIGHT NOW** and not how you think you should feel. There are no right or wrong answers. Treat each question as separate from the rest.

	not at all true			somewhat true			very true
1. I did not feel nervous at all while doing the verbal activity.	1	2	3	4	5	6	7
2. I felt very tense while doing the verbal activity.	1	2	3	4	5	6	7
3. I was very relaxed in doing the verbal activity.	1	2	3	4	5	6	7
4. I was anxious while working on the verbal activity.	1	2	3	4	5	6	7
5. I felt pressured while doing the verbal activity.	1	2	3	4	5	6	7
6. I think I am pretty good at this verbal activity.	1	2	3	4	5	6	7
7. I think I did pretty well at the verbal activity, compared to others.	1	2	3	4	5	6	7
8. After working at the verbal activity for a while, I felt pretty competent.	1	2	3	4	5	6	7
9. The verbal activity was an activity that I couldn't do very well.	1	2	3	4	5	6	7
10. I am satisfied with my performance during the verbal activity.	1	2	3	4	5	6	7
11. I was pretty skilled at the verbal activity.	1	2	3	4	5	6	7

Name: Date: Exp ID: IMI – post PMR

Below is a collection of statements about how you feel. Using the scale of 1-7 below, please indicate how true each statement is for you **RIGHT NOW** and not how you think you should feel. There are no right or wrong answers. Treat each question as separate from the rest.

	not at all true			somewhat true			very true
1. I did not feel nervous at all while doing the relaxation activity.	1	2	3	4	5	6	7
2. I felt very tense while doing the relaxation activity.	1	2	3	4	5	6	7
3. I was very relaxed in doing the relaxation activity.	1	2	3	4	5	6	7
4. I was anxious while working on the relaxation activity.	1	2	3	4	5	6	7
5. I felt pressured while doing the relaxation activity.	1	2	3	4	5	6	7
6. I think I am pretty good at this relaxation activity.	1	2	3	4	5	6	7
7. I think I did pretty well at the relaxation activity, compared to others.	1	2	3	4	5	6	7
8. After working at the relaxation activity for a while, I felt pretty competent.	1	2	3	4	5	6	7
9. The relaxation activity was an activity that I couldn't do very well.	1	2	3	4	5	6	7
10 I am satisfied with my performance during the relaxation activity.	1	2	3	4	5	6	7
11. I was pretty skilled at the relaxation activity.	1	2	3	4	5	6	7

Name: Date: Exp ID: DEBQ p.1

Below is a collection of statements about your everyday experience. Using the scale of 1-5 below, please indicate how frequently or infrequently you currently have each experience. Please answer according to what really reflects your experience rather than what you think your experience should be. Please treat ea[illegible]m separately fror [illegible]ry other item.

	not relevant	never	seldom	sometimes	often	very often
1. If you have put on weight, do you eat less than you usually do?	□	1	2	3	4	5
2. Do you try to eat less at mealtimes than you would like to eat?		1	2	3	4	5
3. How often do you refuse food or drink offered because you are concerned about your weight?		1	2	3	4	5
4. Do you watch exactly what you eat?		1	2	3	4	5
5. Do you deliberately eat foods that are slimming?		1	2	3	4	5
6. When you have eaten too much, do you eat less than usual the following days?	□	1	2	3	4	5
7. Do you deliberately eat less in order not to become heavier?		1	2	3	4	5
8. How often do you try not to eat between meals because you are watching your weight?		1	2	3	4	5
9. How often in the evening do you try not to eat because you are watching your weight?		1	2	3	4	5
10. Do you take into account your weight with what you eat?		1	2	3	4	5
11. Do you have the desire to eat when you are irritated?	□	1	2	3	4	5
12. Do you have a desire to eat when you have nothing to do?	□	1	2	3	4	5
13. Do you have a desire to eat when you are depressed or discouraged?	□	1	2	3	4	5
14. Do you have a desire to eat when you are feeling lonely?	□	1	2	3	4	5
15. Do you have a desire to eat when somebody lets you down?	□	1	2	3	4	5
16. Do you have a desire to eat when you are cross?	□	1	2	3	4	5
17. Do you have a desire to eat when you are approaching something unpleasant to happen?		1	2	3	4	5
18. Do you get the desire to eat when you are anxious, worried or tense?		1	2	3	4	5

	not relevant	never	seldom	sometimes	often	very often
19. Do you have a desire to eat when things are going against you or when things have gone wrong?		1	2	3	4	5
20. Do you have a desire to eat when you are frightened?	□	1	2	3	4	5
21. Do you have a desire to eat when you are disappointed?	□	1	2	3	4	5
22. Do you have a desire to eat when you are emotionally upset?	□	1	2	3	4	5
23. Do you have a desire to eat when you are bored or restless?	□	1	2	3	4	5
24. If food tastes good to you, do you eat more than usual?		1	2	3	4	5
25. If food smells and looks good, do you eat more than usual?		1	2	3	4	5
26. If you see or smell something delicious, do you have a desire to eat it?		1	2	3	4	5
27. If you have something delicious to eat, do you eat it straight away?		1	2	3	4	5
28. If you walk past the baker, do you have the desire to buy something delicious?		1	2	3	4	5
29. If you walk past a snack bar or café do you have the desire to buy something delicious?		1	2	3	4	5
30. If you see others eating, do you also have the desire to eat?		1	2	3	4	5
31. Can you resist eating delicious foods?		1	2	3	4	5
32. Do you eat more than usual, when you see others eating?		1	2	3	4	5
33. When preparing a meal, are you inclined to eat something?		1	2	3	4	5

Name: Date: Exp ID: TEFQ-DISINHIBITION

1. When I smell a sizzling steak or see a juicy piece of meat, I find it very difficult to keep from eating, even if I have just finished a meal.	T F
2. I usually eat too much at social occasions, like parties and picnics.	T F
3. Sometimes things just taste so good that I keep on eating even when I am no longer hungry.	T F
4. When I feel anxious I find myself eating.	T F
5. Since my weight goes up and down, I have gone on reducing diets more than once.	T F
6. When I am with someone who is overeating, I usually overeat too.	T F
7. Sometimes when I start eating, I just can't seem to stop.	T F
8. It is not difficult for me to leave something on my plate.	T F
9. When I feel blue, I often overeat.	T F
10. My weight has hardly changed at all in the last ten years.	T F
11. When I feel lonely, I console myself by eating.	T F
12. Without even thinking about it, I take a long time to eat.	T F
13. While on a diet, if I eat a food that is not allowed, I often then splurge and eat other high calorie foods.	T F

14. Do you eat sensibly in front of others and splurge alone?

1	2	3	4
never	rarely	often	always

15. Do you go on eating binges though you are not hungry?

1	2	3	4
never	rarely	sometimes	at least once a week

16. To what extent does this statement describe your eating behaviour?

'I start dieting in the morning, but because of any number of things that happen during the day, by evening I have given up and eat what I want, promising myself to start dieting again tomorrow.'

