Understanding the relationship between mindfulness and eating behaviour

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Abstract

Mindfulness is a meditation practice and personality trait that concerns the extent to which an individual attends to present-moment experience in an open and non-judgemental manner. Mindfulness has been associated with a wealth of benefits for both psychological and physical wellbeing. With respect to eating behaviour, mindfulness has been linked with more favourable eating practices and positive outcomes for weight management, encompassing reduced energy intake, greater intake of fruit and vegetables, lower BMI, and greater success in weight loss efforts. In order to best apply mindfulness to eating and weight management a greater understanding of the *mechanisms* underlying the relationship between mindfulness and eating would be beneficial. Here, I investigated these mechanisms by focusing on the extent to which mindfulness may allow greater self-regulation of eating behaviour. Across six studies I used a variety of methods to examine processes of self-regulation in relation to mindfulness in the context of eating behaviour. This included investigating the mediating role of executive function in determining food consumption following a mindfulness induction, as well as implementing food cueing paradigms that manipulated the need for self-control to observe effects of dispositional mindfulness on eating behaviour. Finally, I examined the cognitive accessibility of dieting goals and motivational styles of behavioural regulation in relation to mindfulness and how they predicted weight and diet outcomes across time. Overall, the effects of mindfulness on eating behaviour were nuanced and complex. Rather than simply reducing energy intake *per se*, mindfulness may increase healthy food choices or act as a moderator of effects, and its benefits may be overridden by the motivational state of hunger. I found no evidence for enhanced self-control in the form of executive function or accessibility of dieting goals as being a mechanism underlying the effects of mindfulness. Instead, mindfulness may be predictive of slower responses to food stimuli and specific styles of behavioural regulation which represent more deliberative self-regulation rather than automatic self-control.

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This work has not been submitted in substance for any other degree or award at this or any other university or place of learning, nor is being submitted concurrently in candidature for any degree or other award.

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Table of contents

Abstract i

Declaration ii

Acknowledgments iii

Chapter 1. General Introduction 1

1.1 Eating Behaviour and Weight Management 1

1.1.1 Obesity and the need for intervention 1

1.1.2 Interacting factors influencing eating behaviour 2

1.2 The Mindfulness Construct 6

1.2.1 Mindfulness practice 6

1.2.2 Mindfulness as a personality trait 9

1.2.3 The benefits of being present 11

1.3 Mindfulness and Eating Behaviour 15

1.3.1 The relationship between mindfulness and eating behaviour 15

1.3.2 The need to understand mechanisms 19

1.4 Self-Regulation 22

1.4.1 Behavioural self-regulation 22

1.4.2 Self-regulation of eating behaviour 23

1.5 Mindfulness and Self-Regulation 24

1.5.1 How might mindfulness allow regulation of behaviour? 24

1.5.2 Mindfulness and self-regulation of eating behaviour 26

1.6 Synopsis 27

Chapter 2. Correlational investigation of the relationship between mindfulness and key facets of eating behaviour in student and general population samples 29

2.1 Introduction 30

2.2 Study 1 35

2.2.1 Method 35

2.2.2 Results and Discussion 38

2.3 Study 2 40

2.3.1 Method 40

2.3.2 Results and Discussion 41

2.4 General Discussion 44

Chapter 3. Investigation of the mediating role of attentional control in determining food choice and energy intake following a mindfulness induction exercise 50

3.1 Introduction 51

3.2 Method 58

3.2.1 Participants 58

3.2.2 Design 58

3.2.3 Materials 58

3.2.4 Procedure 60

3.3 Results 61

3.3.1 Manipulation check 61

3.3.2 Internal analyses 63

3.4 Discussion 65

Chapter 4. Investigating processes of self-control in determining eating behaviour according to dispositional mindfulness: Two food cueing studies informed by Cybernetic models of control 74

4.1 Introduction 75

4.2 Study 4 81

4.2.1 Method 83

4.2.2 Results and Discussion 85

4.3 Study 5 87

4.3.1 Method 88

4.3.2 Results and Discussion 90

4.4 General Discussion 91

Chapter 5. Longitudinal investigation of the role of mindfulness, Self-Determination Theory, and the cognitive accessibility of dieting goals in determining self-regulation of diet and weight in a first year student sample 99

5.1 Introduction 100

5.2 Method 108

5.2.1 Participants 108

5.2.2 Materials 108

5.2.3 Procedure 111

5.3 Results 112

5.3.1 Demographics 112

5.3.2 Diet and weight outcomes 112

5.3.3 Self-Determination Theory constructs 114

5.4 Summary Discussion 122

5.5 Supplementary Study 122

5.6 Discussion 125

Chapter 6. General Discussion 136

6.1 Summary and Discussion of Findings 136

6.1.1 The self-control mechanism 136

6.1.2 The effect of mindfulness on eating and weight 140

6.1.3 The role of hunger 143

6.1.4 The body scan manipulation 145

6.1.5 Mindfulness and regulatory style 147

6.2 Directions for Further Research 149

6.2.1 Alternative conceptualisations of self-control 149

6.2.2 Non-conflict driven self-regulation 153

6.3 Limitations 154

6.3.1 Use of lab studies 154

6.3.2 Sampled population 155

6.3.3 Mixed outcomes measures 156

6.3.4 Failed manipulations 157

6.3.5 Concern for dieting 158

6.3.6 Defining mindfulness 159

6.4 Conclusions 162

References 163

Appendices 193

Chapter 1.
General Introduction

In this thesis, I set out to investigate behaviours and personality characteristics that enable control over eating, in order to better understand differences in weight regulation between individuals. In particular, I focussed on the role of mindfulness, a meditation practice and dispositional trait characterised by present moment awareness and non-judgmental attention. I hoped to elucidate the mechanisms that underlie the established relationship between mindfulness and more favourable eating behaviours and weight management outcomes by assessing whether mindfulness allows greater self-regulation of eating behaviour.

In this chapter I introduce this topic in greater detail and review the relevant theoretical and empirical literatures. I begin by introducing problems posed by rising rates of obesity, and reviewing the complexity of factors that interact to influence eating behaviour. I then describe the mindfulness construct and the physical and psychological benefits that have been associated with it. I review literature which demonstrates a relationship between mindfulness and more favourable eating behaviours and greater success in weight management. I discuss the importance of research that considers the mechanisms responsible for this effect for furthering understanding and application of mindfulness in aiding weight management efforts. I then introduce self-regulation as a potential mediator and discuss its importance for the regulation of eating and weight. Finally, I cover theoretical and empirical literature which points to a role of mindfulness in supporting self-regulation, and outline my aims in investigating the self-regulation as a mechanism underlying the relationship between mindfulness and eating behaviour and weight regulation.

1.1 Eating Behaviour and Weight Management

1.1.1 Obesity and the need for intervention. Obesity has long been acknowledged as a growing public health concern. Body mass index (BMI) has been steadily increasing worldwide, with global obesity rates nearly doubling since 1980 (Stevens et al., 2012). The latest figures

from the World Health Organization show that in the majority of European countries over 50% of the adult population is obese or overweight (i.e., BMI > 25; World Health Organization, 2013), and figures from the Centre for Disease Control reports more than a third of the American adult population as being obese (i.e., BMI $\geq$ 30; Ogden, Carroll, Fryar, & Flegal, 2015). In the most recent NHS Health Survey for England 57% of women and 66% of men were overweight or obese. Rates of obesity in England have risen noticeably in recent decades, increasing from 15% in 1993 to 26% in 2016 (Fuller, Mindell, & Prior, 2017). Obesity is associated with multiple adverse health outcomes including excess mortality (Prospective Studies Collaboration, 2009), cardiovascular disease (Asia-Pacific Cohort Studies Collaboration, 2004), cancer (Renehan, Tyson, Egger, Heller, & Zwahlen, 2008), hypertension, and diabetes (Mokdad et al., 2003). Excess weight is a leading contributor to the non-communicable diseases of cardiovascular disease, cancer, respiratory disease, and diabetes, which account for 77% of burden of disease and 86% of excess mortality in Europe (World Health Organization, 2014). Although this thesis focuses on processes governing eating behaviour in all individuals, regardless of obesity, understanding the determinants of eating behaviour and weight management in the general population may inform the design of health promotion interventions targeted at reducing obesity and improving eating behaviour and help curb the growing trend in obesity.

1.1.2 Interacting factors influencing eating behaviour. The extreme positions in weight management research have historically been that excess weight[1] is wholly biologically/genetically determined, and so out of individual control, or that being overweight is entirely behaviourally determined. However, the more widely accepted position among researchers is that human eating behaviour is influenced by a multitude of factors including physiological, cognitive, and sociocultural antecedents (Rogers, 1999). This thesis focuses on

[1] Throughout this thesis, and in line with nomenclature of wider healthcare research, the term *overweight* is used to refer to BMI of 25 to 30, while the term *obese* refers to BMI of greater than 30. *Excess weight* refers to both overweight and obesity together.

individual level factors and the way in which they influence behaviour, but acknowledges that a diverse and interacting array of genetic, individual level, environmental, and evolutionary or developmental factors also contribute to weight management and excess weight. To illustrate the complex processes in play I review some examples of the factors that have been identified as contributing to excess weight and highlight how they frequently interact.

One individual level variable that has been widely characterised as contributing to excess weight is *impulsivity*. Impulsivity has been assessed in a number of ways, including delay discounting, the tendency to prefer immediate but smaller rewards over larger delayed rewards (Richards, Zhang, Mitchell, & Wit, 1999), and trait disinhibition, an impulsive or habitual response to food cues (Bryant, King, & Blundell, 2008). Overweight and obese adults display significantly higher temporal discounting rates, indicating difficulty in suppressing impulsive desire for immediate rewards over delayed but greater reward (Jarmolowicz et al., 2014). Trait disinhibition, as well as being positively correlated with impulsivity, is associated with excess weight, and has been considered as a behavioural proxy for body weight variation (Bryant et al., 2008; Provencher et al., 2008; Yeomans, Leitch, & Mobini, 2008). However, a recent meta-analysis by Emery and Levine (2017) concluded that, while there was a significant positive association between impulsivity and BMI, this effect was small and heterogeneous, suggesting that impulsivity is only one of many meaningful contributors to body weight.

Although impulsivity is a personality trait, it is ultimately reflective of an individual's response to an *environmental* stimulus, and as such its effect on weight reflects an interaction between the individual and their environment. The impact of these additional interacting factors accounts for the heterogeneous effect of impulsivity on weight. In their review of the effect of trait disinhibition on eating behaviour, Bryant et al. (2008) concluded that trait disinhibition plays a significant mediating role between the individual and environment. Demonstrating the interplay between environmental factors and individual characteristics, Ferriday and Brunstrom (2011) have shown that food cues elicit greater response, in the form of desire to eat and salivary response, in overweight and obese participants compared to lean

participants. Although these results are correlational and, as such, do not confirm whether heightened reactivity leads to development of excess weight or whether existing excess weight increases reactivity, they do demonstrate interaction between environment and individuals. Relevant to this perspective, Blundell et al. (2005) have identified what they term a 'cluster of risk factors' that explain why some individuals are more susceptible to weight gain under fixed environmental conditions than others. They propose that this collection of individual level risk factors, trait disinhibition, weakened satiety response, preference for high fat foods, and hedonic attraction to food, constitute a vulnerable phenotype that leads some individuals to respond to an 'obesogenic' environment with reduced appetite control.

An obesogenic environment is one in which surroundings, opportunities, and conditions of the environment act as barriers to maintaining a healthy weight and promote weight gain in individuals and populations (Swinburn, Egger, & Raza, 1999). Factors which have been shown to increase the risk of excess weight include aspects of the built environment such as urban design, land use, and public transport, all of which can hinder both physical activity and healthy eating (Booth, Pinkston, & Poston, 2005). Changing aspects of the modern social environment may also promote weight gain (Chaput, Klingenberg, Astrup, & Sjödin, 2011). For example, sedentary activities such as television viewing and video game playing are associated with increased rates of obesity (Dietz & Gortmaker, 1985; Hu, Li, Colditz, Willett, & Manson, 2003; Salmon, Bauman, Crawford, Timperio, & Owen, 2000; Stettler, Signer, & Suter, 2004). Dining out is associated with increased energy intake and higher BMI (Duffey, Gordon-Larsen, Jacobs, Williams, & Popkin, 2007; McCrory et al., 1999; Thompson et al., 2003). The portion size effect, whereby individuals consume more when presented with a larger portion, has been well documented (Diliberti, Bordi, Conklin, Roe, & Rolls, 2004; Rolls, Morris, & Roe, 2002; Zlatevska, Dubelaar, & Holden, 2014), and trends for increasing portion sizes are likely to contribute to increasing rates of excess weight (Smiciklas-Wright, Mitchell, Mickle, Goldman, & Cook, 2003; Young & Nestle, 2002).

The role of the environmental milieu in driving overeating should not be surprising when one considers evolutionary influences. From an evolutionary perspective, in the presence of food cues or environmental opportunity to eat, it is adaptive for an organism to seek food as consistent food sources are not guaranteed in nature (Bellisari, 2008). Animal models of feeding have demonstrated that energy intake is not only dependent on physiological energy depletion, but may instead be triggered by conditioned stimuli (Weingarten, 1983). Developmental accounts have discussed how similar processes might operate in humans, and propose that early development of food preferences and eating behaviour in infancy and childhood shape enduring patterns of behaviour and risk for excess weight.

The prenatal and neonatal periods have been described as sensitive periods for food preference learning, with effects extending to later food preference and choice (Mennella & Castor, 2012). Infants develop preferences based on their mothers' diets resulting from exposure in utero or during breastfeeding (Mennella, Jagnow, & Beauchamp, 2001; Schaal, Marlier, & Soussignan, 2000). Similar processes of associative learning to those demonstrated by Weingarten (1983) also operate in humans; as three and four year olds may learn to prefer flavours paired with high calories drinks (Johnson, McPhee, & Birch, 1991; Kern, McPhee, Fisher, Johnson, & Birch, 1993). Such learned preferences for energy dense foods can be maladaptive in obesogenic environments where high energy density food is abundant and easily available (Birch & Anzman, 2010). Children may also learn food preferences through pairing of foods with social consequences and via observational learning. This can include learned dislike of foods that are associated with coercion or incentives (Galloway, Fiorito, Francis, & Birch, 2006; Newman & Taylor, 1992), while peers and parents can be effective models. Birch (1980) found that peer models were effective in increasing preference for and intake of vegetables in pre-schoolers and that parental diet is highly predictive of child diet, including fruit and vegetable consumption (Kratt, Reynolds, & Shewchuk, 2000; Wardle, Carnell, & Cooke, 2018).

The literature above provides a by no means exhaustive review of the multitude of factors that have been proposed to work together to influence weight management. It may even be impossible to totally disentangle the effects of different interacting influences. However, we may investigate such factors in isolation with the aim of informing interventions designed to bolster protective influences against weight gain or understand the network of factors which determine eating behaviour and weight management. Ultimately, a personality trait can only influence physical condition indirectly through interaction or co-varying with behaviours that contribute directly (Davis et al., 2007). This thesis investigates one such personality trait that has been linked to weight management, that of mindfulness, with the aim of understanding the interactions and determinants of eating behaviour that allow it to influence weight outcomes.

1.2 The Mindfulness Construct

Mindfulness has been defined by Buddhist scholars and researchers as "the art of conscious living" (Kabat-Zinn, 1994, p. 6), or the practise of "keeping one's consciousness alive to the present reality" (Hanh, 1976, p. 11). In striving to provide an operational definition of mindfulness, Bishop et al. (2004) proposed a two component model of mindfulness. According to this perspective, mindfulness represents (i) the self-regulation of attention so that it is maintained on immediate experience, allowing for increased recognition of mental events in the present moment, and (ii) orientation toward one's experiences in the present moment that is characterized by curiosity, openness, and acceptance.

Mindfulness is rooted in Buddhist practice, and has been described as being at the heart of the Buddha's teachings (Hanh, 1998). Mindfulness has a prominent place among the virtues and qualities that Buddhist monks are expected to achieve, it is one constituent of the eightfold path, that makes up the essential practices on the Buddhist path to enlightenment (Gethin, 2015). Principles of mindfulness practice outlined in the Buddhist scriptures the Sutras (see Gethin, 2015) include:

- *Observation of the body*

  Including observing the breath and being aware of one's posture and physical body, being aware when engaged in everyday activities, and considering one's body as consisting of the four elements of earth, water, fire, and air

- *Observation of feelings*

  Paying attention to feelings as pleasant, unpleasant, and neutral

- *Observation of state of mind*

  As being affected by desire, aversion, or delusion

- *Observation of mental qualities*

  Including the ways in which the mind may be diverted by the senses, presence of qualities that obstruct meditation such as desire, ill-will, depression, and doubt

Mindfulness has long been practiced by proponents of Buddhism, often in the form of sitting or breathing based meditations, but also during everyday actions, as a means of achieving tranquillity and clarity of mind (Hanh, 1976).

1.2.1 Mindfulness as a personality trait. Although mindfulness is a practice outlined in the Sutras, the mindful perspective is just as important when carrying out everyday actions. To illustrate this, Hanh (1976) provides the example of dishwashing; while a non-mindful person washes dishes in order to have clean dishes to use, a person with a mindful perspective washes their dishes in order to wash dishes. Without a mindful outlook, time spent washing dishes, or engaged in any other task, is not truly experienced. The individual instead spends their time caught up in a myriad of other thoughts, thinking about the past or contemplating the future.

Given that any action can be performed with a quality of mindfulness, it is perhaps not surprising that a large body of work within psychology has examined the extent to which the

tendency to be mindful in daily life can be considered a personality trait, which varies naturally in the population regardless of experience with mindfulness practice. Early work by Langer (1989) introduced mindfulness within the context of social psychology, proposing that mindfulness is a basic underlying state of being involving cognitive and affective factors. In Langer's conceptualisation, mindfulness is a state of alertness, heightened awareness, and active information processing. Further work defined mindfulness as a process of cognitive differentiation, involving the noticing and creation of categories and distinctions, which keeps the individual in the present-moment and allows greater awareness of the context and perspective of actions (Langer & Moldoveanu, 2000). Although Langer's definition of mindfulness includes key aspects of the mindfulness construct outlined above, such as present moment focus and openness to experience, it is not formally aligned with the construct of mindfulness as defined in contemplative Buddhist practice or in the meditation literature. Furthermore, Langer's work predominantly focused on the implications of the absence of these characteristics, a form of *mindlessness* rather than mindfulness. More recent work from Brown and Ryan (2003) has drawn more directly on the concept of mindfulness as defined in the literature concerning mindfulness practice.

Brown and Ryan (2003) proposed that individuals may differ in their ability or propensity to be aware of and to sustain attention in the present moment, and that this ability, representing mindfulness, varies within individuals as it can be enhanced or supressed by a variety of factors. For example, the propensity to ruminate on the past, or fantasise about the future can draw attention away from the present. Compulsive or automatic behaviour reduces awareness of or attention to one's actions. Absence of mindfulness may also be defensively motivated, in the form of avoidance of thoughts, emotions, or objects of perception. In order to investigate mindfulness as a personality trait, or *dispositional* mindfulness, Brown and Ryan devised a measurement scale intended to capture individual differences in the frequency of a mindful state characterised by presence or absence of attention to and awareness of the present moment. The resultant Mindful Attention Awareness Scale (MAAS) was shown to

predict multiple wellbeing outcomes associated with mindfulness practice in a general population sample and to reliably distinguish between general population and experienced meditator samples, confirming the validity of both the scale and the dispositional conceptualisation of mindfulness.

Following Brown and Ryan's work, multiple further mindfulness scales have been developed. Like the MAAS, which conceptualises mindfulness simply as present-moment awareness and attention, many of these scales represent mindfulness as a unidimensional construct. Subsequent work then examined whether mindfulness should, in actuality, be considered a multifaceted construct (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006). Based on factor analysis of pooled responses to five mindfulness scales, including the MAAS, a five factor structure was derived in work by Baer and colleagues. These factors, labelled observing, describing, acting with awareness, non-judging, and non-reactivity, make up the Five Facet Mindfulness Questionnaire (FFMQ; Baer et al., 2006). These facets represent distinct contributions to the mindfulness trait (see Table 1) and are differentially related to psychological and wellbeing outcomes in a theoretically consistent manner. For example, alexithymia and emotional intelligence, which relate to the ability to recognise and label emotions are predicted by the *describe* facet, while dissociation and absent-mindedness are significantly negative correlated with the *acting with awareness* facet (Baer et al. 2006).

Table 1.

Subscales of the Five Facet Mindfulness Questionnaire (Baer et al., 2006)

FFMQ Facet	Description
Observing	Noticing or attending to internal and external experiences, such as sensations, cognitions, emotions, sights, sounds, and smells
Describing	Labelling internal experiences with words
Acting with Awareness	Attending to one's activities of the moment, can be contrasted with behaving mechanically while attention is focused elsewhere (often called automatic pilot)
Non-Judging	Taking a non-evaluative stance toward thoughts and feelings
Non-Reactivity	Tendency to allow thoughts and feelings to come and go, without getting caught up in or carried away by them

1.2.2 Mindfulness practice. More recently, the principles of mindfulness and mindfulness practice have been applied in a clinical or therapeutic context, or as a more secular practice. Kabat-Zinn (1982) devised a behavioural medicine intervention for patients experiencing chronic pain that is centred around mindfulness meditation. Based on Kabat-Zinn's own experiences as a practitioner of Buddhist mindfulness meditation, theoretical considerations of pain perception, and its regulation during meditation, the programme was successful in significantly reducing pain and associated psychological symptoms. These principles were subsequently further developed and refined into the highly influential therapy programme of Mindfulness Based Stress Reduction (MBSR; Kabat-Zinn, 1990). MBSR is an 8-week mindfulness meditation course delivered in a group setting, with the aim of reducing experiences of chronic stress and enhancing wellbeing. MBSR uses guided meditation sessions

and individual homework sessions to progressively build mindful awareness. MBSR has been delivered to a wide range of patient groups, including those suffering from stress induced by chronic pain, mood disorders, cancer and other chronic illnesses, and in contextual settings such as medical school or prison life (Grossman, Niemann, Schmidt, & Walach, 2004). Although no explicit mention of Buddhist teachings is made during the MBSR course, Kabat-Zinn (2011) has stressed the importance of the Dharma[2] in grounding MBSR. Outside of the clinical application of MBSR, Kabat-Zinn (1994) has also advocated the use of mindfulness mediation for those who wish to increase their day-to-day wellbeing and ability to cope with the stresses of daily life. Kabat-Zinn sees MBSR as being a 'consciousness discipline' rather than a spiritual practice. Although MBSR is based upon Buddhist teachings and principles, it is not constrained by the historical cultural, or religious manifestations associated with Buddhism or its traditions (Kabat-Zinn, 2011).

Based on the principles of MBSR, a further application of mindfulness for clinical therapy has been Mindfulness Based Cognitive Therapy (MBCT; Segal, Williams, & Teasdale, 2002). This therapy was developed for treatment of recurrent depression and combines mindfulness with the cognitive approaches advocated in cognitive therapy (Beck, 1979). Cognitive therapy and mindfulness make differing contributions to MBCT, meaning that MBCT is more than merely a mindfulness intervention. However, the programme contains significant amounts of meditation practice, and both cognitive therapy and mindfulness converge in their non-judgemental and compassionate approach to removing suffering using a present-moment 'now' focus (Fennell & Segal, 2011).

There have been critiques of the extent to which the secular and Westernised conceptualisations of mindfulness truly reflect Buddhist Dharma (Grossman, 2008; Grossman & Van Dam, 2011). However, others have argued that no matter which approach or tradition is taken towards meditation the practice of concentration or calmness, and experiential enquiry

[2] Dharma in the Buddhist context signifies both the teachings of the Buddha and the lawfulness of things in relationship to suffering and the nature of the mind

or insight developed through these practices will lead to greater mindfulness (Batchelor, 2011).

1.2.3 The benefits of being present. In keeping with the Buddhist foundations of mindfulness as being a key component on the path to enlightenment, mindfulness, in the form of disposition and practice, is associated with a range of positive outcomes for health and psychological wellbeing (for a general review see Brown, Creswell, & Ryan, 2015). Research that has examined the effects of dispositional mindfulness supports the role of mindfulness in producing favourable psychological outcomes outside a therapeutic context. Dispositional mindfulness has been shown to predict positive and negative affect and depressive symptoms in a general population sample (López, Sanderman, & Schroevers, 2016) and was associated with lower perceived stress and greater psychological wellbeing in a student sample (Zimmaro et al., 2016). Allen, Henderson, Mancini, and French (2017) report that both dispositional mindfulness and self-reported mindfulness practice moderate the relationship between age and measures of subjective wellbeing, such that mindfulness can protect against age-related declines in wellbeing. In the domain of organisational psychology, dispositional mindfulness has been shown to predict job satisfaction and emotional exhaustion in employees working in interactive service jobs, further investigation utilising a self-guided mindfulness meditation design confirmed the causal role of mindfulness in driving these outcomes (Hülsheger, Alberts, Feinholdt, & Lang, 2013). Dispositional mindfulness has been identified as a potential protective factor in the face of trauma (Hanley, Garland, & Tedeschi, 2017). In a sample of firefighters, a profession associated with greater risk of post-traumatic stress disorder (PTSD), mindfulness was associated with fewer PTSD symptoms, depressive symptoms, and alcohol problems (Smith et al., 2011).

Given the clinical application of mindfulness therapies such as a MBSR and MBCT, there has been a large body of work examining the outcomes of these approaches. In the first publications introducing MBSR, Kabat-Zinn and colleagues reported that the majority of patients treated with MBSR for chronic pain experienced meaningful reductions in pain,

accompanied by significant reductions in accompanying mood disturbance, and retained pain management improvements four years after treatment (e.g., Kabat-Zinn, 1982; Kabat-Zinn, Lipworth, Burncy, & Sellers, 1986). More recent studies have also confirmed the efficacy of MBSR in reducing pain and increasing physical functioning and quality of life in patients suffering from chronic lower back pain (Banth & Ardebil, 2015; Morone, Greco, & Weiner, 2008). Following the introduction of MBSR in the management of chronic pain it has been further applied to a variety of stress related and psychological disorders. In patient populations MBSR has been shown to reduce depressive symptoms in women suffering from the pain disorder fibromyalgia (Sephton et al., 2007), improve psychological functioning and quality of life in breast cancer survivors (Lengacher et al., 2009), and result in greater psychological functioning and reduced stress and mood disturbance in cancer patients and their partners (Birnie, Garland, & Carlson, 2010). Applied to the treatment of psychological disorders, MBSR has been shown to decrease symptoms of depression and anxiety in patients with social anxiety disorder (Goldin & Gross, 2010) and lifetime history of depression (Ramel, Goldin, Carmona, & McQuaid, 2004). Furthermore, improvements in psychological symptoms and perceived stress following MBSR treatment are mediated by increases in mindfulness, assessed with the FFMQ, signifying a meaningful effect of the mindfulness component of this treatment over generalised effects of relaxation or group treatment (Carmody & Baer, 2008). Mindfulness based cognitive therapy (MBCT), an alternative mindfulness based intervention, is effective in both reducing risk of relapse in patients with recurrent depression (Ma & Teasdale, 2004; Teasdale et al., 2000), and in improving symptoms of active depression (Finucane & Mercer, 2006). MBCT has also been effectively applied to improve outcomes in a diverse range of psychological disorders including obsessive compulsive disorder (Key, Rowa, Bieling, McCabe, & Pawluk, 2017) and attention deficit hyperactivity disorder (Gu, Xu, & Zhu, 2018).

There is also a comprehensive literature demonstrating the positive effects of mindfulness based interventions on psychological functioning. However, these interventions are predominantly applied to treatment seeking clinical populations. Furthermore, such

interventions often contain additional components beyond simple mindfulness practice, for example, the cognitive therapy component of MBCT. This literature, therefore, might not provide much insight into the effect of mindfulness practice in a non-therapeutic context or as a personality trait. A recent study has attempted to clarify the role of mindfulness mediation practice in these interventions. Lacaille et al. (2018) used a diary methodology to monitor meditative practice, use of mindful responding throughout the day, and stress and wellbeing outcomes in participants undergoing MBSR. They found that on days when participants meditated, they demonstrated greater mindfulness in their everyday functioning, which in turn predicted improved psychological outcomes. These results suggest that meditation practice, and its effect on daily mindfulness, accounts for improved outcomes in mindfulness meditators. Cross-sectional studies have also found an association between mindfulness meditation experience and greater wellbeing. In a sample of participants who meditated weekly, and were not recruited via mindfulness intervention courses such as MBSR, meditation experience was positively associated with psychological wellbeing, a relationship that was partially explained by greater dispositional mindfulness, assessed with the FFMQ (Baer, Lykins, & Peters, 2012). Frequent self-guided mindfulness practice is also associated with reduced stress, anxiety, and depression (Cavanagh et al., 2013); reduced perceived stress and accompanying biomarkers of stress (Rosenkranz et al., 2016); and greater emotional wellbeing (Fredrickson et al., 2017). Even brief experience with mindfulness meditation can produce psychological benefits, Arch and Craske (2006) found that a 15-minute mindful breathing induction in meditation-naïve participants improved emotional regulation, indicated by reduced affective response to negative imagery.

Although the literature examining the benefits of mindfulness has largely focused on wellbeing and psychological health, there is a growing body of evidence linking mindfulness to improved outcomes for physical health. For example, Reibel, Greeson, Brainard, and Rosenzweig (2001) found MBSR to result in greater physical functionality and reduced self-reported medical symptoms such as asthma, headaches, or sinusitis. Therapies incorporating

mindfulness meditation have also resulted in improved physical function and quality of life in patients with somatization disorders such as irritable bowel syndrome, fibromyalgia, and chronic fatigue syndrome (Fjorback et al., 2013), and improved metabolic outcomes in patients with diabetes (Friis, Johnson, Cutfield, & Consedine, 2016). Several studies have reported that, as well as reducing perceived stress, mindfulness meditation affects biomarkers of stress, such as cortisol levels and presence of pro-inflammatory cytokines (Carlson, Speca, Faris, & Patel, 2007; Rosenkranz et al., 2016; Zimmaro et al., 2016). As well as reducing physiological stress response, MBSR results in increased immune system functioning (Davidson et al., 2003), and has been linked to reduced inflammatory response, indicating that it may be useful as a therapeutic tool for chronic inflammatory conditions such as psoriasis (Rosenkranz et al., 2013). Indeed, the addition of mindfulness practice to standard treatment for psoriasis has been shown to increase clearing rate of psoriasis lesions (Kabat-Zinn et al., 1998).

1.3 Mindfulness and Eating Behaviour

One aspect of physical health in which the role of mindfulness has been investigated, and the focus of this thesis, is that of weight management. As with psychological health, an emerging evidence base shows the benefit of dispositional mindfulness and mindfulness practice for diet and weight outcomes. Mindfulness has been shown to be beneficial in aiding healthier eating practices such as fruit and vegetable consumption (Gilbert & Waltz, 2010) and portion control (Annameier et al., 2018; Beshara, Hutchinson, & Wilson, 2013), and is negatively associated with eating behaviour that predict obesity such as binge and emotional eating (Levin, Dalrymple, Himes, & Zimmerman, 2014). Furthermore, mindfulness is associated with reduced risk of obesity (Camilleri, Mejean, Bellisle, Hercberg, & Peneau, 2015) and lower BMI (Moor, Scott, & McIntosh, 2013) and predicts success in weight loss efforts (Kristeller, Wolever, & Sheets, 2014). Multiple large-scale meta-analyses have acknowledged the effect of mindfulness in supporting healthier eating practices and weight management (Carrière, Khoury, Günak, & Knäuper, 2018; O'Reilly, Cook, Spruijt-Metz, & Black, 2014; Ruffault et al., 2017).

1.3.1 The relationship between mindfulness and eating behaviour.

Several studies have employed cross-sectional designs to investigate the relationship between dispositional mindfulness and weight relevant outcomes - including specific eating behaviours, dietary content, and BMI. Dispositional mindfulness has been shown to be predictive of lower levels of uncontrolled eating and trait disinhibition, factors predicting obesity (Lattimore, Fisher, & Malinowski, 2011). Greater mindfulness is also associated with reduced incidence of binge eating in adolescent and adult samples (Pivarunas et al., 2015; Roberts & Danoff-Burg, 2010). Ouwens, Schiffer, Visser, Raeijmaekers, and Nyklíček (2015) found that dispositional mindfulness was negatively associated with emotional and external eating (tendency to eat in response to negative affect and external cues), but positively associated with control over eating in the form of the tendency to restrict eating in order to manage weight. A similar pattern of effects, in which dispositional mindfulness was positively associated with restraint and negatively associated with emotional and external eating, was replicated in a national cohort study of Dutch adults with type I and II diabetes (Tak et al., 2015). Levin et al. (2014) found that dispositional mindfulness predicts lower levels of problem eating behaviours, such as binge eating, habitual over-eating, and emotional eating, in a sample of obese adults seeking weight loss surgery, showing that mindfulness continues to predict behaviours among participants who have gained significant amounts of weight.

Cross-sectional studies have also shown dispositional mindfulness to be associated with positive dietary behaviours. More mindful participants in a community sample of Australian adults reported smaller serving sizes of energy dense foods (Beshara et al., 2013). Greater mindfulness was predictive of greater fruit and vegetable intake, lower fat intake, and greater dietary self-efficacy in a large student sample (Gilbert & Waltz, 2010). Although these studies rely on participants accurately self-reporting their dietary intake, laboratory studies have also shown that dispositional mindfulness predicts covertly recorded eating behaviour (Annameier et al., 2018; Jordan, Wang, Donatoni, & Meier, 2014). More mindful eating practices are predictive of healthier diet, indexed by fruit and vegetable consumption, in

pregnant women (Hutchinson, Charters, Prichard, Fletcher, & Wilson, 2017). An effect which may account for the negative association between dispositional mindfulness and gestational weight gain in the first trimester of pregnancy (Matthews, Huberty, Leiferman, & Buman, 2018).

Reduced incidence of maladaptive eating behaviours and more positive dietary content among more mindful individuals also translates to more positive weight outcomes. Mindful eating practices have been shown to be associated with lower BMI in a student sample (Moor et al., 2013). Large scale cohort studies have also found significant negative associations between dispositional mindfulness and weight status. Dispositional mindfulness, assessed with the FFMQ, predicted significantly lower odds of obesity in both men and women in a national cohort of over 60,000 in France (Camilleri et al., 2015). Data from the New England Family Study birth cohort found significant negative associations between mindfulness and both BMI and adiposity, an assessment of fat mass which is not affect by factors such as muscle mass or bone density that can distort BMI assessment. These associations remained significant when controlling for age, race, birthweight, childhood SES and childhood intelligence. Furthermore, participants who were not obese in childhood but developed obesity later in life had significantly lower MAAS scores than participants who did not develop obesity, suggesting that mindfulness may predict obesity trajectories across the lifespan (Loucks et al., 2016).

Although these cross-sectional studies establish the relationship between dispositional mindfulness and eating behaviour and weight management outcomes they are merely correlational and, as such, cannot establish causal relationships. Studies which have investigated the effect of mindfulness practice using laboratory or intervention designs can help bridge this gap. Fisher, Lattimore, and Malinowski (2016) used a mindful breathing task to induce a state of mindfulness and examine the causal role of mindfulness in determining food intake in a laboratory setting. Participants who underwent a mindful breathing task subsequently ate fewer cookies in a free eating period than participants in a non-mindful

control condition, after both groups had been exposed to appetitive food cues. Mindfulness tasks specifically tailored to experiences of eating, based on the mindful raisin eating task (in which participants consume a raisin while paying mindful attention to all aspects of the eating experience), can also result in reduced intake on subsequent *ad libitum* eating tasks (Arch et al., 2016). A brief mindfulness meditation exercise conducted in a laboratory setting has also been shown to enhance the extent to which participants reduce energy intake in a subsequent eating episode in order to compensate for prior consumption, thus regulating amount of calories consumed throughout the day (Van De Veer, Van Herpen, & Van Trijp, 2016).

Further support for the causal role of mindfulness in producing beneficial effects for eating behaviour and weight management comes from research looking at the effects of mindfulness based interventions. Mindfulness has been applied both in interventions designed specifically to target eating behaviour or assist weight loss and through the application of existing programmes such as MBSR. Mindfulness Based Eating Awareness Training (M-BEAT; Kristeller & Wolever, 2011) employs mindfulness meditation and teaches its application to eating with the aim of fostering greater regulation of eating. The amount of mindfulness practice that participants engage in during M-BEAT treatment significantly predicts reductions in weight (Kristeller, Wolever, & Sheets, 2014), and M-BEAT results in significant decreases in weight and energy intake, as well as increased cognitive control over eating and decreased disinhibited eating (Miller, Kristeller, Headings, & Nagaraja, 2013). Participation in standard MBSR, without any specific focus on eating or weight loss, leads to reductions in emotional eating in a general population sample (Levoy, Lazaridou, Brewer, & Fulwiler, 2017), and MBCT, again without specific adaptations for eating or weight loss, has also been shown to result in reductions in external and emotional eating, and food cravings in a non-clinical sample exhibiting eating disorder behaviours (Alberts, Thewissen, & Raes, 2012).

In a study of the effects of an intervention specifically targeting weight loss, women who were attempting to lose weight were randomly assigned to a mindfulness-based intervention intended to be used alongside their own dieting plans or a control condition

where participants pursued their own dieting plans without additional intervention support. As such this intervention did not contain any dietary advice or support and was based solely on principles of acceptance, self-awareness and mindfulness. This intervention resulted in significantly greater reductions in weight than control participants (Tapper et al., 2009), albeit only in participants who reported adhering to mindfulness practice. These reductions in BMI were mediated partially by reductions in binge eating frequency, a result which supports the importance of mindfulness driven reductions in maladaptive eating behaviours in aiding weight management. Further studies have applied the use of mindfulness strategies to experiences of food craving and subsequent consumption. Alberts, Mulkens, Smeets, and Thewissen (2010) delivered a mindfulness based intervention in which participants were taught to manage cravings and reduce food intake using mindfulness meditation practices over a 7-week period. This intervention led to significant decreases in food craving experiences and concomitant significant decreases in body weight. In addition, Jenkins and Tapper (2014) found that use of a self-guided mindfulness based exercise in response to chocolate cravings significantly reduced chocolate consumption over a 5 day period.

One difficulty in interpreting the effects of mindfulness interventions on weight is that the interventions may contain multiple active components, of which mindfulness is just one. The effects of such interventions are difficult to disentangle and the contributory effect of mindfulness is not always clear. For example, Mindful Eating and Living (MEAL) is a 6-week programme incorporating mindfulness meditation alongside group exercises addressing social components of eating behaviour. MEAL resulted in significant weight loss over a 12-week period as well as reductions in disinhibited and uncontrolled eating (Dalen et al., 2010). One approach which can aid researchers in understanding the role of mindfulness within multi-component interventions is to look at the predictive effects of mindfulness practice in isolation. Carmody et al. (2012) found that frequency of mindfulness practice predicted major outcomes of improvements in dietary content in dietary intervention which incorporated mindfulness training alongside nutritional education and instruction.