1	2	3	4
not like me	little like me	pretty good description of me	describes me perfectly

Name: Date: Exp ID:

SELF-PERCEIVED STRESS-INDUCED EATING

Below is a collection of statements about your everyday experience. Using the scale of 1-7 below, please respond to each statement as accurately as possible. There are no right or wrong answers. Treat each question as separate from the rest.

	less			the same			more
1. When I am stressed, I sleep	1	2	3	4	5	6	7
2. When I am stressed, I drink alcohol	1	2	3	4	5	6	7
3. When I am stressed, I eat	1	2	3	4	5	6	7
4. When I am stressed, my work efficiency is	1	2	3	4	5	6	7

Appendix F

Questionnaires (Chapter 4)

Name: Date: Exp ID: SMM-G

Please rate the extent to which you agree or disagree with the following statements

	strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
1. The effects of stress are negative and should be avoided.	0	1	2	3	4
2. Experiencing stress facilitates my learning and growth.	0	1	2	3	4
3. Experiencing stress depletes my health and vitality.	0	1	2	3	4
4. Experiencing stress enhances my performance and productivity.	0	1	2	3	4
5. Experiencing stress inhibits my learning and growth.	0	1	2	3	4
6. Experiencing stress improves my health and vitality.	0	1	2	3	4
7. Experiencing stress debilitates my performance and productivity.	0	1	2	3	4
8. The effects of stress are positive and should be utilised.	0	1	2	3	4

Name: Date: Exp ID: PEMS

Below is a list of reasons that people sometimes give for eating tasty foods and drinks such as

– Sweets like chocolate, doughnuts, cookies, cake, lollies, ice cream, other desserts.

– Salty snacks like chips, pretzels, and crackers.

– Fast foods like hamburgers, cheeseburgers, pizza, fried chicken and French fries.

– Sugary drinks like soft drinks, sweet tea, milkshakes, and sweet coffee drinks.

Thinking of all the times you ate these kinds of foods/drinks, how often would you say that you ate/drank them for each of the following reasons? Circle the answer that best describes you.

		almost never/never	some of the time	half of the time	most of the time	almost always/always
1.	To forget your worries	1	2	3	4	5
2.	Because your friends want you to eat/drink them	1	2	3	4	5
3.	Because it helps you enjoy a party	1	2	3	4	5
4.	Because it helps you when you feel depressed or nervous	1	2	3	4	5
5.	To be sociable	1	2	3	4	5
6.	To cheer up when you are in a bad mood	1	2	3	4	5
7.	Because you like the feeling	1	2	3	4	5
8.	So that others won't kid you about not eating or drinking these items	1	2	3	4	5
9.	Because it's exciting	1	2	3	4	5
10.	To get "high-like" feelings	1	2	3	4	5
11.	Because it makes social gatherings more fun	1	2	3	4	5
12.	To fit in with a group you like	1	2	3	4	5
13.	Because it gives you a pleasant feeling	1	2	3	4	5
14.	Because it improves parties and celebrations	1	2	3	4	5
15.	*Because you feel more self-confident and sure of yourself	1	2	3	4	5
16.	To celebrate a special occasion with friends	1	2	3	4	5
17.	To forget about your problems	1	2	3	4	5
18.	Because it's fun	1	2	3	4	5
19.	To be liked	1	2	3	4	5
20.	So you won't feel left out	1	2	3	4	5

Name: Date: Experimental ID: FCI

Below is a list of food that people sometimes crave. For each item of food, first tick the column that describes how often you have craved the food - from Never to Always. Then secondly, tick the column to tell us how often you have given in to the craving, again from never to always, and finally tell us how hard it was to resist your craving.

		Craving 1. Over the past month, how often have you experienced a craving for the food?					Giving In 2. Of these times in the past month during which you craved a particular food, how often did you "give in" to the craving and eat the food?					Difficulty 3. How difficult was it to resist temptation?				
		Never	Rarely	Sometimes	Often	Always/almost every day	Never	Rarely	Sometimes	Often	Always/almost every time	Easy	A bit difficult	Difficult	Very difficult	So difficult that I gave in
1	Bacon															
2	Baked potato															
3	Biscuits															
4	Bread															
5	Burger															
6	Cake/muffin															
7	Chocolate															
8	Curry															
9	Crisps/Snack foods															
10	French Fries or Chips															
11	Fried Chicken															
12	Cheese															
13	Hot dog															
14	Ice cream/Milkshake															
15	Ice block															
16	Mashed potato															

		Craving 1. Over the past month, how often have you experienced a craving for the food?						Giving In 2. Of these times in the past month during which you craved a particular food, how often did you "give in" to the craving and eat the food?						Difficulty 3. How difficult was it to resist temptation?				
		Never	Rarely	Sometimes	Often	Always/almost every day		Never	Rarely	Sometimes	Often	Always/almost every time		Easy	A bit difficult	Difficult	Very difficult	So difficult that I gave in
17	Pasta																	
18	Pastries or Pies																	
19	Pizza																	
20	Donut																	
21	Rice																	
22	Sausage																	
23	Steak																	
24	Lollies																	

Name: Date: Exp ID: PSQI (q.1-9)

The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month.

Please answer all questions.

1. During the past month, what time have you usually gone to bed at night? _____

2. During the past month, how long (in minutes) has it usually taken you to fall asleep each night? _____

3. During the past month, what time have you usually gotten up in the morning? _____

4. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spent in bed). _____

5. During the past month how often have you had trouble sleeping because you ..	**Not during the past month**	**Less than once a week**	**Once or twice a week**	**Three or more times a week**
a. Cannot get to sleep within 30 minutes				
b. Wake up in the middle of the night or early morning				
c. Have to get up to use the bathroom				
d. Cannot breathe comfortably				
e. Cough or snore loudly				
f. Feel too cold				
g. Feel too hot				
h. Have bad dreams				
i. Have pain				
j. other reason(s), please describe:				
6. During the past month, how often have you taken medicine to help you sleep (prescribed or "over the counter")?				
7. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?				
	No problem at all	**Only a very slight problem**	**Somewhat of a problem**	**A very big problem**
8. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?				
	Very good	**Fairly good**	**Fairly bad**	**Very bad**
9. During the past month how would you rate your sleep quality overall?				

Name: Date: Exp ID: State Rumination

Please read each of the items below, in relation to the verbal ability exercise just completed, and indicate whether or how often you thought as described below.

	never	sometimes	often	always
1. Thought "Why do I always react this way?"?	1	2	3	4
2. Thought about the tasks, wishing they would have gone better?	1	2	3	4
3. Thought "Why can't I handle things better?"?	1	2	3	4

Name: Date: Exp ID: SMM-S

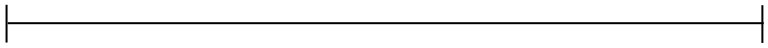
In relation to the verbal ability task you just completed, please rate the extent to which you agree or disagree with the following statements.

	strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
1. The effects of this stress are negative and should be avoided.	0	1	2	3	4
2. Experiencing this stress facilitates my learning and growth.	0	1	2	3	4
3. Experiencing this stress depletes my health and vitality.	0	1	2	3	4
4. Experiencing this stress enhances my performance and productivity.	0	1	2	3	4
5. Experiencing this stress inhibits my learning and growth.	0	1	2	3	4
6. Experiencing this stress improves my health and vitality.	0	1	2	3	4
7. Experiencing this stress debilitates my performance and productivity.	0	1	2	3	4
8. The effects of this stress are positive and should be utilised.	0	1	2	3	4

Name: Date: Session: Exp ID: Post MM

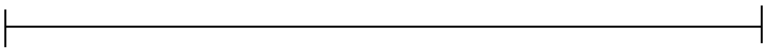
5. During the guided session, I felt myself getting carried away by my thoughts rather than just noticing them

Never All the time



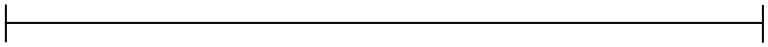
6. During the guided session I paid attention to my thoughts and feelings

Never All the time



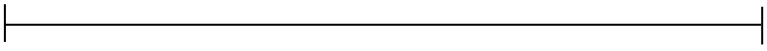
7. During the guided session, I was aware of my thoughts, feelings and bodily sensations

Never All the time



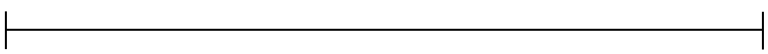
8. During the guided session, I paid attention to my thoughts and feelings without judging them

Never All the time



9. During the guided session, I was aware of my thoughts, feelings and bodily sensations with a sense of acceptance

Never All the time

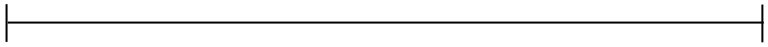


Name: Date: Session: Exp ID: Post PMR/MM

For each of the scales below place a vertical stroke at the point which best describes how you feel.

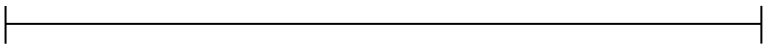
1. How stressed do you feel now?

Not stressed at all — As stressed as I have ever felt



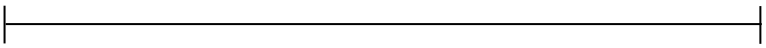
2. How relaxed do you feel now?

Not relaxed at all — As relaxed as I have ever been



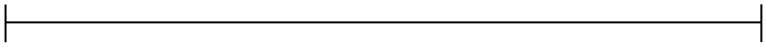
3. How demanding was the exercise for you?

Not at all — Very much



4. How enjoyable was the exercise for you?

Not at all — Very much

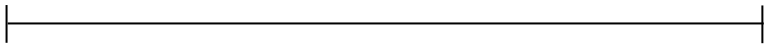


Name: Date: Session: Exp ID: Pre PMR/MM

For each of the scales below place a vertical stroke at the point which best describes how you feel.

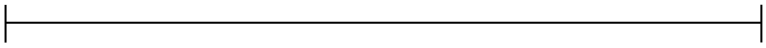
1. How stressed do you feel now?

Not stressed at all As stressed as I have ever felt



2. How relaxed do you feel now?

Not relaxed at all As relaxed as I have ever been



Appendix G

Lab booking sheet (Chapter 3)

Lab booking sheet (Chapter 4)

Food, Drink & Behaviour Diary (Chapters 3 & 4)

Mindful Relaxation Diary (Chapter 4)

Lab booking sheet (Chapter 3)

Your lab sessions are on the following dates:

Lab session #	Time	Date
Lab Session 1		
Lab Session 2		
Lab Session 3		
Lab Session 4		

Please remember:

- Wear loose, comfortable clothing
- Bring your diary for the 24 hours prior to each lab session. (a copy of this will be returned to you so you can maintain the same pattern of behaviour [food and drink intake, activity and sleep] for subsequent lab sessions).

For the 24 hours before each laboratory session do NOT:

- Consume any caffeine (e.g. tea, coffee, Coke, Red Bull),
- Consume alcohol, other medications including supplements
- Do any exercise

On the day of your laboratory session:

- Please have lunch at 12.00pm

Any questions, please ring me, Tas, on 0421 130 222 … thank you ☺

Lab booking sheet (Chapter 4)

Your lab sessions are on the following dates:

Lab session #	Time	Date
Lab Session 1		
Lab Session 2		

Please remember:

- Wear loose, comfortable clothing
- Bring your diary for the 24 hours prior to each lab session. (a copy of this will be returned to you so you can maintain the same pattern of behaviour [food and drink intake, activity and sleep] for subsequent lab sessions).

For the 24 hours before each laboratory session do NOT:

- Consume any caffeine (e.g. tea, coffee, Coke, Red Bull),
- Consume alcohol, other medications including supplements
- Do any exercise

On the day of your laboratory session:

- Please commence fasting from 10pm, the night before your laboratory session.

Any questions, please ring me, Tas, on 0421 130 222 … thank you ☺

Food, Drink & Behaviour Diary (Chapter 3 &4)

Name:

TO BEGIN FOOD AND BEHAVIOUR DIARY: **DATE:** **TIME:**

FOR LAB SESSION: **DATE:** **TIME:**

Date	Time	Food	Quantity cups/T/tsp /standard serves (e.g. I small apple)	Drink	Quantity cups/200 ml glass	Other comments
Example	*8am*	*Kellogg's Sultana Bran*	*0.5c*			
		Full cream milk	*0.75c*			
				OJ	*200ml*	
		Canned peach pieces (drained from juice)	*0.5c*			
	11am	*apple*	*1 x large*			

Sleep schedule

At what time did you sleep last night? (i.e. night before lab session) _____ p.m.

At what time did you awake? (day of lab session) _____ a.m.

Activity Level

How would you describe your activity level for the 24 hours before attending the laboratory session?