Despite the heterogeneity in intervention methods and composition, study samples, and outcomes assessments several large-scale reviews have supported the efficacy of mindfulness based interventions for eating behaviour and weight management. The most recent of which reports a moderate effect of MBIs in reducing weight (Hedge's *g* = .42), with a mean post-treatment weight loss of 6.8lb (3.08kg), increasing to 7.5lb at follow up (3.40kg). MBIs further had a large effect (Hedge's *g* = .70) in reducing obesity-related eating behaviours of binge eating, emotional eating, and external eating (Carrière et al., 2018).

1.3.2 The need to understand mechanisms. Although the beneficial effect of mindfulness for eating and weight outcomes is well established (Carrière et al., 2018; Ruffault et al., 2017), less attention has been dedicated to understanding the mechanisms that underlie this relationship. A recent review by Tapper (2017) considers a number of potential mechanisms for the effect of mindfulness on eating behaviour, but highlights the current gap in understanding of this relationship. In fact, the mechanism by which mindfulness influences outcomes in a range of domains has yet to be identified (Malinowski, 2008). In the context of this thesis I refer to mechanisms as being the processes through which therapeutic change, such as reductions in weight or improvements in eating behaviour, occurs (Kazdin & Nock, 2003). Review studies which synthesise the results of mindfulness based interventions for weight loss have highlighted the need for further research on the mechanisms responsible for effects (see e.g., Rogers, Ferrari, Mosely, Lang, & Brennan, 2017). Following a review of 19 mindfulness based interventions, Olson and Emery (2015) concluded that although there is evidence of weight loss as a result of MBIs, we cannot be certain that these effects are brought about by increases in mindfulness. Some interventions contain components that could arguably bring about weight loss in the absence of any improvement in mindfulness.

Guidelines published by the Medical Research Council have highlighted the importance of understanding processes of change when developing and evaluating any intervention intended to improve health. In order to develop the most effective interventions for health promotion, these guidelines highlight the need for pre-intervention phases identifying the

underlying mechanisms by which the components of the intervention elicit effects. A series of studies may be required to progressively build understanding of these mechanisms before a full intervention is developed and evaluated (Campbell et al., 2000; Craig et al., 2008). Understanding mechanisms of mindfulness interventions would allow us to optimize their outcomes. Isolating and understanding process of change allows interventions to foster and maximise improvements, and to identify moderators that might boost or undermine the effect of mindfulness (Kazdin & Nock, 2003).

While the process of identifying mechanisms of action is a common practice in biological research, it is often neglected in health behaviour research (Baranowski, Anderson, & Carmack, 1998). Failure to consider or understand mechanisms may explain why, despite the numerous intervention and cross-sectional studies reporting beneficial associations between mindfulness and weight, several interventions fail to find significant effects when applying comparable methods. For example, Kearney et al. (2012) found no significant effect of a standard MBSR course on any eating behaviour outcome, including energy intake, fruit and vegetable intake, uncontrolled eating, or external eating. Similarly, Raja-Khan et al. (2017) found no effect of MBSR on weight loss.

Research that does little to consider *how* and *why* mindfulness results in favourable outcomes for eating and weight management is unlikely to lead to meaningful developments in the effectiveness of mindfulness based interventions for weight management, or contribute to more general understanding of determinants of eating behaviour or individual differences in the ability to manage one's weight. Although some studies have attempted to bridge this gap there is little consensus on the exact mechanisms underlying the relationship between mindfulness and eating behaviour. The investigation of these mechanisms constitutes a primary ethos of this thesis.

1.4 Self-Regulation

1.4.1 Behavioural self-regulation. Understanding the mechanisms underlying the relationship between mindfulness and eating behaviour, and by extension weight management, requires an understanding of the processes that govern behaviour in the domain of eating, and identification of how such processes might differ as a function of mindfulness. Investigation of how individuals are able to regulate their behaviour in all domains of life has long focused on the study of self-regulation. According to Karoly (1993), self-regulation refers to the internal psychological processes that guide goal directed behaviour across time and in differing contexts, and encompasses modulation of thought, affect, behaviour, or attention, in a deliberative or automatic manner. Put more simply, self-regulation refers to the regulation of behaviour in order to meet a goal defined standard. Vohs and Baumeister (2004) see self-regulation as a defining feature of human evolution, in that it allows transformation of the "inner animal nature into a civilized human being" by allowing the human psyche to exercise control over its functions, states, and inner processes (Vohs & Baumeister, 2004, p.1).

Self-regulation involves three major components or stages: (i) standards of thought or behaviour that an individual endorses and uses as a reference to guide behaviour; (ii) motivation to reduce discrepancies between this standard and current behaviour; (iii) sufficient capacity to reduce this discrepancy and meet goals (see Baumeister & Heatherton, 1996; Carver & Scheier, 1982). Hofmann, Schmeichel, and Baddeley (2012) propose that these aspects of self-regulation, but particularly the capacity to reduce discrepancies, are supported by executive function. Executive functions, the higher order processes that allow regulation of cognition, fall into three categories: *shifting*, which refers to the ability to shift between multiple tasks or mental sets; *updating*, which refers to the monitoring and updating of working memory representations; and *inhibition*, which refers to the ability to deliberately inhibit dominant or prepotent responses (Miyake et al., 2000). Hofmann et al. outline how these executive functions support self-regulation. The shifting executive function supports the ability to switch between different methods of attaining the same goal and to flexibly manage

the needs of multiple goals in parallel. Updating and working memory processes allow active representations of self-regulatory goals and standards, suppression of ruminative thoughts, and shielding of goals and standards from interference. Finally, inhibition allows active inhibition of prepotent impulses or habitual behaviours that are in conflict with goals and standards.

1.4.2 Self-regulation of eating behaviour. Eating behaviour can be thought of as a prototypical example of a domain where self-regulation must be enacted (Crescioni et al., 2011). The ability to monitor and regulate behaviour around food is an important predictor of nutritional quality and body mass index. Bandura (2005) identified the ability to exercise motivational and self-regulatory skills as integral in determining health behaviours, including the components of self-regulation identified above: adoption of goals to guide behaviour, self-monitoring of behaviour and environment, and strategies for attaining goals. With respect to eating behaviour, Anderson, Winett, and Wojcik (2007) demonstrated in a large cross-sectional study that enactment of self-regulatory strategies predicts healthier nutritional behaviour (grocery purchases and food consumption) over and above the influence of factors such as self-efficacy, social support, and anticipated negative consequences. Self-regulatory capacity, assessed using task measures of planning, cognitive flexibility, task switching, and inhibition, also accounts for significant variance in the ability to adhere to healthy eating intentions (Allan, Johnston, & Campbell, 2011).

Self-regulatory skills such as self-monitoring have also been shown to predict long term ability to maintain weight loss. In a prospective study, participants who had already lost at least 10% of their body weight received a simple intervention in which they were taught to weigh themselves daily and use the information to determine if changes in behaviour were required, thus fostering the self-regulatory skill of monitoring for discrepancies between a goal or standard and current state (Wing et al., 2008). Use of this strategy was significantly associated with the ability to maintain weight loss over an 18-month period, compared to a control group that had not been taught this self-regulatory strategy. Wing et al. propose that

this difference is attributable to control participants failing to use self-weighing to actively identify and correct for discrepancies between the goal of weight loss and current weight. The importance of emergence of efficient self-regulation for weight control has also been noted in developmental accounts, domain general self-regulatory skills including emotion regulation, inhibitory control and sustained attention at age two has been shown to predict both normal variations in BMI and development of paediatric obesity (BMI in the 85th percentile) at age five (Graziano, Calkins, & Keane, 2010).

1.5 Mindfulness and Self-Regulation

1.5.1 How might mindfulness allow regulation of behaviour? Mindfulness is associated with several outcomes that may reflect greater ability in self-regulation, including improved emotional regulation (Keng, Smoski, & Robins, 2011), reduced procrastination (a behaviour which typically represents a failure of self-regulation, see Sirois & Tosti, 2012), increased perseverance on difficult tasks (Evans, Baer, & Segerstrom, 2009), and improved anger regulation (Rodriguez Vega et al., 2014). A defining characteristic of self-regulation is that it refers not just to regulation *of* the self, but regulation *by* the self (Vohs & Baumeister, 2004). As such, individuals seek to control their behaviour only to the extent that they are aware of their own standing in relation to their goals, that is the degree to which they are self-aware. Mindful self-awareness therefore may support and facilitate self-regulation. Evans et al. (2009) examined this assumption in a correlational study of task perseverance. This study found that dispositional mindfulness, in particular facets relating to non-judging and non-reactivity, predicted perseverance in a difficult anagram task, a process requiring self-regulation. Evans et al. postulate that these results reflect mindfulness promoting the acknowledging and acceptance of critical thoughts and feelings, thus allowing negative emotions, which may arise from more critical forms of self-awareness and usually frustrate efforts to persevere with a difficult task, to dissipate.

The results of Evans and colleagues present an interesting argument for the potential role of mindfulness in supporting self-regulation, however they relate only to one example of the general faculty of self-regulation, namely task persistence. Hölzel et al. (2011) conducted a review of empirical work examining attentional processes in mindfulness and argue that the positive effects of mindfulness practice across domains are attributable to the effect of the attentional components of mindfulness in enhancing self-regulation. They outline four distinct but interacting mechanisms that produce the benefits of mindfulness, all of which are underpinned by attentional processes and together constitute enhanced self-regulation. During meditation practice the goal state is the maintenance of attention on current internal and external experience, without judgement or reactivity. In order to attain this state, interacting mechanisms of (i) attention regulation, (ii) body awareness, (iii) emotional regulation, and (iv) changing perspective of the self are consistently engaged. Hölzel et al. illustrate this process with the following example: during meditation an emotional reaction may be triggered by internal or external stimuli. Attention regulation (i) via the executive attention system detects the conflict of this intrusion to maintaining a mindful state. Body awareness (ii) provides further information about the nature of this conflict (e.g., emotional response to internal stimuli, physical distraction by environmental stimuli). Emotion regulation processes (iii) are then engaged to produce an appropriate response to the conflict. Greater awareness of the transitory nature of the self (iv) further facilitates appropriate responding by reducing self-referential processing and enhancing present moment experiencing of the event. Attentional regulation is the primary process in this iterative sequence and underpins all subsequent mechanisms. In their interacting forms these mechanisms represent greater self-regulation as they enable goal oriented pursuit of the mindful state through modulation of thought, affect, and behaviour; as outlined by Karoly (1993). As such, the mindful state is postulated to represent a continual process of self-regulation, the benefits of which may extend to self-regulation in other behavioural domains.

Consistent with this idea, improvements in self-regulation and executive function, the cognitive capacity thought to determine self-regulatory ability (Hofmann et al., 2012), have been identified as potential mechanisms underlying the benefits of mindfulness. In investigating the causes of greater wellbeing in mindful individuals, Short and colleagues identified a mediating role of both self-regulation and executive functioning (Short, Mazmanian, Oinonen, & Mushquash, 2016). Self-regulatory ability, assessed with the Self-Control Management scale, a measure incorporating self-monitoring, self-evaluation, and self-reinforcement ability (Mezo, 2009), mediated the relationship between dispositional mindfulness and positive affect. Self-regulation and self-reported executive function both mediated the relationship between mindfulness and negative affect.

1.5.2 Mindfulness and self-regulation of eating behaviour. Given the critical role of self-regulatory ability in determining eating behaviour and weight management, and the body of evidence linking mindfulness to greater executive function and self-regulatory capacity, it is perhaps not surprising that several studies have suggested that enhanced self-regulatory ability, as a result of greater mindfulness, might translate into benefits for weight management. For example, McKee and Ntoumanis (2014) found that a self-regulatory training intervention that included mindfulness practice as one self-regulatory skill was effective at reducing weight, however the effect of mindfulness in isolation was not examined so the exact contribution of mindfulness to the effect on self-regulation cannot be established. However, mindful attention training, in which participant view images of foods whilst considering their thoughts as transient states of mind, has been shown to reduce approach bias towards attractive foods (Papies, Barsalou, & Custers, 2012). The authors argue that as approach biases towards attractive stimuli are indicative of self-regulatory failure in a variety of domains, and that reducing approach biases facilitates self-regulation, the mindful attention intervention is a technique which enhances self-regulation in a food-specific context. Similarly, Forman et al. (2016) employed mindful decision making training in an attempt to enhance self-regulation and reduce snack consumption. Mindful decision making was hypothesised to facilitate a

slower, more deliberative decision making process in which the individual can give greater consideration to their long-term health goals and was shown to result in significantly reduced day-to-day snack consumption. Studies on impulsive responding to food stimuli, which apply a delay discounting paradigm to food consumption, have found that mindful eating training, in which participants are taught to observe an eating event in a non-judgemental and present focused manner, leads to less impulsive eating decisions (Hendrickson & Rasmussen, 2013, 2017). Although mechanisms of action were not directly investigated in these studies, the authors propose that these effects are likely attributable to boosted executive function allowing greater control over eating after mindfulness training (Jordan et al., 2014).

1.6 Synopsis

This thesis set out to further understand the link between mindfulness and eating behaviour. In addition to better understanding the correlates of mindfulness and healthy eating, it also sought to devote direct attention to the consideration of mechanisms by which mindfulness enables control over eating behaviour and so produces more favourable weight management outcomes. Regarding this latter point, based on literature that characterises mindfulness practice and mindful attention as a process of self-regulation (e.g., Hölzel et al., 2011), I proposed that mindfulness allows greater ability in self-regulation, enabling greater control over eating. I conducted six studies examining the role of self-control and self-regulatory processes in determining eating behaviour and weight management as a function of state and dispositional mindfulness. I used self-report, task measures, and inductions to assess the role of self-regulation, and examined multiple outcomes relating to weight management including self-reported dietary behaviour, covertly monitored food intake, and BMI.

I began by investigating associations between dispositional mindfulness and key variables implicated in the control of eating. Studies 1 and 2 (Chapter 2) were correlational studies intended to inform the direction and design of future studies. Based on these findings of the correlational studies, Study 3 (Chapter 3) aimed to test the causal role of mindfulness

and the mediating role of attentional control in determining eating behaviour in a laboratory setting. Participants underwent a brief mindfulness manipulation before taking part in an *ad lib* eating task. I hypothesised that the mindfulness induction would result in healthier eating behaviour and that this relationship would be mediated by attentional control. Studies 4 and 5 (Chapter 4) examined the potential role of self-control by inducing the need for self-control through the use of a cueing paradigm, rather than relying on self-report measures of self-control. These studies investigated how mindful people respond to cues in their environment that might trigger eating, as such situations represent 'goal conflict events' where self-control must be enacted. Finally, Study 6 (Chapter 5) took a longitudinal approach and aimed to relate mindfulness to more day-to-day weight management outcomes rather than laboratory behaviours. In this study, I used a task measure to investigate cognitive accessibility of the dieting goal in mindful individuals as an indicator of self-control capacity. As well as investigating this specific self-control process, which gives an indication of how individuals respond during specific goal conflict events, I also looked at goals and motivations underlying everyday regulation of behaviour by assessing regulatory style in the context of self-determination theory.

Chapter 2.

Correlational investigation of the relationship between mindfulness and key facets of eating behaviour in student and general population samples

Overview

The studies detailed in this chapter provided an initial investigation of the relationships between mindfulness and a range of variables that are implicated in the control of eating and weight management. The primary aim of these studies was to identify relationships that might indicate mechanisms underlying the relationship between mindfulness and weight management, so that these constructs could be explored further using experimental designs. These variables included factors that have been linked to mindfulness and can exert a direct effect on eating behaviour, and include food preferences, nutritional knowledge, and food neophobia. Also included were factors with a theoretical connection to both mindfulness and eating behaviour, in particular feelings of guilt or ambivalence relating to eating. In addition, assessment of dietary restraint and health values were included to give an indication of how individual differences in mindfulness relate to how individuals think about their health and weight more generally. Finally, Study 2 included a measure of attentional control, intended to assess the more specific mechanism of self-control. Study 1 failed to confirm a number of the hypothesised associations between mindfulness and target variables, however the use of an exclusively student sample from a narrow age range may have dampened effects in this study. Study 2 used a sample with a wider age range drawn from the general population and found that mindfulness was associated with more favourable attitudes and behaviours concerning eating behaviour and diet, including greater preference for healthy foods and willingness to try new foods, and greater concern for health. Furthermore, mindfulness was positively associated with attentional control. Taken together, these results suggest that more mindful individuals have both the motivation and ability to regulate their eating and weight.

2.1 Introduction

The aim of the studies described in this chapter was to identify variables that might represent potential mechanisms in the relationship between mindfulness and eating behaviour. In order to select variables for inclusion I reviewed the literature, searching for variables that were empirically and/or theoretically linked to both mindfulness and eating behaviour or weight management. The resulting variables encompassed attitudes and knowledge, behaviour, and cognitive processes, with the aim of building a knowledge basis which would inform development of hypotheses and designs for further experimental studies.

Eating behaviour, in particular healthy eating, is often partly dependent on an individual's level of knowledge about healthful foods (Serlachius, Hamer, & Wardle, 2007; Wardle, Parmenter, & Waller, 2000), and decisions about food consumption are partially driven by perceptions of nutritional value and health properties (Furst, Connors, Bisogni, Sobal, & Falk, 1996). Pidgeon, Lacota, and Champion (2013) report that dispositional mindfulness is positively associated with nutritional knowledge, finding that adults who reported higher levels of dispositional mindfulness scored higher on a measure of nutritional knowledge that assessed awareness of healthy dietary guidelines and the nutritional content of different food types. However, this result can be described as an incidental finding, the nutritional knowledge measure had been included as a covariate and the authors had no a priori hypothesis regarding the relationship between mindfulness and nutritional knowledge. To the best of my knowledge no studies have yet attempted to replicate this association. In addition to increased nutritional knowledge, there is a small body of research which suggests that mindfulness may be associated with greater preference for healthy foods. Jordan et al. (2014) found that greater levels of dispositional mindfulness predicted a greater likelihood of selecting a healthy fruit snack over an unhealthy confectionary snack in student participants. Furthermore, they found that this effect was mediated by an attitudinal preference for fruit, with more mindful participants reporting greater preference for fruit than confectionary. Jordan et al. suggest that these results provide preliminary evidence that mindfulness may improve diet as a result

of attitudinal food preferences. Such a suggestion is consistent with research showing that mindfulness inductions can alter the perceived palatability of food. Hong, Lishner, and Han, (2014) found that exposure to a mindful raisin eating task increased enjoyment of sample foods that had previously been rated as neutral or distasteful. In addition, individuals treated with mindfulness-based therapies for eating disorders have reported subsequently experiencing less enjoyment of previously favoured unhealthy foods (Kristeller & Wolever, 2011).

Hong et al. (2014) propose that their results may be used to address problems such as picky eating and food neophobia. Food neophobia, an unwillingness to try novel and unfamiliar foods, can be more broadly related to the issue of food preference. Food neophobia affects both the quality and variety of food in the diet. Adults with higher food neophobia consume less fruit and vegetables and have a more restricted range of foods in their typical intake than less neophobic individuals, as evidenced by less adherence to healthy dietary patterns such as the Mediterranean diet, healthy breakfast consumption, and Asian dietary practices (Jaeger, Rasmussen, & Prescott, 2017). Neophobia may, therefore, act as a barrier to positive dietary change (Knaapila et al., 2011) and is positively associated with obesity (Proserpio, Laureati, Invitti, & Pagliarini, 2018). Although food neophobia has not yet been investigated in relation to mindfulness, neophobia is concerned with an unwillingness to approach unfamiliar situations, whereas mindfulness includes a curious and open approach to present moment experience (Bishop et al., 2004). Whilst food neophobia is negatively related to the Big Five personality trait of openness to experience, which reflects the depth, breadth, and originality of an individual's experiences (Day, McHale, & Francis, 2012; John & Srivastava, 1999; Knaapila et al., 2011), mindfulness has been repeatedly shown samples to be associated with *greater* openness to experience (e.g., Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006; Giluk, 2009; Lau et al., 2006), particularly those facets of mindfulness that reflect attentiveness and receptivity to new experiences and behaviour (Brown & Ryan, 2003).

A further area for investigation is the potential role of ambivalence with respect to food and eating behaviour. Certain prototypes of unhealthy foods (e.g., chocolate) can induce ambivalent feelings, as they represent a trade-off between positive short-term gratification and negative long-term health consequences. Ambivalent attitudes towards healthy eating have been shown to be counter-productive in maintaining a healthy diet (Conner et al., 2002) and feelings of guilt associated with foods such as chocolate cake have been linked to poorer long-term weight management (Kuijer & Boyce, 2014). Luttrell, Briñol, and Petty (2014) have proposed that a mindful approach may reduce aversive subjective feelings that usually accompany ambivalence. Consistent with this rationale, Haddock, Foad, Windsor-Shellard, Dummel, and Adarves-Yorno (2017) found mindfulness to be associated with increased comfort in holding ambivalent attitudes, and reduced frequency of subjective and objective attitudinal evidence. Furthermore, greater dispositional mindfulness buffered the relationship between experiences of ambivalence and negative affect in the domain of sexual orientation. Reduced frequency of ambivalent attitudes concerning food may contribute toward greater management of a healthy diet and weight in mindful individuals.

The influence of factors such as nutritional knowledge, food neophobia and preference, and feelings of ambivalence concerning food may have a direct effect on eating behaviour and dietary content and may allow more mindful people to regulate their eating in an 'incidental' manner. In other words, these factors may cause more mindful people to select a healthier diet without deliberate effort or active striving towards a goal of healthy eating, they simply prefer to eat that way. However, deliberative processes and goal striving are also important factors in health behaviour (e.g., Prochaska & Velicer, 1997). For example, the Health Belief Model proposes that belief in the value of a behaviour for reducing risk or severity of disease is the main motivation to become involved in health protective behaviour. Such readiness to undertake health actions is termed health consciousness (Becker, Maiman, Kirscht, Haefner, & Drachman, 1977). Health conscious individuals tend to be concerned with nutrition and physical fitness (Kraft & Goodell, 1993) and concern about health is significantly

related to self-reported healthy eating (Reime, Novak, Born, Hagel, & Wanek, 2000). Therefore, the current studies also aim to investigate the more direct ways in which mindful individuals think about their health. In order to assess health consciousness, I included a measure intended to assess the degree to which participants endorse values relating to health and physical fitness.

Alongside this measure of health values, I also included a measure of explicit weight regulation behaviour - dietary restraint. Although the caveats of dietary restraint as a construct are noted in the general introduction, behavioural measures of dietary intake or a lengthy food frequency questionnaire intended to assess dietary content would not be suitable for the design of the current studies. This is because this study was intended as a large-scale investigation that would obtain data from a large number of participants in a single, relatively brief, experimental session. As such it would be impractical to include a food frequency questionnaire, which can contain up to 50 items (e.g. Margetts, Cade, & Osmond, 1989) or to ask participants to complete and return a food diary over the course of several days. The evidence linking dietary restraint to dispositional mindfulness is mixed, with some studies showing a positive association (Ouwens et al., 2015; Tak et al., 2015) and others showing no association (Anderson, Reilly, Schaumberg, Dmochowski, & Anderson, 2016; Lattimore et al., 2011). It should be noted that these studies used differing samples and measures of dietary restraint. The two studies reporting no association (Anderson et al., 2016; Lattimore et al., 2011) both used student samples and the Three Factor Eating Questionnaire (TFEQ; Stunkard & Messick, 1985). In contrast, the studies reporting a positive association both used the Dutch Eating Behaviour Questionnaire (DEBQ; Van Strien, Frijters, Bergers, & Defares, 1986) and clinical samples (participants seeking bariatric surgery or adults with diabetes, see Ouwens et al., 2015; Tak et al., 2015). Both the TFEQ and the DEBQ have been shown to be poor predictors of short-term calorie intake (Stice, Fisher, & Lowe, 2004), an effect that may be driven by the 'all or nothing' effects which result from breaking diet boundaries (Herman & Mack, 1975). To address these concerns, the current studies employed the Dietary Intent Scale

(Stice, 1998), a measure of dietary restraint that may be more valid in predicting calorie intake than the TFEQ and DEBQ (Stice et al., 2004).

Finally, in addition to these variables pertaining to knowledge, implicit preferences, values, and behaviour, I also considered the influence of cognitive processes which allow control of behaviour, namely the role of executive function. Teper, Segal, and Inzlicht (2013) have proposed that mindfulness improves executive function by enhancing present moment awareness and acceptance of experience, allowing for greater experience of and attention to goal conflict events. This enhances capacity for self-control, specifically in the form of inhibition of prepotent responses (Elkins-Brown, Teper, & Inzlicht, 2017), one of three executive functions outlined by (Miyake et al., 2000). In the current context, resisting consumption of tempting but unhealthy foods may be considered a prototypical example of a goal conflict event. An individual must enact self-control to override the desire to consume energy dense foods in order to maintain their weight in the long term. Indeed, individuals high in dispositional self-control report healthier eating practices and lower BMI (Junger & van Kampen, 2010; Konttinen, Haukkala, Sarlio-Lähteenkorva, Silventoinen, & Jousilahti, 2009). Furthermore, mindfulness has been linked to greater executive control capacity, a factor implicated in self-control ability (Baumeister & Vohs, 2003; Miyake et al., 2000). Correlational research has shown a positive association between dispositional mindfulness and self-reported self-control (Bowlin & Baer, 2012; Fetterman, Robinson, Ode, & Gordon, 2010). Experimental studies have found that mindfulness training results in improvements in executive function, as assessed by task measures in populations such as adults attending an introductory meditation seminar (Friese, Messner, & Schaffner, 2012), older adults (Moynihan et al., 2013) and clinical psychologists (Rodriguez Vega et al., 2014) who completed eight-week mindfulness based stress reduction courses. Given the theoretical and empirical link between mindfulness and executive function, enhanced self-control ability as a result of increased executive function capacity might represent a potential mechanism by which mindfulness improves weight

management. Therefore, Study 2 included a measure of executive function as an initial investigation of the role of executive function as a potential mechanism.

In sum, in two correlational studies I set out to investigate the relationship between dispositional mindfulness and the range of variables outlined above that might contribute to adaptive regulation of body weight. By investigating relationships between mindfulness and such variables I intend to identify areas for further experimental work and use the results of the following studies to inform further experimental design.

2.2 Study 1

Study 1 aims to identify variables that may indicate potential mechanisms in the relationship between mindfulness and eating attitudes and behaviour. This study seeks to build upon findings by Jordan et al. (2014) and Pidgeon et al. (2013) regarding a positive relationship between mindfulness and healthy food preference and nutritional knowledge. I will also examine relationships between mindfulness and behaviours relating to control and manner of eating, specifically food neophobia, unhealthy food preference, and dietary restraint. In addition, the extent to which participants value health, and feelings of ambivalence and worry relating to food are also included. I used both the MAAS and FFMQ to assess dispositional mindfulness, in order to broadly capture the multidimensional nature of the mindfulness trait.

2.2.1 Method.

Participants. A convenience sample of 121 participants (107 females; M_{age} = 19 years; SD = 1.4 years) were recruited from the undergraduate pool in the School of Psychology at Cardiff University and participated in return for course credit.

Materials.

Mindful Attention Awareness Scale (MAAS). The MAAS (Brown & Ryan, 2003) is a self-report scale assessing individual differences in dispositional mindfulness, with an emphasis on

attention to, and awareness of, present moment experience. MAAS scores predict a number of theoretically consistent behavioural outcomes, such as higher levels of subjective well-being and lower levels of emotional disturbance (Brown & Ryan, 2003; Carlson & Brown, 2005) and has robust convergent, criterion, construct and content validity (Brown, Ryan, Loverich, Biegel, & West, 2011). Example items include "I could be experiencing some emotion and not be conscious of it until sometime later". Participants responded on a five-point scale from 1 (never or very rarely true) to 5 (very often or always true)[3].

Five Facet Mindfulness Questionnaire (FFMQ). The FFMQ (Baer et al., 2006) is a composite of 39 items from a variety of mindfulness measures and aims to examine multiple of components of the mindfulness trait (observing, describing, acting with awareness, non-judging of inner experience, and non-reactivity to inner experience). The FFMQ was used because distinct subcomponents of mindfulness can play different roles in the relationship between mindfulness and weight (see e.g., Camilleri, Mejean, Bellisle, Hercberg, & Peneau, 2015). Example items include "I make judgments about whether my thoughts are good or bad" and "I watch my feelings without getting lost in them." Participants responded using a six-point scale from 1 (*almost always*) to 6 (*almost never*), with higher scores representing greater mindfulness. Global and facet scores were computed. The reliability indices of the facets and the use of a single score are comparable to other studies using the FFMQ (Baer et al., 2006; Barnhofer, Duggan, & Griffith, 2011).

Food Neophobia Scale. This is a 10-item measure assessing avoidance of novel foods (Pliner & Hobden, 1992). Example items include "I am constantly sampling new and different foods" and "I don't trust new foods." Participants responded using a five-point scale from 1 (*strongly disagree*) to 5 (*strongly agree*). A higher score on this measure indicates a greater neophobia, that is, less willingness to try new foods.

[3] Throughout reliability statistics for all measures are reported in relevant tables or text in the results sections

Consumer Nutrition Knowledge Scale (CoNKS). This scale assesses respondents' nutrition knowledge. Participants answered true or false to 20 items designed to assess consumer nutritional knowledge (Dickson-Spillmann, Siegrist, & Keller, 2011). Example items include "Oily fish (salmon, mackerel) contain healthier fats that red meat" and "The same amount of sugar and fat contain equally as many calories". A higher score represents greater knowledge.

Dietary Intent Scale. This is a nine-item measure of restrained eating style (Stice, 1998). Example items include "I take small helpings in an effort to control my weight" and "I count calories to try to prevent weight gain". Participants responded on a five-point scale from 1 (*never*) to 5 (*always*), with a higher score representing greater restraint.

Health values. Participants were asked about the extent to which they endorsed health values. These items were based on the Schwartz Value Survey (Schwartz, 1992) and included items such as physical health and healthy eating (see Tapper, Jiga-Boy, Haddock, Maio, & Valle, 2012). Participants indicated on a scale of -1 to +7 whether these values were important to them (-1 = *opposed to my values*; 0 = *not important*; +7 = *extremely important)*, with a higher score representing greater importance attached to the value.

Attitudes towards healthy and unhealthy foods. Participants rated their attitude towards for 10 healthy and 10 unhealthy foods on a scale of 0 to 100, with a higher number representing a more positive attitude. Healthy foods were fruit (oranges, apples, bananas, grapes, pears) and vegetables (tomatoes, broccoli, red peppers, carrots, spinach) while unhealthy foods were sweet (cake, chocolate, sweets, biscuits, chocolate bars) and savoury (pizza, nachos, chips/French fries, pasties, crisps) snacks. These foods were selected as they were deemed to be common and familiar examples of healthy and unhealthy foods and have previously been used in laboratory studies on eating behaviour (Bodenlos & Wormuth, 2013; Fisher et al., 2016; Zellner et al., 2006).

Food-related worry and ambivalence. Worries about and ambivalent attitudes towards unhealthy food were assessed using a measure adapted from Rozin, Fischler, Imada, Sarubin, and Wrzesniewski (1999). In order to assess worry about unhealthy food participants were given an example of a food (e.g., chocolate cake) and asked to select, from a choice of two words, which word they most associate with that food. The two words related to one positive and one negative feeling about the food (e.g., indulgent versus guilt). Participants were allocated a score of 1 if they selected the positively valenced word and 0 if they selected the negatively valenced word. A lower score was then taken to indicate greater worry about unhealthy food. To assess ambivalence participants then indicated on a nine-point scale (1 = *somewhat;* 9 = *extremely*) the extent to which they associate *each of* the positive and negative words with each food. For example, with respect to chocolate cake, participants were asked "When you think about yourself eating chocolate cake to what extent do you see chocolate cake as indulgent?" and "When you think about yourself eating chocolate cake to what extent does eating chocolate cake make you feel guilty?". Three examples of unhealthy foods were included (chocolate cake, ice-cream, and chips). An ambivalence index was calculated across foods using a formula from Thompson, Zanna, and Griffin (1995), with a higher score reflecting greater ambivalence.

Procedure. All materials were delivered digitally using Qualtrics survey software. Questionnaires were administered in the order presented above. Participants attended group sessions (16 participants per session) and completed assessments whilst seated in individual booths. Participation took approximately 20 minutes.

2.2.2 Results and Discussion. Pearson correlation coefficients between dispositional mindfulness (both FFMQ and MAAS) and the target variables are presented in Table 2. There was a significant negative association between mindfulness and dietary restraint when using the MAAS (r = -.23, p = .01), indicating that more mindful people were less likely to restrict food intake for the purposes of weight control. However, there were no other significant

associations between mindfulness and any of the outcome variables. Examination of the individual facets of the FFMQ yielded one significant association, between dietary restraint and the *acting with awareness* facet (r = -.24, p =.01). Given the lack of associations between target variables and any of the other facets of the FFMQ or global FFMQ score it is possible that this significant association reflects type I error. However, it should also be noted that this facet reflects the mindful awareness component of mindfulness and shares items with the MAAS and so this result converges with the association between DIS and MAAS.

Table 2.

Pearson correlation coefficients for target variables in Study 1, Cronbach's α given in parentheses

	Five Facet Mindfulness Questionnaire (.72)	Mindful Attention Awareness Scale (.87)
Health Values (.84)	.13	.03
Healthy Food Attitude (.78)	-.03	.04
Unhealthy Food Attitude (.86)	-.00	.01
Nutrition Knowledge[a]	-.00	-.01
Food Neophobia (.94)	-.11	-.09
Dietary Restraint (.94)	-.13	-.23*
Food Ambivalence (.64)	.01	-.00
Food Worry (.46)	.01	-.07

* Significant at the $p < .05$ level (two-tailed)

[a] Split half reliability using odd and even items was employed due to the true/false nature of this scale and produced a significant correlation (r = .40, $p < .001$; 2-tailed)

The lack of significant associations is surprising, given that the variables of interest have all previously been linked in theoretical or empirical work to the construct of

mindfulness. These null results may, in part, be explained by the use of an exclusively student sample, a population shown to be at risk for poor diet (Bagordo, Grassi, Serio, Idolo, & De Donno, 2013). Students experience unique environmental constraints, such as student lifestyle and reduced access to healthy foods (Deliens, Clarys, De Bourdeaudhuij, & Deforche, 2014; Greaney et al., 2009) that may reduce the effect of individual level factors, such as mindfulness, in determining behaviour. For this reason, assessments were repeated using a sample drawn from the general population and with a wider age range.

2.3 Study 2

Study 2 continued the exploratory investigation of the relationship between dispositional mindfulness and variables implicated in the control of eating behaviour. However, this study used a larger sample drawn from the general population, rather than the student sample used in Study 1. For parsimony, and because many items from the MAAS are included in the acting with awareness facet of the FFMQ, MAAS was excluded and only the FFMQ used to assess dispositional mindfulness. In addition, Study 2 aimed to extend the scope of investigation by including a measure intended to tap processes of self-control, in line with the theoretical model outlined by Teper et al. (2013). Whilst Study 1 focused solely on factors which directly relate to eating behaviour, Study 2 also investigates a proposed mechanism that may allow more mindful individuals to control their behaviour more generally. For this purpose, the Attentional Control Scale (Derryberry & Reed, 2002) was included as a self-report measure of executive function.

2.3.1 Method.

Participants. 200 participants (119 female; M_{age} = 26 years; SD = 9.7 years) were recruited via Prolific Academic, an online research recruitment service. Participants were paid £2 for their participation in the study.

Materials.

Materials for this study were identical those used in Study 1 with two exceptions. First, because the *Acting with Awareness* facet of the FFMQ is closely aligned with the content of the MAAS, MAAS was excluded and only the FFMQ was used to assess mindfulness. Second, the Attentional Control Scale (Derryberry & Reed, 2002) was included as a measure of self-control.

Attentional Control Scale (ACS). The ACS (Derryberry & Reed, 2002) is a self-report scale assessing the ability to focus and shift attention and to flexibly control thought. This measure has high internal reliability and can be divided into focusing and shifting subscales (Ólafsson et al., 2011). Focusing refers to the ability to control attention by focusing it in the face of distraction and shifting represents flexible control over the content of one's thoughts. ACS scores have been shown to be positively associated with working memory capacity (Judah, Grant, Mills, & Lechner, 2014). Example items include "It's very hard for me to concentrate on a difficult task when there are noises around" and "I can quickly switch from one task to another". Participants responded on a four-point scale from 1 (*almost never*) to 4 (*always*), with higher scores reflecting greater control. For parsimony, an overall attentional control score was computed, as the results of the focusing and shifting components showed the same pattern.

Procedure. Users of the Prolific Academic website responded to an advert for a '20-minute questionnaire study'. All assessments were completed online, delivered digitally using Qualtrics survey software. The full questionnaire was estimated to take 20 minutes to complete and participation was limited to 40 minutes. All assessments had to be completed in one session, participants were unable to save and return later. All participants completed the questionnaires in the order presented above, to ensure that there would be no potential sequence effects across participants.

2.3.2 Results and Discussion. Pearson correlation coefficients between overall FFMQ scores and the target variables are presented in Table 3. Mindfulness was positively associated

with positive attitude towards healthy food (r = .22, p < .01) replicating Jordan et al. (2014) and was not associated with positive attitude towards unhealthy foods, although this correlation approached significance (r = -.13, p =.07). More mindful people also had lower levels of food neophobia (r = -.30, p < .01), indicating that they are more willing to try novel foods. There was no significant association between mindfulness and dietary restraint (r= -.04, p = .29), suggesting the mindful people are no more likely to restrict their eating to control their weight than less mindful people. However, mindfulness was significantly associated with health values (r = .15, p = .03), indicating that mindful individuals do place value in physical health and fitness even if they are not restricting food intake.

Table 3.

Pearson correlation coefficients for target variables in Study 2, Cronbach's α given in parentheses

	Five Facet Mindfulness Questionnaire
Attentional Control (.83)	.61*
Health Values (.78)	.15*
Healthy Food Preference (.83)	.22*
Unhealthy Food Preference (.89)	-.13
Nutrition Knowledge[a]	.07
Food Neophobia (.90)	-.30*
Dietary Restraint (.89)	-.04
Food Ambivalence (.50)	-.04
Food Worry (.46)	-.01

* Significant at the p < .05 level (two-tailed)

** Significant at the p < .001 level (two-tailed)

[a] Split half reliability using odd and even items was employed due to the true/false nature of this scale and produced a significant correlation (r =.56, p <.001; 2-tailed)

All patterns of effect remained unchanged when controlling for gender

Table 4.

Pearson correlation coefficients for target variables and subscales of FFMQ, Cronbach's alpha given in parentheses

	NR (.83)	Obs. (.79)	AWA (.86)	Desc. (.88)	NJ (.86)
Att. Control	.34**	.12	.52**	.40**	.38**
Health Values	-.01	.08	.21**	.14	.02
Healthy Pref.	.14	.20**	.21**	.10	.04
Unhealthy Pref.	-.04	-.07	-.13	-.04	-.10
Nut. Knowledge	-.06	.05	.03	.03	.12
Food Neophobia	-.11	-.12	-.24**	-.27**	-.13
Dietary Restraint	.01	-.09	-.02	-.11	-.13
Food Ambivalence	-.02	.01	-.05	.00	-.06
Food Worry	-.02	-.04	-.04	-.03	.09

** Significant at the p < .01 level (2-tailed)

NR – Non-Reactivity; Obs. – Observing; AWA – Acting with Awareness; Desc. – Describing; NJ – Non-Judging

There was no association between mindfulness and nutritional knowledge (r = .07, p = .18), contrary to Pidgeon et al. (2013). Similarly, there was no evidence of a relationship between mindfulness and food worry (r = -.01, p = .47) or ambivalent attitudes towards food (r = -.04, p = .27).

Greater mindfulness was associated with greater attentional control (r = .61, p < .01). Teper et al.'s (2013) model implies that the acting with awareness facet should be most highly correlated with attentional control compared to the other four facets, as improvements in

executive function are said to be driven by enhanced awareness. While each facet was significantly associated with attentional control (see Table 4), the facet with the strongest association was acting with awareness (r = .52, p < .01). The correlation between acting with awareness and ACS was in fact significantly greater than those for the non-reactivity (r = .34; z = 2.40, p <.01), observing (r = .12; z = 4.66, p <.01), describing (r = .40; z = 1.70, p = .04), and non-judging facets (r = .38; z = 2.01, p = .02) when examined using the procedure outlined by Lee and Preacher (2013) for testing the difference between dependent correlations.

2.4 General Discussion

The current studies were designed to investigate the relationship between mindfulness and facets of eating behaviour in order to determine potential mechanisms that might underlie the relationship between mindfulness and positive weight management outcomes.

Study 1 did not find significant associations between mindfulness and any of the target variables, aside from dietary restraint. A possible reason for the lack of effect in this study might be the sample, which was made up entirely of undergraduate students. Students have been identified as a group who are at high risk for poor diet. Undergraduate students living away from home show a deviation from an ideal healthy diet, increased alcohol, sugar, and fast food intake, and reduced intake of fruits, vegetables, and pulses (Bagordo et al., 2013; Papadaki, Hondros, Scott, & Kapsokefalou, 2007). These differences may be attributed to environments and circumstances unique to the student population. Individual determinants of eating behaviour such as preference are moderated by university influences such as student lifestyle (Deliens et al., 2014). Students report time constraints, lack of access to healthy foods, cost, and social influences as barriers to healthy eating (Greaney et al., 2009; Hilger, Loerbroks, & Diehl, 2017). For this reason, Study 2 replicated the measures used in Study 1 but recruited a sample from the general population.

Study 1 found MAAS scores to be negatively associated with dietary restraint. This effect was not replicated in Study 2. These data provide no consistent evidence to suggest that more mindful people are more likely to restrict intake in order control weight, in fact in student samples mindfulness appears to be associated with *lower* levels of dietary restriction. Although the current evidence regarding mindfulness and dietary restraint is mixed, these data contribute to those studies that show that mindfulness is either negatively related or unrelated to dietary restraint (Anderson et al., 2016; Atkinson & Wade, 2016; Lattimore et al., 2011). The fact that more mindful individuals do not appear to exhibit high levels of dietary restriction might be favourable for weight management. As discussed in the general introduction, dietary restriction represents a cognitive control of eating which may result in counterproductive effects when these cognitive control mechanisms are disrupted (Herman & Polivy, 1980). Restricting foods from the diet can lead to increased craving and higher BMI (Meule, Westenhöfer, & Kübler, 2011)

Although more mindful participants do not appear to be more restrictive, Study 2 did find a positive association between mindfulness and health values, suggesting that more mindful people place greater value in their health, physical fitness, and diet. Concern for health is positively associated with self-reported healthy eating (Reime et al., 2000) and the fact that more mindful individuals value health, but do not demonstrate higher levels of dietary restriction, suggests that they may engage in healthy dietary practice outside of potentially detrimental processes of cognitive restriction. For example, more health conscious individuals may take a flexible approach to dietary control, where unhealthy foods are not forbidden but are eaten in limited quantities without feelings of guilt (Westenhoefer, 1991), an approach which predicts lower BMI (Westenhoefer, Stunkard, & Pudel, 1999). Alternatively, health consciousness may predicted an intuitive approach to eating where food intake is controlled in line with internal sensations of hunger and satiety rather than cognitive rules, and where food is selected to meet body and health needs (Tribole & Resch, 1995; Tylka & Kroon Van Diest, 2013).

These studies failed to replicate the effect of Pidgeon et al. (2013) in finding greater levels of nutritional knowledge in more mindful individuals. This may be due to use of differing measures. Pigeon et al. used the General Nutritional Knowledge Questionnaire (GNKQ; Parmenter & Wardle, 1999) rather than the Consumer Nutrition Knowledge Survey (CoNKS) used in the current studies. Although scores on these two measures are positively associated (Dickson-Spillman et al., 2011) they differ in their conceptual approach. The GNKQ is much longer and more comprehensive than the CoNKS and aims to assess the extent to which individuals understand expert dietary recommendations, the health implications of certain diets, and the nutrient content and healthiest option of a range of foods. In contrast, the CoNKS was developed on the basis of participants' *natural language* surrounding food and their everyday cognitions relating to nutrition, and was intended to be more reflective of the type of knowledge that drives consumption. It is also important to note that Pidgeon et al. included the GNKQ in their study as a control variable. They did not seek to demonstrate a relationship between mindfulness and nutritional knowledge, and had no reason to hypothesise one. Given the failure to replicate in the current studies it is possible that their relationship is simply a spurious result.

Although effects relating the nutritional knowledge were not replicated, Study 2 did find a positive association between mindfulness and positive attitude towards healthy foods, replicating Jordan et al. (2013). There was no association between mindfulness and positive attitude towards unhealthy foods, although the direction of this correlation was negative and approached significance, complementing the positive association seen for healthy food attitude. As the current data are correlational one cannot draw conclusions about the direction of the relationship between mindfulness and food attitudes. However, the research of Hong et al. (2014), which found that mindfulness training can alter enjoyment of foods, along with reports of changes in food preference following mindfulness therapy (Kristeller & Wolever, 2011) point to the possibility that mindfulness can alter perceptions of, and preference for, certain foods. Alternatively, the negative association between mindfulness and food

neophobia highlights a different mechanism whereby reduced avoidance of novel foods, facilitated by mindfulness, leads to greater dietary variety and familiarity with different foods resulting in greater preference for foods which are typically considered less appetitive.

There was no evidence to suggest that more mindful people experience lower levels of worry or ambivalence relating to unhealthy foods. Haddock et al. (2017) reported that dispositional mindfulness was associated with reduced frequency of ambivalent attitudes, however this only covered general feelings of ambivalence or ambivalent attitudes relating to social issues (e.g. abortion, blood donation). The results of the current study suggest that this effect might not extend to the domain of eating attitudes. Luttrell et al. (2014) suggest that mindfulness might reduce aversive subjective feelings associated with ambivalence. The measure included in this study only assessed the presence of ambivalent attitudes, rather than the aversive emotions associated with them. Mindfulness may still play a role in the relationship between food ambivalence and eating outcomes not by *reducing* ambivalence but by acting as a buffer. Indeed, Haddock et al. found that mindfulness protected against the negative impact of sexual orientation ambivalence on affect.

Study 2 included a questionnaire measure of executive function, the Attentional Control Scale (Derryberry & Reed, 2002). This measure was included to test the assumption of the model proposed by Teper et al. (2013) that mindfulness is associated with greater executive function. Such improvements in executive function should result in greater self-control which may represent a mechanism by which mindfulness allows greater weight regulation. There was a significant positive association between mindfulness and attentional control, which was consistent across all but one of the facets of the FFMQ. In addition, examination of facet correlations showed that the association between attentional control and the Acting with Awareness facet was significantly greater than those of the all other facets. This result lends further support to the processes outlined in Teper et al.'s model, which postulates that the key driver of improved executive function is greater attention to and *awareness of* goal conflict events. The association between mindfulness and attentional

control seen in this study is consistent with previous research which has demonstrated improved performance on task measures of executive function following mindfulness training (Friese et al., 2012; Moynihan et al., 2013; Rodriguez Vega et al., 2014). It is also in line with studies that have shown a positive association between dispositional mindfulness and self-reported self-control (Bowlin & Baer, 2012; Fetterman et al., 2010) and confirms that the Attentional Control Scale would be a useful alternative to lengthy task measures of executive function.

This increased capacity for executive function may allow greater control over eating. However, healthy eating involves both the *inhibition* of an undesirable behaviour (such as snacking on cookies and potato chips) and the *initiation* of a desirable one (such as fruit and vegetable consumption). Recent research has shown that distinct components of executive function contribute to inhibition and initiation; inhibitory control predicts reductions in fat intake whereas updating predicts increases in fruit and vegetable consumption (Allom & Mullan, 2014). Although the ACS assesses the ability to focus and shift attention, which map on to the updating component of executive control, it does not include items relating to behavioural inhibition (Derryberry & Reed, 2002). Therefore, the present research does not allow for investigation of whether mindfulness may offer greater benefits in terms of inhibition of unhealthy eating, initiation of healthy eating, or both. The choice between healthy and unhealthy foods is something that will be investigated in further research.

The positive association between mindfulness and attentional control is the first step in investigating a potential pathway from mindfulness to healthy eating via improved executive function and increased self-control. However, it is important the note that although improved executive function allows greater control over behaviour, executive function is concerned with the ability to carry out goal-directed behaviours (Allom & Mullan, 2014). The fact that mindfulness was *also* associated with valuing health suggests that mindful people may have both the motivation and capacity to control their eating. In fact, executive function might

predict the ability of individuals to meet their goals. Allan, Johnston, and Campbell (2011) demonstrated a role of executive function in the intention-behaviour gap, with higher executive control being associated with greater likelihood of achieving or exceeding healthy eating intentions.

These studies have revealed several important associations that may help to shed further light on the relationship between mindfulness and weight management. The relationship between mindfulness and health values suggests that more mindful people are concerned about their health and physical fitness. As a result, they may be more motivated to engage in behaviours that will improve their health. However, these behaviours do not appear to include dietary restriction or seeking out nutritional knowledge. The associations between mindfulness and healthy food preference and neophobia show that more mindful people are more willing to try novel foods and have greater preference for foods that are good for them. This effect may mean that they gravitate to more healthful foods, representing a non-goal directed mechanism. Alternatively, such preferences may have developed as a result of engaging in health conscious behaviours. Of key importance are the results relating to executive function and health values as these associations suggest that more mindful people not only have a greater drive to achieve a healthy lifestyle but also have the necessary executive function to turn their intentions into behaviours.

Chapter 3.

Investigation of the mediating role of attentional control in determining food choice and energy intake following a mindfulness induction exercise

Overview

The studies described in the previous chapter investigated associations between mindfulness and a range of variables implicated in control of eating. The results suggested that more mindful people have both the motivation and capacity to regulate their eating. The study described in this study expanded on these results by using an experimental design to examine causal links among mindfulness, attentional control, and eating behaviour. This study focused on the mediating role of self-control, based on a model from Teper et al. (2013) which proposes that enhanced executive function induced by mindfulness allows greater capacity for self-control. In this study (Study 3), I applied this model to control of eating by investigating the mediating role of attentional control, a measure of executive function, in determining food choice and energy intake following a mindfulness induction. I also considered the role of hunger as a moderating influence. I proposed that attentional control would mediate the relationship between mindfulness and eating behaviour. As manipulation check analyses showed a null effect of the mindfulness induction, I conducted internal analyses using state mindfulness across conditions in place of the mindfulness manipulation. Although I found no direct evidence to support a mediating role of attentional control, analyses revealed a moderating role of hunger, such that greater mindfulness resulted in healthier food choice, but only under conditions of low hunger. This result may be interpreted as hunger have an overriding effect on the benefits of being in a mindful state. This interpretation is consistent with wider literature that characterises hunger as a fundamental visceral drive that can have a significant impact on behaviour. Although further investigation on the role of self-control is necessary, this study has established a beneficial effect of mindfulness on the control of eating and identified hunger as a notable moderator of this effect.

3.1 Introduction

The studies discussed in the previous chapter provided an insight into the relationships between mindfulness and several key variables implicated in the control of eating, with the aim of identifying avenues for further experimental work. These studies showed a positive association between mindfulness and health values, and preference for healthy foods, as well as a positive association between executive function and mindfulness. These associations suggest that mindful individuals have both the motivation and capacity to regulate their eating behaviour in a healthy manner. Study 3 aims to build on these results by investigating the role of executive function in enabling greater self-control in mindful individuals.

Self-control is the ability to override or inhibit undesired behavioural tendencies and refrain from acting on them (Tangney, Baumeister, & Boone, 2004). As such, self-control is particularly relevant to motivational conflicts in which one must resist a pleasurable temptation in order to satisfy a long-term goal, as is the case in dieting (Crescioni et al., 2011). Dispositional self-control is associated with lower BMI (Junger & van Kampen, 2010) and with less calorie consumption and greater physical activity in both adults and adolescents (Schroder & Schwarzer, 2005; Wills, Isasi, Mendoza, & Ainette, 2007). These associations also persist across time. In a longitudinal study Keller, Hartmann, and Siegrist (2016) found that higher dispositional self-control predicted lower increases in overeating behaviour and BMI, and greater increases in healthy diet over a four year period. The component of self-control that appear to be of most relevance to the control of eating is response inhibition. Numerous studies have shown that response inhibition predicts weight and eating outcomes. For example, obese women display impaired response inhibition on a food related stop-signal task compared to normal weight women (Nederkoorn, Smulders, Havermans, Roefs, & Jansen, 2006), an effect that also extends to obese children (Nederkoorn, Braet, Van Eijs, Tanghe, & Jansen, 2006). Response inhibition has also been shown to predict one-year weight gain in a student sample (Nederkoorn, Houben, Hofmann, Roefs, & Jansen, 2010), food intake in normal weight participants (Guerrieri et al., 2007), and daily eating habits measured using ecological

momentary assessment (Hofmann, Adriaanse, Vohs, & Baumeister, 2014). Furthermore, training response inhibition has been identified as a valid intervention for inhibiting responses to palatable food in dieters (Veling, Aarts, & Papies, 2011).

Of relevance to the current thesis, theoretical models have considered the role of mindfulness in relation to self-control and response inhibition. As noted in the previous chapter, Teper et al. (2013) proposed a model which describes how core components of mindfulness might enhance self-control ability (see also Elkins-Brown et al., 2017). In this model mindfulness is proposed to improve *executive function* by enhancing present moment awareness and acceptance of experience, allowing for greater experience of and greater attention to goal conflict events, thus increasing the capacity for self-control. By having greater awareness of thoughts and feelings in the experiential field, it is argued that mindful people are better able to acknowledge changes in affect that result from goal conflict events and signal the need for greater self-control (Teper et al., 2013). Accompanying this process, non-judgmental acceptance allows this heightened awareness of changing affect to efficiently engage self-control without cognitive intrusion from additional thoughts or appraisals. In this way, present moment awareness and non-judgmental acceptance are believed to work iteratively to enhance self-control in mindful individuals (see Figure 1). Within this model, self-control is conceptualized as the inhibition of pre-potent and impulsive behaviour (Elkins-Brown et al., 2017), the ability to override dominant responses, which is one of three executive functions outlined by Miyake et al. (2000). Although Teper et al. devised this model in order to explain improvements in emotion regulation that are associated with mindfulness, the authors state that there are likely to be additional consequences of improved executive function and self-control that are yet to be researched. In the current study, I propose and test improved control over eating as one of these hypothesised outcomes.

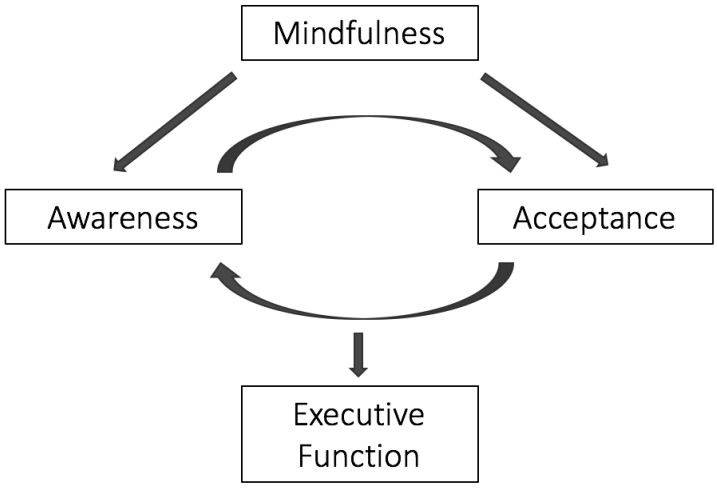

Figure 1. Model outlining how mindfulness improves executive function through iterative action of awareness and acceptance, adapted from Teper, Segal, and Inzlicht (2013)

The model proposed by Teper et al. (2013), along with research which demonstrates the importance of self-control in regulation of eating, point to a role of self-control as a potential mediator in the relationship between mindfulness and eating behaviour. However, to date few studies have directly investigated the relationship among mindfulness, self-control, and eating behaviour.

To the best of my knowledge, only one study has examined the role of self-control as a mechanism in governing eating behaviour in relation to mindfulness. Jordan et al. (2014) examined whether self-regulatory capacity contributes to healthier eating practices in mindful individuals. In this study, experimental participants completed an ego depletion task (the e crossing task; Baumeister, Bratslavsky, Muraven, & Tice, 1998) designed to deplete self-control capacity. Control participants completed an easier, non-depleting version of the same task. Participants were then offered a choice of a fruit or confectionary snack as a reward for participation. Jordan et al. hypothesized that higher levels of dispositional mindfulness would buffer the effect of the ego depletion task and thus reduce the likelihood of these participants selecting an unhealthy snack. However, no such relationship was found. Although mindfulness

did predict food choice, with more mindful participants being more likely to select healthy snacks, there was no evidence that this effect was related to ego depletion. Neither was there a mediating role of self-reported self-control, assessed with the Self-Control Scale (Tangney et al., 2004), in predicting eating behaviour as a function of dispositional mindfulness.

The primary approach taken by Jordan et al. (2014) in assessing the role of self-control, the use of the e crossing task, is based on the strength model of self-control (Baumeister et al., 1998; Baumeister, Vohs, & Tice, 2007). This model proposes that self-control is governed by a domain general and finite internal resource, which may become fatigued. Performance across sequential self-control tasks will become impaired as capacity for self-control is diminished, a state known as *ego depletion.* By asking participants to complete the e-crossing task Jordan et al. aimed to diminish self-control capacity, if mindfulness buffered the effect of this ego depletion then it could be implied that mindfulness enhances self-control capacity. However, the validity of such tasks, and the strength model in general, has recently been called into question. Carter, Kofler, Forster, and McCullough (2015) conducted a meta-analysis of experimental studies which examined the ego depletion effect, this analysis included unpublished data and corrected for small study bias, the increased likelihood of improbably high effect sizes relative to study precision in a sample of studies included in a meta-analysis. A subsequent multisite preregistered replication study involving 23 laboratories and over 2000 participants (Hagger & Chatzisarantis, 2016) found no evidence for an ego depletion effect when using the e-crossing paradigm. Therefore, the methods and theoretical basis used by Jordan et al. may not offer the best approach to testing the role of self-control in relation to mindfulness and eating behaviour. Although Carter et al. (2015) have argued, based on meta-analytic review, that the probable effect of the ego-depletion effect is zero, others have believe that dismissal of the ego-depletion effect is premature (Friese, Loschelder, Gieseler, Frankenbach, & Inzlicht, 2018). Freise et al. acknowledge that the burden of proof concerning ego-depletion falls to proponents of the phenomenon, but argue that the current evidence for the effect is inconclusive.

The model proposed by Teper et al. (2013) provides a conceptualization of self-control that does not rely on the strength model. Several studies have examined relationships between mindfulness, eating, and factors such as impulsivity, which lend support to Teper et al.'s model, in particular the role of awareness. For example, Lattimore, Fisher, & Malinowski (2011) found that reduced impulsivity partially mediated the relationship between mindfulness and disinhibited eating in a cross-sectional study. The authors propose the role of mindfulness in reducing propensity to act without awareness reduces the likelihood of automatic response to external and internal cues. Brief experience with mindfulness, in the form of a single session mindful eating workshop, has been shown to increase self-control in the domain of eating as demonstrated in less impulsive decision making concerning foods (Hendrickson & Rasmussen, 2013, 2017).

One variable likely to be implicated in understanding the impact of mindfulness on eating behaviour is hunger. Marchiori and Papies (2014) investigated the effect of a brief mindfulness manipulation on eating behaviour in a laboratory design and found that mindfulness can buffer the impact of hunger on unhealthy eating. In this study participants underwent a 14-minute mindfulness body scan exercise and then gave a rating of their level of hunger before being presented with cookies to eat. Although mindfulness did not have any effect in reducing the portion size effect (i.e., the tendency to eat more when presented with larger portions), it did prevent participants from increasing their intake of cookies in line with their hunger levels. Although this study did not set out to examine self-control processes, participants were asked to rate the magnitude of three attentional foci during the eating task, how much their attention was focused on (a) their eating, (b) their body sensations, and (c) anything else other than their eating or body sensations. Mindful and control participants showed differing levels of attention when eating, with individuals in the mindful condition reporting more eating focused attention compared to body or other focused attention. This result suggests that greater awareness of, or attention to, eating events may underlie the

beneficial effects of mindfulness in this study. Such an effect could be interpreted as lending support to Teper et al.'s model, which postulates a key role of awareness in driving the improvements in executive function that are associated with greater mindfulness.

This study aims to build upon and extend the work of Jordan et al. (2014) and Marchiori and Papies (2014), using a laboratory design to examine the potential mediating role of self-control. Marchiori and Papies found that a mindfulness manipulation buffered the effect of hunger on eating, indicating that induced mindfulness helps protect against increased food consumption under high hunger when compared to a non-mindful control group. The current study sought to extend these findings in two ways. First, I investigated whether this effect was mediated by self-control. Although Jordan et al. (2014) failed to find any effect of self-control, it is possible that this was because the role of hunger was not considered in Jordan et al.'s research. In this study, I predicted that self-control would play a mediating role in the relationship between mindfulness and food choice, but only under conditions of high hunger (see Figure 2). Hunger is a significant motivational drive (Lowenstein, 1996) which can lead individuals to overvalue high calorie foods (Tal & Wansink, 2013). Therefore, when participants are not hungry there should be less need to control their desire to eat. Indeed, Nederkoorn, Guerrieri, Havermans, Roefs, and Jansen (2009) found that hunger moderated the effect of impulsivity on food intake, such that impulsivity only lead to increased consumption when participants were in a state of hunger. The direct effect of attentional control on food intake was hypothesized to be conditional on the effect of hunger, such that attentional control has little impact on food choice under conditions of low hunger.

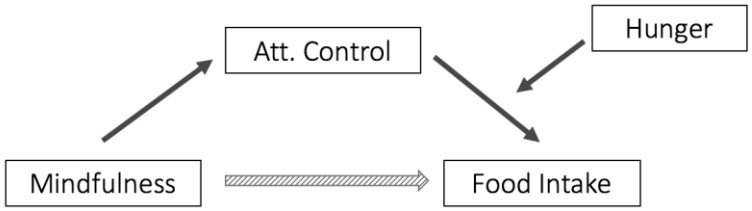

Figure 2. Moderated mediation model in which mindfulness reduces food intake via enhanced attentional control under conditions of high hunger

Second, the current study compared healthy and unhealthy food choices. Healthy eating practices involve both the inhibition of an undesirable behaviour (such as snacking on cookies and potato chips) and the initiation of a desirable one (such as fruit and vegetable consumption). Recent research has shown that distinct components of executive function contribute to inhibition and initiation (Allom & Mullan, 2014). The research by Marchiori and Papies (2014) assessed eating behaviour by focusing solely on the consumption of chocolate chip cookies. In the present study, I assessed participants' consumption of healthy *and* unhealthy foods, to explore whether total caloric consumption remains unchanged (with participants replacing unhealthy eating with healthy eating) and/or whether mindfulness influences the consumption of both healthy and unhealthy foods.

In order to investigate the role of mindfulness I used a mindfulness manipulation exercise, the same approach that was taken by Marchiori and Papies (2014). Several paradigms have been designed that aim to induce a state of mindfulness using brief exercises which can be conducted in the laboratory. These are usually adapted from existing mindfulness exercises used in Buddhist or secular mindfulness practise. These inductions are an attempt to mimic the state experienced as a result of more extended mindfulness practice. Furthermore, as mindfulness practice results in greater levels of *dispositional* mindfulness (Carmody & Baer, 2008; Kiken, Garland, Bluth, Palsson, & Gaylord, 2015), and as mindfulness practice and dispositional mindfulness predict similar outcome (Brown et al., 2007), these brief inductions

can also be thought of an experimental paradigm equivalent to the investigation of pre-existing dispositional mindfulness. The benefit of such approaches is that manipulating mindfulness in a laboratory setting allows us to draw inferences about causality. Two of the most frequently applied mindfulness manipulations are the raisin eating exercise and the body scan, both taken from Kabat-Zinn's Mindfulness Based Stress Reduction course (MBSR; Kabat-Zinn, 1990). In the raisin exercise, participants are given a few raisins to observe, touch, and eventually eat in a mindful manner, guided by an instructor or audio recording. Although this exercise been found to be effective (Hong et al., 2014; Hong, Lishner, Han, & Huss, 2011) it was not considered for use in the current study as I felt that the eating based nature of the exercise would act as a confound. The body scan exercise was developed for MBSR, based upon principles of Hatha yoga and sweeping practice used in Buddhist contemplative practise (Drummond, 2006). The body scan represents a form of guided meditation in which attention is focused on somatic experience throughout various regions of the body, typically starting at the toes and moving upwards (Dreeben, Mamberg, & Salmon, 2013). This was the form of exercise used by Marchiori and Papies (2014) in their investigation of the influence of mindfulness on food intake and will be applied in the current study.

In this study, experimental participants underwent a mindfulness body scan exercise and completed a questionnaire assessment of attentional control. They were then presented with a selection of foods to eat in an ostensibly unrelated task, the amount of healthy and unhealthy foods that participants ate was recorded and calorie intake computed. Participants allocated to the control condition listened to a portion of an audiobook before completing the food selection component of the study. Participants' self-reported level of hunger was also assessed.

3.2 Method

3.2.1 Participants. A convenience sample of 128 females (M_{age} = 20 years; range 18-42) participated in return for course credit or payment. I used female participants because gender

differences in food intake have been documented in laboratory work (e.g., Greenwood, Broadbent, & Fuller-Tyszkiewicz, 2014; Sharp, Sobal, & Wansink, 2014) as well as the limited availability of males among the undergraduate participant pool. Individuals with food allergies or intolerances or other special dietary requirements (e.g., fasting) were excluded from taking part in the study.

3.2.2 Design. A between-participants design was used with the mindfulness manipulation as the independent variable and food intake as the dependent variable. Hunger was not directly manipulated but measured as a moderator with self-reported self-control as a mediator.

3.2.3 Materials.

Mindfulness manipulation. Participants assigned to the mindfulness condition heard a 10-minute audio recording of a body scan exercise. This audio recording has been used successfully in past research (see Cropley, Ussher, & Charitou, 2007), and Marchiori and Papies (2014) employed a similarly brief recording in their work. In the recording used in this study, participants were instructed that the aim of the exercise was to increase awareness of body and mind; no direct mention was made of the terms mindfulness or meditation. Participants were told to focus on their breathing before attention was guided to the abdomen and stomach. Participants randomly assigned to the control condition heard the first 10 minutes of Dan Brown's *The Digital Fortress.* This extract has no food, body, or weight related themes and has been used in previous research (Marchiori & Papies, 2014).

The Toronto Mindfulness Scale (TMS). The TMS is a 13-item *state* measure of mindfulness that was used to assess the impact of mindfulness manipulation. This measure has been shown to have high internal consistency and criterion validity (Lau et al., 2006). According to Lau et al., the TMS has two distinct subscales, *curiosity*, which reflects awareness of the present moment with a quality of curiosity, and *decentering*, which represents distance from one's thoughts and feelings. Example items include "I remained curious about the nature

of each experience as it arose" and "I experienced myself as separate from my changing thoughts and feelings". Participants responded on a five-point scale from 0 (*not at all*) to 4 (*very much*).

Attentional Control Scale (ACS). The ACS (Derryberry & Reed, 2002) is a 20-item self-report scale assessing the ability to focus and shift attention and to flexibly control thought. This measure was discussed in more detail in Chapter 2.

***Foil questionnaire*.** A foil questionnaire was provided for participants to complete whilst they had the opportunity to eat. This questionnaire required participants to describe taste sensations and did not contain any questions that may have influenced food choice or intake (e.g., references to satiety or health properties). Participants also completed the BIS/BAS measure (Carver & White, 1994) during this stage of the session to further mask the study aims. The BIS/BAS generated no meaningful effects and is not discussed any further.

Food Intake. Unhealthy foods consisted of biscuits (Maryland Cookies; Burton Biscuits Company) and cheese flavoured savoury crackers (Jacobs Mini Cheddars; United Biscuits). Healthy foods were red grapes and carrot sticks. These foods were selected based on practicality (i.e., all foods could be easily stored and did not require cooking) and according to participant preferences indicated in my previous studies (Chapter 2, Studies 1 and 2). So that participants were not limited in what they could eat, portions were provided that were twice the recommended portion size (based on manufacturer or government recommendations), resulting in 160g portions of carrots and grapes, and 50g portions of crackers and cookies. Portions were kept consistent across all participants as portion size has a documented effect on amount consumed (Zlatevska et al., 2014). All foods were presented together and participants were also provided with a glass of water. All food was weighed using digital electronic scales (1066 WHDR08; Salter) and the amount consumed was subtracted from amount served. Food intake was conceptualized both as *total calorie intake* and as *food choice*,

an index of healthy eating which was calculated as: kcal consumed from healthy foods minus kcal consumed from unhealthy foods.

3.2.4 Procedure. Participants were alternately assigned to the body scan or control condition. Participants were told that they would be taking part in two studies during a single session and that the first study would involve listening to an audio recording and completing questionnaires. The researcher left the room and participants listened to either the body scan or control audio recording. Upon completing the audio recording participants completed the TMS and ACS measures. These measures were completed in the same order by all participants with the TMS presented first. Next, the researcher returned to the room and introduced the second study, which was presented as being concerned with how hunger levels affect taste perception. Participants rated their current levels of hunger and thirst (0 = *not at all*; 10 = *extremely*) and recorded when they last ate. Participants were then presented with the selection of foods and the foil questionnaire relating to taste perception. The researcher left the room and participants had 10 minutes to select and eat foods. All study sessions took place between 10am and 12pm or between 3pm and 5pm to help ensure consistency in hunger levels between participants by avoiding times when participants were most likely to have just eaten (though participants were not specifically instructed to refrain from eating prior to the study, to help mask the study aims). Following food presentation participants completed the BIS/BAS and were debriefed based on Chartrand & Bargh's (1996) procedure for funnel debriefing, in order to probe suspicions about study aims and hypotheses.[4]

3.3 Results

3.3.1 Manipulation check. A principle components analysis (using varimax rotation) was conducted on responses to the TMS. Three factors were extracted with eigenvalues

[4] Five participants (all in the body scan condition) explicitly noted that they believed that the study was assessing the role of mindfulness in determining eating behaviour. A further six (five in the body scan condition) stated that they thought that the study was assessing the role of relaxation in determining eating behaviour. The reported results did not differ when data from these participants was excluded from analyses. As a result, these individuals are included in all analyses.

greater than 1. These factors were labelled openness, acceptance, and separation. Openness (α = .91) can be conceptualized as openness to new unfolding experiences. The openness subscale contains the same items as Lau et al.'s curiosity subscale, with the exception of one item ('I remained curious about the nature of each experience as it arose') which did not load on any factor. Acceptance (α = .73) can be conceptualized as a non-judgmental acceptance of present moment experiences. Separation (α = .53)[5] represents seeing oneself as separate from current experiences and feelings. The acceptance and separation facets together contain the items that make up Lau et al.'s decentering factor. Consistent with previous research, I also computed a single TMS score (α = .85; Altmaier & Maloney, 2007; Garland, Hanley, Farb, & Froeliger, 2015). Correlations among these facets are reported in Table 5.

An independent samples t-test using the overall TMS score as the outcome variable showed no significant difference between the mindfulness group (M = 1.93) and the control group (M = 1.80; t (126) = 1.11, p = .27). Regarding the subscales from the factor analysis, analyses revealed that the body scan group had significantly higher openness scores (M_M = 2.05, M_C = 1.55; t (126) = 2.86, p < .01), whilst the control group had significantly higher separation scores (M_M = 1.37, M_C = 1.79; t (126) = -2.62, p = .01). The groups did not differ on the acceptance items (M_M = 2.01, M_C = 2.02; t (126) = -.04, p = .97). As a result, the body scan manipulation did not have its intended effect (see Bellinger, DeCaro, & Ralston, 2015, for a similar pattern when using a 15-minute mindful breathing manipulation).

In addition to a lack of effect of the manipulation on TMS scores, there was no significant difference in overall attentional control scores (α = .87) between the body scan and control groups (M_M = 2.27, M_C = 2.35; t(126) = -1.01, p = .32). Further, there were no significant differences when ACS was broken down into the Focusing (α = .83) or Shifting (α = .73) subscales outlined by Judah et al. (2013).

[5] The low alpha for the separation subscale is likely due to the fact that this subscale was only made up of two items. This low reliability should be considered when interpreting effects derived with the separation subscale, however no pertinent interaction effects were reported for this subscale.

Given that the manipulation check showed no effect of the mindfulness manipulation on ACS scores, the intended analysis of conditional direct and indirect effects was not carried out. In their place, I conducted a series of internal analyses.

3.3.2 Main effects. There was no main effect of condition on food choice (F (1,26) = .79, p = .38; R^2 = .01) or total calorie intake (F (1,26) = .03, p = .87; R^2 = .00).

3.3.3 Internal analyses. Internal analyses were conducted using the subscales of TMS identified in the factor analysis in place of the manipulated independent variable. I conducted correlational and regression analyses to assess the degree to which state mindfulness scores and hunger influenced food consumption. These correlations are presented in Table 5. All TMS subscales were significantly associated with each another and the total TMS score. Both total TMS and openness were significantly associated with current hunger level, however there were no significant associations between TMS scores and ACS or either of the outcome variables.

Table 5

Pearson correlation coefficients for TMS subscales and key variables

	Openness	Acceptance	Separation	ACS	Hunger	Total Kcal	Food Choice
TMS	.83**	.72**	.54**	.09	.16*	-.08	-.05
Openness	-	.27**	.24**	.03	.16*	-.05	.02
Acceptance	-	-	.35**	.12	.02	-.12	-.09
Separation	-	-	-	.06	.14	-.01	-.01
Hunger	-	-	-	-	-	.32**	-.28**

* Significant at p < .05 level (1-tailed)

** Significant at p < .01 level (1-tailed)

Building upon these correlational results, I conducted regression analyses in which individual TMS components from the factor analysis[6] and self-reported hunger scores (mean centered; Aiken & West, 1991), along with their interaction, were used as predictor variables, with food choice and total calories consumed as outcome variables.

Food choice. Food choice, an index of healthy eating, was operationalized as kcal consumed from healthy foods minus kcal consumed from unhealthy foods. The results of the regression analysis for the openness facet of TMS scores revealed no main effects of openness (β = .09, p = .28) or hunger (β = -.02, p = .92). However, there was a significant interaction between hunger and openness (β = -.32, p = .05; see Figure 3). Simple effects analyses revealed that individuals high in openness tended to eat more healthily than those low in openness, but only under conditions of low hunger (t(124) = 1.75, p = .08). For those experiencing high hunger, individual differences in openness had no impact on healthy eating (t(124) = .15, p = .88).

There was a main effect of hunger when using the acceptance (β = -.28, p < .01) and separation (β = -.27, p < .01) subscales, but no significant interactions were found.

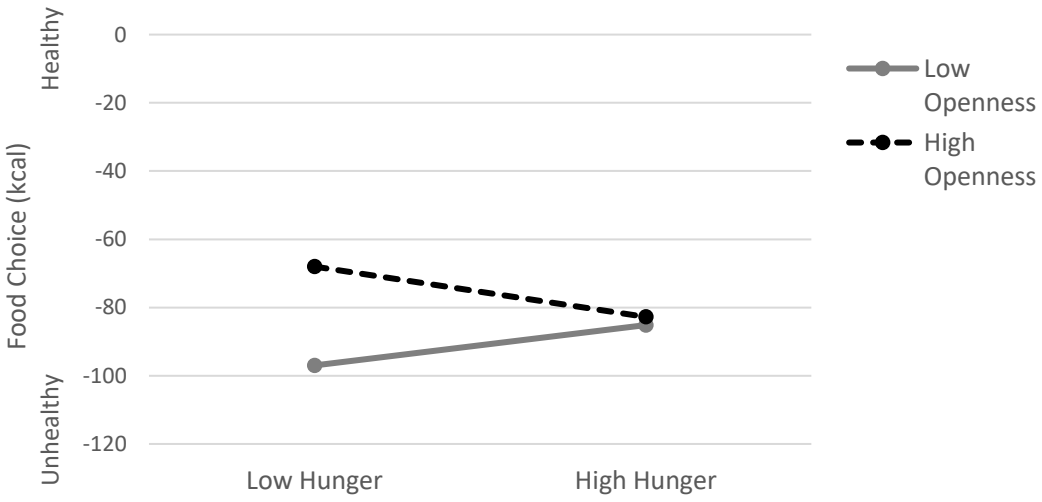

Figure 3. Hunger x openness interaction for healthy food choice high (+1SD) and low (-1SD) hunger

[6] The pattern of results for all analyses remained the same when using subscales from Lau et al. (2006).

Total calorie intake. Regression analyses revealed a significant main effect of hunger when using all three facets of the TMS (all β between .32 and .34, all $p < .01$). In all cases, greater hunger resulted in greater total calorie intake. These analyses revealed no significant main effect of mindfulness or any significant interactions.

3.4 Discussion

This study aimed to build on my previous two studies by investigating the hypothesis that executive function plays a mediating role in the relationship between mindfulness and eating behaviour, as well as considering the potential moderating role of hunger. Unfortunately, the failure of the manipulation did not allow for the intended test of the hypothesis. Furthermore, subsequent internal analyses, which used state mindfulness across conditions in place of the manipulation, did not demonstrate the hypothesized moderated mediation links between mindfulness, attentional control, hunger, and food intake. Despite this, internal analyses did reveal an interacting effect of hunger and mindfulness, such that under conditions of low hunger greater mindfulness resulted in healthier food choice.