Not active at all Very active

Describe how the 24 hours before attending the laboratory session was in any way different to what you consider a normal day or different to the same day last week.

_____
_____
_____
_____

Mindful Relaxation Diary (Chapter 4)

Name: **Study ID:**

Lab session dates: **and**

Week number	Date	PMR/MM	Class/home practice	Time commenced	Time ended	Other comments
Week 1						
Week 2						
Week 3						
Week 4						
Week 5						

	Date	PMR/MM	Class/home practice	Time commenced	Time ended	Other comments
Week 6						
Week 7						
Week 8						
N.B. The rows below are to be filled should your second lab be delayed, and you are continuing your practice until this date						
Week 9						
Week 10						

Appendix H

Publications generated from this thesis

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Stress-induced eating and the relaxation response as a potential antidote: A review and hypothesis

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ABSTRACT

There is an accumulating body of evidence to indicate that stress leads to the consumption of unhealthy, energy-dense, palatable food, potentially contributing to the alarming global prevalence of chronic diseases, including obesity. However, comparatively little research has been devoted to addressing how best to remedy this growing problem. We provide an overview of the influence of stress on dietary intake, and then explore the novel, yet simple, possibility that regular elicitation of the relaxation response may effectively reduce stress-induced eating via both physiological neuroendocrine and reward pathways and psychological pathways involving emotion regulation, and habitual coping. If shown to be effective, the regular practice of relaxation may provide a convenient, cost efficient, patient-centered therapeutic practice to assist in the prevention of unhealthy weight gain and other negative consequences of unhealthy food intake.

Contents

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0195-6663/

1. Introduction

Stress-induced eating is characterised by an increased intake of energy-dense, highly palatable food, when faced with psychological stress (Gibson, 2012; McEwen, 2008). Indeed, numerous studies over the last 20 years have shown that stress leads to a change in eating behavior (Block, He, Zaslavsky, Ding, & Ayanian, 2009; Born et al., 2009; Dallman, 2010; Epel, Lapidus, McEwen, & Brownell, 2001; Kandiah, Yake, Jones, & Meyer, 2006). As a result, research, has served to highlight the prevalence of this problem (Diggins, Woods-Giscombe, & Waters, 2015; Mouchacca, Abbott, & Ball, 2013), delineate the underlying physiological and psychological drivers (Merali, Graitson, Mackay, & Kent, 2013; Pool, Delplanque, Coppin, & Sander, 2015; Rower, Maria Teresa, Tonantzin, & Pattussi, 2017), as well as attempt to identify those individuals most vulnerable to stress-induced eating (Darling, Fahrenkamp, Wilson, Karazsia and Sato, 2017; Neseliler et al., 2017; Rodrigues et al., 2017). However, potential solutions remain elusive.

The purpose of this narrative review is to explore the proposal that regular elicitation of the relaxation response, the very opposite of the stress response, may alleviate stress-induced eating. We begin by presenting the premise of our argument; followed by (a) a brief overview of the research pertaining to stress-induced eating, (b) coverage of the possible physiological and psychological drivers of stress-induced eating, and (c) a discussion of how relaxation techniques may influence the drivers of stress-induced eating, thus providing a simple and feasible, yet novel solution to dealing with the issue.

2. The stress response versus the relaxation response

Stress is commonly defined as a physiological and psychological state in which the demands upon an individual are perceived as outweighing the resources available to contend with them (Lazarus & Folkman, 1984). A stressor may be of a physiological or psychological nature, or simply the anticipation of such (McEwen, 2008). The acute physiological response to the stressor or the 'flight or fight' response sees that energy stores are mobilized and cardiovascular efforts are aimed at the delivery of essential nutrients to areas of high priority (McEwen, 2005). While the primary objective of this acute stress response is to ensure survival of the organism, unnecessary and/or chronic elicitation of the stress response (known as chronic stress) can have deleterious effects on the body (McEwen, 2008).

The relaxation response is the parasympathetic physiological opposite of the stress response. First coined by Herbert Benson (Benson, Greenwood, & Klemchuk, 1975), the relaxation response consists of four basic components including: 1) A mental focus: a repetitive sound, words or visual stimulus such as a symbol by which to minimize distraction. 2) A non-judgmental attitude: to allow the recognition and passing of thoughts. 3) Decreased muscular tone: the posture to be held during the practice should be relaxed. 4) A quiet environment: often with the eyes closed (Benson et al., 1975). It is important to note that we do not refer to 'relaxation' as engaging in pleasant activities that are popularly thought of as relaxing, such as occasional hobbies, watching television, socializing, or even massage. Nor do we consider relaxation to refer to all forms of mind-body practices, such as yoga, tai chi and meditation, as it cannot be assumed that all of these practices unequivocally elicit the relaxation response. For instance, Lumma, Kok, and Singer (2015) found that styles of meditation requiring relatively greater cognitive effort (such as focus on thoughts, or on the cultivation of positive feelings) were less relaxing (both psychologically and physiologically) than a meditation focused on the breath. Furthermore, for those mind-body practices that do elicit the relaxation response, it is unclear whether it is this specific component of the practice that provides benefit, or the holistic effects of such activities on both the body and the mind.

Regardless, it is well established that relaxation reduces general stress (for example, Chellew, Evans, Fornes-Vives, Pérez, & Garcia-Banda, 2015). Indeed, the earliest studies that drew attention to relaxation as a potential healing modality were prompted by 'hypometabolic' changes seen in transcendental meditators. Such changes, distinct from those seen in sleep, included a decrease in oxygen consumption, carbon dioxide production, respiratory rate, and alterations in brainwave activity (Wallace, Benson, & Wilson, 1971). Other studies have reported reduced levels of stress hormones (such as cortisol) and central nervous system arousal in response to relaxation (Chellew et al., 2015; Dolbier & Rush, 2012; Jacobs, 2001), reduced anxiety and depression (Manzoni et al., 2009), in addition to heightening positive affect (Jain et al., 2007; Unger, Busse, & Yim, 2017). The proposition that elicitation of the relaxation response may also attenuate stress-induced eating is discussed in the following sections.