In this study, there was no significant effect of the mindfulness manipulation on participants' level of state mindfulness, indicating that the manipulation did not have the intended effect. Previous studies using mindfulness manipulations have encountered similar problems with a lack of effect from brief manipulations (see e.g., Bellinger et al., 2015). However, despite the lack of effect between conditions some authors have found hypothesised effects when considering the actual *state* of mindfulness attained by participants. For example, Ortner & Zelazo (2014) investigated the effect of a 10-minute mindfulness meditation task (versus a distractor control condition) on self-reported affect in response to an anger inducing situation. They reported that, although there was no difference in affect between mindfulness and control conditions, *within* the mindfulness condition higher state mindfulness scores on the TMS predicted greater reductions in negative affect. This led

the authors to conclude that the mindfulness manipulation might only have been successful in a subset of participants, in particular those who had greater ease entering a mindful state. Further, Petter, McGrath, Chambers, and Dick (2014) failed to find an effect of a mindfulness audio task on pain perception during a cold pressor task, however further analyses revealed a significant effect of state mindfulness on this outcome. In light of such results, it may be reasonable to assume that it is the mindful *state* that each participant is in, rather than their allocation to condition, that is of importance to experimental outcomes. For this reason, and owing to the failed manipulation, I conducted internal analyses in which state mindfulness scores *across* conditions were used in place of the mindfulness manipulation. This approach has been used in other domains of research in which the manipulation failed to produce its intended effect (e.g., Haddock, Zanna, & Esses, 1994; Kroon, Van Kreveld, & Rabbie, 1991).

These analyses found no relationship between state mindfulness and attentional control, therefore I did not proceed to test the proposed mediational relationship between mindfulness, attentional control, and food intake. Although this result appears to support the results of Jordan et al. (2014), who found no evidence for a role of self-control as a mechanism, Jordan et al. *did* find dispositional mindfulness to be significantly related to individual differences in self-control. In addition, the lack of relationship between mindfulness and attentional control is inconsistent with the results reported previously in this thesis (Chapter 2, Study 2) and other studies that have demonstrated a relationship between mindfulness and similar measures of executive function or self-control (e.g., Friese, Messner, & Schaffner, 2012; Moynihan et al., 2013; Rodriguez Vega et al., 2014)

A possible explanation for this lack of association is that the *state* measure of mindfulness used in this study was not sufficiently correspondent with the *trait* measure of executive function. As such, immediate changes in executive function arising from moment-by-moment differences in state mindfulness may not have been captured by the trait-level ACS (see Ajzen & Fishbein, 1977, for a similar argument regarding levels of correspondence between measures of attitude and behaviour). Alternatively, it may be that a brief mindfulness

manipulation is not sufficient to enhance executive function. Although brief body scans have been shown to successfully impact behaviour (see Cropley et al., 2007; Marchiori & Papies, 2014), effects on executive function have not been investigated and studies demonstrating a causal impact of mindfulness on executive function have focused on long-term mindfulness training programs (e.g., Rodriguez Vega et al., 2014).

Consistent with this proposal, recent work from Inzlicht and colleagues supports the notion that that a brief mindfulness induction does not necessarily impact executive function. While Teper and Inzlicht (2013) reported that mindfulness enhances attentional control (i.e., fewer Stroop errors), Saunders, Rodrigo, and Inzlicht (2016) found that participants either become slower and more accurate *or* faster and less accurate in responses to a go/no-go task depending on the nature of the 15-minute mindfulness induction used (emotion versus thought focused meditation). Saunders et al. suggest that this discrepancy was due to differences in samples. While the sample used by Teper and Inzlicht (2013) consisted of experienced meditators (average three years of mediation experience), the sample used by Saunders et al. simply underwent a 15-minute mindfulness induction. This led Saunders and colleagues to propose that induced mindfulness-based improvements in attentional control might only occur after extended training. Given these caveats, both the minimal effect of the mindfulness manipulation and the differing levels of measurement between state mindfulness and state self-control, the current study can neither reliably support or reject the hypothesis that self-control plays a mediating role in the relationship between mindfulness and eating behaviour.

Despite the lack of evidence for mediation by self-control, internal analyses did suggest a moderating role of hunger in understanding the link between mindfulness and eating behaviour. Openness to experience, as a component of mindfulness, was associated with less intake of unhealthy calories and a greater proportion of consumption from healthy calories under conditions of low hunger, whilst under conditions of high hunger these participants increased their intake to the level of low openness participants. This may be interpreted as the

benefit of mindfulness being overridden by a state of hunger. Hunger can be considered as a fundamental visceral factor that affects the relative desirability of goods and actions and can cause individuals to act in a way contrary to their long-term self-interest (Loewenstein, 1996). Hunger has been shown to increase the likelihood of selecting unhealthy foods rather than healthier alternatives (Read & van Leeuwen, 1998; Tuorila, Kramer, & Engell, 2001) and to increase the reward value attached to unhealthy foods (Siep et al., 2009). Furthermore, a state of hunger has been shown to decrease feelings of self-efficacy relating to health beliefs so that hungry individuals feel that they have less control over their diet (Nordgren, van der Pligt, & van Harreveld, 2008). Therefore, it is reasonable to conclude that although openness may have a positive impact on food choice in some cases, the motivational effect of hunger is sufficient to override this effect and cause individuals who are high in openness to behave in the same way as those low in openness.

That said, these results diverge from the results of Marchiori and Papies (2014), who found that a mindfulness manipulation buffered the effects of hunger. This implies that further research on the precise nature of the relationship between mindfulness and hunger would be beneficial. Mindfulness has been shown to be negatively related to impulsivity (Peters, Erisman, Upton, Baer, & Roemer, 2011) and individuals are more likely to respond to hunger by selecting unhealthy snack foods if they have poor response inhibition (Nederkoorn et al., 2009). Therefore, there is also a rationale for the hypothesis that mindfulness training of a sufficient intensity to reduce impulsivity might be able to have an impact on eating behaviour even in the face of hunger. Therefore, further research that uses a more intensive mindfulness training task may be necessary to produce an effect of mindfulness on food choice in the face of hunger. Given the current paucity of research that examines the influence of mindfulness and hunger on food choice this question merits further investigation.

The key results discussed above, which demonstrate an interacting effect of hunger and mindfulness, pertain to the outcome variable of food choice, an index of healthy eating. Participants were given a choice of both healthy and unhealthy foods so that the effect of

mindfulness on both inhibition of unhealthy eating and initiation of healthy eating could be examined. Despite greater mindfulness resulting in healthier food choice (under conditions of low hunger), there was no effect on total calorie intake. This result implies that more mindful participants are replacing unhealthy eating with equivalent intake from healthy foods. It would appear, therefore, that a state of mindfulness allows both inhibition of unhealthy eating and initiation of healthy eating. Taken together with the results of Marchiori and Papies (2014), who found that mindfulness reduced consumption of cookies, these results suggest that mindfulness is sufficient to inhibit consumption of unhealthy snack foods and to initiate consumption of healthy alternatives when these are also presented. Although these results do not tell us whether mindfulness results in initiation of healthy eating in day to day life, where healthy options may be seen as less convenient or attractive, results such as those reported by Gilbert and Waltz (2010) which show healthier eating practice, including greater intake of fruit and vegetables, among more mindful people suggest that this may be the case.

The fact that state mindfulness did not affect total calorie intake despite resulting in healthier food choices suggests that those participants in a greater state of mindfulness are simply replacing unhealthy eating with healthy intake. The implications of such a result for weight management must be considered. Although more mindful participants were consuming the same amount of energy as their less mindful counterparts they may still be at an advantage in weight management. There is evidence that the source of calories, rather the just energy intake per se, has an impact on body weight, as foods and macronutrients with the same calorie content exert different effects on satiation and satiety independent of calorie content (Gerstein, Woodward-Lopez, Evans, Kelsey, & Drewnowski, 2004). Satiation refers to feelings of fullness that inhibit consumption within an eating episode whilst satiety refers to the sensation of fullness between eating episodes that inhibits further eating (Gerstein et al., 2004). Foods high in complex carbohydrate and dietary fibre, such as fruit and vegetables, can be beneficial in aiding maintenance of a healthy weight as they result in greater satiation and longer lasting satiety thus extending the interval between eating episodes and reducing

subsequent energy intake. Holt, Miller, Petocz, and Farmakalidis (1995) found that more energy dense, high fat foods, such as the cookies and crackers presented as unhealthy foods in the current study, have a lower satiety index than bulky, hydrated food high in fibre, carbohydrate, or water, such as the healthy carrots and grapes presented to participants in this study.

Fruit and vegetable consumption can increase satiation as they provide a greater bulk than more energy dense foods. Carrots and grapes have a much lower energy density (0.4 kcal/g and 0.7 kcal/g respectively) than cookies and crackers (4.9 kcal/g and 5.2 kcal/g), as such the greater the proportion of healthy calories participants the greater physical mass of food they consumed. Stomach distension, by volume of food consumed, is a key indicator of satiation, playing a powerful role in inhibiting further eating (Powley & Phillips, 2004). In addition, foods high in complex carbohydrate and dietary fibre can extend satiety as they are digested more slowly. These foods slow gastric emptying and small bowel transit, as a result nutrients are absorbed more slowly in the small intestine, prolonging satiety (Burton-Freeman, 2000). Indeed, studies have shown that controlled breakfast meals that are high in fibre or complex carbohydrate, and preload meals which contain dried fruit can significantly reduce lunch time energy intake and increase self-reported satiety (Farajian, Katsagani, & Zampelas, 2010; Levine et al., 1989; Pasman, Blokdijk, Bertina, Hopman, & Hendriks, 2003). By including both healthy and unhealthy foods the current study has been able to give a more nuanced picture of eating behaviours in mindful individuals. Mindfulness appears to allow both the inhibition of unhealthy eating and the initiation of healthy eating. Furthermore, although mindfulness may not reduce energy intake in a single eating episode it may promote healthier food choices which can aid in reducing energy intake over a more extended period.

As noted earlier, a pertinent methodological limitation of the current study was the failure of the mindfulness manipulation. I chose to use a mindfulness induction exercise to examine the role of mindfulness as this approach would enable me to infer the causal role of mindfulness. A typical body scan exercise as applied in Mindfulness Based Stress Reduction

(MBSR) lasts 45 minutes (J Kabat-Zinn, 1990) however in this study I applied a reduced 10-minute exercise in order to reduce the overall time of the study session and so minimise burden on participants. Unfortunately, manipulation check analyses showed that the mindfulness induction had not had the desired effect, there was no significant difference between body scan and control participants in state mindfulness immediately after engaging in the audio exercises. The approach taken in this study is analogous to that taken by Marchiori and Papies (2014) who found that a 14-minute mindfulness exercise buffered the effect of hunger on food intake. Furthermore, multiple studies have found effects when using similarly brief mindfulness manipulations including on recall of positively versus negatively valenced words (Alberts & Thewissen, 2011), and on state mindfulness assessed using the TMS, negative affect, and urge to drink alcohol (Vinci et al., 2014).

However, multiple researchers have also reported limitations in applying such brief mindfulness manipulations. Remmers, Topolinski, and Michalak (2015) found that an eight minute 'mindful mindset' induction produced no effect on intuitive thinking. Although this study did not include a manipulation check, the authors attribute the lack of effect to difficulties in inducing mindfulness in a laboratory setting, especially in novice participants and conclude that more intensive manipulations are required. Similarly, Parkin et al. (2014) found that a 15-minute body scan exercise, followed by one week of mindfulness practise and a further 15 minutes of mediation immediately prior to the experimental task, had no effect on interoception. These authors concluded that this was likely due to failure of the manipulation, as participants did not demonstrate an increase in dispositional mindfulness during the course of the study compared to a control group. Bellinger et al. (2015) abandoned their use of a 15-minute mindful breathing exercise after it failed to produce an effect on the same measure of state mindfulness used in the current study.

As discussed above, Petter et al. (2014) and Ortner & Zelazo (2014) found no main effect of brief mindfulness manipulations on experimental outcomes but did report that state mindfulness within the mindful condition was associated with hypothesised outcomes (see

also Eddy, Brunye, Tower-Richardi, Mahoney, & Taylor, 2015). These results that mindfulness inductions, particularly brief ones, may only be effective for a subgroup of participants who are able to enter a mindful state more quickly or with greater ease (Kabat-Zinn, 1990).

This literature suggests that whilst brief mindfulness manipulations may be sufficient to elicit hypothesised experimental effects they can be inconsistent or unreliable. The body scan recording used in this study was provided by Cropley et al. (2007) and has been shown to be successful in reducing cigarette craving among temporarily abstinent smokers in two separate studies (Cropley et al., 2007; Ussher, Cropley, Playle, Mohidin, & West, 2009). However, when applied in a different context and with further investigation of mindfulness processes it has failed to provide such robust effects. Ussher et al. (2014) applied the same 10-minute body scan manipulation in a population suffering with chronic pain. They found that, compared to a control task of listening to an audio book, the body scan exercise led to significant reductions in pain when conducted in a clinic. However, when the body scan was repeated by participants at home it did not result in significantly greater reductions in pain than the control condition. Furthermore, the body scan exercise did not lead to significantly greater changes in mindfulness measures which assessed present moment focus and pain-specific acceptance and decentring. It appears then that brief laboratory manipulations, such as the one used in this study, may not always be sufficient to induce a state of mindfulness in all participants and that inductions which have been successful in one population or context may not extend to alternative research questions. Taken together, mindfulness manipulations should be applied with caution and that manipulations that have been used successfully in one domain should be assumed to be equally successful in another. In subsequent studies, I consider such limitations when determining the most appropriate manner in which to assess mindfulness.

In this study, I aimed to investigate the mediating role of self-control in the relationship between mindfulness and eating behaviour. I had hoped to explore causal mechanisms by using a mindfulness manipulation exercise, unfortunately the failure of the

mindfulness manipulation prevents me from drawing reliable conclusions on the mediating role of self-control. Despite this, internal analyses offered an interesting insight into the interacting role of mindfulness and hunger in determining food choice. Specifically, mindfulness results in healthier food choices but only under conditions of low hunger, high levels of hunger are sufficient to override the benefits of a mindful state. Subsequent studies in the remainder of the thesis will now aim to investigate processes of mindfulness in a manner which is not reliant on brief inductions and use alternative measures of self-control in order to draw more robust conclusions about the mediating role of self-control.

Chapter 4.

Investigating processes of self-control in determining eating behaviour according to dispositional mindfulness: Two food cueing studies informed by Cybernetic models of control

Overview

Study 3 investigated the potential mediating role of self-control in the relationship between state mindfulness and eating behaviour, using a self-report measure of executive function. No such effect was found, but this study may have been hampered by the weakness of the mindfulness induction and the concordance between measures of state mindfulness and trait executive function. The studies described in the current chapter aimed to investigate the role of self-control without relying solely on self-reported executive function and focused on dispositional, rather than state, mindfulness. To do this, these studies are embedded in a theoretical approach based on the principles of cybernetic models of self-control. In two studies, one conducted online and one conducted in the laboratory, I presented food cues in an attempt to manipulate the need for self-control and observe the degree to which more and less dispositionally mindful participants were able to notice and respond to goal conflict. I hypothesised that more mindful participants would be less likely to respond to the presence of food cues with impulsive or automatic eating behaviour, inferring greater self-control in these individuals. Study 4 found a direct main effect of mindfulness, with more mindful participants reporting less intention to eat cookies after exposure to food cues, but Study 5 found no similar effect on consumption of chocolate. Although more mindful people appear to form more favourable dietary intentions, these intentions are not translated into action. There was no main effect of the cueing manipulation in either study, limiting the conclusions that can be drawn about the role of self-control.

4.1 Introduction

Thus far, my research has demonstrated a significant association between executive function, as an indicator of self-control, and dispositional mindfulness, but failed to find a mediating role of this variable in the governing eating behaviour following a mindfulness induction. The studies described in this chapter take a different approach to investigating processes of self-control. As covered in previous chapters, Teper et al. (2013) propose a model whereby mindfulness allows for greater awareness of and attention to goal conflict events, thus facilitating greater self-control. Based on this model I have proposed that greater capacity for self-control (as a result of greater mindfulness) may account for more favourable weight regulation outcomes in mindful individuals. In this chapter I consider this model within a wider framework of self-regulation processes and attempt to investigate behavioural indicators of self-control in more and less mindful individuals.

The model proposed by Teper et al. (2013) embodies the principles of cybernetic models of self-control. Self-control can be defined as an individual's ability to control or change responses to meet a given standard (Carver & Scheier, 2004) allowing individuals to alter their behaviour to be in line with their goals. Cybernetic models offer a transdisciplinary approach to understanding self-regulating systems. When applied to human behaviour, cybernetic models of control propose that self-control is defined by goal setting, monitoring for discrepancies between current behaviour and active goals (known as *error monitoring*), and then implementing behaviour to reduce the size of these discrepancies (Carver & Scheier, 1981). Thus, the cybernetic model operates on a negative feedback loop, the purpose of which is to reduce deviations from a comparison value (Carver & Scheier, 1982). In this feedback loop (shown in Figure 4a), the input value is the individual's perception of their current state, this is compared to a reference value representing the ideal desired state. If a discrepancy between the current perception and reference value is detected then behaviour is enacted with the aim of reducing this discrepancy. The behaviour impacts the environment and if this alters the current state then it is again compared to the reference value, forming a closed feedback loop.

External disturbances may alter the environment, and so the present state, independently of the feedback loop. The ability to monitor and respond to discrepancies between current and desired state, whether caused by one's own behaviour or external disturbance, reflects an individual's capacity for self-control. In the absence of control, the default response is to respond to external stimuli or transient desires without consideration of one's goals representing an automatic or habitual response (Metcalfe & Mischel, 1999).

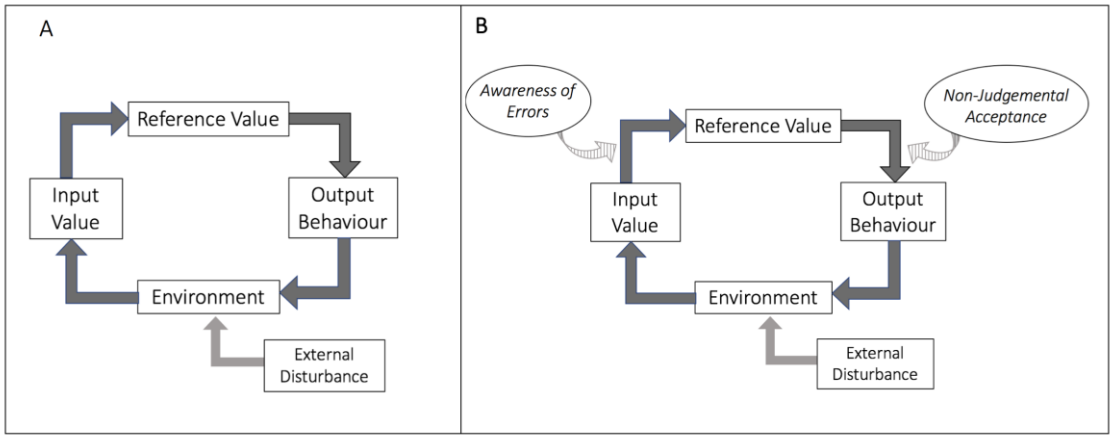

Figure 4. The negative feedback loop operating in cybernetic control (Panel A) and the role of mindfulness in supporting control (Panel B)

The model proposed by Teper et al. (2013) gives an account of how mindfulness enhances executive function and self-control and the process they outline is linked with principles of cybernetics. According to Teper and colleagues (see also Elkins-Brown, Teper, & Inzlicht, 2017) conflict between long-term goals and immediate desires or behaviours (i.e., a discrepancy between input and reference values) produces negative affect. Within this model self-control is seen as the inhibition and substitution of automatic response to these immediate desires with behaviours that are consistent with long term goals (Elkins-Brown et al., 2017). Greater moment-to-moment awareness, as is characteristic of mindfulness, increases attention to and awareness of the negative affect that arises from goal conflict, meaning that the discrepancy should be more likely to be noticed and therefore acted upon. In addition, acceptance of negative affect, another key tenet of mindfulness, enhances the ability

of negative affect to disrupt behaviour and engage self-control. Acceptance of the negative affect that arises from errors, rather than rumination, frees resources to remain focused on goals and error monitoring. Therefore, mindfulness enhances self-control at two points in the negative feedback loop, awareness of discrepancies between input and reference values (error monitoring), and more efficient response to this discrepancy (reduced habitual responding; see Figure 4b). Indeed, the act of meditation and application of mindful awareness have, in themselves, been characterised as a form of error monitoring, in order to keep attention focused on the present one must be able to detect when attention has deviated from this goal state and bring it back to the present moment (Marlatt & Kristeller, 1999).

Multiple studies point to the role of mindfulness in supporting error monitoring and in reducing habitual responding. Experimental paradigms that require participants to rapidly respond to incongruent and congruent stimuli, such as the Stroop Task (Stroop, 1935) and the Attentional Network Task (Fan, McCandliss, Sommer, Raz, & Posner, 2002), can give an indication of an individual's level of ability in error monitoring. During incongruent trials an automatic response must be overridden in favour of a less automatic but goal directed behaviour, producing a high level of response conflict. Such tasks offer a parallel to self-control conflict in the real world where individuals must override desires and cravings that conflict with long-term goals. Jha, Krompinger, and Baime (2007) found improved performance on the conflict monitoring component of the Attentional Network Task in experienced mediators compared to meditation naïve controls, whilst Tang et al. (2007) demonstrated improved performance on the same task following a 5-day meditation training programme. Similarly, several studies have shown that meditators outperform control groups in Stroop Tasks, demonstrating reduced interference from conflict on incongruent trials compared to non-meditators (Chan & Woollacott, 2007; Moore & Malinowski, 2009; Wenk-Sormaz, 2005). Also considering the outcomes of error monitoring in analytical thinking, mindfulness has also been shown to improve ability to override erroneous 'gut' responses in favour of further cognitive

reflection in order to reach a correct answer in problem solving tasks (Fitzgerald & Lueke, 2017).

Extending beyond studies of behavioural outcomes, EEG studies have monitored neural correlates of conflict monitoring. Error related negativity (ERN) is a brain potential generated by the anterior cingulate cortex (ACC) thought to reflect detection of and affective response to errors or conflict (Inzlicht & Al-Khindi, 2012), higher levels of ERN represent greater levels of conflict monitoring. In the first direct investigation of ERN and mindfulness Teper and Inzlicht (2013) had experienced meditators and controls complete a Stroop task whilst ACC activity was recorded using EEG. They found that meditators showed improved attention to goal conflict, indicated by higher ERN. In further support of Teper et al.'s (2013) model, this effect was directly predicted by acceptance of negative affect. This effect of greater ERN during conflict inducing tasks among more mindful participants has subsequently been replicated in a range of contexts including among experienced meditators (Andreu et al., 2017), following mindfulness inductions (Bing-Canar, Pizzuto, & Compton, 2016; Saunders et al., 2016), and in as a result of MBSR in older adults, a population that typically shows a decline in markers of performance monitoring (Smart & Segalowitz, 2017).

Eating behaviour is a typical example of an action that may trigger goal conflicts and the need for control, as desirable stimuli, such as calorie dense foods, must be resisted in order to satisfy long-term goals, such as a maintaining a healthy weight. Accordingly, individuals high in dispositional self-control report more healthy eating practices, lower BMI, fewer maladaptive eating behaviours (Junger & van Kampen, 2010; Konttinen et al., 2009) and have greater success in weight loss (Crescioni et al., 2011). Good health, however defined, represents a reference value or standard to be applied within a negative feedback loop (Carver & Scheier, 1982). For example, an individual may have a self-concept of being a healthy person or have a superordinate goal of weight loss, this goal informs subordinate reference values relating to quality of behaviour (e.g., following a healthy diet), which in turn determines a general course of action and more specific behaviours (such as avoiding high fat foods).

Although individuals who report having greater self-control have been shown to be quicker to identify and respond to goal conflict relating to unhealthy foods (Gillebaart, Schneider, & De Ridder, 2016), few studies have directly examined the relationship between obesity and error monitoring. However, those that do suggest that diminished ability in conflict monitoring is associated with poorer weight control. Kamijo et al. (2014) found that obesity in children predicted reduced ERN and post-error positivity (Pe), a slightly later potential than ERN which has increased motivational salience reflecting more conscious awareness of making an error, on a Flanker task, and Skoranski et al. (2013) demonstrated similar effects of blunted ERN and Pe in obese children. Franken, Nijs, Toes, and van der Veen (2018) found that adults who were categorised as having a food addiction showed reduced magnitude of ERN and Pe following a Flanker task. Furthermore, there was a significant association between BMI and Pe amplitude, indicating that less adequate conscious processing of errors is associated with greater BMI.

The available evidence, both in the form of the cybernetic model and empirical evidence linking reduced error monitoring to obesity and greater BMI, suggests that self-control afforded by awareness of goal conflict, and the ability to bring behaviour in line with goals rather than responding habitually, will be beneficial to regulation of a healthy weight. Given the role of mindfulness in supporting error monitoring, and in line with Teper et al.'s (2013) model, I propose that mindfulness should allow greater control over eating by increasing awareness of behaviour or environments which conflict with goals and by facilitating more efficient response to such conflicts. As discussed in Chapter 3, the current research base on the relationship between mindfulness and self-control in the context of eating is minimal. Although Jordan et al. (2014) found no effect of self-control in determining food choice in more mindful individuals, the use of an ego-depletion paradigm may represent a methodological limitation. My previous study attempted to investigate executive function (representing self-control) as a mediator using a self-report measure. This study also failed to find a mediating role of self-control following a mindfulness induction, but suffered from

limited utility of the mindfulness induction and a degree of incompatibility between the measures of executive control and mindfulness. The studies described in the current chapter apply a cybernetic model of control to examine behavioural processes of self-control rather relying on self-report measures constrained to the construct of attentional control.

According to the principles of cybernetic models (Carver & Scheier, 1982), environmental disturbance alters the present state of an individual independent of the negative feedback loop. These disturbances may take the form of external cues, such as presence of appetitive foods, that will elicit automatic responses that conflict with long term goals unless the individual is able to apply self-control (Metcalfe & Mischel, 1999). Those with greater capacity for self-control are more likely to demonstrate reflective behaviour in line with their long-term goals. In the current study I applied a cueing paradigm in which participants were presented with appetitive, environmental food cues intended to trigger a desire to eat, and monitored subsequent eating behaviour in order to infer the degree to which more and less mindful participants are able to enact self-control in situations of goal conflict.

Presentation of food-relevant stimuli is an external cue that can increase the chances of engaging in eating and amount of food consumed (Ferriday & Brunstrom, 2008). Even among those who aim to restrict their food intake, cues such as images and physical presence of food have been shown to increase motivation to eat and energy intake (Rogers & Hill, 1989), including greater consumption of high energy foods such as pizza and cookies following exposure to olfactory cues (Fedoroff, Polivy, & Herman, 1997). Cornell, Rodin, and Weingarten (1989) demonstrated that exposure to attractive foods increased desire to eat, which in turn predicted subsequent intake of that food, even in participants who had just eaten to satiety. Similarly, food advertising increases snack consumption in an automatic or non-conscious manner (Harris, Bargh, & Brownell, 2009). Such results suggest that exposure to food cues can trigger an impulsive or automatic response which results in food consumption. Indeed, Ditto, Pizarro, Epstein, Jacobson, and MacDonald (2006) found that food cues can trigger impulsive

behaviour across domains. In this study, the presence of freshly baked cookies resulted in more impulsive behaviour on a gambling task than simply being told that cookies would be available. By presenting participants with appetitive food cues I intend to make salient the discrepancy between desire to eat and healthy eating goals, the subsequent behaviour of participants when they are asked to indicate their intention to snack or are presented with the opportunity to eat will give an indication of their ability to override automatic responses and enact self-control.

The studies presented in this chapter use cueing paradigms, in which participants are presented with visceral food cues which should trigger the need for self-control. Subsequent behaviour, either self-reported motivation to eat or energy intake, will be examined in relation to participant's levels of dispositional mindfulness and be used to infer level of self-control.

4.2 Study 4

This study was conducted online and aimed to test the hypothesis that greater mindfulness would reduce the likelihood that participants would report a greater desire to eat following exposure to attractive food cues. The relative salience of food images was manipulated in order to vary the intensity of environmental food cues. Moore and Konrath (2015) have successfully used written and pictorial stimuli of varying descriptive or visual intensity to manipulate exposure to appetitive food cues. Their pilot testing of stimulus materials revealed that the relatively subtle manipulation of presenting identical images of pizza in either colour or black and white had a direct effect on self-reported craving for pizza, with colour images resulting in significantly greater craving (Moore & Konrath, 2015; *Study 4*). Adapting this paradigm, participants in the current study were presented with either black and white (pallid) or colour images (vivid) of cookies before reporting their desire to eat cookies. I predicted an interaction between mindfulness and the stimulus intensity manipulation, such that individuals high in dispositional mindfulness would not increase their intention to eat in response to vivid images as compared to pallid images. Conversely, I anticipated that

individuals low in dispositional mindfulness would report greater intentions to eat following the vivid image compared to the pallid image.

In light of results obtained in my previous studies, I included two additional variables of interest. In Study 2 I found a significant association between dispositional mindfulness and executive function as assessed by the Attentional Control Scale (ACS; Derryberry & Reed, 2002). However, in Study 3 I failed to find a significant association between state mindfulness and attentional control or, as a result, a mediating role of ACS on eating behaviour following a mindfulness manipulation. These conflicting results may be attributable to the discrepancy in state (mindfulness manipulation) versus trait (ACS) measurement used in the Chapter 3 study. Therefore, as the current study concerns dispositional rather than state mindfulness, I included ACS in order to test for a potential mediating effect of executive function.

In addition, I aimed to follow up on the results of Study 3 which showed a moderating effect of hunger, whereby hunger had an overriding effect on the benefits of a mindful state. Behavioural studies of eating tend to enact controls to ensure that hunger levels are consistent among participants (e.g. Federoff et al. 1997), rather than examining the moderating effects of hunger. However, neuroimaging studies have shown a modulating effect of hunger states on response to food cues, in which hunger is associated with increased neural activation following food cue exposure (Chin, Kahathuduwa, Stearns, Davis, & Binks, 2018; van der Laan, de Ridder, Viergever, & Smeets, 2011). Furthermore, Piech, Pastorino, and Zald (2010) have demonstrated enhanced attentional capture by food cues when participants are hungry, showing that food cues are more salient, and so likely to elicit greater effects, under conditions of hunger. Given the moderating role of hunger found in Study 3, I included a self-report measure of hunger level in the current study, and hypothesised a similar moderating effect to that seen in Study 3.

4.2.1 Method.

Participants. 150 participants (60 female, 89 male, 1 unreported; M_{age} = 29 years, SD = 9.02) were recruited using online using the Prolific Academic recruitment database. Participants were paid £2.17 for their participation.

Materials.

Mindful Attention Awareness Scale (MAAS). This is the same measure used in previous studies in this thesis, in this case Cronbach's alpha = .82.

Attentional Control Scale (ACS). The ACS (Derryberry & Reed, 2002) is the same measure used in previous studies in this thesis.

Derryberry and Reed (2002) state that the ACS can be split into shifting and focusing subscales. *Focusing* refers to the ability to control attention by focusing it in the face of distraction, whereas *shifting* represents flexible control over the content of one's thoughts. However, details of which items belong to each scale have not been published. Two previous factor analyses have been published which give factor structures for the two subscales (Judah et al., 2014; Ólafsson et al., 2011). These structures differ slightly though they are complementary, for this reason I conducted a new factor analysis on the current data. Principle components analysis using varimax rotation was conducted on responses to the ACS. Two factors were extracted with eigenvalues over 1.5 accounting for 40% of the variance and were labelled focusing (α = .84) and shifting (α = .75). I also computed an overall ACS score (α = .86).

Picture task. Participants were presented with a series of images and asked to assign them to one of two categories presented on screen (e.g., man-made or natural object; object does/does not begin with a vowel). Images designed to cue food craving were of cookies, foil images of a neutral object (trees) were also presented in order to mask study aims. In total 20 unique images were presented (10 food cues and 10 foils). Cookies and trees were presented

together in a random order, only one image and category decision question was presented at a time. Category judgement questions did not make any reference to eating or the nutritional properties of the item (for a similar use of a picture matching task as a means of priming see Geyskens, Dewitte, Pandelaere, & Warlop, 2008). For an example of stimuli presented to participants see Figure 5.

Figure 5. Examples of foil (trees) and food cue (cookies) images and accompanying category decision questions in vivid and pallid conditions

Behavioural intention. In a measure adapted from Moore and Konrath (2015), participants were asked four questions about their intentions to eat cookies (α = .91). Participants indicated the likelihood that they would: (1) “take a quick cookie snack if you had the chance now”, (2) “sample a cookie if you had the chance right now”, (3) “buy a cookie if you were out shopping right now”, (4) “eat a cookie in the near future” (1 = very unlikely; 9 =very likely).

***Procedure*.** All measures were delivered digitally using Qualtrics online survey software. Participants first completed the MAAS and ACS questionnaires before being randomly allocated to either the vivid (colour images) or pallid (black and white images)

condition and completing the picture task. Following the picture task participants answered the behavioural intention questions, gave a rating of their current level of hunger (1 = not at all hungry; 9 = extremely hungry) and an estimate of their height and weight. Participants were also asked some foil questions about nature (likelihood of donating to a woodland charity) to mask the true aims of the study.

4.2.2 Results and Discussion.

Body mass index. 131 participants reported height and weight data, mean BMI was 24.31 (SD = 5.36). There was a significant negative association between MAAS and BMI (r = -.19, p = .03, 2-tailed).

Primary analysis. In order to investigate the effects of mindfulness and condition on intention to eat cookies a hierarchical multiple regression analysis was conducted. In the first block condition and MAAS, along with their interaction were used as predictor variables with behavioural intention as the outcome. Mindfulness scores significantly predicted behavioural intention, (β = -.17, p = .03), such that greater mindfulness was associated with a lower intention to eat cookies. There was no main effect of condition (β = .17, p = .71) or an interaction between condition and mindfulness (β = -.04, p = .93)[7].

In the second block hunger scores (mean centred; Aiken & West, 1991) and the interaction between hunger and mindfulness were added. The effect of MAAS on intentions was reduced to marginal significance when controlling for hunger (β = -.14, p = .06). There was no significant direct effect of hunger (β = .17, p =.70) or a significant interaction between mindfulness and hunger (β = .23, p = .59).

Attentional control. When controlling for attentional control the impact of MAAS on intentions remains significant (β = -.174, p = .05). In order to examine the indirect effect of attentional control process analysis was conducted using a simple mediation model (Model 4,

[7] There was no moderating effect of gender on the effect of mindfulness on behavioural intention (β = -.03, p = .77)

Hayes, 2013) with 10,000 bootstrap resamples. MAAS was taken as the independent variable, attentional control as the mediating variable and behavioural intention as the dependent variable. MAAS had a direct effect on both intention (effect = -.65, p = .037, 95% CI [-1.26, -.034]) and ACS (effect = .27, p < .001, 95% CI [.016, .38]) but there was no indirect effect of ACS (effect = .00, 95% CI [-.26, .026])[8].

This study set out to investigate the role of self-control in the relationship between mindfulness and eating behaviour by exposing participants to vivid or pallid picture based foods cues and assessing their subsequent desire and intention to eat a high calorie snack (cookies). I hypothesised an interaction between mindfulness and condition such that participant with low levels of dispositional mindfulness would have greater intention to eat cookies following exposure to vivid food images as compared to pallid images. In contrast, those participants with high levels of dispositional mindfulness were not expected to increase their intention to eat as a function of intensity of food cues thus demonstrating greater self-control in the face of attractive visceral cues.

The results revealed a significant main effect of dispositional mindfulness on eating behaviour, such that individuals who were higher in mindfulness had less intention to eat cookies. Further analyses revealed that this relationship was not mediated by attentional control. Furthermore, although the effect of mindfulness on intention was reduced to marginal significance when controlling for self-reported hunger scores there was no interaction between hunger and mindfulness, suggesting no moderating role of hunger in the relationship between mindfulness and intention to eat.

However, the study revealed a non-significant interaction between mindfulness and condition. This might be attributable to the lack of a significant effect of condition, as the manipulation, by itself, did not elicit an effect on eating intentions. This implies that the vivid

[8] When using the shifting and focusing subscales of the ACS the overall pattern of results remained the same

versus pallid manipulation might not have been sufficiently strong. One factor that may have reduced the efficacy of this manipulation was the fact that this study was conducted online, thereby reducing experimenter control over extraneous variables that may have affected participants' attention to cues.

4.3 Study 5

The results of Study 4 showed that mindfulness predicted behavioural intention to eat following exposure to food cues. However, as there was no main effect of condition I was unable to provide a stringent test of the main hypothesis that mindfulness would buffer the impact of more vivid food cues. Therefore, a second study was conducted which applied a similar design in a more controlled laboratory setting, rather than being conducted online. In addition, this study used actual food consumption (of chocolate) as the dependent variable, rather than the behavioural intention proxy measure used in Study 4.

Study 5 used a lexical decision task to manipulate the presence of food cues. Previous research has used such a paradigm to vary the salience of food cues. For example, Papies, Stroebe, and Aarts (2008a) used a lexical decision task to expose participants to either attractive food words (e.g., pizza) or control food words (e.g., oatmeal) and found that attractive food words elicited attentional bias for food woods in a subsequent probe classification task among restrained eaters. The current study adapted this paradigm. Participants in the control condition (no cue) conducted a task using neutral words whereas those in the experimental condition (cued) were exposed to food related words. After completing this task, participants read two filler articles, during which time they were given the opportunity to consume chocolate. Chocolate was presented as a token of appreciation for participation, and whether or not participants took chocolate when offered was recorded as a binary variable. I predicted that participants with lower levels of dispositional mindfulness would consume more chocolate after they had been primed with food words, demonstrating an automatic response to environmental stimuli. In contrast, participants with high levels of

dispositional mindfulness would not increase their chocolate intake in response to cues as they will demonstrate greater levels of self-control governed by the ability to override automatic response in favour of behaviours in line with reference values and long-term goals.

4.3.1 Method.

Participants. A convenience sample of 100 undergraduate students (M_{age} = 21 years, SD = 3.67) were recruited and took part in return for course credit or payment (£3). Eligibility was restricted to female participants because gender differences in food intake have been documented in laboratory work (e.g., Greenwood, Broadbent, & Fuller-Tyszkiewicz, 2014; Sharp, Sobal, & Wansink, 2014) as well as the limited availability of males among the undergraduate participant panel. Data from three participants were excluded as these participants reported being vegan or dairy free and so were not able to eat chocolate. Data from one further participant were excluded as she reported difficulty in understanding the lexical decision task procedure, resulting in a final sample size of 96.

Materials.

Mindful Attention Awareness Scale. This was the same measure as used in previous studies.

Lexical decision task. A lexical decision task (Papies et al., 2008a) in which participants had to indicate whether a string of letters forms a real word or not, was used in order to manipulate the presence of food cues. All participants were presented with 60 letter strings, 30 of which represented real words and 30 of which were non-words. In the experimental (cued) condition 15 of the real words related to food, these words concerned foods which are typically considered to be highly palatable and/or unhealthy (e.g., pizza, cake, chocolate), the remaining 15 real words were neutral (e.g., cabin, photograph). Nonsense words were taken from the English Lexicon Project database (see Balota et al., 2007). Words in each category were matched for length and ranged from 3 to 10 letters. In the control (no cue) condition all real words were neutral. Stimuli were presented using DirectRT (Version 2012; Empirisoft). All

letter strings were presented individually, preceded by a fixation cross. Participants indicated whether the letter string was a word or non-word with a key press.

Food. Individually wrapped chocolate wafers (KitKat Mini; Nestlé) were presented to participants. All participants were presented with 10 chocolates (87 kcal per piece), as portion size has a documented effect on amount consumed (Zlatevska et al., 2014). Chocolate was not visible to participants until after they had completed the lexical decision task in order to prevent the presence of chocolate from acting as an additional food cue.

Filler tasks. Participants read two popular science articles, one taken from BBC news and one from The Guardian newspaper. These articles concerned space travel and electronics and did not contain any references to food, eating, or mindfulness. Participants then rated their enjoyment of the article on Likert scales. Participants also completed the BIS/BAS measure (Carver & White, 1994) during this stage of the session, this measure was included only as a foil, it did not generate any meaningful effect and is not discussed any further.

Procedure. Upon arrival participants were seated at a computer and first completed the MAAS and then the lexical decision task. After completing these tasks, they moved to another desk and completed the filler tasks. During this part of the session participants were presented with the chocolates and told that they may take as many as they wished, as a thank you for their participation, whilst completing the reading and questionnaire tasks. Chocolate was not visible to participants until after they had completed the lexical decision task. The purpose of the filler tasks was to create an interval in which participants were free to eat chocolate. The researcher remained in the room, seated with their back to the participant for the duration of the session. Once participants had completed these tasks and had the opportunity to take chocolate they provided demographic information, including age and an estimate of their height and weight. Participants were also asked to give an estimate of how long it had been since they last ate. This measure was used as a proxy for hunger (Shimizu, Payne, & Wansink, 2010), as by the time that participants provided demographic information

they had already had an opportunity to eat chocolate which may have biased ratings of hunger given on a Likert scale such as the one used in Study 4. Before being debriefed participants were asked if they had any ideas about what the study hypothesis might be[9] and were asked not to discuss the study aims with any other potential participants.

4.3.2 Results and Discussion.

Body mass index. Height and weight data were provided by 88 participants, mean average BMI was 21.96 (SD = 2.89). There was no significant association between MAAS and BMI (r = -.12, p = .29), though the effect was in the same direction as Study 4.

Primary analysis. In order to investigate the effects of mindfulness and condition on chocolate consumption a hierarchical multiple logistic regression analysis was conducted. Logistic regression was used as the outcome measure in this case was binary, 35 participants took chocolate when offered a reward for their participation and 61 did not. In the first block condition and MAAS, along with their interaction, were used as the predictor variables and whether or not participants took chocolate when offered a reward (as a categorical variable) was the dependent variable. Mindfulness had no significant main effect on chocolate consumption (OR 1.59, p = .39), neither was there a main effect of condition (OR 14.46, p = .29), or an interaction between condition and mindfulness (OR 0.47, p = .27).

The time in minutes since participants had last eaten (TSE) was used as a proxy measure of hunger. In the second block TSE and the interaction between TSE and mindfulness were included. There was no main effect of TSE (OR 1.00, p = .41) or an interaction between TSE and mindfulness (OR 1.00, p = .47).

Building upon Study 4, this study aimed to further investigate the role of mindfulness in buffering the effect of environmental food cues, in this case presenting food cues in a more

[9] Six participants reported suspicions about their eating behaviour being assessed and one participant was familiar with the mindfulness measure, but no participants made a connection between mindfulness and eating. A further four participants requested chocolate after they had been fully debriefed and informed of the study aims. All patterns of results remained the same when data from these participants (n =11) were excluded.

controlled environment and covertly monitoring food intake. I hypothesised an interaction between mindfulness and condition, in which participants with lower levels of dispositional mindfulness would eat more chocolate following exposure to food cues than participants high in dispositional mindfulness. No such interaction was identified and there was no main effect of condition, suggesting that the food cues used in this manipulation were not salient enough[10].

4.4 General Discussion

The studies outlined in this chapter investigated the role of self-control in the relationship between mindfulness and eating behaviour. This was tested by manipulating the environmental antecedents that signal the need for self-control. Specifically, I presented participants with appetitive food cues and monitored subsequent behaviour based on the assumption that those participants with greater capacity for self-control would demonstrate behaviour that was less influenced by the presence of food cues. Although Study 4 revealed a main effect of mindfulness in determining behavioural intention to eat cookies, this effect was not replicated in Study 5, when chocolate consumption was monitored. Furthermore, there were no main effects of condition in either study, suggesting that the cueing manipulations may not have been of sufficient intensity or salience.

Study 4 found a main effect of dispositional mindfulness, in which more mindful participants reported lower behavioural intention to eat cookies following exposure to images of cookies (regardless of the intensity of the food cue). This effect is consistent with work showing reduced reactivity to food cues as a function of mindfulness (Fisher et al., 2016; Hendrickson & Rasmussen, 2017; Keesman, Aarts, Häfner, & Papies, 2017). Mindfulness has also been shown to reduce reactivity to addiction relevant cues in the context of alcohol (Garland, 2011), opioids (Garland, Froeliger, & Howard, 2014), and tobacco (Westbrook et al.,

[10] In further investigation of the null effect of the cueing paradigm I compared reaction time in the cued and non-cued condition. There was no significant difference between these conditions (t (97) = .33, p = .74) suggesting no enhanced motivational salience of the food cue over neutral words.

2013). However, Study 5 found no main effect of the same measure of dispositional mindfulness on energy intake, assessed by chocolate consumption. These results suggest that greater mindfulness may be sufficient to alter healthy eating *intentions* but that this does not necessarily translate into healthier behaviour. In the context of Teper et al.'s (2013) model these results could be interpreted as mindfulness allowing greater recognition of goal conflict which then allows more positive intentions regarding eating, however more mindful individuals are then failing to respond to this goal conflict in a meaningful way and so do not translate these intentions into behaviour. This pattern of results is consistent with a large body of work on the intention-behaviour gap (Sheeran, 2002), which shows that intentions are often not predictive of corresponding behaviour. Indeed, a review by Webb and Sheeran (2006) of experimental tests of intention-behaviour relations found that, in terms of effect size, medium to large changes in intention only translate into small to medium changes in behaviour. Similarly, large intention-behaviour gaps have been demonstrated in the context of health and eating behaviours (Baumann et al., 2015; de Bruijn, Kroeze, Oenema, & Brug, 2008), with intentions only accounting for 7.6% of variance in fruit and vegetable intake and 4.8% of variance in saturated fat intake in one sample (Mullan, Allom, Brogan, Kothe, & Todd, 2014). Mullan et al. note that their study continued a trend of wide intention gaps for eating behaviours in young adults and student samples (Allom & Mullan, 2012; Kothe, Mullan, & Butow, 2012). Given that the sample used in Study 5 consisted of young adults, the majority of whom were students, it is likely that disparities between intentions and behaviours were amplified which may account for the failure to find any effect of mindfulness on eating behaviour in Study 5 despite favourable outcomes for intentions in Study 4.

Nevertheless, the lack of a main effect of mindfulness on chocolate consumption in Study 5 appears to be at odds with research which shows an association between mindfulness and healthier day-to-day eating habits (Beshara et al., 2013) and with the results of the study reported in Chapter 3, where state mindfulness resulted in healthier food choice. This effect may be attributable to the method of assessing eating behaviour used in the current study.

Unlike the study in Chapter 3, where participants were presented with both healthy and unhealthy foods to eat, in the current study only chocolate was available, and consumption was assessed as a dichotomous variable. The previous study found an effect of mindfulness on food choice, with greater mindfulness resulting a greater calorie intake from fruit and vegetables, but no effect on *total* calorie intake. This suggests that more mindful people are more inclined to make healthy decisions when given the option, however if no alternative is presented (as in the current study) the benefits of mindfulness may not be apparent. As such, mindfulness may aid individuals in making healthier food choices in complex environments which present multiple eating opportunities, but be of less use in suppressing tendencies to eat a single salient food presented in a controlled laboratory environment. In addition, the fact that chocolate was wrapped and presented as a 'reward' may have affected behaviour in this study in a way which explains the difference between these results and those of study 3. When participants were presented with unwrapped food and asked to eat at least one item in study 3, their level of consumption may reflect their ability to inhibit automatic tendency to continue to eat. In this study, whether participants choose to take a wrapped chocolate may reflect a more conscious decision to eat. It may, therefore, be more enlightening to investigate relationships between mindfulness and more holistic, everyday eating behaviours.

The failure to demonstrate a main effect of condition in either study limits the conclusions that can be drawn about the role of mindfulness in determining self-control responses following exposure to food cues. Although both the image task and the LDT task used in the current studies have been used successfully in previous research to manipulate the presence of food cues (see Moore & Konrath, 2015; Papies et al., 2008a) in the current research neither manipulation produced a main effect on eating behaviour outcomes.

Given the nature of food as a primary reinforcer with intrinsic hedonic value (Beaver et al., 2006; Passamonti et al., 2009), the lack of a main effect of cueing in these studies was unexpected. Food cueing is a commonly used procedure and a wide body of research has successfully utilised food cueing paradigms similar to that employed in the current study (e.g.

Cornell, Rodin, & Weingarten, 1989; Fedoroff, Polivy, & Herman, 1997; Ferriday & Brunstrom, 2008; Harris, Bargh, & Brownell, 2009; Rogers & Hill, 1989). That said, since Studies 4 and 5 were conducted there has been a critique of research relying on priming effects, amid concern about the replicability of such effects (Schimmack, Heene, & Kesavan, 2017). Harris, Coburn, Rohrer, and Pashler (2013) argue that whilst perceptual priming (the cognitive priming of semantically or conceptually related representations) is a robust effect, the more recent advent of priming of motivational states, behaviour, or attitudes may be less valid. Harris et al. (see also Pashler, Coburn, & Harris, 2012) reported null effects in a direct replication of a seminal study of such motivational priming, the priming of achievement through exposure to performance goals (Bargh, Gollwitzer, Lee-Chai, Barndollar, & Trötschel, 2001). Harris et al. argue that, in part, researchers should be sceptical of social or motivational priming as there is no clear functional purpose to such priming effects and so the mechanism of action of these effects is unclear. However, although this may be a valid critique of motivational priming in general, the priming of feeding behaviour with food cues may be an exception as it serves a clear adaptive purpose. Food detection and acquisition is essential in the survival of all species (Morley & Levine, 1983) and serves a basic evolutionary purpose (Denton, 2005). Berthoud (2007) has proposed a model of the evolved mechanism of food seeking which includes a role of cues in stimulating food intake through the action of visual and olfactory cues on the thalamus and limbic system, an effect which is enhanced by modern environments and lifestyles. Nummenmaa, Hietanen, Calvo, and Hyönä (2011) used a visual search paradigm to demonstrate that the human visual system is biased towards detecting food objects among non-food objects in cluttered visual environments, and suggested that the human cognitive system has evolved to facilitate energy intake by biasing attention towards environmental food cues. Taken together these examples provide both a functional purpose and mechanism of action for priming of energy intake through presentation of food cues. In combination with the studies mentioned above which show a facilitatory effect of food cues on consumption it appears that the food cueing paradigm is a valid research tool.

That said, there are several potential moderators and extraneous influences that have been documented as having an effect on food cueing, failure to account for these moderators may explain the null effects of condition observed in the current studies. For example, cue specificity may play a role, food cues are more likely to trigger craving for or consumption of matched foods. Olfactory cues of fruit scent increase likelihood of selecting fruit based desserts but do not affect vegetable selections (Gaillet, Sulmont-Rossé, Issanchou, Chabanet, & Chambaron, 2013; Zoon, de Graaf, & Boesveldt, 2016), and similar effects have been reported for unhealthy foods such as pizza and cookies (Fedoroff et al., 1997). Although cue and outcome foods were matched in Study 4 (cookies), Study 5 merely used general food words to prime chocolate consumption. Ferriday and Brunstrom (2011), however, have reported that cueing effects may generalise beyond the cued food. Participant characteristics may also impact the effect of food cueing, Forwood, Ahern, Hollands, Ng, and Marteau (2015) have reported that educational level moderates the effect of cueing, with more educated participants being more susceptible to healthy eating priming. Fishbach, Friedman, and Kruglanski (2003) demonstrated that for individuals who reported being successful in regulating their weight, and placed greater value on the importance of dieting, the use of primes can actually activate representations of dieting goals, and so reduce energy intake. Yet another factor which may alter the effect of food cueing is the intensity of the cue or the context in which it is presented. Coelho, Jansen, Roefs, and Nederkoorn (2009) draw a distinction between 'attended' and 'incidental' cues, they found that the mere presence of food did not significantly alter energy intake compared to a control condition on a bogus taste test but that an attended cue, in which participants wrote about their thoughts relating to presented foods, resulted in significantly increased intake. Similarly, although participants have been shown to eat more when watching a cookery TV show (Bodenlos & Wormuth, 2013), watching a TV show that contains subtly embedded food cues throughout can result in *reduced* food intake compared to controls (van Nee, Larsen, & Fisher, 2016). The food cues used in the current studies, particularly the lexical decision task in Study 5, could be said to

represent incidental cues and as such may have had a weaker effect on eating behaviour than cue tasks in which participants are required to specifically attend to the qualities of food stimuli. A final factor which has been shown to have an important moderating influence is that of dietary restraint, the tendency to restrict diet in order to control weight. Participants high in dietary restraint are frequently found to be more responsive to food cues (Polivy & Herman, 2017). Hofmann, van Koningsbruggen, Stroebe, Ramanathan, and Aarts (2010) used a Lexical Decision Task manipulation, similar to that used in Study 5, to examine hedonic responses to food. They found that restrained eaters responded to food cueing to a significantly greater extent than non-restrained eaters. A similar pattern of results was reported by Papies et al. (2008a). It appears then that although food cueing is considered a valid paradigm, the action of multiple moderators means that it may not always reliable. Failure to carefully consider and control for these influences *a priori* can undermine the efficacy of food cueing approaches.

Although the primary method of investigating the role of self-control, the priming procedure, was not successful, the inclusion of the Attentional Control Scale (ACS) in Study 4 does provide some useful insights into the role of executive function and extends the results obtained in Chapter 3. Study 4 found that ACS did not mediate the relationship between dispositional mindfulness and intention to eat cookies, across cue intensity conditions. This result is consistent with work from Jordan et al. (2014) that found no effect of ego-depletion in moderating the relationship between mindfulness and food choice. It is also consistent with the results of Chapter 3 where ACS did not mediate the relationship between state mindfulness and food selection. However, in this previous study my results were open to some speculation as there was no significant relationship between mindfulness and ACS. This raised the possibility that the mindfulness manipulation used was simply not sufficient to affect attentional control, rather than there being no true effect of ACS. In contrast, in the current study there was a direct effect of MAAS on ACS, thus providing further support for the proposal that attentional control may not play a mediating role in the relationship between mindfulness and eating behaviour.

Across these two studies, I did not find an interaction between hunger and mindfulness, suggesting no moderating effect of hunger. This contrasts with the results of the study reported in Chapter 3 which showed an 'over-riding' effect of hunger on the benefits of mindfulness such that greater mindfulness was only associated with reduced food consumption under conditions of low hunger. However, there are important methodological and design differences between that study and the studies reported in the current chapter which might explain this disparity. In Study 5 rather than using ordinal hunger ratings participants reported how long it had been since they last ate and this was used as a proxy measure for hunger. I took this approach in an attempt to mask the true aims of the study as much as possible so that participant's eating behaviour was not affected by the knowledge that their consumption was being monitored (see Stubbs et al., 2014). This meant that hunger ratings were not obtained until *after* participants had been given the opportunity to eat and so ordinal hunger rating were not used as they may have been biased by recent consumption. This proxy measure is likely to give an inaccurate measure of the levels of hunger that participants were truly experiencing when compared to the self-report measure that was used in our previous study (Mattes, Hollis, Hayes, & Stunkard, 2005).

However, this explanation does not apply to the results of Study 4, as this study used the same hunger measure as that used in Chapter 3. The difference in methodology here pertains to differences in the measurement of mindfulness rather than hunger. Chapter 3 concerned the role of *state* mindfulness, assessed using the Toronto Mindfulness Scale (TMS; Lau et al., 2006). In contrast, the MAAS used in the current study assesses mindfulness at the *dispositional* level. Mindfulness as a personality trait could be considered as more stable and enduring that a mindfulness state induced by a brief manipulation. This may explain why hunger did not have an overriding effect in this study as it did in our previous work. Indeed, TMS and MAAS may in fact measure slightly distinct constructs. Thompson and Waltz (2007) found no significant association between mindfulness scores assessed by MAAS and scores on

the TMS following a 15-minute manipulation and suggested that state mindfulness may not be representative of more general dispositional or 'everyday' mindfulness.

These studies attempted to investigate processes of self-control in more and less mindful individuals by manipulating presence of food cues, however the cueing paradigm did not have an effect in either study. There was a main effect of mindfulness in Study 4, with more mindful participants less likely to report intention to eat across conditions. However, this effect was not replicated in Study 5 when participants were presented with chocolate to eat. This effect may represent an intention-behaviour gap whereby mindfulness allows individuals to better recognise goal conflicts and so form self-control intentions, but does not aid translation of such intentions into action. Alternatively, given that my previous study indicated that mindfulness facilitates healthier food choice but not necessarily calorie intake it may be that assessing consumption of a single unhealthy foodstuff in isolation is not the most appropriate method of assessing eating behaviour in mindful individuals. Considering the difficulties in applying cueing methods encountered in these studies, and the potential confound presented by use of a single outcome measure, further studies are likely to utilise alternative measures of self-control or self-regulation and investigate food choices or daily eating behaviour.

Chapter 5.

Longitudinal investigation of the role of mindfulness, Self-Determination Theory, and the cognitive accessibility of dieting goals in determining self-regulation of diet and weight in a first-year student sample

Overview

In the final study of this thesis I expanded my investigation beyond the assessment of self-control to include broader processes of self-regulation. This approach allowed the study to encapsulate not only capacity to control behaviour but also the motivations and goals that govern behaviour. I applied Self-Determination Theory (Ryan & Deci, 2000), a model of motivation and behavioural regulation, to examine motivations and values underlying day-to-day eating behaviour and self-regulatory styles in more or less mindful individuals. Alongside this I also applied a task measure of self-control specific to dietary behaviour, an assessment of goal accessibility. This measure assesses the extent to which participants cognitively activate representations of their dieting goals when presented with food relevant primes, with greater accessibility of dieting goals indicative of greater self-control (Fishbach et al., 2003). In a longitudinal design, I collected data from participants over 18 weeks during a high-risk period for poor diet and weight gain, namely the transition to university. I hypothesised that mindfulness would be associated with more favourable weight and dietary outcomes through use of more adaptive regulatory styles, and greater accessibility of dieting goals, indicating greater self-control. Although mindfulness was not associated with greater autonomous regulation, it was associated with lower levels of controlled regulation and buffered against the detrimental effect of controlled regulation on BMI. Rather than increasing use of adaptive regulatory styles, mindfulness appears to reduce the impact of detrimental styles. There was no evidence to support greater levels of goal accessibility in response to food primes as a function of mindfulness. In fact, mindfulness was associated with increased response latencies suggesting that mindfulness may be associated with more deliberative responding rather than automatic self-control processes.

5.1 Introduction

Self-regulation refers to the ability to regulate one's behaviour to a given standard via deliberative or automated use of specific mechanisms, and incorporates goal directed and self-control behaviours (Hofmann et al., 2012; Karoly, 1993; Vohs & Baumeister, 2004). As such, it is relevant to weight management and eating behaviour, which often requires that individuals meet appropriate standards of diet and activity. Research has demonstrated that self-regulatory capacity accounts for significant variance in the ability to adhere to healthy eating intentions (see e.g., Allan, Johnston, & Campbell, 2011). Thus far, the studies in this thesis have focused on examining the role of self-control in determining eating behaviour in more and less mindful individuals. While self-regulation can be broadly defined as goal directed behaviour, self-*control* represents a narrower subset of self-regulatory processes which predominantly aim to override impulsive, or prepotent, responses (Hofmann et al., 2012). Self-regulation is thought to comprise of three main components: standards of thought or feeling that an individual endorses, motivation to invest effort in reducing discrepancies between these standards and current behaviour, and capacity to reduce such discrepancies (Hofmann et al., 2012). Self-control, and the studies investigating it in this thesis, concern the capacity to reduce discrepancies between goals and desired behaviour. In this final study, I took a broad approach that examined both overarching processes of self-regulation, conceptualised within the framework of Self-Determination Theory (Deci & Ryan, 2000; Ryan & Deci, 2000), and more specific processes of self-control in relation to food cues, based on the principles of Counteractive Control Theory (Trope & Fishbach, 2000).

The studies in the previous chapters have investigated self-control in discrete events, when one's behaviour or environment is not in line with one's goals, through investigation of executive function, or by manipulating environmental cues in order to observe habitual responses and the ability to override them. Although this approach is informative regarding self-control processes, it is not intended to offer insights about the more general motivations and goals underlying behaviour, in other words the overarching self-regulatory processes that

govern behaviour on a daily basis. Self-Determination Theory (SDT; Deci & Ryan, 2000) further elaborates on the role of motivation in shaping behaviour. SDT is a model of motivation and behavioural self-regulation that distinguishes between motivations that emanate from the *self* (i.e., are self-determined) and those that are *externally* controlled.

According to SDT, an individual's motivations for a behaviour can be classified along a continuum that varies from non-self-determined, known as *controlled motivation,* to self-determined, *autonomous motivation* (see Figure 6). Motivations affect behaviour by determining the style in which individuals regulate their behaviour. Controlled motivations give rise to controlled styles of behavioural regulation (external regulation and introjection). These are characterised by an external locus of causality in which behaviours are performed as a result of external reward and punishment contingencies or internal self-imposed pressures such as guilt or shame. In contrast, styles of regulation driven by autonomous motivations (integration, identification, and intrinsic motivation) are characterised by an internal locus of causality, whereby behaviours are performed because they are congruent with the individual's values and sense of self, or for their own enjoyment (see Pelletier, Dion, Slovinec-D'Angelo, & Reid, 2004; Ryan & Deci, 2000).

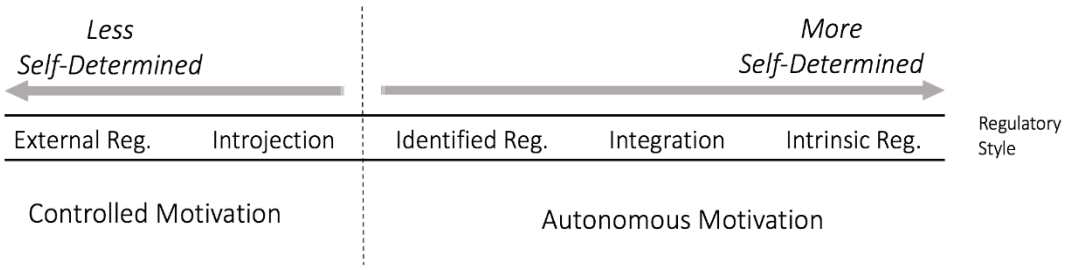

Figure 6. Motivation and regulatory style placed along the scale of self-determination

Within the principles of SDT, the maintenance of behaviours over time is dependent on the extent to which an individual internalises and values the behaviour, that is, the extent of autonomous motivation (Ryan, Patrick, Deci, & Williams, 2008). SDT has been frequently applied to health behaviours as it focusses on the processes through which an individual

acquires motivation for initiating or maintaining new behaviours over time. As such, SDT can be readily applied to weight management. Indeed, cross-sectional designs have shown that greater autonomous motivation (as a global trait) is positively related to weight regulation, and support for autonomy from significant others being associated with healthier eating and greater physical activity (Guertin, Barbeau, Pelletier, & Martinelli, 2017; Hartmann, Dohle, & Siegrist, 2015; Ng, Ntoumanis, & Thogersen-Ntoumanis, 2014). Furthermore, autonomous regulation and autonomy support have consistently been shown to predict favourable outcomes in weight loss interventions. For example, Silva and colleagues have found that satisfaction of basic needs, as outlined in SDT, during a behavioural weight loss intervention predicted greater autonomous regulation and resulted in greater physical activity throughout the intervention and at 1-year follow up, and predicted weight loss at 3-year follow up (Silva et al., 2010, 2011). Similarly, Gorin, Powers, Koestner, Wing, and Raynor (2014) found support for autonomy and autonomous self-regulation to predict weight loss over 18 months following an intervention. Baseline autonomous regulation has also been shown to predict weight loss and weight loss retention in a diabetes prevention intervention targeted at obese adults at risk of type 2 diabetes (Trief, Cibula, Delahanty, & Weinstock, 2017), and support for autonomy from parents predicts more favourable dietary practices in adolescents with type 1 diabetes, a population who must carefully control their dietary content (Austin, Senecal, Guay, & Nouwen, 2011). Integrating these lines of work, a recent review by Teixeira, Silva, Mata, Palmeira, and Markland (2012) concluded that autonomous forms of motivation are associated with more positive diet and exercise outcomes in studies of weight loss interventions, including physical activity and weight loss maintenance. In contrast, none of the studies reviewed suggested that more controlled forms of regulation were conducive to improved weight control, especially in the long term.

Self-determination theory has also been theoretically linked to mindfulness. Mindfulness may support autonomous functioning as it plays a central role in integrated regulation. Weinstein, Przybylski, and Ryan (2013) highlight three key components of

integration, one of which is awareness. Awareness, or access to self-knowledge, including emotions, motives, and values, facilitates integration because it allows individuals to determine behaviours based on pre-existing beliefs, values, and needs (see also Deci et al., 2015). Awareness is a key component of dispositional mindfulness (Brown & Ryan, 2003), and Weinstein et al. (2013) focus their discussion particularly on *mindful* awareness because of its nature as an open and receptive, rather than evaluative, form of self-awareness. In the context of SDT, mindful attention allows individuals to openly consider their own needs and values, rather than imposing judgements on their desires (Ryan, 1995) and so facilitates integrated regulation by allowing individuals to pursue their own interests and values as they appear, without imposing personal contingencies and expectations on them (Weinstein & Ryan, 2011). Indeed, mindfulness has been linked to indicators of integration. In particular, dispositional mindfulness, as assessed by the Mindful Attention Awareness Scale (MAAS; Brown & Ryan, 2003), is associated with greater levels of day-to-day autonomous functioning (Brown & Ryan, 2003; Levesque & Brown, 2007).

Alongside this investigation of self-regulatory processes, the current study also continues investigation of the role of more specific self-control processes. Studies 4 and 5 used a food cueing paradigm that was intended to manipulate the need for self-control. However, because the manipulation did not elicit a main effect of food cueing, I was unable to draw clear conclusions regarding the role of self-control. A key moderator on the impact of food cues that was not addressed in these studies is the role of dietary restraint. Restraint is the tendency to restrict energy intake in order to lose or manage one's weight (Herman & Polivy, 1980). Food cueing appears to have a greater effect in restrained than in non-restrained eaters, with restrained eaters showing elevated responsivity to food cues and greater energy intake following exposure to food cues than non-restrained eaters (Fedoroff et al., 1997; Harvey, Kemps, & Tiggemann, 2005; Polivy & Herman, 2017). Hofmann, van Koningsbruggen, Stroebe, Ramanathan, and Aarts (2010) found that food cueing elicited elevated response in which restrained eaters were increasingly sensitive to the hedonic aspects of foods over time,

whereas non-restrained eaters showed down-regulation of hedonic affect over time. Indeed, the lexical decision task used in Study 5 was based on a study design used by Papies et al. (2008a) which only recruited restrained eaters as participants. Not accounting for dietary restraint and so distinguish restrained from non-restrained eaters in the previous studies may have masked effects of the cue manipulation.

The results of Hofmann et al. (2010) and Papies et al. (2008a) suggest that food cueing may still be a useful and informative paradigm when participants' level of dietary restraint is taken into account. Fishbach et al. (2003) demonstrated an interesting pattern of results when using subliminal food priming in a lexical decision task which suggests that priming procedures may be used as a task measure of self-control in themselves. Fishbach et al. recruited participants who scored highly on concern for dieting, a measure analogous to dietary restraint, and presented them with food related subliminal primes in a lexical decision task. They found that participants who reported greater success in managing their weight were quicker to respond to diet goal words following food primes than following control primes. In contrast, participants who reported being unsuccessful in weight management responded more slowly to diet words after being primed with food words. This finding implies that successful dieters respond to food relevant primes by activating cognitive representations of dieting goals, whereas unsuccessful dieters inhibit such representations. A further study demonstrated that environmental food primes resulted not only in increased goal accessibility on the lexical decision task, but also led to healthier food choices when participants were offered the choice of an apple or chocolate bar. Further, this pattern of goal activation and inhibition in successful and unsuccessful self-regulators has been replicated by Papies, Stroebe, and Aarts (2008b). It appears then that this technique can be used to identify more and less successful dieters, as indicated by degree of goal activation in response to primes, and so may be used as a task measure of self-control in the specific context of dietary behaviour.

This work is in line with the principles of Counteractive Control Theory (Trope & Fishbach, 2000), which proposes that, in some situations or individuals, environmental cues or

temptations can actually trigger, rather than undermine, self-control. In the face of immediate temptation individuals must enact self-control in order to meet long term goals. The pattern of results demonstrated by Fishbach et al. (2003) represents cognitive goal activation, or *goal accessibility,* which is one strategy for exerting counteractive control. Cognitive connectionist principles assume that goals are held in cognitive networks supported by facilitative and inhibitory links (Kruglanski et al., 2002). The principles of automaticity state that environments can automatically elicit representations of goals without conscious awareness and produce the same effects as conscious goal pursuit (Bargh & Chartrand, 1999). Goal accessibility, therefore, is a process by which temptations in one's environment activate non-conscious representations of long term goals triggering goal congruent behaviour. The degree to which individuals activate or inhibit goals in the face of temptation is, therefore, an indicator of their ability to engage in in self-control.

Fishbach et al. (2003) propose that repeated pairing of temptation and awareness of one's long term goals results in the development of automatic facilitative links between the temptation and long term goals. These facilitative links then function as a form of low level self-control in themselves, as the need for conscious control 'drops out' (Bargh & Chartrand, 1999), and operate independently of conscious control or cognitive resources. Fishbach and colleagues suggested that the development of such facilitative links contributes to self-regulatory success. Although the nature of such results is correlational and bidirectionality cannot be ruled out, more recent work from Kroese, Adriaanse, Evers, and De Ridder (2011) has shown that temptation-goal associations can be established in non-successful dieters with subsequent impact on eating behaviour.

This line of work can be integrated with conceptualisations of mindfulness. Most notably, Teper et al. (2013) propose that mindfulness enhances executive function by increasing awareness of and attention to goal conflict events, thus allowing greater self-regulation. The principles of goal activation propose that facilitative links develop over repeated use of conscious self-regulation. The fact that more mindful people are better able to

recognise and respond to goal conflict may give them an advantage in developing automatic associations between temptations and goals and lead to self-control becoming automatically activated more readily. Indeed, researchers from the field of meditative practice have suggested a similar process in attentional regulation. Cultivation of focused attention meditation, a common feature of mindfulness practice, involves conflict monitoring, and selective and sustained attention and develops following an inverted U-shaped function. Novice meditators must continually monitor for mind wandering and re-centre attention, however at more advanced levels the need for such active regulatory skills becomes less frequent and a process of 'effortless concentration' develops (see Lutz, Slagter, Dunne, & Davidson, 2008).

In this study, I investigated both processes of Self-Determination Theory and Counteractive Control in a longitudinal design which monitored dietary content and body mass index (BMI) over a period of 18 weeks. The specific context of this study was that participants were monitored during a high-risk period for poor diet and weight gain - the beginning of undergraduate university study. Starting university is a significant transition period that has been identified as a risk period for poor diet and weight gain. Students living away from home for the first time report a marked change in their eating habits, with a deviation from an ideal healthy diet (Bagordo et al., 2013) and an increase in sugar and fast food intake (Papadaki et al., 2007). In addition, several studies have demonstrated significant weight gain in student samples during their first year at university. Separate studies from the USA and UK have found that around 50% of participants gained weight and of these the average weight gain was around 7lb (Mihalopoulos, Auinger, & Klein, 2008; Serlachius et al., 2007).

It is worth noting that this study is informed by methodological lessons learnt in the previous studies in this thesis. In this study, participants will be preselected on the basis on concern for dieting, this is a measure analogous to dietary restraint. Given that self-regulation is concerned with the management of goal directed behaviour, this restriction is important in such that all participants endorse minimum standards of desired behaviour relating to weight

management or dietary goals. I have also attempted to include a measure of self-control that is more specific to dietary behaviour than previous assessments of general executive function and sought to ensure that all measures are matched with regard to levels of measurement. This study, therefore, matches assessment of dispositional mindfulness with a trait level assessment of self-control that can be used to predict success in weight management. Furthermore, assessment of Self-Determination Theory constructs, which reflect overarching regulatory style, will be used to predict day-to-day dietary content and control of weight over time, rather than discrete lab events. This day-to-day behaviour assessment may also be more in keeping with results from previous studies which have suggested an intention-behaviour gap when examining eating behaviour in the lab (Studies 4 and 5) or an effect of mindfulness on food *choice* but not total calorie intake (Study 3), as these results suggest that mindfulness may have an effect on general composition of diet rather than singular laboratory eating events.

Based on previous research documenting poor diet and weight gain in first year student samples, I predicted that participants would gain weight and increase their intake of fat and sugar over the course of the study. Given the role that mindful awareness is thought to play in facilitating integrated regulation (Weinstein et al., 2013), and the previously documented links between mindfulness and autonomous functioning (Brown & Ryan, 2003; Levesque & Brown, 2007), I hypothesised that more mindful participants would demonstrate more self-determined forms of regulation, specifically greater autonomy and/or less controlled regulation. In examining self-control, I hypothesised that more mindful individuals would display greater levels of goal accessibility, in which they are more likely to activate dieting goals in response to primes, due to their enhanced ability to recognise and respond to goal conflict (Teper et al., 2013). I further hypothesised that mindfulness would predict less weight gain and more favourable dietary practices via these mechanisms of self-regulation and self-control.

5.2 Method

5.2.1 Participants. Participants were pre-selected on the basis of dietary concern using a measure devised by Fishbach et al. (2003). Participants indicated on a 7-point scale the extent to which they were concerned with a) watching their weight and b) being slim. This measure was included in a battery of measures completed by all first year undergraduate students in the School of Psychology. Only those with high levels of dietary concern, classified using a median split, were eligible to participate. Eligibility was restricted to females because gender differences have been documented in self-reporting of dietary intake (Hebert et al., 1997), a primary outcome measure in this study. For the first study session 77 participants were recruited, 57 returned for participation at time 2 and 53 remained at time 3 (see below for data comparing completers versus non-completers). Participants received course credit in exchange for their time.[11]

5.2.2 Materials.

Lexical decision task. A lexical decision task was used to assess accessibility of the dieting goal, and followed the exact procedure used by (Papies et al., 2008b), but using English rather than Dutch words. Five diet related words (*fit, diet, thin, slim, weight*) were presented as goal words, along with five office related words of equal length (*pen, book, desk, file, office*) which served as control words. Ten neutral words (e.g. *zoo, medal*) and 20 nonsense words were also presented as filler words. Nonsense words were taken from the English Lexicon Project database (see Balota et al., 2007) and were matched in length to real words.

The task, which is depicted in Figure 7, was presented on desktop PCs using DirectRT software (Empirisoft, v2012). Participants were presented with target words (indicated by a string of asterisks presented on either side of the word) and were instructed to respond to targets by pressing clearly marked keys on a keyboard to indicate if the target word was a real

[11] Completion of time 2 assessments was not a pre-requisite for time 3 participation and 5 participants returned at time 3 who had not completed the time 2 assessments, in total 48 participants completed all three study sessions.

English word or not. In between target words a series of random letter strings were presented as masks, participants were instructed not to respond to these strings. In each trial between 4 and 22 random letter strings preceded the target word, this meant that the duration of trials varied randomly and participants were not able to form expectancies about when a target would be presented. Random letter strings were presented alternately for 30ms and 150ms, targets were presented until participants had given a response. Trials fell into 3 categories; critical, baseline, and filler. On critical trials goal/control words were preceded by a food prime (*cake, pizza, chocolate, chips, cookie*) presented for 30ms. Primes were always presented 540ms before the target word, as Papies et al. (2008b) demonstrated that goal accessibility effects do not occur at stimulus onset asynchronies of less than 540ms. On baseline trials goal/control words were presented without a prime, therefore each goal and control word was presented twice, once with a prime and once without. On filler trials neutral and nonsense words were presented without primes, giving a total of 50 trials. Trials were presented in a random order but with critical trials in fixed positions in order to ensure enough distance between them. The procedure was explained both verbally and in written form to participants and five practice trials were presented in order to familiarise participants with the task.

In this task the reaction time to target words is the dependent variable and represents the degree of goal activation triggered by food primes. If a participant responds more quickly to food target words following a food prime than on non-primed trials then the prime has resulted in activation of dieting goals. However, if a participant responds more slowly on primed than non-primed trials then the prime has resulted in *inhibition* of goal representations. Control target words (office words) are included as a comparison to demonstrate that the effect of food primes is specific to food target words.