3. The problem: stress-induced eating

The phenomenon of stress-induced eating has been previously reviewed (Adam & Epel, 2007; Fink, 2016; Maniam & Morris, 2012; Rabasa, Dickson, Rabasa, & Dickson, 2016; Torres & Nowson, 2007). Indeed, numerous studies have demonstrated that *food choice* is markedly affected by stress (Dallman, 2010; Roberts, 2014). More specifically, preference for high fat-high sugar foods has been repeatedly documented (Epel et al., 2001; Macht, 2008; Newman, O'Connor, & Conner, 2007; Rutters, Nieuwenhuizen, Lemmens, Born, & Westerterp-plantenga, 2009). In parallel, reductions in the intake of nutritious mealtime foods such as vegetables during times of stress has been reported (Ledoux et al., 2012; Mikolajczyk, El Ansari, & Maxwell, 2009; O'Connor, Jones, Conner, McMillan, & Ferguson, 2008; Unusan, 2006). Stress, therefore, may foster dietary habits that are in conflict with healthy eating guidelines, likely predisposing individuals to increased risk of chronic diseases, particularly the cluster of abnormalities associated with the metabolic syndrome (Mendoza, Drewnowski, & Christakis, 2007; Mikolajczyk et al., 2009). In addition, given excess intake by as little as 50–100 kcal/d can result in weight gain of clinical concern in the long-term (Mozaffarian, Hao, Rimm, Willett, & Hu, 2011), stress may be an important driver of poor dietary habits leading to weight gain, potentially contributing to the worldwide epidemic of obesity we face today (Jauch-Chara & Oltmanns, 2014; Sinha & Jastreboff, 2013). Of equal relevance, research also highlights the role of stress in the development of diagnosed conditions of uncontrolled eating such as binge-eating disorder and bulimia (Hilbert, Vögele, Tuschen-Caffier, & Hartmann, 2011; Smyth et al., 2007; Sulkowski, Dempsey, & Dempsey, 2011). Notwithstanding these issues, it should be acknowledged that there is significant inter-individual variation in the precise effect of stress on *total* energy intake (Wallis & Hetherington, 2009; Yeomans & Coughlan, 2009). Admittedly, the dietary response to stress can be subject to a vast array of physiological and psychological factors, including perception of stressor type, length, intensity, and the impact of environment (Adam & Epel, 2007). It is not our intention, however, to provide an extensive summary of the literature relating to stress-induced eating here, but rather to highlight a potential solution to this issue.

4. The relaxation response – a potential antidote for stress-induced eating?

Stress has the potential to increase the intake of unhealthy

energy-dense foods, and relaxation is purported to be the physiological opposite to stress (Adam & Epel, 2007; Wallace et al., 1971). It is therefore reasonable to suggest that elicitation of the relaxation response may be protective in those susceptible to stress-induced eating. Yet, in stark contrast to the plethora of research devoted to stress-induced eating, the effect of the relaxation response on stress-induced eating has not been directly examined. Nonetheless, there is some evidence to suggest that relaxation can affect appetite. Pawlow, O'Neil, and Malcolm (2003), for example, reported reduced feelings of evening hunger after one week of daily home-based guided relaxation in the form of Abbreviated Progressive Muscular Relaxation (APMR) in individuals suffering from night-eating syndrome. Progressive Muscular Relaxation was also shown to reduce evening dietary intake amongst individuals with night-eating syndrome in a study by Vander Wal, Maraldo, Vercellone and Gagne, (2015). Meanwhile, others have observed reductions in emotional eating in obese emotional eaters compared with wait-list controls 3 months following a 3-week intervention period consisting of regular relaxation that incorporated PMR in conjunction with exposure to calming visual images (Manzoni et al., 2008, 2009). In another study of obese women, Christaki et al. (2013) compared an integrated stress reduction program consisting of dietary and stress management training (including PMR) with a control group that received dietary advice alone. Relaxation participants were required to maintain a twice daily home practice of relaxation for eight weeks. The eight week program resulted in greater weight loss in the relaxation group compared with the control group. The authors attributed the encouraging results to greater compliance with a dietary regime and higher restrained eating scores due to relaxation training, despite no change in perceived stress levels (Christaki et al., 2013). Also of relevance, based on the understanding that mindfulness practice may include some components of the relaxation response Benson et al. (1975), an emerging body of research supports a role for mindfulness in the treatment of disordered eating (Haynos, Forman, Butryn, & Lillis, 2016; Mason et al., 2016), and the intake of energy dense foods (Fisher, Lattimore, & Malinowski, 2016). For example, Jordan, Wang, Donatoni, and Meier (2014) demonstrated that a brief 15-min body scan led to 24% less energy intake in a sham taste testing of snack foods relative to a control group. However, as mentioned above, it is important to acknowledge that mindfulness and relaxation are not necessarily synonymous (Lumma et al., 2015).

Taken together, these findings suggest a potential role for relaxation in the regulation of food intake, although no research has specifically investigated whether relaxation can attenuate stress-induced eating. In this review, it is proposed that relaxation may provide a simple, cost-efficient, patient-centered approach to disrupt stress-induced eating at two critical points; 1) in ameliorating the stress response, itself, and/or 2) intervening at the stage at which the stress response leads to stress-induced eating. Given that stress may affect appetite through both physiological and psychological mechanisms, a discussion of how relaxation may play an equivalent opposing role in both respects follows.

5. Physiological mechanisms by which relaxation may attenuate stress-induced eating

Normal appetite (or the desire to eat) is determined by the integration of homeostatic (metabolic requirements of the body) and hedonic control (the body's drive for seeking reward and pleasure) (Begg & Woods, 2013). Research indicates that stress influences the impetus to eat; however, the precise mechanism by which homeostatic and hedonic control of appetite interact during stress is yet to be elucidated. It is evident, however, that a complex interaction of appetite-related neuropeptides and stress hormones are involved, and relaxation may have the potential influence some of these.

5.1. Homeostatic determinants of appetite during stress: an interplay of appetite and stress hormones

5.1.1. Cortisol

The physiological stress response involves a coordinated neuro-endocrinological cascade of events that involves a number of hormones that may influence subsequent eating. However, cortisol is most commonly implicated in stress-eating, with levels beginning to increase between 15 min and 60 min after the onset of an acute stressor (Sapolsky, Romero, & Munck, 2000). Experimental evidence for the stimulatory effect of cortisol on appetite has been found in humans, with peak cortisol release (in response to intravenously administered corticotropin-releasing hormone) significantly corresponding with increased ad libitum intake of snack foods in comparison with a placebo infusion (George, Khan, Briggs, & Abelson, 2010). Likewise, daily oral administration of 40 mg of cortisol over four days in healthy males resulted in a significant increase in total daily ad libitum energy intake, compared with a placebo group (Tataranni, Larson, Snitker, & Young, 1996). In relation to an acute stress-induced increase in cortisol, Epel et al. (2001) stratified participants according to a median division of their total cortisol release in response to a laboratory stressor. Those participants with a high cortisol response ate more energy dense foods compared with those participants exhibiting a low cortisol response to stress. In a separate study, participants exhibiting the highest cortisol response to a similar laboratory stressor were more likely to snack in response to daily life hassles compared with those individuals with a low cortisol response (Newman et al., 2007). In contrast, Appelhans, Pagoto, Peters, and Spring (2010) found that obese women with a higher cortisol response to a lab-induced stressor ate less, compared with a healthy weight control group in which dietary intake was unaltered by the magnitude of cortisol response. This inconsistency in past research may be related to variability in the individual sensitivity to stress, the ability to adapt, the acute versus chronic nature of the stressor, how this is reflected in the cortisol response and consequent dietary intake.