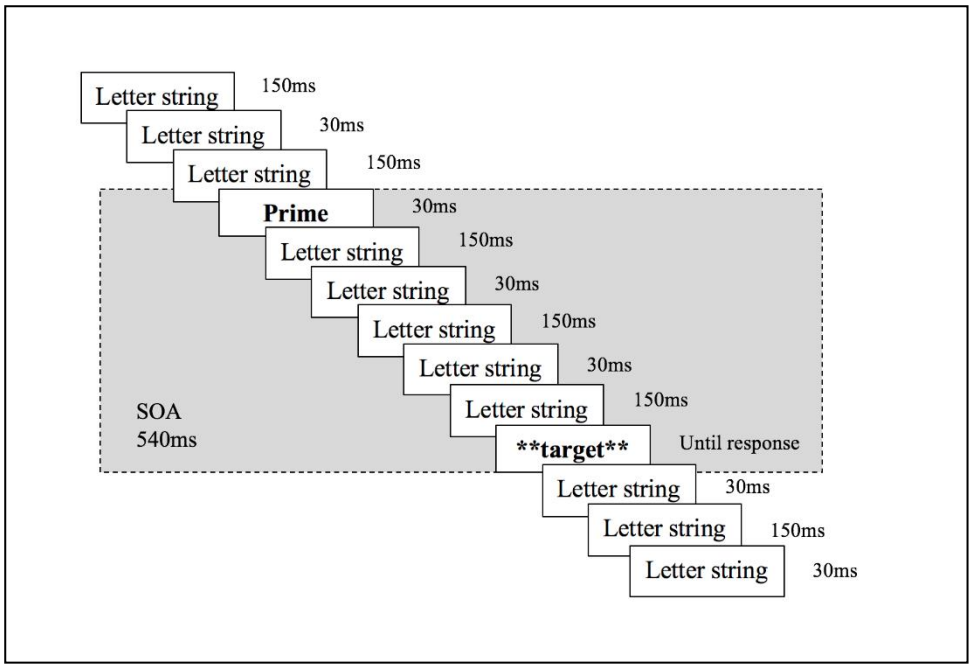

Figure 7. Example of a critical (primed) trial in the lexical decision task

Mindful Attention Awareness Scale (MAAS). This is the same measure used in previous studies in this thesis.

Regulation of Eating Behaviours Questionnaire (REBS). The REBS (Pelletier et al., 2004) is a 24-item measure that assesses self-regulatory style along the continuum of self-determinism in the pursuit of dietary goals. The scale may be split in two subscales that give global scores of autonomous and controlled regulation. These may be then further divided into six subscales: intrinsic motivation, integrated regulation, identified regulation (which make up autonomous regulation), and introjected regulation, external regulation, and amotivation (which make up controlled regulation). In this measure, autonomous regulation is positively associated healthy eating practices and the scale globally predicts changes in dietary fat intake in longitudinal analysis (Pelletier et al., 2004). Participants responded on a 7-point scale from 1 (*does not correspond at all*) to 7 (*corresponds exactly*). Example items include "Eating healthy is an integral part of my life" (autonomous regulation) and "I would feel ashamed if I was not eating healthy" (controlled regulation).

Behavioural outcomes. In order to monitor participants dietary intake I administered a Food Frequency Measure devised by Margetts, Cade, and Osmond (1989). In this measure participants indicated how frequently, on average, they consumed a variety of foods and beverages each week. Participants were instructed to complete this measure with reference to their typical diet in the past month. Responses were converted to weighted responses (once a day = 1; never or rarely = 0) and multiplied by typical nutrient value per serving for each food item[12]. This information was used to calculate typical daily intake of fat and sugar for each participant. Margetts et al. have reported that energy intake data assessed with this measure is statistically consistent with data from via 24-hour dietary records obtained through interviews. The measure also has good test-retest validity (Armitage & Conner, 1999) and shows convergent validity with 10-day weighed food records (Thompson & Margetts, 1993). Participants' height and weight were recorded and BMI computed.

5.2.3 Procedure. Students responded to a request for participants for a three-part study taking part over the course of two semesters. The study ran throughout the course of the first semester of the academic year and the winter break, with final data collection taking place at the beginning of the second semester. Recruitment took place during weeks 2 to 4 of semester one. Upon arrival in the laboratory at Time 1 participants were briefed on what to expect in each study session and gave written consent for participation. They first completed the lexical decision task followed by all questionnaire measures. Participants then had their height and weight measured by the researcher. Height and weight were recorded without shoes or outdoor clothing. Height was recorded in centimetres to the nearest cm, weight was recorded in kilograms rounded to one decimal place. Time 2 assessments took place 7-9 weeks later, these assessments were delivered online using Qualtrics survey software. This method was used in order to minimise attrition by maximising convenience for students during a busy

[12] Nutrient information was kindly provided by Katy Tapper. See Tapper, K., Baker, L., Jiga-Boy, G., Haddock, G., & Maio, G. R. (2015). Sensitivity to reward and punishment: Associations with diet, alcohol consumption, and smoking. *Personality and Individual Differences*, 72, 79-84.

period in the semester. Time 2 assessments required participants to repeat the MAAS, in order to ensure stability of the dispositional mindfulness measure. Participants also completed the FFQ again, and self-reported their current weight. Time 3 assessments took place 6-8 weeks later, participants again repeated the MAAS and FFQ, had their weight recorded and repeated the lexical decision task.

5.3 Results

5.3.1 Demographics. At Time 1 the mean age of the sample was 18 years (range 17-21; SD = 0.66). The majority of the sample (89.6%) reported living away from their family home and speaking English as their first language (80.5%). Participants who dropped out by Time 3 did not significantly differ from those who completed Time 3 with respect to age (t (70) = .12, p = .91); BMI (t (73) = .40, p = .67); mindfulness (t (75) = -1.32, p = .19); or first language (χ^2 (1) = .04, p = .84). MAAS scores were significantly correlated at all time points (see Table 6), therefore Time 1 MAAS scores were used in all subsequent analyses.

Table 6.

Pearson correlation coefficients and p-values (2-tailed) for MAAS scores at all time points

		MAAS (Time 2)	MAAS (Time 3)
MAAS (Time 1)	*r*	.70	.67
	p	<.001	<.001

5.3.2 Diet and weight outcomes. Mean BMI was 23.59 (SD = 4.09) at time 1 and 23.91 (SD = 3.10) at time 3. Contrary to the hypothesis that participants would gain weight during the course of the study, a paired samples t-test indicated that BMI did not significantly change over time (t(50) = 1.48, p = .15). Participants were classified as either weight gainers or non-gainers (lost or maintained weight), based on Stevens, Truesdale, McClain, and Cai's (2006) criteria (weight maintenance classed as within 3% of original weight). Seventeen participants

gained weight, of these the average gain was 3.06 kg (a change of 1.13 BMI units). Eight participants lost weight, with an average loss of 3.86 kg (1.39 BMI units). MAAS at time 1 did not predict weight change across the sample (F (1, 49) = .015, p = .90; R^2 = .02, β = .02) or just within those who gained weight (F (1, 15) = .139, p = .71; R^2 = .01).

I also hypothesised a deterioration in the quality of participants' diet over time, based on research showing poor diet in university students (Papadaki et al., 2007). Mean fat and sugar intake at all time points are presented in Table 7. A one-way repeated measures ANOVA showed that fat intake significantly changed over time (F (2, 94) = 11.07, p < .001). Post hoc analyses with Bonferroni adjustment revealed that fat intake significantly decreased between time 1 and time 2 (adjusted p = .001) and between time 1 and time 3 (adjusted p < .001) but remained stable between time 2 and 3 (adjusted p = 1).

When using saturated fat intake as the outcome variable the pattern of effects and significance for the main effect and pairwise comparisons remained the same.

A one-way repeated measures ANOVA showed that sugar intake significantly changed over time (F (2, 94) = 3.964, p = .02). Post hoc analyses with Bonferroni adjustment revealed that sugar intake marginally decreased between time 1 and time 2 (adjusted p = .08) and had significantly decreased by time 3 (adjusted p = .03), sugar intake remained stable between time 2 and 3 (adjusted p = 1).

When using added sugar intake as the outcome variable the pattern of effects and significance for the main effect and pairwise comparisons remained the same.

Table 7.

Mean daily fat and sugar intake in grams across time

	Time 1	Time 2	Time 3
Mean fat intake (g)	57.07	49.39	47.63
Mean sugar intake (g)	135.71	121.53	111.34

MAAS was consistently negatively associated with fat intake across time, and significantly to marginally associated with saturated fat intake at times 2 and 3. There was a marginal negative association between MAAS and sugar intake at time 1 and time 3, see Table 8.

5.3.3 Self-Determination Theory constructs. I hypothesised that mindfulness would be associated with more self-determined regulatory styles (as assessed by the REBS). Mindfulness was significantly negatively associated with controlled regulation (r = -.36, p < .001). Surprisingly, there was no association between mindfulness and autonomous regulation (r = -.05, p = .21). To further explore how mindfulness and controlled regulation interact to predict hypothesised behavioural outcomes I conducted regression analyses. As there was no significant association between mindfulness and autonomous regulation I did not conduct any further analyses using this construct.

Body mass index. MAAS scores, controlled regulation, and their interaction were regressed onto BMI at Time 1, 2, and 3.

Time 1 BMI. The model significantly predicted BMI at time 1 (F (3, 71) = 2.904, p = .041; R^2 = .109). There was a marginal main effect of mindfulness (β = .71, p = .06), a main effect of controlled regulation (β= 1.29, p = .02) where both mindfulness and controlled regulation predicted higher BMI, but these effects were qualified by interaction between mindfulness and controlled regulation (β=-2.14, p = .04; see Figure 8). Simple effects analysis revealed that controlled regulation predicted higher BMI, but only for those individuals with low levels of

dispositional mindfulness (t (70) = 2.77, p =.01). For those high in mindfulness controlled regulation had no effect on BMI (t (70) = -0.02, p = .82). The difference in BMI between high and low MAAS within participants high in controlled regulation was marginally significant (*p* = .08).

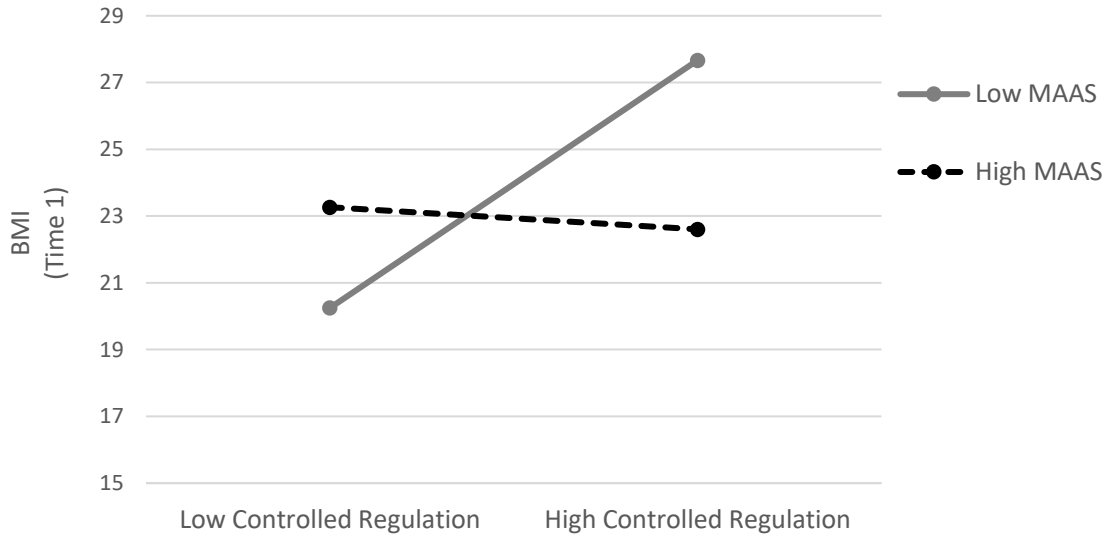

Figure 8. Interaction showing effect of high (+1SD) and low (-1SD) controlled regulation and mindfulness (MAAS) on BMI at time 1

Time 2 BMI. At time 2 the regression model also significantly predicted BMI (*F* (3, 50) = 5.11, p =.004; R^2 = .24). There was a marginal main effect of mindfulness (β= .89, *p* = .06), a significant main effect of controlled regulation (β= 1.57, *p* = .01), again with both predicting higher BMI, and a marginal interaction (β= -1.17, *p* = .06; see Figure 9). Simple effects analysis revealed that controlled regulation predicted higher BMI but only for those individuals with low levels of dispositional mindfulness (t (70) = 3.71, p =.001). For those high in mindfulness controlled regulation had no effect on BMI (t (70) = 0.66, p = .51). These results show the same pattern as was found at time 1.

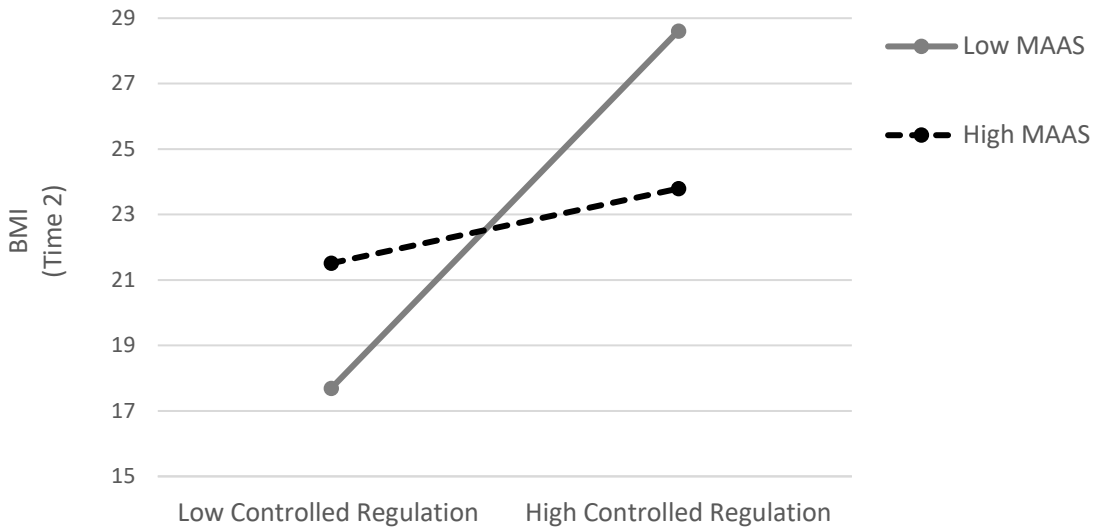

Figure 9. Interaction showing effect of high (+1SD) and low (-1SD) controlled regulation and mindfulness (MAAS) on BMI at time 2

Time 3 BMI. At time 3 the regression model marginally predicted BMI (F (3, 47) = 2.60, p =.06; R^2 = .14). However, there were no significant effects (all *p*s >.10).

These results suggest that although mindfulness is not associated with lower BMI in and of itself, it does offer a protective influence against the effect of controlled regulation in producing higher BMI. This effect was replicated at Time 1 and 2, but not at Time 3

Dietary outcomes. MAAS, controlled regulation, and their interaction were regressed onto sugar and fat intake at all time points.

Fat and saturated fat intake. When regressing MAAS, controlled regulation, and their interaction onto fat intake or saturated fat intake there were no significant main effects or interactions at any time point.

Sugar intake. The statistical model did not significantly predict sugar intake at time 1 (F (3, 73) = 2.71, p = .10; R^2 = .08). However, there was a main effect of mindfulness (β = -.82, p =

.03), whereby mindfulness predicted lower sugar intake, but no main effect of controlled regulation (β = -.82, p = .10), and a marginal interaction between mindfulness and controlled regulation (β = .91, p = .08; see Figure 10). Simple effects analyses for this interaction showed that the negative main effect of mindfulness on sugar intake was only present for those with low controlled regulation (t = -2.28, p = .03), those with high levels of controlled regulation mindfulness had no effect on sugar intake (t = -1.12, p = .27).

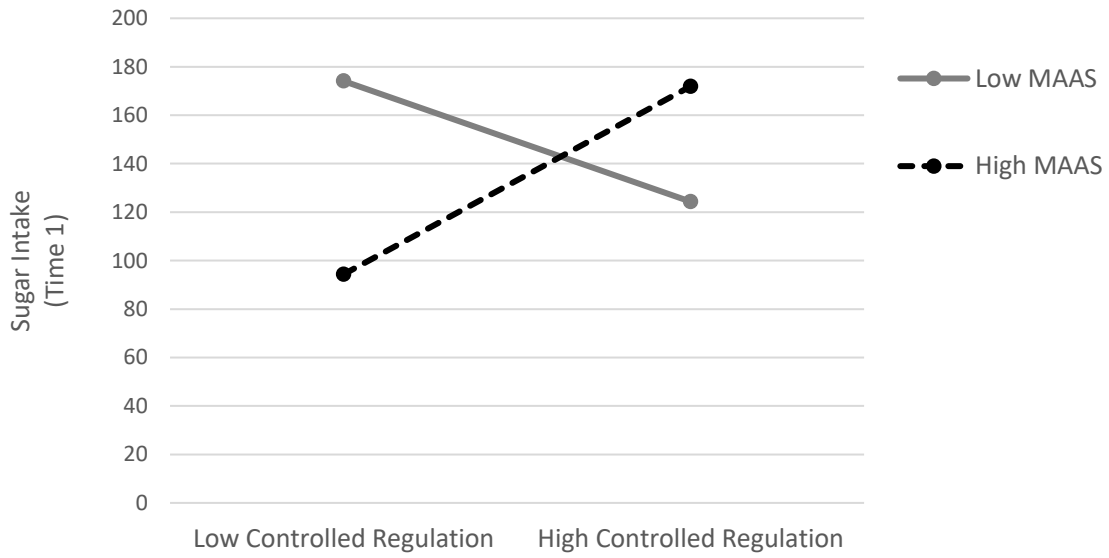

Figure 10. Interaction showing effect of high (+1SD) and low (-1SD) controlled regulation and mindfulness (MAAS) on sugar intake at time 1

At time 2 there were no significant main effects or interactions.

The statistical model significantly predicted sugar intake at time 3 (F (3, 49) = 3.11, p = .04; R^2 = .16). There was a significant main effect of mindfulness (β = -1.32, p = .01), a main effect of controlled regulation (β = -1.46, p = .03) with both mindfulness and controlled regulation predicting lower sugar intake, but this was qualified by a significant interaction between mindfulness and controlled regulation (β = 1.41, p = .03). This interaction showed the same pattern of effects as time 1, those high in mindfulness ate less sugar but only if they were

low in controlled regulation (t = -2.28, p = .03). Those high in controlled regulation did not differ in their sugar intake according to mindfulness (t = .28, p = .77).

When added sugar intake was used as the outcome variable the same pattern of main effects and interactions was obtained.

These results suggest that while mindfulness produces advantageous effects in reducing sugar consumption, this effect may be overridden by high levels of controlled regulation.

5.3.4 Goal accessibility. Data from the lexical decision task, which was completed at Time 1 and Time 3, were analysed based on the technique used by Papies et al. (2008b), with the dependent variable being reaction time to diet and office words. Responses on office trials were analysed as a control comparison, to ensure that any effects of priming are specific to congruence between food primes and diet targets, rather than a non-specific effect of priming. Response latencies for incorrect responses and those larger than 3 standard deviations from a participant's overall mean were excluded (this resulted in < 1% of responses being excluded at both time points). Remaining response latencies were then analysed as a function of mindfulness, trial type, and their interaction. In these analyses a faster reaction time on primed trails indicates activation of goals in response to primes and represents a marker of greater self-control. I hypothesised an interaction between mindfulness and trial type suggesting that goal accessibility is greater in more mindful individuals.

Time 1. The regression model was marginally significant (F (3,150) = 2.54, p = .06; R^2 = .22). There was a main effect of mindfulness on response time (β = .21, p = .01), such that more mindful individuals responded more slowly to target words. There was no significant main effect of trial type (β = -.22, p = .56) nor a significant interaction between MAAS and trial type (β = .24, p = .53).

There were no significant effects when responses to office words were analysed in the same way.

Time 3. The regression model was not significant (F (3,102) = 1.88, p = .13; R^2 = .05). However, there was a main effect of mindfulness on response time (β = .21, p = .03), in which mindful individuals responded more slowly. Similar to Time 1, there were no significant main effects of trial type (β = -.21, p = .66) nor interaction between MAAS and trial type (β = .28, p = .53). In this case, when response to office words was analysed the same pattern of results emerged. The regression model was not significant (F (3,102) = 1.69, p = .17; R^2 = .05). There was a main effect of mindfulness on response time (β = .21, p = .03), no main effect of trial type (β = .27, p = .55), and no interaction between MAAS and trial type (β = -.27, p = .55).

5.3.5 Exploratory analyses. The measure of self-regulatory success (SRS) included in this study was taken from Fishbach et al. (2003) and gives an indication of participants' perceptions of their success in regulating their weight. In order to further explore how well this measure predicts objectively measured weight outcomes and in order to see how it is related to mindfulness I conducted exploratory analyses.

SRS was significantly positively associated with MAAS and significantly negatively associated with BMI at all time points (see Table 8). However, SRS did not predict weight gain status (Wald χ2 (1) = .13, p = .72 [95%CI .63-1.97], OR = 1.11) or weight change (F (1,49) = 1.04, p = .31; R^2 = .02, β = .14).

To further explore the relationship between mindfulness and participants' perceptions of their own self-regulatory success I performed regression analyses in order to look at how SRS interacts with mindfulness to predict BMI. SRS, MAAS, and their interaction were regressed onto BMI. The statistical model significantly predicted BMI at time 1 (F (3, 73) = 7.58, p < .001; R^2 = .24). There was a main effect of mindfulness (β = -1.20, p = .002) and a main effect of SRS (β = -1.84, p < .001), such that both greater mindfulness and greater SRS were associated with lower BMI. There was also a significant interaction between mindfulness and SRS (β =2.19, p = .001; see Figure 11). Simple slopes analysis suggest that low SRS is associated with higher BMI (suggesting greater accuracy between self-reported SRS and actual weight

management) but only for those who are low in mindfulness (t = -4.65, p < .001). For those high in mindfulness SRS is not predictive of BMI (t = -.08, p = .42).

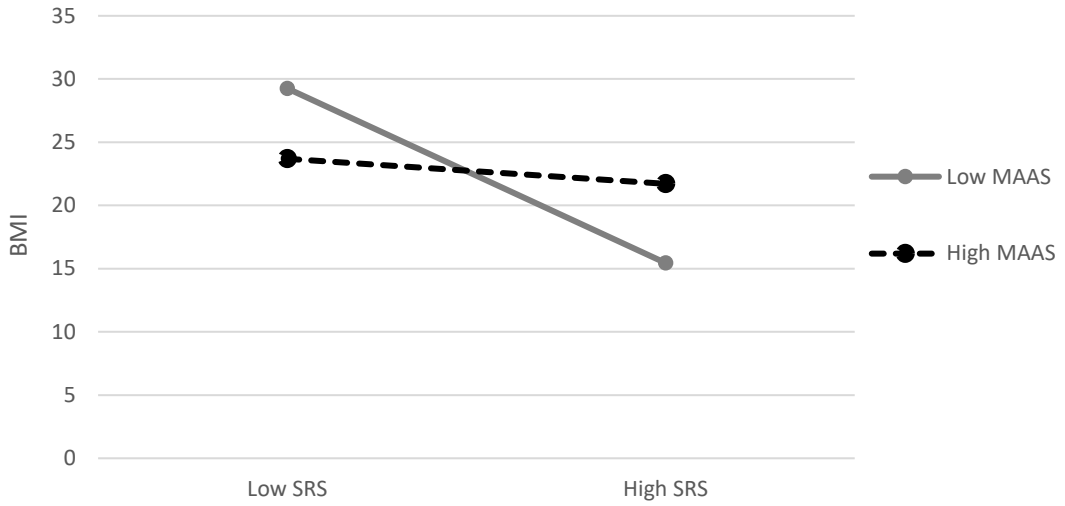

Figure 11. Interaction showing effect of high (+1SD) and low (-1SD) self-regulatory success (SRS) and mindfulness (MAAS) on BMI at time 1

The statistical model significantly predicted BMI at time 2 (F (3, 53) = 5.23, p = .003; R^2 = .24). There was a main effect of mindfulness (β = -1.20, p = .009) and a main effect of SRS (β = -1.80, p = .002), such that both greater mindfulness and greater SRS were associated with lower BMI. There was also a significant interaction between mindfulness and SRS (β =2.10, p = .009). Simple slopes analysis for this interaction showed the same pattern of results as the interaction for time 1 BMI, SRS was predictive of BMI only for participants low in mindfulness (t = -3.82, p < .001), not for those high in mindfulness (t = -.61, p = .55).

The statistical model significantly predicted BMI at time 3 (F (3, 49) = 8.10, p < .001; R^2 = .36). However, there was no main effect of mindfulness (β = -.26, p = .56), SRS (β = -.85, p = .12), or an interaction between them (β = .38, p = .62).

Table 8.

Pearson correlation coefficients and p-values (2-tailed) for associations between key variables, Cronbach's alpha given in parentheses

	PSRS (α = .66)	Aut. Reg. (α = .89)	Con. Reg. (α =.82)	BMI			Fat Intake (Saturated fat)			Sugar Intake (Added sugar)		
				T1	T2	T3	T1	T2	T3	T1	T2	T3
MAAS (α = .84)	.30*	-.05	-.39*	-.11	-.13	-.19	-.27* (-.15)	-.31* (-.24^)	-.38* (-.28*)	-.20^ (-.16)	-.20 (-.19)	-.26^ (-.18)
PSRS		.30*	-.37**	-.35**	-.35*	-.60**	.04 (-.07)	-.07 (.00)	-.01 (-.13)	-.11 (.08)	-.09 (-.14)	-.02 (-.11)
Autonomous Regulation			.03	-.06	-.07	-.05	.12 (-.06)	-.01 (-.14)	-.08 (-.23)	-.08 (-.21)	-.22 (-.30*)	-.02) (-.16
Controlled Regulation				.23	.42*	.34	-.10 (-.10)	.00 (-.10)	.04 (-.01)	.10 (.05)	-.04 (-.07)	.02 (.05)
	T1						-.06 (-.09)	-.17 (-.26*)	-.07 (-.01)	-.29 (-.26*)	-.32* (-.36*)	-.18 (-.15)
BMI	T2						-.07 (-.07)	-.09 (-.17)	-.07 (-.03)	-.21 (-.20)	-.23^ (-.29*)	-.15 (-.13)
	T3						-.02 (-.04)	-.08 (-.21)	-.05 (.02)	-.14 (-.14)	-.19 (-.25)	-.13 (-.10)

* Significant at the $p < .05$ level

** Significant at the $p < .001$ level

^ Marginal effect ($p = .06$ to $.09$)

5.4 Summary Discussion

This study investigated diet and weight change over an 18-week period in first year undergraduate sample with the aim of examining the role of mindfulness in relation to Self-Determination Theory and accessibility of dieting goals. Surprisingly, there was no significant change in BMI over the course of the study. Fat and sugar intake decreased over time, an effect that may be attributable to inflated intake at Time 1. Mindfulness was associated with lower intake of fat and sugar across time. Contrary to hypotheses there was no association between mindfulness and autonomous regulation, but there was a significant negative relationship between mindfulness and controlled regulation, such that more mindful individuals showed less controlled regulation. Furthermore, there was an interaction between mindfulness and controlled regulation, whereby mindfulness buffered the significant association between controlled regulation and BMI. However, controlled regulation appears to *override* the benefits of mindfulness for sugar intake. Analysis of data from the lexical decision task showed no evidence of mindfulness being associated with greater accessibility of dieting goals in response to food primes. Finally, exploratory analyses investigating the role of perceived self-regulatory success found that participants' self-reported success in weight management was only predictive of actual BMI for those participants with who were low in dispositional mindfulness.

5.5 Supplementary Study

The results of these exploratory analyses revealed an interesting interaction between mindfulness and SRS in predicting BMI, an interaction that was replicated in two out of three cases. However, given the exploratory nature of these analyses I conducted a further supplementary study to further understand the nature of this interaction. This interaction suggests a disjunct between perceived and actual success in weight management among more mindful individuals. This effect may be attributable to more mindful individuals being less aware of the extent to which they are regulating their weight, and so having an inaccurate

perception of their body weight. This may reflect a more indirect or non-conscious form of weight regulation, in which more mindful individuals are regulating their weight without explicit dieting behaviour or awareness of body weight. Alternatively, more mindful individuals may have different interpretations of what successful self-regulation means which are not necessarily related to lower BMI, leading them to give responses on the PSRS which are not predictive of body weight. In order to examine these competing explanations, I conducted a mixed methods study which examined accuracy of participants' body weight estimations as well as their personal interpretations of PSRS scale items.

Fifty-one participants were recruited based on the same inclusion/exclusion criteria as in the primary study. Participants first completed the MAAS and then the PSRS, they were then presented with the items of the PSRS again and asked to give open-ended feedback on how they had interpreted each item, and what each item meant to them personally. Participants self-reported their height and weight and then had their height and weight recorded in the lab.

As can be seen in Table 9, unlike in the primary study there were no significant associations between MAAS, PSRS, and BMI (either self-reported or recorded). Furthermore, the interaction effect seen in the primary study was not replicated. The statistical model did not significantly predict BMI (F (3, 45) = 1.38, p = .26; R^2 = .08). There was no main effect of mindfulness (β = .74, p = .10) or a main effect of SRS (β = .54, p = .31) or an interaction between them (β =-1.05, p = .16).

Table 9.

Pearson correlation coefficients and p-values (2-tailed) for the associations between mindfulness (MAAS), perceived self-regulatory success (PSRS), and BMI assessments in the supplementary study

		Self-reported BMI	Recorded BMI	PSRS
MAAS	*r*	.16	.10	.19
	p	.13	.24	.18
PSRS	*r*	-.20	-.15	
	p	.08	.30	

There was no significant difference between self-reported and recorded BMI across the sample (t(46) = 1.46, p = .15; 2-tailed), suggesting that participants were accurate in estimating their BMI (when providing both height and weight data). There was no association between mindfulness and absolute accuracy of BMI estimation (r = -.02, *p* = .89).

Participants' written responses were subject to summative content analysis which examined frequency and context of use of weight management terminology (Hsieh & Shannon, 2005). Manifest analysis revealed that high and low mindfulness participants, classified using a median split (median = 3.35), did not differ on frequency of use of weight loss terminology (46 vs. 49 incidences). Latent analysis, which examines and interprets the context in which language is used, identified themes of weight loss and wellbeing. The weight loss theme referred explicitly to losing weight or striving for a lower body weight. The wellbeing theme referred to maintaining one's weight, feeling comfortable with one's body, and maintaining health or physical fitness (see Hsieh & Shannon, 2005 for further detail on the summative content analysis method used in this study). Participants high versus low in mindfulness did not differ in frequency of use of wellbeing themes (47 vs. 44 instances). Although more mindful participants spoke less frequently about weight loss than less mindful participants (29 vs. 39 instances), this difference did not reach significance (see Table 10).

Latent analysis suggests that the items of the PSRS may be interpreted differently by different participants, some participants made no reference at all to weight loss in their answers and many talk about maintaining body shape and feeling comfortable in their body. However there appeared to be no difference between more and less mindful participants in their interpretation of scale items.

Table 10.

Use of weight loss terminology, weight loss themes, and wellbeing themes in high and low mindfulness (MAAS) participants (classified based on median split)

		High MAAS	Low MAAS	
Total count	Freq.	46	49	
	Mean	1.84	1.88	*(t*(49) = .13, *p* = .90 [95%CI -.63 to .72])
Wellbeing themes	Freq.	47	44	
	Mean	1.88	1.69	*(t*(49) = .-.72, *p* = .47 [95%CI: -.71 to .36])
Weight loss themes	Freq.	29	39	
	Mean	1.16	1.5	*(t*(49) = 1.28, *p* = .21 [95%CI -.19 to .87])

5.6 Discussion

In this longitudinal study, I aimed to investigate processes of self-regulation of diet and weight in the context of dispositional mindfulness in a student sample during their transition to university. I hypothesised that mindfulness would allow greater success in diet and weight regulation through the use of more adaptive regulatory styles and increased application of counteractive control processes. Although I did not find any significant weight gain over the course of the study, I did find that controlled regulation and mindfulness interacted to predict BMI at discrete time points, such that controlled regulation resulted in higher BMI only in those individuals with low levels of dispositional mindfulness. In addition, mindfulness was associated with lower fat and sugar intake. I did not find evidence to support the hypothesis

that mindfulness would allow greater application of counteractive control strategies in the form of automatically activated associations between food cues and representations of dieting goals.

The transition to first year undergraduate study has previously been identified as a risk period for weight gain (Serlachius et al., 2007), however in this sample of first year undergraduates there was no significant increase in BMI over the course of the study. There are several potential explanations for this discrepancy. The first is that previous studies demonstrating this effect had much larger sample sizes than was used in the current study, in these studies samples have ranged from 120 to 268 (Finlayson, Cecil, Higgs, Hill, & Hetherington, 2012; Serlachius et al., 2007). Among participants who did gain weight in this study, weight gain was comparable to figures reported in previous studies. Furthermore, changes in BMI in this sample may have also been masked by attrition. Studies of this kind are open to self-selection bias and, although those who dropped out of the study did not differ from the rest of the sample on Time 1 BMI, it is possible that those participants who were aware that they had gained weight were less inclined to return for further assessment sessions (Finlayson et al., 2012). In addition, all participants in this sample had been pre-selected on the basis of their holding weight management goals, only participants who had indicated that they were concerned with watching their weight and being slim were eligible to participate, although participants were not asked about whether they were actively dieting. This restriction was necessary as the study investigated processes of self-regulation. Self-regulation and self-control are concerned with goal directed behaviour (Allom & Mullan, 2014). In particular, for investigation of counteractive control processes it was necessary to select participants with weight management goals. A key assumption of Counteractive Control Theory is that the behaviour must have value to the individual in order for counteractive control processes to be enacted (Trope & Fishbach, 2000). Indeed, Fishbach et al. (2003) demonstrated that the greater the importance attached to weight goals the faster successful dieters were to react to diet words following priming.

In addition to the lack of change in BMI over time I also found unexpected results with regard to dietary change, whereby fat and sugar intake *decreased* over time. This surprising result may be be attributed to the pre-selection criteria, with all participants reporting weight management goals. However, an alternative explanation may concern the timing of the first assessment session. Dietary reports provided at this time point covered the very first weeks of the university term and anecdotal reports from several participants implied that they felt their diets had been poorer than usual during this time. In many UK universities the first week of the semester, 'fresher's week', typically involves a wide variety of social activities that offer increased opportunity for alcohol consumption (see Riordan, Scarf, & Conner, 2015). Alcohol intoxication has been shown to increase short term appetite (Yeomans, 2010) and so may also have affected fat intake. Indeed, post hoc tests revealed that whilst fat and sugar intake significantly decreased between time 1 and 2 it remained stable between time 2 and 3. It is possible that dietary self-report assessments obtained at time 1 reflect an unusually high intake of fat and sugar, causing an apparent decrease in intake during the full study period.

Analysis of self-report dietary measures revealed mindfulness to be significantly negatively associated with fat intake at all three time points, and marginally associated with sugar intake at Time 1 and Time 3. These results suggest healthier dietary practices in mindful individuals and are consistent with wider literature which as show mindfulness to be associated with reduced fat intake both when using dispositional mindfulness (Gilbert & Waltz, 2010) and following a mindfulness based intervention (Timmerman & Brown, 2012).

Contrary to my predictions, mindfulness was not positively associated with autonomous regulatory style, however there was a significant negative association between mindfulness and controlled regulation. Although the lack of association between mindfulness and autonomous regulation is surprising given previous work showing an association between mindfulness and day-to-day autonomous functioning (Levesque & Brown, 2007), previous research has not investigated autonomous regulation in the specific context of eating behaviour. Furthermore, a simplex pattern, in which each regulatory style displays positive

correlations with adjacent regulatory styles on the continuum and negative correlations with distant ones, is hypothesised within Self-Determination Theory, and has been demonstrated in previous work that has used the REBS (Pelletier et al., 2004). Therefore, the result of a negative association between mindfulness and the opposing construct of controlled regulation, rather than a positive association between mindfulness and autonomous regulation is not entirely anomalous. Further investigation of the relationship between mindfulness, controlled regulation, and BMI revealed a main effect of controlled regulation on BMI as well as an interaction between controlled regulation and mindfulness. The main effect of controlled regulation, in which controlled regulation was associated with significantly higher BMI at Time 1 and 2 is in line with previous research (see e.g., Leong, Madden, Gray, & Horwath, 2012; Pelletier et al., 2004). This effect is consistent with the predictions of Self-Determination Theory, which posits that controlled forms of regulation will not lead to long term maintenance of health behaviours (Ryan et al., 2008). Controlled regulation is less likely to lead to long-term behaviour change because healthy eating practices are not integrated with other goals or values, or being experienced as intrinsically enjoyable, as in autonomous regulation. As a result, over time behaviour returns to baseline practices of unhealthy eating, particularly if controlling influences are removed (Teixeira, Patrick, & Mata, 2011). Leong et al. (2012) found the relationship between controlled regulation and BMI to be partially mediated by binge eating frequency and suggested that controlled motivations for eating regulation may be associated with rigid or inflexible forms of dieting. Such practices comprise periods of restriction followed by loss of control and binging often followed by further compensatory restriction and are associated with poorer weight control outcomes (Timko & Perone, 2005; Westenhoefer et al., 1999) which would explain the positive association between controlled regulation and BMI.

The interaction between mindfulness and controlled regulation may be interpreted as a buffering effect of mindfulness, as controlled regulation was associated with higher BMI only among those participants who had low levels of dispositional mindfulness. These results

suggest that dispositional mindfulness offers some form of protection against the negative influence of controlled regulation in the context of dietary practices. A key principle of SDT is that both contextual and personality factors interact to determine need satisfaction and motivation. Mindfulness may act as a personality trait that alters reactions to perceptions of external control. Hagger and Chatzisarantis (2011) demonstrated that autonomy orientation, the tendency to experience actions and events as originating from the self rather than being externally controlled, can attenuate the undermining effects of external rewards on intrinsic motivation. They suggest that individuals with high levels of autonomy orientation interpret rewards, a form of external control which usually undermines intrinsic motivations, as an opportunity to demonstrate competence, whereas those with high levels of control orientation are more likely to attend to the controlling function of the reward. Mindfulness has been shown to be positively associated with autonomy orientation (Leigh & Anderson, 2013) and it might be that a mindful disposition allows a different interpretation of controlling influences. For example, more mindful people might interpret external contingencies regarding controlling the shape of one's body as an opportunity to demonstrate competence, or perceive pressure from others as supporting autonomy thus minimising the negative behavioural impact of controlled regulation (i.e. greater BMI).

It is important to note, however, that the interaction between controlled regulation and mindfulness for sugar intake did not converge with the effects seen for BMI. In these analyses sugar intake (at Time 1 and Time 3) was lower in more mindful participants but only when controlled regulation was low. These results seem to suggest an overriding effect of controlled regulation, rather than the protective effect of mindfulness seen in the BMI analyses. An unanticipated effect in these analyses was that the main effect of controlled regulation on sugar intake was negative. This relationship is contrary to that predicted by SDT, whereby controlled regulation should be associated with *less* healthy behaviour, and is also at odds with the positive relationship seen between controlled regulation and BMI. Whilst BMI was objectively measured by the researcher at time 1, dietary intake was self-reported at all

time points. Our results regarding dietary intake might be subject to reporting bias, in particular participants are likely to under-report food items with a negative health image, such as sugar (Macdiarmid & Blundell, 1998). It is possible that individuals with high controlled regulation are more likely to under-report their sugar intake due to their use of restrictive dietary practices, as discussed above. Such individuals may report their usual restrictive patterns of eating behaviour and overlook periods of lack of restraint or bingeing. The fact that mindfulness buffers the effects of controlled regulation on BMI but does not seem to alter the relationship between controlled regulation and diet suggests that mindfulness may be protecting against the adverse effect of controlled regulation via a mechanism other than diet, or more specifically sugar intake. Instead, mindfulness might counteract the effects of controlled regulation on BMI by facilitating behaviours which 'compensate' for diet such as increased physical activity, something which was not assessed in the current study. However, given the unanticipated relationship between controlled regulation and sugar intake in these analyses additional work is required to clarify the relationship between mindfulness, controlled regulation, and BMI and the mechanisms underlying it.