Although no studies have directly examined whether relaxation can reduce stress-induced eating, there is evidence in the literature that relaxation can attenuate the cortisol response to stress. Pawlow et al. (2003), found that a 20-min session of guided relaxation (APMR) administered before and after a week of daily home-based reduced salivary cortisol levels and subjective reports of stress and anxiety compared with a control group. Chellew et al. (2015) also reported reductions in cortisol levels following a series of five 45-min sessions of PMR held over a week. Similar findings are reported by others (Krajewski et al., 2011; Pawlow & Jones, 2005). However, the implications of these changes for eating behavior remain to be determined.

5.1.2. Insulin, ghrelin, and leptin

Other hormones that may play a role in mediating the relationship between stress and energy intake include insulin, ghrelin and leptin. Although insulin is considered an anorexigenic hormone (Könner, Klöckener, & Brüning, 2009), in tandem with high levels of cortisol, and the presence of energy dense palatable food, insulin may promote consumption, thus acting to palliate the chronic hypothalamic-pituitary axis (HPA) activation associated with stress (Dallman, 2010). This may occur at the cost of increased risk of abdominal obesity and associated metabolic imbalance (Dallman, 2010). In support of this, Epel et al. (2004) found that in a

group of 131 university students, self-reported stress-hyperphagics had higher cortisol and insulin profiles compared with their hypophagic counterparts during periods of high academic stress.

Meanwhile, ghrelin exerts its orexigenic effect through both homeostatic and hedonic pathways, and is known to rise during stress (Rouach et al., 2007). Rouach et al. (2007) undertook one of the first studies in humans to show that the commonly used laboratory stressor, the Trier Social Stress Test, increased the concentration of both cortisol and ghrelin. However, the rise in ghrelin seen by Rouach et al. (2007) was not strongly correlated with the self-reported compulsion to eat, although self-reported measures may not necessarily represent true behavior when actually in the physical presence of palatable food (Adams, Greenway, & Brantley, 2011). This stress-induced rise in ghrelin has been confirmed by others (Jaremka et al., 2014; Monteleone et al., 2012), while some studies have not reported significant alterations in ghrelin with stress (Macedo & Diez-Garcia, 2014; Raspopow, Abizaid, Matheson, & Anisman, 2010). Studies specifically addressing the response of leptin and energy intake to an acute stressor indicate great variation in leptin reactivity, with those individuals with a lower leptin response having greater subsequent food intake. For instance, Appelhans (2010) observed an inverse relationship between stress-induced intake and leptin levels following an acute mental stressor, independent of BMI. A later study by Tomiyama et al. (2012) specifically highlighted increased intake of high energy food being related to lower plasma leptin after exposure to an acute lab-stressor, also independent of BMI.

While there is evidence in the literature that relaxation can attenuate the response of cortisol to stress, no research to date has examined the effect of eliciting the relaxation response on the circulating concentrations of insulin, ghrelin, and leptin, which also appear to have a role in stress-induced eating. Future research is needed to address this issue.

5.2. Hedonic influences on appetite during stress

In addition to the above-mentioned pathways through which stress may influence dietary intake, it is acknowledged that the hedonic reward system may also play a significant role in determining dietary intake in response to stress (Yau & Potenza, 2013). For instance, a Brazilian study reported that 77% of women suffering from stress reported having sweet cravings (defined as “a strong desire to eat sweet foods over the last 3 months”), compared with only 31% in individuals assessed as not stressed (Macedo & Diez-Garcia, 2014). Others claim that acute stress can manifest in reduced sensitivity to the perception of sweetness (Al'absi, Nakajima, Hooker, Wittmers, & Cragin, 2012), while Luckett et al. (2015) showed that chronically stressed individuals found the look and taste of low-calorie chips less acceptable compared with less stressed individuals. This finding was in agreement with Born et al. (2009), who found that acutely stressed participants sought more richness of taste compared with their control counterparts. Thus, stress may alter the reward activation system such that increased dietary intake is necessary to obtain the usual reward (Born et al., 2009).

The manner in which reward, stress, and appetite interact is unclear, although the appetite-related hormones thus far discussed may play a role. For instance, the anorexigenic function of insulin may in part be achieved by reducing the rewarding value of food, as evidenced by insulin receptors in the limbic system (Davis, Choi, & Benoit, 2010). In regard to insulin's effect on reward pathways during stress, Jastreboff et al. (2013) found that insulin resistance in a group of obese women was positively correlated with activation in reward centers in the brain after exposure to personalized stressful scenarios and palatable food prompts. The authors suggested that insulin sensitivity may play a significant role in motivating the intake of palatable food when stressed.

Similarly, researchers focusing on the hedonic influence of ghrelin postulate that eating palatable food may ameliorate the stress response via reward pathways that involve the neurotransmitters serotonin and dopamine (Malik, McGlone, Bedrossian, & Dagher, 2008). Dopamine acts to create the motivation (known as ‘incentive salience’) to obtain what is desired (such as highly palatable food) (Berridge & Robinson, 2003). Accordingly, during stress, dopamine release motivates the search for distraction and palatable food, or heightened alertness to unhealthy food cues (Morris, Beilharz, Maniam, Reichelt, & Westbrook, 2015). In support of this notion, intravenous injection of ghrelin in humans undergoing magnetic resonance imaging resulted in activity in brain regions associated with reward (Malik et al., 2008). More specifically, injection of ghrelin into reward areas has been shown to increase dopamine release in rodents, as well as increase subsequent dietary intake (Abizaid et al., 2006). Leptin, on the other hand, has been shown to reduce dopamine action, the hedonic appeal of food, and subsequent urges to eat in rodents (Hommel et al., 2006). However, Burghardt et al. (2012) found that leptin levels were positively associated with dopamine release in reward areas after exposure to a laboratory pain stressor in healthy men and women. The apparent inconsistency demonstrated in this study may reflect the specific changes seen under the influence of stress, and particularly, a physical stress. Alternatively, it may illustrate the diverse action of leptin on functionally distinct groups of dopamine neurons, yet to be identified (Opland, Leinninger, & Myers, 2010).