The lexical decision task was included to assess cognitive accessibility of dieting goals. In such tasks, faster reaction time to diet words following a subliminal food prime is taken to indicate greater cognitive accessibility of the dieting goal, this is seen as a form of counteractive control strategy which characterises successful dieters (Fishbach et al., 2003). I proposed that mindfulness supports development of this counteractive control process, therefore I expected that more mindful individuals would show greater cognitive accessibility of dieting goals following food primes.

Contrary to expectations there was no interaction between mindfulness and trial type (primed vs. non-primed). These results appear to suggest that mindfulness does not play a role in supporting counteractive control. Although I failed to find an interaction between mindfulness and trial type there was a main effect of mindfulness on reaction time to diet words whereby more mindful people responded more *slowly* to target words. Brown and Ryan

(2003) have proposed that mindfulness may facilitate the creation of a time interval in which individuals are able to view their behavioural choices rather than simply reacting to internal or external stimuli. Rodriguez-Vega et al. (2014) reported slower reaction times, with fewer errors, on a Stroop task among participants who had undergone an 8-week mindfulness intervention. They interpreted these results as supporting Brown and Ryan's time interval hypothesis. In addition, Di Francesco et al. (2017) found that the *acting with awareness* facet of the Five Facet Mindfulness Questionnaire (Baer et al., 2003) predicted longer response latencies on the Attentional Network Task, those individuals higher in mindfulness are slower to respond when a stimulus is presented. The authors suggest that more mindful individuals were more actively and deliberatively engaging in the task rather than proceeding on 'automatic pilot'. This conclusion was supported by the fact that, in Di Francesco et al.'s study, mindfulness was associated with slower RT in both valid and invalid cue conditions, suggesting that, regardless of cue condition, mindful participants were focusing more on the fixation point as requested by the task instructions. These results are consistent with the effect observed in the current study, in which mindful individuals (as assessed with the MAAS, a scale which focuses on the awareness component of mindfulness) were slower to respond to both diet words (Time 1 and Time 3) and control words (Time 3 only).

In fact, such results may explain the lack of interaction between mindfulness and trial type. Such an interaction would indicate a counteractive control effect, whereby automatically activated associations allow non-conscious self-control, I had hypothesised that greater present moment awareness in mindful individuals might allow for greater development of such automatic links. However, the results indicating a slower RT in more mindful individuals suggest that self-control processes in mindful individuals might actually be driven by more deliberative and reflective processing. This proposal is supported by research from Levesque and Brown (2007) who found that dispositional mindfulness moderates the effect of non-consciously activated motivations allowing greater conscious control over behaviour over and above non-conscious influences.

In addition to analyses which examined my main hypotheses, I also conducted a series of exploratory analyses relating to the role of self-regulatory success (SRS), the degree to which participants perceive themselves as being successful in their weight control efforts. SRS was significantly negatively associated with BMI, suggesting the participants had an accurate perception of their success in weight regulation and was significantly positively associated with mindfulness. When I further explored the role of SRS I found a significant interaction between SRS and mindfulness is predicting BMI at Time 1 and 2. When decomposed these interactions, I found that low SRS predicted greater BMI (suggesting greater accuracy in self-reporting success), but only among those low in mindfulness. For those individuals who had high levels of mindfulness SRS was not predictive of BMI. This effect may be taken as suggesting that more mindful individuals are less aware of their success in weight regulation than less mindful individuals. Such results might reflect individuals who report being successful in weight regulation but are not, *or* might represent those who report being unsuccessful in weight regulation but are, in fact, successful in regulating their weight. As these analyses also showed a main effect of mindfulness, whereby mindfulness was associated with lower BMI, it may be the case that these more mindful individuals are simply less aware of the fact that they are able to regulate their weight at a lower level than less mindful individuals. This may reflect a more implicit or non-conscious form of weight regulation as opposed to explicit dieting behaviour, as such more mindful individuals may have a less accurate perception of their true body weight. Such an effect is consistent with autonomous motivations for eating regulation (i.e. eating healthily for pleasure and enjoyment rather than for weight loss), and is keeping with the results of Studies 1 and 2 in this thesis which showed a negative or null relationship between dispositional mindfulness and active dietary restraint. In order to further examine this question, I conducted a supplementary study which examined both accuracy of BMI estimations, and participants' interpretations of PSRS scale items. However, this study failed to replicate the interaction between mindfulness and PSRS in predicting BMI. This may in part be attributable to the lack of association between PSRS and BMI in the sample as a whole. This

null association contradicts not only the results of the primary study in this chapter, but also previous research which has shown a reliable effect of the PSRS in predicting behavioural outcomes including BMI and diet (Meule, Papies, & Kübler, 2012; Nguyen & Polivy, 2014).

It should be noted that the sample used in this study was a convenience sample, and was not pre-specified based on power analysis. The fact that the study design required eligibility to be restricted to first year students with high levels of dietary concern meant to that the pool of potential participants was greatly reduced. In fact, a substantial proportion of the eligible pool (109 eligible individuals) was recruited into the study. Nonetheless, the final sample size, after attrition, of 57 is relatively small, and this should be considered when considering the interpretation of interactions and the implications of the effects reported in this chapter.

This supplementary study found that participants were generally accurate when self-reporting their height and weight, as there was no significant difference between self-reported and recorded BMI. Although self-reported height and weight data can be marked by a tendency to overestimate height and underestimate weight, particularly among overweight or obese participants (Bolton-Smith, Woodward, Tunstall-Pedoe, & Morrison, 2000; Gorber, Tremblay, Moher, & Gorber, 2007), this results supports those who have concluded that self-report data is, nonetheless, a valid tool for epidemiological research (Brunner Huber, 2007; Spencer, Appleby, Davey, & Key, 2002).

Mindfulness was unrelated to accuracy of BMI estimation, this could be considered a surprising result, given the role that mindfulness is thought to play in facilitating more accurate representations of the self. Overweight and obesity are associated with a high degree of stigma (Puhl & Brownell, 2006) which can lead to social identity threat and negative psychological and physiological outcomes (see Hunger, Major, Blodorn, & Miller, 2015). It is likely, therefore, that overweight individuals resist acknowledging an accurate representation of their weight as this represents a threat the self-concept and ego investment. Mindfulness is

thought to facilitate greater insight into the self and acceptance of threatening information as it allows non-judgemental acceptance of knowledge and associated emotions (Brown, Ryan, & Creswell, 2007). Mindfulness is associated with less defensive processing and reduced ego-threat in a variety of domains including social threat, romantic conflict, and mortality salience (Brown, Ryan, Creswell, & Niemiec, 2008; Niemiec et al., 2010) and with greater clarity of self-concept (Hanley & Garland, 2017) including physical self-concept (Emavardhana & Tori, 1997). Therefore, one would expect more mindful individuals to be better able to acknowledge their weight status and be more accurate in reporting their weight than their less mindful counterparts. However, any effects of mindfulness on estimation accuracy may have been masked by the high levels of accuracy across the sample in the current study.

Although there was no difference in use of language or interpretation of study items based on levels of mindfulness, these qualitative analyses were interesting in highlighting consistent use of wellbeing themes across the sample. This measure was initially devised to indicate success in dieting (Fishbach et al., 2003). It has been used as such in multiple subsequent studies and is often equated with lower BMI, ability to lose weight, or dietary restraint (Meule et al., 2012; Nguyen & Polivy, 2014; Laura Nynke van der Laan, de Ridder, Viergever, & Smeets, 2014). However, the results reported here suggest that this is not always the case and some individuals may give greater consideration to factors such as physical health or fitness, or comfort in one's body. In fact, the high use of wellbeing themes in interpretation of study items in this sample may explain the lack of association between PSRS and BMI. Although the PSRS has been shown to be a reliable predictor of BMI in general (Meule et al., 2012), interpretations of study items may differ according to populations and should be considered when applying this measure.

In this study, I aimed to elucidate processes of self-regulation which might explain the link between mindfulness and weight management. I have shown that mindfulness was associated with more favourable diet and weight outcomes including lower fat and sugar intake and lower BMI. However, this effect does not appear to be explained by processes of

automatic counteractive control. In fact, results from the lexical decision task suggest slower, more deliberative responding in more mindful individuals. However, mindfulness was shown to interact with regulatory style such that dispositional mindfulness ameliorated the negative effect of controlled regulation on BMI. Mindfulness may confer an advantage in protecting against negative effects of external pressures and control relating to diet.

Chapter 6.

General Discussion

This thesis set out to explore the relationship between mindfulness and eating behaviour, with the aim of identifying and understanding the mechanisms that account for more favourable eating and weight management outcomes as a function of greater mindfulness. My investigation focused on processes of self-regulation. I began by looking for a mediating role of self-control, as a result of greater executive function capacity, in determining eating behaviour according to mindfulness state or level of dispositional mindfulness. I then further examined cognitive accessibility of dieting goals as an indicator of self-control ability and investigated the role of mindfulness in determining regulatory styles in the context of Self-Determination Theory (Deci & Ryan, 2000). In this chapter I present a summary of my findings and discuss how they relate to, and build upon, existing literature. Directions for further research and methodological constraints of this programme of research are also discussed.

6.1 Summary and Discussion of Findings

6.1.1 The self-control mechanism. In investigating processes of self-regulation, with the aim of understanding mechanisms underlying the relationship between mindfulness and eating behaviour, I focussed initially on the role of self-control. The term self-control commonly refers to a subset of processes within self-regulation which aim to inhibit or override prepotent or automatic impulses (Hofmann et al., 2012). In the case of eating behaviour, enacting self-control may involve resisting urges to consume appetitive but energy dense foods in favour of pursuing long-term weight regulation goals. Teper et al. (2013) have proposed a model whereby mindfulness is postulated to impact capacity for self-control by increasing awareness of and attention to goal conflict events. In this thesis, I set out to establish whether such hypothesised improvements in self-control would enable greater control over eating. As Teper et al. state that improvements in self-control associated with mindfulness are driven by enhanced executive function, and as executive function underpins self-regulatory capacity more broadly (Hofmann et al. 2012), I began by looking for a mediating

role of executive function in the relationship between mindfulness and eating outcomes before moving onto alternative contextual and task measures of self-control.

In examining the role of executive function, I built a mediation model over the course of three studies (Studies 2 to 4), using the Attentional Control Scale (Derryberry & Reed, 2000) as a measure of self-reported executive function. Study 2 aimed to establish a correlational relationship between mindfulness and executive function, Study 3 then tested the causal role of executive function in relation to state mindfulness, while Study 4 also looked at mediation by executive function, but in relation to dispositional mindfulness.

Consistent with a large body of work linking both dispositional mindfulness and mindfulness practice to greater executive function ability (Friese et al., 2012; Moynihan et al., 2013; Rodriguez Vega et al., 2014; Shin, Black, Shonkoff, Riggs, & Pentz, 2016; Short et al., 2016), Study 2 found a significant positive association between dispositional mindfulness, as assessed with the FFMQ, and attentional control. Following on from this result, Study 3 aimed to test the causal role of attentional control in determining eating behaviour following a mindfulness induction. Although this study found that state mindfulness resulted in healthier food choice, under conditions of low hunger, there was no effect of the body scan manipulation or state mindfulness, collapsed across conditions, on attentional control. This pattern of effects may imply that there is no mediating role of attentional control in the relationship between mindfulness and eating behaviour. However, the lack of association between state mindfulness and attentional control is surprising given the previously established relationship between these variables. According to Baron and Kenny's (1986) seminal paper, in order to establish evidence of mediation there must be a significant relationship between the independent variable and proposed mediating variable, and between the proposed mediator and the dependent variable that account for the relationship between the independent and dependent variables. This necessitates an association between the independent variable and the mediator. I argue that as there was no association between mindfulness and attentional control in Study 3, and because this relationship has been

established in previous research, there is not adequate evidence to disprove the mediating role of attentional control in this sample, and that this is likely attributable to the weak effect of the body scan manipulation used in this study.

More convincing results regarding the role of attentional control were provided in Study 4. In this study, I again examined the mediating role of attentional control in determining eating behaviour, but this time in relation to dispositional mindfulness rather than induced (or state) mindfulness. In this case, dispositional mindfulness resulted in significantly lower behavioural intention to eat cookies following exposure to both vivid and pallid food cues. Furthermore, there was a significant association between mindfulness and attentional control. However, process analysis (Hayes, 2013) found no evidence of a mediating role of attentional control. Taken together, the results of Studies 2, 3, and 4 suggest that although mindfulness is associated with improved executive function, there is no evidence for a mediating role of self-control, as indexed by enhanced attentional control.

The attentional control measure used in these studies is a self-report measure capturing executive function traits relating to the ability to focus and shift attention and flexibly control thought. These studies therefore examined the role of self-control by using executive function capacity as a proxy measure. This approach may be critiqued as conflating executive function with self-control. Tangney, Baumeister, and Boone (2004) present the ability to override or change inner responses as being central to the concept of self-control and emphasise that this requires a degree of self-awareness and comparison to a given standard. As such, self-control is a context specific action that requires a degree of self-awareness concerning one's current actions and desired behaviour. In contrast, executive functions are general purpose control mechanisms pertaining to all forms of cognitive behaviour, and occur without need for self-awareness (Miyake et al., 2000). It could be that assessing executive function in these studies is not sufficient to investigate the role of self-control. I took the approach of assessing executive function in these studies based on the model put forward by Teper et al. (2013), which proposes that the improvements in executing function directly

account for greater ability in self-control and regulation of behaviour. Executive function has also been identified as playing a critical role in supporting self-control by determining an individual's capacity to inhibit responses in favour of goal behaviours (Hofmann et al., 2012). In the context of the current research, I aimed to establish the mediating role of underlying executive function, but also employed alternative measures which also examined the processes of enhanced awareness and present-moment attention outlined by Teper et al.

In Studies 4 to 6 I continued to investigate the role of self-control using alternative methods to self-reported executive function. In Studies 4 and 5 I investigated the processes of response to goal conflict outlined by Teper et al. (2013) using a cueing paradigm based on the principles of cybernetic models of control to manipulate need for self-control. In these studies, I hypothesised that more dispositionally mindful participants would be less likely exhibit automatic or impulsive behaviour triggered by the presence of food cues, inferring greater self-control ability in these individuals. I employed this design in order to observe self-control in a contextually relevant situation, presentation of food stimuli, rather than simply examining the role of domain general executive function. However, there was no main effect of the cueing manipulation in either of these studies, limiting the conclusions that could be drawn about the role of self-control. The lack of effect of food cueing was unanticipated given that food has an intrinsic hedonic value (Beaver et al., 2006) and the priming of eating behaviour by presence of food cues is thought to serve a basic evolutionary purpose (Berthoud, 2007). Food cueing paradigms have been widely used in the eating behaviour literature, and have been shown to increase energy intake and frequency of feeding (Cornell et al., 1989; Ferriday & Brunstrom, 2008). However, failure to consider potential moderators of the effect of cueing, such as cue specificity, participant characteristics, and the nature of employed, may have undermined the effectiveness of the cueing design used in Studies 4 and 5.

In Study 6 I employed a task measure which assessed self-control capacity specific to dietary behaviour. Using a lexical decision task with subliminal primes (Papies et al., 2008b) I assessed the extent to which more and less mindful individuals responded to appetitive food

cues by cognitively activating representations of dieting goals. The tendency to respond to temptation by activating goal representations has been identified as a non-conscious form of self-control and distinguishes between successful and unsuccessful dieters (Fishbach et al., 2003). There was no evidence to support increased accessibility of dieting goals in more mindful individuals. In fact, more mindful participants displayed increased reaction times, suggesting a slower, more deliberative form of responding, rather than the automatic processes of self-control that had been hypothesised.

Taken together these results do not provide strong evidence that mindfulness facilitates enhanced self-control in response to specific goal conflict events, the process outlined by Teper et al. (2013) as accounting for enhanced emotion regulation and alternative favourable self-regulatory outcomes in more mindful individuals. In particular, this conclusion relates to self-control as assessed via executive function abilities. Although the results of the studies involving the cueing paradigm were somewhat inconclusive regarding the role of self-control the results of the goal accessibility task suggest that rather than enacting greater automatic self-control, mindfulness may instead be associated with slower more deliberative forms of regulation.

6.1.2 The effect of mindfulness on eating and weight. The studies included in this thesis utilised a variety of outcome measures to examine the role of mindfulness in determining eating behaviour and weight management outcomes. Correlational evidence in Study 2 showed mindfulness to be associated with favourable dietary practices of reduced neophobia, indicating greater willingness to try new foods, and greater preference for healthy foods. Further investigation using a laboratory design, in which food intake was covertly recorded during an *ad lib* eating task, found that mindfulness did not have an effect on total energy intake, but did result in significantly healthier eating choices, with a greater ratio of consumption coming from healthy foods compared to unhealthy foods. Furthermore, this effect was moderated by hunger, such that mindfulness only had an effect on consumption under conditions of low hunger. Studies 4 and 5 utilised variations of the same cueing

paradigm, with the aim of using food cues to trigger eating behaviour. While Study 4 found that mindfulness predicted in significantly lower behavioural *intention* to eat, Study 5 found no effect of mindfulness on recorded consumption of chocolate, assessed as a binary outcome. The results of Studies 4 and 5 suggest that although mindfulness may produce more favourable intentions regarding eating behaviour, these positive intentions do not necessarily translate into more favourable behaviour. While Study 4 found a significant negative association between mindfulness and self-reported BMI, Study 5 failed to find any significant relationship between these variables. Finally, in Study 6 I investigated the effect of mindfulness on BMI and self-reported dietary content in a longitudinal design. In this study mindfulness was shown to be negatively associated with fat and sugar intake. Mindfulness also had a buffering effect of controlled regulatory style on BMI, whereby controlled regulation predicted higher BMI only in those participants who were low in mindfulness. However, when looking at the outcome of sugar intake, rather than BMI, controlled regulation had an overriding effect on mindfulness, with greater mindfulness resulting in lower sugar intake only among participants who were also low in controlled regulation. These results suggest that the moderating effect on mindfulness in buffering the effect of controlled regulation on BMI is attributable to something other than sugar intake.

The pattern of effects documented in this thesis suggest that the effect of mindfulness on eating and weight is nuanced. While mindfulness may predict lower BMI (Study 4) it may also act as a moderator of the effect of other variables on BMI (Study 6). Rather than resulting in less energy intake *per se* mindfulness predicts reduced intake of fat and sugar (Study 6), or may allow individuals to make healthier choices when eating (Study 3). Finally, although mindfulness can lead to more favourable intentions regarding eating, with more mindful individuals less likely to report intention to eat unhealthy snacks (Study 4), this may not always translate to reduced consumption of such snacks (Study 5).

The complex nature of the influence of mindfulness on eating outcomes seen in this thesis is consistent with the wider literature, which has often found that the effects of

mindfulness may be governed by multiple mechanisms and are not as simple as merely reducing energy intake (Tapper, 2017). In Study 3 I found that although mindfulness did not have an impact on total calorie intake, it did result in healthier eating choices. In analogous results, Arch et al. (2016) also reported a role of mindfulness in improving healthy food choices. In this study, participating in a mindful eating task resulted in significantly fewer calories consumed in a subsequent taste task. This effect was driven by reduced intake just of unhealthy foods, rather than by global reduced intake of both unhealthy and healthy foods, compared to the control condition. Another study showing that the effect of mindfulness may be more complex than simply reducing energy intake at a single eating event was conducted by Van De Veer, Van Herpen, and Van Trijp (2016) and investigated processes of compensation in relation to mindfulness. In a series of studies, Van de Veer et al. demonstrated that both state and dispositional mindfulness allows individuals to adjust their energy intake according to the amount of food that they had previously consumed in a preload meal, thus allowing them to regulate their energy intake across an extended period of time rather than simply reducing the amount of food consumed in a single eating episode. Aside from laboratory studies, other studies have also shown that mindfulness may lead to improvements in weight related health indicators or specific dietary habits without leading to significant reductions in weight or global changes in energy intake. In the SHINE trial, a longitudinal randomised controlled trial investigating the effects of a diet and exercise with or without mindfulness components for obese adults (Daubenmier et al., 2016; Mason et al., 2016), mindfulness did not result in significantly greater weight loss at 18-month follow up, although differences in weight loss between groups did favour the mindfulness group at trend level. However, mindfulness did result in improvements on secondary outcome measures, including fasting glucose levels and indicators of metabolic syndrome (Daubenmier et al., 2016). Elevated fasting glucose levels represent a substantial risk factor for onset of type II diabetes (Barr et al., 2007), and the effects of mindfulness training on fasting glucose in this study represented a clinically meaningful reduction in diabetes risk. Metabolic syndrome refers to the cluster of

conditions associated with, but not limited to, obesity that raise risk of type II diabetes and cardiovascular disease (Alberti, Zimmet, & Shaw, 2005). Furthermore, the effect of the mindfulness intervention on fasting glucose was mediated by reduced consumption of sweet foods and desserts relative to control participants (Mason et al., 2016). The results of lab studies such as those conducted by Asch et al. (2016) and Van de Veer et al. (2016), along with intervention studies such as Daubenmier et al.'s (2016) speak to the complex role of mindfulness in altering specific eating behaviours and resulting in health outcomes that are related to obesity without always resulting in global energy intake or body weight.

Similar to the findings discussed above, the results of the studies in this thesis, which examine multiple outcome measures relating to control of eating and weight management, suggest that the effect of mindfulness is complex and nuanced, extending beyond simply reducing energy intake or decreasing body weight. Taken together with the existing literature concerning the role of mindfulness, these results point to the need for careful selection of outcome variables and consideration of moderating variables.

6.1.3 The role of hunger. I assessed the role of hunger in relation to mindfulness and eating outcomes in Studies 3, 4, and 5, and found varied results. While Study 3 found an interaction between state mindfulness and hunger, such that hunger had an overriding effect on the benefits of a mindful state, there was no interaction between dispositional mindfulness and hunger in Studies 4 and 5. These differing results are likely attributable to meaningful methodological differences between these studies. While there is likely a minor role of the use of a proxy measure of hunger in Study 5 compared to self-reported hunger level used in Studies 3 and 4 (see section 4.4), the principle difference between these studies is the use of state versus trait mindfulness. Study 3 examined the role of state mindfulness, reflecting participants' level of mindfulness state at that moment in time. In contrast, Studies 4 and 5 assessed participants' level of dispositional mindfulness, reflecting more enduring individual personality differences. It has been argued that dispositional and state mindfulness may represent differing constructs (Thompson & Waltz, 2007). Hunger is a fundamental visceral

drive governing behaviour (Loewenstein, 1996) and reflects a short-term desire that is likely to acquire cognitive priority (Hofmann & Van Dillen, 2012). It seems reasonable then to suppose that hunger might interfere with maintenance of a mindful state, a task that requires attentional focus, more than it disrupts effect of the mindful personality trait. In fact, a state of hunger induced by fasting has been shown to increase mind wandering when engaged in a reading task (Rummel & Nied, 2017).

While it appears from the results of Study 3 that hunger has an overriding effect on the benefits of mindfulness, these results contrast with those reported by Marchiori and Papies (2014) who found that mindfulness had a buffering effect on hunger. In Marchiori and Papies' study participants underwent a 15-minute body scan exercise, a manipulation similar to that employed in Study 3. Participants in this mindfulness condition did not increase their subsequent intake of cookies as a result of their hunger, while control participants ate significantly more when they were hungry than when they were not. Fisher, Lattimore, and Malinowski (2016) also investigated the role of hunger in a laboratory eating design, this time examining hunger as an outcome, and also found a protective effect of mindfulness. In this study participants underwent a mindful attention induction, based on mindful breathing exercises, or completed a control task and were then exposed to appetitive food cues. While control participants reported increased hunger levels after exposure to food, participants in the mindfulness condition reported no such increase. Participants in the mindfulness condition also consumed significantly fewer cookies in a subsequent *ad lib* eating period, however the effects of mindfulness on hunger were short lived and had attenuated by the time participants had the opportunity to eat. For this reason, the role of hunger in determining actual food consumption following the mindfulness induction was ambiguous in this study.

The literature concerning the role of hunger in relation to mindfulness has received little attention in laboratory eating behaviour studies. The existing literature tentatively supports a protective role of mindfulness in buffering effects of hunger (Fisher et al., 2016; Marchiori & Papies, 2014). However, given the documented role of hunger in disrupting

attentional and regulatory processes (Hofmann & Van Dillen, 2012; Loewenstein, 1996) it is possible that hunger may actually have an overriding effect on the benefits of mindfulness in relation to eating behaviour, as is suggested in Study 3 of this thesis. Further research which directly examines the role of hunger in relation to mindfulness is necessary.

6.1.4 The body scan manipulation. In Study 3 I used a brief mindfulness induction to manipulate state mindfulness. Participants completed a 10-minute body scan exercise or listened to an audiobook recording in the control condition. The body scan is a form of guided meditation developed as part of the Mindfulness Based Stress Reduction course (MBSR; Kabat-Zinn, 1990), in which non-judgmental attention is guided around regions of the body. I used a mindfulness manipulation rather than observing dispositional mindfulness in this study so that I was better able to draw conclusions about the causal role of mindfulness. However, manipulation check analyses found that there was no effect of the body scan exercise, relative to a control task, on state mindfulness as assessed with the Toronto Mindfulness Scale (TMS; Lau et al., 2006), a measured designed specifically to examine the effects of mindfulness manipulations.

The approach that I took in this study was informed by the results of a study by Marchiori and Papies (2014), who used a similarly brief mindfulness manipulation to demonstrate a role of mindfulness in preventing increased consumption in the face of hunger. Furthermore, the body scan recording used in Study 3 was successful in past research, where it reduced cigarette craving in abstinent smokers (Cropley et al., 2007; Ussher et al., 2009). However, the effects of such brief inductions are far from consistent. Bellinger et al. (2015) also found no effect of a 15-minute induction on TMS scores and further studies have found no main effect of brief manipulations on hypothesised outcomes (Eddy et al., 2015; Petter et al., 2014; Ortner & Zelazo, 2014; Van Dam et al., 2017).

These brief manipulations appear to be unreliable, at least in part, because they fail to sufficiently engage the processes and states in play during extended meditation. This can be

seen in studies which have demonstrated hypothesised effects of mindfulness dependent only on state of mindfulness attained rather than the mindfulness manipulation itself (Eddy et al., 2015; Ortner & Zelazo, 2014; Petter et al., 2014), and is also in line with studies that have found an influence of mindfulness on self-control only after extended mindfulness training rather than following a brief manipulation (Saunders et al., 2016; Teper & Inzlicht, 2013). After failing to demonstrate an effect of a brief mindfulness induction on intuitive thinking, Remmers et al. (2015) suggested that for some participants the mindfulness instructions that they were requested to follow may have served as a distraction task rather than a mindfulness task. Specifically, these participants engaged with task instructions such as focusing on their breath but did not fully engage with the 'here and now' component of mindfulness and mindful thinking, leading to distraction from the present moment rather than awareness of it. In particular, this may have applied to participants with little or no prior experience of mindfulness practise. Reaching and maintaining a mindful state may take longer for some participants than others (Kabat-Zinn, 1990) and in manipulations of only 10-15 minutes novice participants may only just have time to get to grips with the unfamiliar instructions given in mindfulness meditation.

Keng, Smoski, and Robins (2011) conducted a review of the effects of both long-term mindfulness interventions and short term laboratory inductions. This review concluded that the majority of studies support the notion that brief mindfulness manipulations can proffer benefits, at least in the domain of emotional reactivity and recovery from dysphoric mood. However, the authors highlight the need to conduct further research that more closely examines the extent to which a state of mindfulness is truly induced by laboratory manipulations, as few studies report manipulation checks that explicitly assess the extent to which participants were mindfully aware of their emotions and states during the induction procedure or subsequent experimental tasks. It is also likely that a 'file drawer' problem, whereby studies which find a null effect of mindfulness manipulations are less likely to be disseminated or published (Rosenthal, 1979), further clouds the literature in this area, and

makes it difficult to be confident in the efficacy of such designs. Given these concerns over whether brief laboratory manipulations truly induce a state of mindfulness, and the unreliable effects of mindfulness manipulations, I chose to focus on the role of dispositional mindfulness for my subsequent studies. The dispositional conceptualisation sees mindfulness as a personality trait that varies across individuals, regardless of whether or not an individual engages in mindfulness practice (Brown & Ryan, 2003). Dispositional mindfulness predicts a range of psychological outcomes in a theoretically consistent manner (Baer et al., 2006), and is associated with improved outcomes for eating behaviours and weight management (e.g. Beshara et al., 2014; Loucks et al., 2016).

6.1.5 Mindfulness and regulatory style. After finding no support for a mediating effect of self-control, as assessed by executive function, I broadened my investigation to include more overarching processes of self-regulation relating to the standards and motivations that govern self-regulatory behaviour on a day-to-day basis. To do so, I examined regulatory style in the context of self-determination theory (SDT; Ryan & Deci, 2000). According to SDT an individual's motivation for a behaviour, which determines the regulatory style governing behaviour, varies along a continuum from autonomous to controlled. Given past findings on links between mindfulness and self-regulation, I hypothesised that mindfulness would predict more autonomous forms of regulation with regard to eating behaviour, and that this would predict more favourable diet and weight outcomes in more mindful individuals. I did not find this to be the case as there was no significant association between mindfulness and autonomous regulation. However, mindfulness was significantly negatively associated with the opposing construct of controlled regulation. Furthermore, when looking at the outcome of BMI, mindfulness interacted with controlled regulation to provide a protective or buffering effect. Controlled regulation typically predicts higher BMI (Leong et al., 2012; Pelletier et al., 2004), however in this study controlled regulation only predicted higher BMI for those participants who were low in dispositional mindfulness.

I had hypothesised a significant association between mindfulness and autonomous regulation in line with theoretical and empirical evidence linking mindfulness to greater autonomous regulation. Weinstein et al. (2013) have outlined how increased access to self-knowledge in the form of mindful awareness allows individuals to consider their own needs and values, facilitating greater autonomous functioning, and greater dispositional mindfulness is associated with greater day-to-day autonomous functioning (Brown & Ryan, 2003; Levesque & Brown, 2007). Given this established relationship between mindfulness and autonomous regulation, and the theoretically defined mechanisms behind it, the lack of association between mindfulness and autonomous regulation in Study 6 was unexpected. However, SDT specifies that autonomous and controlled regulation are at varying ends of a continuum. A simplex pattern, in which each regulatory style displays positive correlations with adjacent regulatory styles on the continuum and negative correlations with distant ones, is often found in SDT data, including when using the REBS measure used in Study 6 (Pelletier et al., 2004). As such, the significant negative association between mindfulness and the opposing construct of controlled regulation, rather than a positive association between mindfulness and autonomous regulation is not anomalous.

Furthermore, there was a buffering effect of mindfulness on the effect of controlled regulation on BMI, demonstrating a positive outcome of mindfulness in interaction with controlled regulation. Based on previous work by Hagger and Chatzisarantis (2011), which found that the personality characteristic of autonomy orientation attenuated the negative effects of controlling influences, I speculated that mindfulness may act as a protective characteristic by altering perceptions of external control so that they are seen as less undermining to autonomy. This protective effect of mindfulness may be related to a body of work on the relationship between mindfulness and ego involvement. Mindfulness is associated with less defensive processing and ego threat (Brown et al., 2008; Niemiec et al., 2010), and greater clarity of self-concept (Hanley & Garland, 2017), which may contribute to more mindful people being less likely to see controlling external influences as undermining need

satisfaction. However, further work is needed to replicate the protective influence of mindfulness and directly investigate the processes responsible for this effect.

6.2 Directions for Further Research

There are a number of avenues for further research that may be pursued following on from the research presented in this thesis. Here, I focus on two such avenues that I believe are particularly important. First, it is important to continue to pursue the investigation of self-control during discrete goal conflict events. Second, it is important to further examine non-conflict driven self-regulation on a day-to-day basis.

6.2.1 Alternative conceptualisations of self-control. Studies 2 to 6 sought to investigate the role of self-control in relation to mindfulness and eating behaviour. Self-control can be defined as a subset of self-regulatory processes that aim to override prepotent impulses. Self-control concerns the capacity to reduce discrepancies between goal states and current behaviour in situations where they conflict. Although the studies in this thesis do not provide direct evidence for a mediating role of self-control in determining eating behaviour as a function of mindfulness, they are restricted in a number of ways that may be addressed in further research. These include limitations of the Attentional Control Scale, the use of cueing manipulations, and the highly specific nature of the goal accessibility task.

In investigating self-control, I focused on the role of executive function, in line with the model proposed by Teper et al. (2013) which outlines how mindfulness increases self-control ability via improvements in executive function. In Studies 2 to 4 I used the Attentional Control Scale (ACS) to assess executive function ability. The ACS is a self-report measure of executive function with a two-factor structure, the *focusing* subscale refers to the ability to maintain attention while inhibiting attentional capture by distractors, the *shifting* subscale assesses ability to redirect attention between tasks. This structure maps onto the three executive functions of updating, shifting, and inhibition proposed in Miyake et al.'s (2000) influential framework. Accordingly, the ACS predicts performance on numerous indicators of these

executive function abilities including maintenance of task goals, inhibition of responses, and task switching on an anti-saccade task (Judah et al., 2014), rate of inhibition errors on a Go/No-Go task (Wiersema & Roeyers, 2009), and attentional focus and inhibition on the Flanker task (Reinholdt-Dunne, Mogg, & Bradley, 2013).

Although the ACS does predict inhibition on executive function task assessments, the items of the focusing subscale, the subscale most relevant to inhibition (Judah et al. 2014), pertain primarily to attentional focus and ability to inhibit attentional capture by irrelevant information rather than inhibition of response. It is the inhibition of prepotent responses that is the primary feature of inhibition as defined by Miyake et al. (2000), and highlighted by Teper et al. (2013). Whether the ACS is uniquely predictive of *inhibitory* executive function to a large enough extent to accurately test the hypotheses derived from Teper et al.'s model in the current studies require further consideration; it should be noted that the focusing subscale did not provide a predictive advantage over the shifting subscale in any of the studies included in this thesis. An alternative approach to investigating the role of self-control, as conceptualised in Teper et al.'s model, may be to use task measures of executive function that are specifically tailored to investigating inhibition. Two such measures are the Stroop Task (Stroop, 1935) and the Go/No-Go Task (see e.g., Lustig, Hasher, & Zacks, 2007). The Stroop Task requires participants to name the colour of ink that words are presented in, these words may represent the congruous colour to the ink (e.g. *blue* written in blue ink) or be incongruous with ink colour (*blue* written in green ink). Correctly naming ink colour requires inhibition of prepotent impulse to read the word rather than name the colour and involves cognitive functions of response inhibition, interference resolution, and behavioural conflict resolution (Adleman et al., 2002). The Stroop Task has been used to study executive function in a range of cohorts (Zysset, Müller, Lohmann, & von Cramon, 2001), producing large and reliable effects (MacLeod, 1991). Furthermore, poorer response inhibition as assessed with the Stroop Task is associated with greater BMI and adiposity (Deng et al., 2018; Stinson, Krakoff, & Gluck, 2018). In a Go/No-Go Task participants are required to perform a quick motor response, usually a key

press, when certain targets are presented and withhold response when non-targets or distractors are presented, the *go* response is trained over multiple trials to be the prepotent response and false alarms (go responses on no-go trials) are used as the primary outcome measure. This task allows for investigation of response inhibition under conditions in which other cognitive/behavioural processes are minimised (Simmonds, Pekar, & Mostofsky, 2008), and may be used to examine impulsive responses to food stimuli (Meule, 2017).

In addition to my studies that used the Attentional Control Scale to measure self-control, in Studies 4 to 6 I aimed to investigate self-control processes using methods that were less dependent on assessment of executive function, and instead focused on self-control in a more dietary context specific manner. In Studies 4 and 5 I used a food cueing paradigm to manipulate the need for self-control and so infer self-control ability, but found no evidence of an effect of the cueing manipulation. In Study 6 I used a task measure intended to assess self-control ability specifically in the context of dietary behaviour. This goal accessibility task involved a priming procedure in which the degree of cognitive activation of dieting goals in response to food primes gives an indication of the level of self-control specific to eating behaviour. This task is based on the principles of Counteractive Control Theory (Trope & Fishbach, 2000) and relies on testing the strength of automatic associations between food stimuli and goal representations that develop as a result of multiple pairing of temptation and self-control (Fishbach et al., 2003). However, the results of Study 6 showed that more mindful people actually exhibited slower responses to dieting words, suggesting more deliberative, rather than automatic, responses. This result is consistent with Brown and Ryan's (2003) time interval hypothesis, which proposes that mindfulness creates an interval in which individuals are able to observe their own behavioural choices rather than acting in an automatic manner, and with additional studies that suggest more deliberative responding on attentional tasks as a function of mindfulness (Di Francesco et al., 2017; Rodriguez-Vega et al. 2014). To build on this finding, further research may utilise context dependent measures of self-control that do not assess automatic self-control processes, but instead focus on deliberative actions.

One approach may be to assess the degree to which mindful people are able to 'think cool' when presented with goal conflict events. Based on delay of gratification research, in which participants must resist immediate tempting stimuli, Metcalfe and Mischel (1999) proposed a dual-process model in which self-control is governed by interacting 'hot' and 'cool' systems. The hot emotional system reacts to appetitive and fear inducing stimuli to trigger impulsive responding, while the cool system is a cognitive, reflexive system which overrides hot responses to provide self-control. Cool generated ideation in the face of tempting stimuli, or 'thinking cool', involves self-generated thinking about and cognitive transformations of the stimulus to access its cool properties. This thinking allows dominance of the cool system, representing greater self-control and increasing the ability to keep goals in mind and monitor progress in attaining them when presented with goal conflict events.

In a body of work that has developed since the inception of this thesis, the construct of *decentring* as a component of mindfulness has been investigated based on similar principles to those of 'thinking cool'. Based on grounded cognition principles (Barsalou, 2008), Papies and colleagues (e.g., Papies, Pronk, Keesman, & Barsalou, 2015; Papies, van Winckel, & Keesman, 2016) have proposed that exposure to appetitive foods triggers reward simulations of eating and enjoying foods, based on previous experiences. These eating and reward simulations contribute to craving and desire, but applying a decentred perspective, in which thoughts are viewed as transient, may make the reward simulation less subjectively real and prevent the development of full-blown craving and desire. Food specific experiences of decentring, for example, the ability to distance oneself from thoughts about food, have been shown to be associated with reduced instance of food craving in experienced meditators (Papies et al., 2016), and a brief training exercise in which participants were taught to take a decentred perspective when viewing images of food resulted in healthier food choices and reduced energy intake in a student sample (Papies et al., 2015). It appears then that investigation of thought processes and mental representations of attractive environmental stimuli, and the

role that they play in determining control over behaviour in more and less mindful individuals represents a promising avenue for further research.

6.2.2 Non-conflict driven self-regulation. Self-control represents just one aspect of self-regulation, concerning the capacity to reduce discrepancies between goals and behaviour in goal conflict situations. Self-regulation also includes standards of behaviour that an individual endorses and motivation to meet them. In Study 6 I broadened my investigation to include investigation of standards and motivations by investigating motivation and forms of regulation in more and less mindful individuals using Self-Determination Theory (Deci & Ryan, 2000). I found that mindfulness was unrelated to autonomous regulation of eating behaviour, which would represent internally driven motivation for control over eating in line with values, but was negatively correlated with controlled regulation, representing motivation driven by external pressures. Furthermore, mindfulness was shown to have a buffering effect on the effect of controlled regulation on BMI, such that it protected against elevated BMI as a function of greater controlled regulation.

Further research may continue to investigate regulatory processes in the context of Self-Determination Theory. Given the theoretical link between mindfulness and autonomous functioning, in which mindfulness is thought to support integrated regulation (Weinstein et al., 2013), and the correlational relationship between dispositional mindfulness and everyday autonomous functioning (Brown & Ryan, 2003), it was surprising that no relationship between mindfulness and autonomous regulation was present in Study 6. Additional research is necessary to establish whether this lack of effect is specific to autonomous regulation in the specific context of eating behaviour and diet, or whether it was specific to the sample used in Study 6. In addition, it would be useful to replicate the interaction between mindfulness and controlled regulation in determining BMI. If this effect were to replicate further research might aim to establish why it exists. Considering the unusual results concerning sugar intake, in which controlled regulation had an overriding effect on mindfulness rather than the buffering effect of mindfulness seen in relation to BMI, it is important to understand what is driving

effects on BMI. While the results of sugar intake and BMI may suggest that mindfulness has a protective effect on BMI through routes other than diet, specifically sugar intake, such as physical activity, the assessment of sugar intake may have been subject to reporting bias, and so further research is necessary to unpack this effect. Finally, further research should attempt to understand why mindfulness has a buffering effect on controlled regulation, by investigating the characteristics of the mindful personality that allow its protective effects. A starting point for such research may be to examine the role of ego investment, whereby less defensive processing and reduced ego threat may result in more positive appraisals of controlling external influences.

6.3 Limitations

There are several constraints or limitations in the research presented in this thesis that relate to study design and measurement of key variables. These factors should be considered when interpreting the results presented in this thesis.

6.3.1 Use of lab studies. The majority of the studies included in this thesis used laboratory designs to examine the relationships between mindfulness, eating behaviour, and additional variables. Laboratory designs take a highly controlled approach to the study of eating behaviour in order to examine the influence of variables in isolation. As such they sacrifice a degree of ecological validity and have been criticised for obscuring or removing the influence of additional inhibitors and facilitators of eating, overestimating the importance of test variables, and discounting longer-term influences on eating due to the short duration of studies (de Castro, 2017). However, studies have demonstrated the validity of laboratory eating paradigms used in this thesis, such as the bogus taste test (Robinson et al., 2017), and found concordance between food intake measured in the lab and food intake in free living conditions (Dalton, Blundell, & Finlayson, 2013). Furthermore, naturalistic and epidemiological designs are not without flaws and often equally do not represent the environments under which individuals consume the majority of their energy intake, for example observational

studies in food courts and restaurants (Stubbs, Johnstone, O'Reilly, & Poppitt, 1998). Laboratory studies therefore, are essential for establishing relationships between tightly controlled and precisely measured variables which can only be hypothesised in epidemiological studies (Stubbs et al., 1998) and represent a valuable tool for use alongside naturalistic methods (de Castro, 2017).

6.3.2 Sampled population. With the exception of Study 2 and Study 4, which used samples recruited online from the general population, all the studies included in this thesis were conducted using samples made up entirely of (overwhelming female) psychology undergraduate students. The use of student sample raises a number of problems. Student samples are at high risk of poor diet and unhealthy eating habits, including reduced fruit and vegetable consumption and increase sugar, alcohol, and fast food intake (Bargardo et al., 2013; Greaney et al., 2009; Papadaki et al., 2007). Poor eating habits and dietary content in students is likely to be the result of external moderating influences and environmental constraints unique to the student population. Students report time constraints, lack of access to healthy foods, and social influences as barriers to healthy eating (Greaney et al., 2009; Hilger et al., 2017). Deliens et al. (2014) argue that these university specific influences moderate the effect of individual determinants of eating behaviour. as such, the effects of individual level factors such as mindfulness on eating and weight outcomes may be masked or attenuated in student samples. This may be particularly true for Study 6, where dietary content in participants' everyday lives was monitored over time.

Student samples also raise potential issues regarding generalisability, as students represent a specific group that are well educated and predominantly come from Western, democratic, and industrialised societies, a profile that has been described as among the least representative populations for generalising research findings (Henrich, Heine, & Norenzayan, 2010). The motivation of student participants in comparison to paid participants has also been questioned, and motivation and performance of students is likely to decrease throughout the semester (Nicholls, Loveless, Thomas, Loetscher, & Churches, 2015).

A further critique of the populations used in this thesis is that they were predominantly female. This critique is intrinsically tied to the use of student samples - for all experimental studies that were conducted on student samples (Studies 3, 5, and 6) I restricted eligibility to females. This was because gender differences have been well documented in a range of eating behaviour outcomes, including consumption behaviour in the laboratory and self-reported dietary content (Greenwood et al., 2014; Hebert et al., 1997; Roos, Lahelma, Virtanen, Prättälä, & Pietinen, 1998; Wardle et al., 2004). These gender differences may also be amplified in students (Dodd et al., 2010; Keller et al., 2008). Due to the limited availability of males in the student undergraduate pool I chose to restrict eligibility to females only to minimise the potential confounding effect of gender in a non-balanced sample.

Where possible I used more representative and gender balanced samples, however this was only possible in online studies (Studies 2 and 4). The majority of studies in this thesis, along with the arching conclusions of this work, should therefore be considered with the caveat that they are based on female undergraduate student samples, and that further research is necessary to confirm these results in more diverse samples.

A final limitation concerning the samples used in these studies is that of sample sizes, which ranged from 200 to 57. In all cases sample sizes were selected based on convenience, and the main constraint on sample size was time availability of participants from the university pool. This caveat should be considered, especially when interpreting interaction effects, and any future studies which attempt to replicate or expand on these results should use larger sample sizes based on *a priori* power analyses.

6.3.3 Mixed outcome measures. The studies presented in this thesis used a variety of outcome measures to investigate eating behaviour and weight management. Study 3 used covert assessment of energy intake during a bogus taste test, participants' choice between healthy and unhealthy foods was recorded. Study 4 used a measure of behavioural intention in which participants indicated their intention to snack at the next available opportunity. In Study

5 food intake was again assessed by offering food as a reward for their participation. Finally, in Study 6 participants' BMI was recorded at multiple time points and they self-reported their dietary intake. The use of these items, while beneficial in testing a range of relevant outcomes, has the side effect of making it more difficult to make direct comparisons across studies. Given that each study aimed to build on the previous one in establishing the role of self-control and self-regulation, the use of a single outcome measure across studies would increase one's confidence in the ability to attribute any difference in outcome to change in the theoretically defined predictor variables. Furthermore, the use of BMI as an outcome still requires further investigation into the exact behavioural characteristics that contribute to any effect on BMI (e.g., change in diet, physical activity). That said, the outcome measures used in each of the studies in this thesis were justified in each individual study and are comparable to those used in the wider literature. For example, not only has covert monitoring of food intake been established as a valid and reliable paradigm (Robinson et al., 2017), but they have also been used in the investigation of mindfulness and eating behaviour (Fisher et al., 2016; Jordan et al., 2014; Marchiori & Papies, 2014). Self-report dietary and behavioural outcomes have also been frequently used in mindfulness eating behaviour research (e.g. Alberts, Mulkens, Smeets, & Thewissen, 2010; Forman et al., 2016).

6.3.4 Failed manipulations. In a number of instances manipulations used in this thesis failed to produce intended effects. The body scan exercise used in Study 3 was intended to induce a state of mindfulness but did not result in significantly greater levels of state mindfulness compared to a control exercise (in which participants listened to an audiobook recording). Studies 4 and 5 used a food cueing paradigm to manipulate need for self-control. However, there was no main effect of cue in either of these studies, suggesting that there was no difference in intention to eat or food consumption between the vivid cue and pallid cue or the cued and non-cued conditions (cf. Moore & Konrath, 2015). In the case of the failed body scan manipulation, the lack of manipulation effect meant that I was unable to test my hypotheses as intended (by looking for differences between groups). However, based on

previous precedent of examining for effects of mindful state attained by participants, rather than allocation to condition (Eddy et al., 2015; Ortner & Zelazo, 2014), I was still able to investigate the role of state mindfulness in internal analyses and draw meaningful conclusions about the role of mindfulness in this study. In contrast, the failure of the cueing manipulations in Studies 4 and 5 had a more meaningful impact on my ability to examine hypotheses and draw conclusions as the design of these studies meant that self-control ability could only be inferred from participants' response to the manipulation. Nonetheless, Study 4 did allow for investigation of the role of attentional control (collapsed across vivid and pallid cues), and so helped contribute to the body of evidence built in Studies 2 to 4 that suggested no mediating effect of attentional control in the relationship between mindfulness and eating behaviour.

6.3.5 Concern for dieting. Self-regulation concerns the pursuit of goal directed behaviour (Hofmann et al., 2012). In looking at self-regulation of eating behaviour it is important that participants endorse minimum standards of healthy eating or weight regulation behaviour. In Studies 1 and 2 I showed that mindfulness was positively associated with health values, meaning that more mindful individuals placed greater value in health, including healthy eating. As this showed that mindful individuals are motivated to regulate their eating and weight I deemed this to be sufficient to represent goal directed behaviour in subsequent studies. However, this may not be the case. Valuing health is a broader construct than just dietary concern, the health values measure also includes items relating to physical fitness and absence of disease. Furthermore, this motivation applies disproportionally to the more mindful participants in my sample, any effects of mindfulness on self-regulation in these studies may be equally attributable to greater endorsement of dieting goals, rather than greater ability to regulate behaviour. In my final study, I restricted eligibility to only participants who endorse weight management goals, using the *Concern for Dieting* scale devised by Fishbach et al. (2003). This scale requires participants to rate of 7 point scale the extent to which they are concerned with (i) being slim and (ii) watching their weight. It may

have been more appropriate to take this approach throughout all the experimental studies in this thesis.

I used the Fishbach et al. (2003) measure in Study 6 as it was relevant to the study design, which replicated a task used by Fishbach et al. This 2-item measure is much briefer than others used to assess dietary concern in the form of dietary restraint, for example the Restraint Scale (RS; Herman & Polivy, 1980) used by Papies et al. (2008b) in their replication of Fishbach et al.'s effect. However, Fishbach et al.'s measure only assesses motivation for weight management rather than behaviours or cognitive restriction of appetite. As such, I feel that it is a more valid measure of dietary goals and less susceptible to the shortcomings of dietary restraint measures such as the RS, which have been critiqued as only identifying chronic unsuccessful dieters characterised by episodes of bingeing and restriction (Heatherton, Herman, Polivy, King, & McGree, 1988).

6.3.6 Defining mindfulness. Following the failure of the body scan manipulation used in Study 3, and owing to concerns about the reliability of such brief manipulations (Keng et al., 2011), I chose to focus on the role of dispositional mindfulness for the remainder of the studies presented in this thesis. Although the use of the dispositional perspective may overcome issues regarding reliability and validity of brief mindfulness manipulations, there is wider debate concerning whether dispositional conceptualisations, or the measurement thereof, truly reflects mindfulness practise, as it is taught in the Buddhist Dharma (Grossman, 2008). In examining the relationship between mindfulness and affective forecasting, Hong, Lishner, Vogels, and Ebert (2016) used a meditation task to induce mindfulness and also assessed dispositional mindfulness, using the FFMQ, at a later date. They found that mindfulness meditation produced robust effects on affective forecasting accuracy. In contrast, the association between dispositional mindfulness and affective forecasting was only found under specific situational contexts that enhanced or inhibited natural mindfulness tendency. The greater variation in the effect of dispositional mindfulness, and the range of associated variables that may have accounted for the effect, led the authors to conclude that while the

mindfulness manipulation related to a highly controlled construct of mindful state, dispositional mindfulness "likely captures a dispositional aspect of a construct other than mindfulness" (Hong et al., 2016, p. 163). Thompson and Waltz (2007) directly investigated whether dispositional mindfulness and the mindful state are overlapping constructs by comparing dispositional mindfulness, assessed with the MAAS, and mindful state attained during meditation, assessed using the TMS. They found no significant relationship between these constructs following 15 minutes of sitting meditation in either novice or experienced meditators. However, it should be noted that this design only required participants to meditate for 15 minutes, and so is subject to the same critiques of brief manipulations reviewed above (see section 6.1.3). Thompson and Waltz suggest that although dispositional mindfulness may not relate to the state of mindfulness attained during brief meditation, the relationship between everyday mindfulness and *consistent* mindfulness practice may be more important than how mindful one is during *brief* practice. This conclusion is supported by multiple studies that have shown increases in dispositional mindfulness as a function of meditation experience and during the course of MBSR and MBCT courses (Baer et al., 2008; Carmody & Baer, 2008; Kiken, Garland, Bluth, Palsson, & Gaylord, 2015).

Further debate concerning the validity of the dispositional mindfulness construct, along with secular applications of mindfulness therapy, has come from Buddhist scholars, who question whether they truly reflect Buddhist teaching and practice. Although within Buddhist teaching an individual may be mindful in their daily activity (Hanh, 1976), there are concerns about the ways in which contemporary Western psychology has defined and measured mindfulness within individuals. Van Dam et al. (2018) have critiqued researchers for presenting mindfulness as having a single universally accepted definition, and raise concerns over construct validity and the operationalisation and measurement of mindfulness. Gethin (2015) has argued that definitions of mindfulness in modern literature are often highly Westernised and place undue emphasis on present moment awareness and non-judgemental acceptance at the expense of more body focused aspects of meditation. Indeed, the dispositional construct

put forward by Brown and Ryan (2003) focuses solely on attention and awareness and makes no reference to body awareness. Gethin also argues that secular therapies such as MBSR and MBCT conflate the manner of paying attention with the objects of attention, which is to equate mindfulness with vipassana (insight), which in Buddhist Dharma represents only one aspect of mindfulness. This focus on awareness and acceptance also omits important cognitive components of mindfulness; Dreyfus (2011) contends that the ability to retain and recall information, not just how information is attended to, is also central to mindfulness and inclusion of these cognitive aspects in definitions is key to understanding how mindfulness operates. As such, dispositional mindfulness, and even mindfulness therapy in the form of MBSR or MBCT, may really reflect a Westernised construct in which attentional components are more important that spiritual ones. Consistent with this argument, Maex (2011) has discussed the pitfalls of taking mindfulness out of the Buddhist context, and believes that practicing mindfulness simply as a technique, rather than a spiritually grounded practice, risks stripping it of the wisdom and insight that gives it its inherent healing abilities.

These critiques can impact individuals' perceptions about the strengths and weaknesses of dispositional measures of mindfulness, including those used in this thesis. Indeed, I used Brown and Ryan's (2003) conceptualisation and MAAS measure in the majority of my studies and so my investigation of the role of mindfulness in determining eating behaviour may be considered as limited to awareness and acceptance aspects of mindfulness, rather than the more comprehensive Buddhist conceptualisation. However, a large portion of the literature demonstrating a link between mindfulness and eating behaviour or weight management (see section 1.3.1) has relied on dispositional or secular conceptualisations of mindfulness. I am confident therefore that there is a relationship between mindfulness, as defined in this manner, and eating behaviour. By investigating the role of dispositional mindfulness, I am studying a consistently defined personality trait that has been identified as a reliable individual difference variable which predicts psychological and physical wellbeing in theoretically consistent manner (Baer et al., 2006; 2008; Brown & Ryan, 2003). Whether or not

it is a fallacy to label this trait as 'mindfulness' and align it with Buddhist teachings is still a matter of debate (Grossman, 2008; Grossman & Van Dam, 2011; Van Dam et al., 2018).

6.4 Conclusions

In this thesis, I set out to investigate the mechanisms which might account for the relationship between mindfulness and eating behaviour, with the aim of understanding how mindfulness may help aid weight regulation.

Throughout six studies I investigated processes of self-regulation and self-control in determining eating behaviour in the context of mindfulness. My results provided no direct evidence for a mechanism of enhanced self-control in goal-conflict events, as there was no evidence of mediation by executive function or enhanced self-control in the form of increased accessibility of dieting goals. I further demonstrated that the effect of mindfulness on eating behaviour is nuanced, and is not as simple as just reducing energy intake or body weight *per se.* Instead, mindfulness was shown to increase healthy food choices without affecting total energy intake, produce effects on dietary intentions but not eating behaviour, or moderate the effect of a third variable (controlled regulation) on BMI. These studies have also highlighted avenues for further research, including studies which assess regulatory style governing day-to-day behaviour and motivation or investigate the role of self-control and executive function using task measures of inhibitory control and assessment of thought processes and mental representations in response to environmental food stimuli.

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Appendices

Appendix 1. Mindful Attention Awareness Scale (MAAS) 194

Appendix 2. Five Facet Mindfulness Questionnaire (FFMQ) 195

Appendix 3. Attentional Control Scale (ACS) 198

Appendix 4. Health Values Measure 200

Appendix 5. Foods listed in assessment of healthy and unhealthy food preferences used in Studies 1 and 2 201

Appendix 6. Transcript of body scan meditation audio task used in Study 3 202

Appendix 7. Toronto Mindfulness Scale (TMS) 205

Appendix 8. Example image and nutritional information of foods presented during ad lib eating task in Study 3 206

Appendix 9. Stimuli used in food cueing paradigm in Study 4 207

Appendix 10. List of words used in the food cueing lexical decision task used in Study 5 209

Appendix 11. List of words used in the goal accessibility lexical decision task used in Study 6 210

Appendix 12. Regulation of Eating Behaviours Scale (REBS) 211

Appendix 1

Mindful Attention Awareness Scale (MAAS; Brown & Ryan, 2003), used in Studies 1, 4, 5, and 6

Below is a collection of statements about your everyday experience. Using the scale 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.

1. I could be experiencing some emotion and not be conscious of it until sometime later
2. I break or spill things because of carelessness, not paying attention, or thinking of something else
3. I find it difficult to stay focused on what's happening in the present
4. I tend to walk quickly to get where I'm going without paying attention to what I experience along the way
5. I tend not to notice feelings of physical tension or discomfort until they really grab my attention
6. I forget a person's name almost as soon as I've been told it for the first time
7. It seems I am "running on automatic" without much awareness of what I'm doing
8. I rush through activities without being really attentive to them
9. I get so focused on the goal I want to achieve that I lose touch with what I am doing right now to get there
10. I do jobs or tasks automatically, without being aware of what I'm doing
11. I find myself listening to someone with one ear, doing something else at the same time
12. I drive places on "automatic pilot" and then wonder why I went there
13. I find myself preoccupied with the future or the past
14. I find myself doing things without paying attention
15. I snack without being aware that I'm eating

Response scale: 1 (*almost always*) to 6 (*almost never*)

Appendix 2

Five Facet Mindfulness Questionnaire (FFMQ; Baer et al., 2008), used in Study 2

Please read each item carefully and indicate on the scale how often you have the experiences described. Please answer according to what really reflects your experience rather than what other people would expect or what you think you should experience.

Non-reactivity

1. I perceive my feelings and emotions without having to react to them
2. I watch my feelings without getting lost in them
3. In difficult situations, I can pause without immediately reacting
4. Usually when I have distressing thoughts or images, I am able just to notice them without reacting
5. Usually when I have distressing thoughts or images, I feel calm soon after
6. Usually when I have distressing thoughts or images, I "step back" and am aware of the thought or image without getting taken over by it
7. Usually when I have distressing thoughts or images, I just notice them and let them go

Observing

8. When I'm walking, I deliberately notice the sensations of my body moving
9. When I take a shower or a bath, I stay alert to the sensations of water on my body
10. I notice how foods and drinks affect my thoughts, bodily sensations, and emotions
11. I pay attention to sensations, such as the wind in my hair or sun on my face
12. I pay attention to sounds, such as clocks ticking, birds chirping, or cars passing
13. I notice the smells and aromas of things
14. I notice visual elements in art or nature, such as colours, shapes, textures, or patterns of light and shadow
15. I pay attention to how my emotions affect my thoughts and behaviour

Awareness

16. I find it difficult to stay focused on what's happening in the present (R)

17. It seems I am “running on automatic” without much awareness of what I’m doing (R)
18. I rush through activities without being really attentive to them (R)
19. I do jobs or tasks automatically, without being aware of what I’m doing (R)
20. I find myself doing things without paying attention (R)
21. When I do things, my mind wanders off and I’m easily distracted (R)
22. I don’t pay attention to what I’m doing because I’m daydreaming, worrying, or otherwise distracted (R)
23. I am easily distracted (R)

Describing

24. I’m good at finding the words to describe my feelings
25. I can easily put my beliefs, opinions, and expectations into words
26. It’s hard for me to find the words to describe what I’m thinking (R)
27. I have trouble thinking of the right words to express how I feel about things (R)
28. When I have a sensation in my body, it’s hard for me to describe it because I can’t find the right words (R)
29. Even when I’m feeling terribly upset, I can find a way to put it into words.
30. My natural tendency is to put my experiences into words
31. I can usually describe how I feel at the moment in considerable detail

Non-judging

32. I criticize myself for having irrational or inappropriate emotions (R)
33. I tell myself that I shouldn’t be feeling the way I’m feeling (R)
34. I believe some of my thoughts are abnormal or bad and I shouldn’t think that way (R)
35. I make judgments about whether my thoughts are good or bad (R)
36. I tell myself I shouldn’t be thinking the way I’m thinking (R)
37. I think some of my emotions are bad or inappropriate and I shouldn’t feel them (R)
38. I disapprove of myself when I have irrational ideas (R)

39. Usually when I have distressing thoughts or images, I judge myself as good or bad, depending what the thought/image is about (R)

Response scale: 1 (*never or very rarely true*) to 6 (*very often or always true*)

(R) – Reverse scored

Appendix 3

Attentional Control Scale (ACS; Derryberry & Reed, 2002), used in Studies 2,3, and 4

Please read each item carefully and indicate the answer that best describes you

1. It's very hard for me to concentrate on a difficult task when there are noises around. (R)
2. When I need to concentrate and solve a problem, I have trouble focusing my attention. (R)
3. When I am working hard on something, I still get distracted by events around me. (R)
4. My concentration is good even if there is music in the room around me.
5. When concentrating, I can focus my attention so that I become unaware of what's going on in the room around me.
6. When I am reading or studying, I am easily distracted if there are people talking in the same room. (R)
7. When trying to focus my attention on something, I have difficulty blocking out distracting thoughts. (R)
8. I have a hard time concentrating when I'm excited about something. (R)
9. When concentrating I ignore feelings of hunger or thirst.
10. I can quickly switch from one task to another.
11. It takes me a while to get really involved in a new task. (R)
12. I can become interested in a new topic very quickly when I need to.
13. It is easy for me to read or write while I'm also talking on the phone.
14. I have trouble carrying on two conversations at once. (R)
15. I have a hard time coming up with new ideas quickly. (R)
16. After being interrupted or distracted, I can easily shift my attention back to what I was doing before.
17. When a distracting thought comes to mind, it is easy for me to shift my attention away from it.
18. It is easy for me to alternate between two different tasks.

19. It is hard for me to break from one way of thinking about something and look at it from another point of view. (R)
20. It is difficult for me to coordinate my attention between the listening and writing required when taking notes during lectures. (R)

Response scale: *Almost never (1), sometimes (2), often (3), always (4)*

(R) – Reverse scored

Appendix 4

Health values measure used in Studies 1 and 2, taken from Tapper et al. (2012)

On the following pages you will find a list of values. Each value is printed beside a definition of the value (for example, social order: stability of society).

People vary tremendously in their ratings of the relative importance of these values. We would like you to rate each value according to its importance as a guiding principle in your life. You can rate the values using the scale that appears below each value. For each scale, indicate the number that most accurately reflects the importance of the value to you.

PHYSICAL HEALTH (avoiding sickness, being free from sickness)

PHYSICAL FITNESS (being in good shape)

HEALTHY EATING (eating a balanced diet)

PHYSICAL ACTIVITY (getting regular exercise)

Response scale:

Opposed to my values	Not important			Important			Very important	Extremely important
-1	0	+1	+2	+3	+4	+5	+6	+7

Appendix 5

Foods listed in assessment of healthy and unhealthy food preferences, used in Studies 1 and 2

Please read through the following list of foods and indicate on the scale from 0 to 100 how you feel about each food (0 = extremely unfavourable; 100 = extremely favourable)

Healthy Foods	Unhealthy Foods
Oranges	Cake
Apples	Chocolate
Bananas	Sweets
Grapes	Biscuits
Pears	Chocolate bars
Tomatoes	Crisps
Broccoli	French fries
Red peppers	Pasties
Carrots	Pizza
Spinach	Nachos

Appendix 6

Transcript of body scan meditation audio task used in Study 3 (from Cropley et al., 2009)

Please follow the instructions on this recording. The idea is for you to relax and have a little time for yourself.

The aim of this recording is to increase awareness of your body and mind, of your whole self.

It is very important to be kind with yourself, be gentle with yourself and allow yourself to relax.

You do not need to make an effort to relax, simply becoming more aware of yourself will encourage relaxation. During this time there is no right way to feel, whatever you feel is fine because it is the true you.

It is important to pay attention to your body and mind, to recognise your thoughts and feelings and to accept them exactly as they are. See what your body tries to tell you and live with it during these moments. Simply observe yourself and notice the signs that your body and mind give you. Live in the present with your true self with any good feelings as well as with your worries and any feelings of discomfort.

Now it is the time to be with you. Keep always in mind that there is no right or wrong way to feel, everything is acceptable because they are your true feelings, even if you are not feeling anything at all this is alright as well. Just accept your sensations simply because they belong to you and it is the way you feel, give yourself the permission to feel and let that be just fine.

Sit on the chair provided as comfortably as you can, you may have your legs stretched out in front of your or bend them one next to the other but keep them uncrossed. You may sit up straight on the chair or sit lower on the chair, choose the body posture that makes you feel most comfortable.

Allow your eyes to close gently if this feels comfortable but it is important to stay awake.

Listening to the instructions just watch your body and the way your mind works, notice your feelings and any other experience you may have.

Notice that you are breathing, breath deep and fully and notice your breath going in and out of your body. Without trying to control it in any way focus your attention on your breath for some moments. You are breathing.

Feel the breath that enters your body through your nostrils or through your mouth if you have it open. Then become aware of your breath coming out of your body. You may feel different sensations in your whole body, with every in breath notice the sensations in your nostrils, in

your lungs, in your chest or in your abdomen. You may also observe sensations with every out breath as the air leaves your body. Observe your chest rising with the in breath and falling with the out breath. Become aware of the air that fills in your chest every time you breathe in and then of the sensation of emptiness that follows as the air flows out of your chest.

Now feel the breath in your abdominal area, you may want to place your hands on your abdomen. Notice that very gentle rising and falling of the breath as it enters and leaves your body. No need to control this in any way, almost letting the breath breathe itself. Notice how you tummy gently rises with each in breath and then falls with each out breath. Watch the air entering your abdomen and then leaving your abdomen with your hands rising a falling with the rhythm of your breath. Allow your breath to flow naturally in and out of our body without any control. Just let your breath breathe itself, no need to do anything, simply observing it. Watching the breath moving in and moving out just let yourself breathe calmly and be aware of the air that keeps entering your body and then leaving it in a smooth and gentle way.

Observe that every in breath is very naturally followed by an outbreath, and that every out breath is very naturally followed by an in breath.

With no control just let your breath do its natural cycle of in breaths and out breaths. Let your breath breathe on its own. Be aware of this movement of breath in and out of your body and feel it.

Keep in mind that if you become distressed or uncomfortable with your feelings, thoughts or body sensations at any point during this recording it is always possible to return to this sensation of the breath moving in to the body and the breath leaving the body letting the breath breathe itself, not having to control it. Your breathing can become a safe place where you can return if, at any time, you feel uncomfortable. Return to your in breath that is always followed by an out breath and your out breath that is always followed by an in breath.

And if you would like at this point you may remove your hands form your abdomen if you have placed them there and put them alongside your body. Move your awareness away from your breathing and your chest and move it down to your abdomen to your belly and to your stomach. Explore your abdominal area with your awareness. If you do not feel any sensation this is fine, be aware of any tightness or looseness in your stomach. Feel the muscles in your abdomen contracting or remaining still. You may even feel pain, just let the painful feelings be there and do nothing to change them. Explore all the sensations in your abdominal area, you may observe the feeling of the clothing on your tummy. You may even feel their warmth or coldness on your skin. You may realise that you have no sensations in the area of your abdomen or your stomach, this is alright.

And then notice your breath as it enters your body and goes down to your abdomen you observe the rising of your belly as you breath in and then its falling as you breathe out. Imagine that your abdominal area is a safe place where you can feel all the air entering your whole body and transferring this air to every part of your body. Your whole body breathes just from your abdominal area. With every in breath imagine the air entering your stomach and from there travelling all the way down to your hips, to your thighs and toes. And from there the air travels upwards towards your chest, your throat, your face and head.

Then imagine the breath being in your stomach again and from your belly button leaving your body until the next breath comes in. Notice that this journey of the breath was done on its own with you only having to observe it. Allow yourself to feel this journey of the breath for a few moments.

Do not try to control your breath, let it flow freely in and out of your body, encouraging the deepest state of relaxation. As you watch your breath feel a gentle stillness and calmness, observe any thoughts or feelings without trying to control them. Just let them be.

Now slowly open your eyes if they are closed and remain still. You may observe your surroundings, the room you are in right now. See the shape of the room and its colours and textures, as this recording comes to an end here you may start moving your body gently. You may start stretching your legs and arms or stretch your neck. Let any calmness that you are feeling now stay with you for a little longer, remember that if you feel uncomfortable at any time you can always return to this sensation of the breath moving into the body, the breath leaving the body. Letting the breath breathe itself not having to control it.

Appendix 7

Toronto Mindfulness Scale (TMS; Lau et al., 2006), used in Study 3

We are interested in what you just experienced. Below is a list of things that people sometimes experience. Please read each statement.

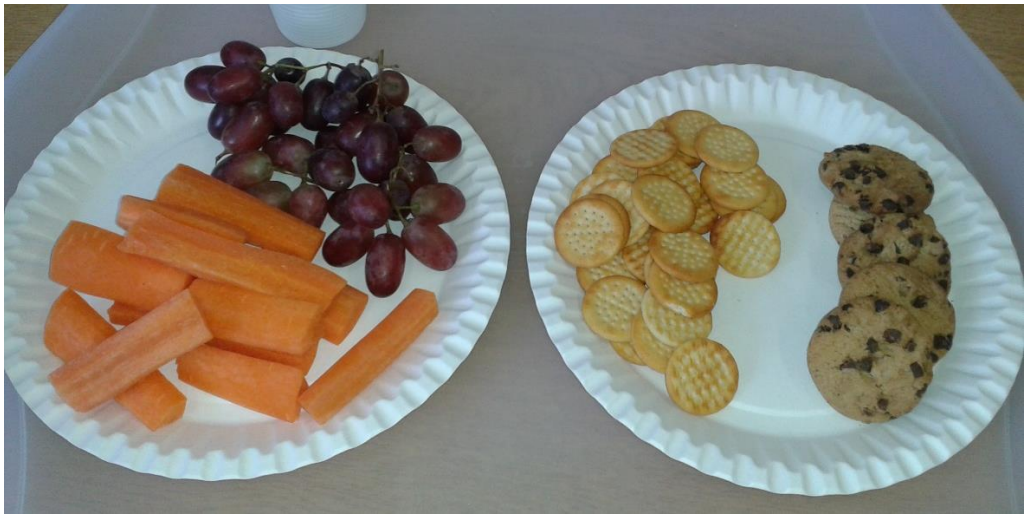
Next to each statement are five choices: “not at all,” “a little,” “moderately,” “quite a bit,” and “very much.” Please indicate the extent to which you agree with each statement. In other words, how well does the statement describe what you just experienced, just now?

1. I experienced myself as separate from my changing thoughts and feelings.
2. I was more concerned with being open to my experiences than controlling or changing them.
3. I was curious about what I might learn about myself by taking notice of how I react to certain thoughts, feelings or sensations.
4. I experienced my thoughts more as events in my mind than as a necessarily accurate reflection of the way things ‘really’ are.
5. I was curious to see what my mind was up to from moment to moment.
6. I was curious about each of the thoughts and feelings that I was having.
7. I was receptive to observing unpleasant thoughts and feelings without interfering with them.
8. I was more invested in just watching my experiences as they arose, than in figuring out what they could mean.
9. I approached each experience by trying to accept it, no matter whether it was pleasant or unpleasant.
10. I remained curious about the nature of each experience as it arose.
11. I was aware of my thoughts and feelings without over-identifying with them.
12. I was curious about my reactions to things.
13. I was curious about what I might learn about myself by just taking notice of what my attention gets drawn to.

Response scale: *Not at all* (1)*, a little* (2)*, moderately* (3)*, quite a bit* (4)*, very much* (5)

Appendix 8

Example image and nutritional information of foods presented during *ad lib* eating task in Study 3



	Amount provided (g)	Calories per 100g
Red Grapes	~ 160	70
Carrots (peeled)	~ 160	39
Cheese Crackers McVities Mini Cheddars	~ 50	516
Chocolate chip cookies Maryland cookies, Burtons biscuits	~ 50	487

Appendix 9

Stimuli used in food cueing paradigm in Study 4

All images were presented in either colour *or* black and white and participants were required to assign them to one of two categories presented below the image

Image stimuli

			
1	2	3	4
			
5	6	7	8
			
9	10	11	12
			
13	14	15	16
			
17	18	19	20

Category judgement questions accompanying image stimuli

Image #	Category question
1	Is man made / Is not man made
2	Begins with a vowel / Does not begin with a vowel
3	Can be used as a tool / Cannot be used as a tool
4	Is a heavy object / Is not a heavy object
5	Is easily broken / Is not easily broken
6	Has an even number of letters / Does not have an even number of letters
7	Can be bought in a store / Cannot be bought in a store
8	Is a portable object / Is not a portable object
9	Ends with a vowel / Does not end with a vowel
10	Begins with a vowel / Does not begin with a vowel
11	Can be bought in a store / Cannot be bought in a store
12	Is a heavy object / Is not a heavy object
13	Has an odd number of letters / Does not have an odd number of letters
14	Can be used as a tool / Cannot be used as a tool
15	Is a portable object / Is not a portable object
16	Has an even number of letters / Does not have an even number of letters
17	Ends with a vowel / Does not end with a vowel
18	Is easily broken / Is not easily broken
19	Is man made / Is not man made
20	Has an odd number of letters / Does not have an odd number of letters

Appendix 10

List of words used in the food cueing lexical decision task used in Study 5

Food words	Neutral words	Additional neutral words for control condition	Nonsense words	
Pie	Zoo	Ant	Bem	Ake
Cake	Whip	Veil	Fias	Ablo
Toast	Medal	Chair	Druip	Athed
Chips	Llama	Shelf	Gevel	Muite
Pizza	Cabin	Broom	Bitar	Pabid
Crisps	Booth	River	Slent	Ralen
Burger	Studio	Carpet	Bewaig	Accree
Cookie	Jungle	Window	Fibles	Cuirks
Popcorn	Village	Notepad	Hetting	Flender
Biscuit	Fuchsia	Kneecap	Acetobe	Gallade
Caramel	Costume	Isotope	Cuixote	Barbaru
Sandwich	Rickshaw	Envelope	Deverage	Quotanle
Doughnut	Graffiti	Scissors	Ashieves	Mestowal
Chocolate	Celluloid	Dormitory	Stowtorch	Alquiesce
Cheesecake	Photograph	Hippodrome	Aderration	Quarreding

Appendix 11

List of words used in the goal accessibility lexical decision task used in Study 6

Diet words	Office words	Neutral words	Nonsense words	Diet primes
Fit	Pen	Zoo	Zad	Cake
Diet	Book	Whip	Bip	Pizza
Thin	Desk	Veil	Byll	Chips
Slim	File	Jury	Vead	Cookie
Weight	Office	Medal	Toak	Chocolate
		Cabin	Seef	
		Booth	Velt	
		Studio	Kend	
		Jungle	Pabid	
		Village	Ralen	
			Gijou	
			Bifge	
			Glast	
			Slase	
			Brouse	
			Flotch	
			Forrow	
			Tarpal	
			Gallade	
			Barbaru	

Appendix 12

Regulation of Eating Behaviours Scale (REBS; Pelletier et al., 2004)

Below are a collection of statements which describe some of the reasons that people may regulate their eating behaviour.

Please read each statement and indicate the extent to which they correspond to a reason that *you personally* regulate your eating behaviour from 1 (does not correspond at all) to 7 (corresponds exactly).

Intrinsic Motivation

1. It is fun to create meals that are good for my health
2. I like to find new ways to create meals that are good for my health
3. I take pleasure in fixing healthy meals
4. For the satisfaction of eating healthy

Integrated Regulation

5. Eating healthy is an integral part of my life
6. Eating healthy is part of the way I have chosen to live my life
7. Regulating my eating behaviours has become a fundamental part of who I am
8. Eating healthy is congruent with other important aspects of my life

Identified Regulation

9. I believe it will eventually allow me to feel better
10. I believe it's a good thing I can do to feel better about myself in general
11. It is a good idea to try to regulate my eating behaviours
12. Is a way to ensure long-term health benefits

Introjected regulation

13. I don't want to be ashamed of how I look
14. I feel I must absolutely be thin
15. I would feel ashamed of myself if I was not eating healthy
16. I would be humiliated I was not in control of my eating behaviours

External regulation

17. Other people close to me insist that I do
18. Other people close to me will be upset if I don't
19. People around me nag me to do it
20. It is expected of me

Amotivation [13]

21. I don't really know. I truly have the impression that I'm wasting my time trying to regulate my eating behaviours
22. I don't know why I bother
23. I can't really see what I'm getting out of it
24. I don't know. I can't see how my efforts to eat healthy are helping my health situation

Response scale: 1 (*does not correspond at all*) to 7 (*corresponds exactly*)

[13] The Amotivation subscale was not included in analyses in Study 6