Research related to stress-eating and reward is still in its infancy. However, evidence indicating that reward areas of the brain are also affected by relaxation (Jastreboff et al., 2011), suggests the intriguing notion that relaxation may provide a counteracting stimulus for dopamine, thus overriding the need to stress-induce eat. In other research, relaxation meditation (which may also induce the relaxation response) (Esch, Fricchione, & Stefano, 2003) has been shown to produce a 65% increase in dopamine release (a key player of reward) in the ventral tegmental area of the brain (Kjaer et al., 2002). Future research is needed to explore the possibility of whether relaxation −mediated increases in dopamine release can influence stress-induced eating.

5.3. Interrelationships between physiological mechanisms

In summary, each of the hormones discussed have both a metabolic and hedonic role. As to which component is dominant during times of stress remains unknown. Although research has identified apparent independent roles of cortisol, insulin, ghrelin and leptin (amongst a large number of other polypeptides mediating appetite), this oversimplifies the complexity of the stress-appetite system. It is probably more correct to state that each hormone is subject to the effect of the other components in the system, with varying sensitivity and responses depending on the individual and whether acute or chronic stress is at play. Stress-induced eating can thus be described as a neurobiological interplay of energy homeostasis and brain reward mechanisms falling prey to a maladapted stress response system in an environment that offers symptomatic relief by way of highly palatable, readily available processed food (Jauch-Chara & Oltmanns, 2014). If the stress response is the original impetus from which stress-induced eating results, intuitively, the effects of relaxation may offer a means by which to reduce stress, and the concomitant desire to stress-induce eat. As to how these physiological mechanisms manifest in behavior when stressed, or when relaxed, leads to a consideration of the psychological aspect of the stress response.

6. Psychological mechanisms by which relaxation may attenuate stress-induced eating

The psychological effects of stress may lead to cognitive, emotional, and behavioral consequences that may impact food choice, either in isolation or through interaction (Kandiah et al., 2006). They may be deliberate and conscious attempts to comfort oneself, or unconscious and driven more by habit for reduction of negative affect. Here, we review some of the findings from research on psychological factors associated with stress-induced food consumption and consider where relaxation may play a role in moderating these responses.

6.1. Stress, cognition and behavior

Consistent with the strength model of self-control (Muraven & Baumeister, 2000), coping in the face of stress, along with the required regulation of aversive thoughts, emotions, and behaviors, draws on one's finite ability to maintain self-control (Muraven & Baumeister, 2000). Thus, high stress impairs planned behavior and can lead to more automatic and unconscious actions to seek highly palatable food that is easy to access. Cognitive consequences of stress include an inability to focus, ruminative thinking (the dwelling on one's thoughts), and thinking the worst of a situation (Gianferante et al., 2014), all of which may compromise one's ability to make an informed decision regarding food choice (Dallman, 2010). In support of this notion, Kandiah et al. (2006) found that academic stress in female college students was associated with an increase in appetite coupled with less care for healthy dietary practices. While 80% of the participants believed they made healthy choices normally, only 33% did so during times of stress imposed by personal, environmental, and academic pressure. Likewise, Sims et al. (2008) found that perceived stress was associated with less ordered meal planning and eating in response to emotional cues in a group of African American men and women.

6.2. Stress and emotion regulation

Stress leads to a range of negative emotions, and eating may be used, both consciously and unconsciously, to down-regulate negative affect. Increased intake of energy-dense foods in response to negative mood states may be related, in part, to the presence of a negative feedback system between mood and food. For example, Macht and Mueller (2007) showed that consumption of palatable chocolate alleviated laboratory induced-negative mood compared with eating less palatable chocolate or eating nothing. The effect was seen instantly but lasted only a few minutes, thus potentially promoting overeating in order to prolong the desirable effect (Macht & Mueller, 2007). The consumption of foods that are perceived as personally enjoyable can be seen, therefore, as a means to avert the negative feelings associated with stress, giving rise to the term 'comfort foods' (Dallman, Pecoraro, & la Fleur, 2005). More recently, however, Wagner, Ahlstrom, Redden, Vickers, and Mann (2014) published findings contrary to those of Macht and Mueller (2007), serving to illustrate that mood is yet another variable further complicating our understanding of stress-induced eating.

While the remedial effect of palatable food consumption during stress is the most commonly stated cause of stress-eating, an interesting alternate hypothesis is presented by Pool et al. (2015). They suggest that stress may actually reduce the enjoyment associated with high energy food (thereby encouraging greater intake to attain the same pleasurable experience), promoting increased awareness of surrounding stimuli (palatable food or food cues), and increased motivation to access high energy foods. This behavior is not motivated by wanting to reduce the initial stressor (as is the motivation purported by physiologists). Rather, stress may exhaust the ability of the individual to employ goal-driven behavior, leading one to succumb to habit-driven behavior, potentially leading to mindless eating (Neal, Wood, & Drolet, 2013; Pool et al., 2015).

6.3. Stress, coping style and drive to eat

A plausible unifying theory that may explain stress-induced eating, whether it be conscious planned behavior or an automatic response, is that proposed by Heatherton and Baumeister (1991). These researchers proposed that a stressful task can heighten one's awareness of his/her inadequacies or inabilities to cope. The resulting aversive state would then prompt the seeking out of an escape/avoidance, or relief from the external environment, in the form of palatable food intake. Thus, stress-induced eating according to this theory allows for a state of reduced self-awareness (Heatherton & Baumeister, 1991). Accordingly, the coping style (involving cognitive and subsequent behavioral responses to stress) of the individual may be an important moderator of the relationship between stress and unhealthy eating (Raspopow et al., 2010). Broadly categorized, individuals may utilize a coping response that involves a problem solving approach (aiming to manage the stressor), an emotion-focused approach (eating to regulate the emotional reaction to the stressor), or an avoidance focused approach (turning to food as a distraction or to seek distance from the stressor) (Raspopow et al., 2010). Expectancies related to reinforcement from eating may also constitute a mechanism for stress-induced eating. In other words, an individual's drive to eat in response to stress may be impelled by the expectation that such behavior will lead to escape, the ability to cope, provide comfort, or reward, and alleviate negative affect (Combs, Smith, & Simmons, 2011). In support of this mechanism, numerous studies have shown that expectancies for reinforcement from eating predicts disordered eating behavior (e.g., Fischer, Settles, Collins, Gunn, & Smith, 2012; Smith, Simmons, Flory, Annus, & Hill, 2007).

6.4. Characteristics of the stressor and individual stress appraisal

In addition to individual attributes that may influence the association between stress and eating, characteristics of the stress stimuli itself are an important consideration. Indeed, the type of stress (psychological versus physical, for instance) can produce varying effects on appetite with more psychological stressors leading to overeating in contrast with physical stressors (O'Connor et al., 2008). Furthermore, the nature of the psychological stressor and whether an ego-threat is involved may also be of relevance, with the latter tending to result in increased dietary intake versus those of traumatic origin leading to a reduction in energy intake (Jaremka et al., 2014). As previously discussed, the length of exposure to a stressor (acute versus chronic) is also an important factor leading to variation in the stress response (Dallman et al., 2003).

Derived from theories of stress appraisal, more recently, literature has emerged that questions the harmful effect of stress itself and posits that it may not be stress, per se, that leads to negative health consequences, but rather one's *perception* of the likely negative consequences (Crum, Salovey, and Achor, 2013; Lazarus & Folkman, 1984). This has been identified as one's 'stress mindset' which is one's perception of how harmful or beneficial stress is. Hence, re-appraising stress in a positive way – by focusing on the components of the stress response that allow an individual to survive in the wake of a challenge (increased arousal, sharpness, improved immunity, intellectual growth) may offset the potentially harmful effects of stress on the body by not only influencing

behavioral outcomes, but by also influencing hormonal effects leading to health and wellbeing (Crum et al., 2013). Whether this influences the relationship between stress and subsequent energy intake remains to be elucidated.

6.5. Effect of the relaxation response on psychological pathways for stress-induced eating

Amongst the limited collection of studies that have explored the influence of relaxation on appetite, the previously mentioned study by Manzoni et al. (2008) compared groups of obese emotional eaters receiving (a) PMR combined with calming visual imagery, (b) a relaxation recording with imagined calming scenarios, and (c) control (neutral) conditions. The relaxation sessions were administered nine times over three weeks and supplemented by a home-based relaxation practice. These researchers reported a significant reduction in resting heart rate (within single relaxation sessions), and reduced symptoms of anxiety and depression post intervention in both relaxation groups. A three month follow-up revealed that participants also reported significantly less emotion-induced eating in contrast with controls, together with an increase in self-efficacy in eating control (a measure of their coping ability when faced with a challenging situation) (Manzoni et al., 2009).

Further evidence of a beneficial effect of relaxation on self-efficacy for healthy eating comes from a study by Katzer et al. (2008), in which a ten-week relaxation intervention that included PMR, was followed by eight months of group-support for overweight/obese women and compared with non-relaxation controls. After 12 months, effect sizes for reduction in symptoms of depression, improvement in stress reduction, reporting of medical symptoms and self-efficacy for healthy eating were greatest for the relaxation group compared with the non-relaxation control group. A 24-month follow-up of the same cohort found that only the relaxation group participants (compared to non-relaxation controls) continued to maintain reduced levels of depression, reduced rate of suffering from general medical symptoms, together with improved self-efficacy for healthy eating (Hawley et al., 2008). Similarly, Christaki et al. (2013) provided evidence of the beneficial effect of the addition of PMR to a weight loss intervention, by promoting healthier eating, higher restrained eating, and resultant weight loss, though perceived stress remained unchanged (Mendoza et al., 2007). Together, these findings suggest that relaxation may improve behavioral and psychological resources such that individuals can better deal with a perceived stressor instead of resorting to food (Manzoni et al., 2009).

In support of the notion that relaxation may be of therapeutic benefit in stress-induced eating, studies that have examined the effect of mindfulness, which may have a component of the relaxation response (Benson et al., 1975), purport that the mechanism by which mindfulness may reduce stress is by purposefully and non-judgmentally paying attention to the present moment (Kabat-Zinn, 2013) by detaching from the source of stress. If the psychological effect of relaxation is similar, this creation of distance may lead to less reactive or habitual behavior in relation to food intake. Additionally, the cultivation of awareness of bodily sensations and cues can arise from a relaxation response, especially when practiced in the context of mindfulness training. The focus on sensations within the body cultivated by relaxation techniques may draw one's attention to interoceptive awareness and the distinction between metabolic hunger and hedonic hunger. Beyond this, mindful relaxation may influence how one acts on feelings of hunger, or cravings for palatable food. For instance mindfulness has been associated with decreased intake of palatable food (Mason et al., 2016). Further, as illustrated by Marchiori and Papies (2014), mindful body scanning led to reduced propensity to satisfy hunger with energy dense cookies compared with 'non-mindful' controls. However, to what degree the relaxation component of mindfulness may influence stress-induced eating remains to be determined.

7. An integrative summary

Taken together, research thus far suggests a potential role for relaxation in the regulation of food intake, although no research has specifically investigated whether relaxation can attenuate stress-induced eating. Nonetheless, there are several mechanisms through which such an effect may operate. Given that stress may affect appetite through both physiological and psychological mechanisms, relaxation may play an equivalent opposing role in both respects. Physiologically, relaxation may reduce the activation of the HPA and the subsequent hormonal response resulting in a decrease in cortisol. Furthermore, the role of insulin, ghrelin, and leptin in stress-induced eating leads us to question whether these appetite-related peptides may be favorably influenced by relaxation and therefore reduce eating due to stress – an area yet to be investigated. In addition, relaxation may act as an alternative form of 'reward', displacing the neuropeptide-induced dopamine release that may promote hedonic overeating. From a psychological perspective, regular practice of the relaxation response may influence the appraisal of, and ability to cope with, a stressor, thereby weakening the cognitive component of the stress process that may lead to overeating, in addition to facilitating less impulsive eating typically promoted by stressful states.

8. Conclusion

Research indicates that stress is associated with the consumption of energy-dense palatable food driven by a complex interaction of physiology and psychology, fettered by our desire for reward. The relaxation response involves a mental focus, a non-judgmental attitude, and relaxed body, and thus is the physiological and psychological opposite of stress. This raises the question of whether it may play a role in attenuating stress-induced eating, by dampening the neuro-endocrinological response, and raising the awareness of one's psychological and bodily states. Future research is needed to investigate if the relaxation response alone can reduce stress eating, both in the laboratory and when practiced regularly in the long-term. Furthermore, given that it is commonly believed that the relaxation response may be achieved using an array of mind-body practices that are becoming more widely available, such as meditation, yoga, PMR and breathing exercises that train ability to focus, examination of which specific aspects of mind body practices, including components of the relaxation response, are effective at targeting stress-induced eating is needed. If shown to be effective, regular relaxation practice may provide a convenient, patient-centered, cost and time efficient intervention that could be implemented in a broad range of population groups to enhance the health and wellbeing of our community.

Conflicts of interest

None.

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Authors contribution

TM, JD, EE, and KG contributed to the conception, design,

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