"A TEMPERAMENT BASED PERSPECTIVE ON EATING BEHAVIOUR AND APPETITE IN THE OVERWEIGHT AND OBESE"

Lynette Mackey

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Faculty of Health

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Abstract

The prevalence of overweight and obesity is predicted to increase to 70% by the year 2025 in Australian adults aged 25 to 65. Associated with this is a trend for an increase in the prevalence of morbid obesity relative to mild obesity. Whilst easy access to an increased supply of readily available and highly palatable energy-dense foods is contributing to the current obesogenic environment, not everyone gains weight. The literature suggests that high levels of emotional and disinhibited eating behaviour may lead to less successful weight management outcomes, whether the intervention is surgically managed or delivered via dietary prescription. Subsequently, a greater understanding of the psychobiological factors that motivate overconsumption in response to an obesogenic environment has been recommended. In line with these recommendations, a psychobiological approach towards understanding eating behaviours that are associated with weight management failure has guided the focus of this thesis.

Rothbart and Bates' (2006) definition of psychobiological temperament can be conceptualised as a two-tiered system of behaviour management encompassing 'bottom-up' reactivity from Reinforcement Sensitivity Theory's Behavioural Inhibition System and Behavioural Approach System and by 'top-down' self-regulation via the executive function of effortful control (Carver, 2008; Derryberry & Rothbart, 1997). High levels of reactivity within these systems can overwhelm the self-regulatory capacity of effortful control and lead to high levels of negative affect, which in turn could lead to the subsequent use of maladaptive behaviours such as emotional and disinhibited eating behaviour. Therefore, this psychobiological model of temperament was utilised to determine whether reactivity within these lower order systems and an inability to manage them, via lower effortful control, is associated with eating behaviour, heightened levels of psychological food-reward behaviours and BMI.

In a cross-sectional sample of 138 adults in study one (Chapter 4), it was revealed that the BAS was not significantly associated with emotional eating behaviour in males or females. However, higher levels of the BIS were significantly associated with higher levels of emotional eating in males and external eating in

females. High trait anxiety was also associated with higher levels of emotional eating in females when both BIS and BAS were concurrently high but not when BIS levels were high and BAS levels were low. Under these circumstances, reactivity within the BIS attenuated high levels of effortful control when BAS was low and was associated with greater emotional eating behaviour. The association between the BIS and external eating in females suggested that reactivity within the BIS may have a stronger association with disinhibited eating behaviour than emotional eating behaviour in females.

To determine if the BIS influenced disinhibited eating behaviour, the Three Factor Eating Questionnaire was included in the second study (Chapter 5). In a cross-sectional sample of 169 adults, a median split of BIS and BAS scores and Disinhibition and Restraint scores were used to categorise the sample into four BIS_BAS phenotypes and four eating-behaviour subtypes. Psychobiological measures of liking and wanting were included in the second study to determine if a reactive temperament that was ineffectively regulated predicted enhanced wanting and liking food-reward behaviours. The results of this study revealed that BIS but not BAS was significantly associated with disinhibited eating behaviour in both genders. Moreover, the BIS but not the BAS was significantly associated with implicit wanting and explicit liking for high-fat sweet and savoury foods. Effortful control significantly mediated the relationship between the BIS and disinhibited eating behaviour and fully mediated the relationship between the BIS and implicit wanting of high-fat sweet foods. A significantly greater proportion of females with a high BIS, low BAS phenotype were found to be high in Disinhibition and low in Restraint (HDLR) when compared to women with a low BIS, low BAS phenotype, who were proportionately higher in Restraint and lower in Disinhibition (LDHR). The proportion of individuals in the HDLR eating behaviour subtype was significantly greater in the obese weight category than individuals with the LDHR eating-behaviour subtype, who were more prominent in the overweight category.

These findings suggest that, in females, a high BIS, a low level of effortful control and higher levels of liking for high-fat sweet foods will predict disinhibited eating behaviour and ongoing weight gain in the HDLR eating behaviour subtype but not the LDHR subtype. The HDLR eating behaviour subtype is characterised by a liking for high-fat sweet foods and a proneness to over-consumption that is not actively restrained. The LDHR eating behaviour subtype is characterised by behaviours associated with successful dieting; this subtype is less responsive to highly palatable food cues and has the capacity to actively restrain eating behaviour.

To determine if temperament had an effect on these behaviours, the final study (Chapter 6) recruited specifically for these temperament and eating behaviour subtypes. These subtypes were classified as: high in Disinhibition and low in Restraint (HDLR) and low in Disinhibition and high in Restraint (LDHR). It employed a mixed model repeated measures design. The between factor was participant group (high BIS, HDLR subtype and low BIS, LDHR subtype). Subjective appetite sensations and food preferences were measured immediately before, (fasted) and periodically after, (fed) a fixed meal. Total energy intake was measured using an ad libitum test lunch.

The results showed that the BIS but not the BAS was associated with total energy intake of an ad libitum test meal, explicit liking of high-fat sweet and savoury foods and wanting of high-fat sweet foods in the fed state. A low level of effortful control was associated with wanting for high-fat savoury foods, and the energy intake of high-fat non-sweet foods; whilst a high level of emotion regulation difficulties was associated with explicit liking of high-fat sweet and savoury foods, total energy intake of all categories of foods, and the energy intake of high-fat sweet snack foods. The high BIS, HDLR eating behaviour subtype had a higher level of explicit liking for high-fat sweet and savoury foods, total energy intake of high-fat non-sweet foods and higher levels of hunger and reduced levels of fullness after a preload, when compared to the low BIS, LDHR eating behaviour subtype. The BIS was inversely associated with the satiety quotients for hunger and fullness and the high BIS, HDLR subtype was shown to have a significantly attenuated capacity to be sensitive to satiety signals, when compared to the low BIS, LDHR subtype. Furthermore, the high BIS, HDLR eating-behaviour subtype had a lower level of effortful control (activation control and attentional control subscales), and a higher level of emotion regulation difficulties (non-acceptance of emotional state, a lack of strategies to deal with emotions, and impulsive responding to emotions subscales) than a low BIS LDHR eating behaviour subtype.

Collectively, these results suggest that an attenuated capacity to perceive satiety, when coupled with enhanced liking, affect regulation difficulties, and a low level of activation control could increase risk for over-consumption. Subsequently, it is possible that the high BIS group is more likely to choose and consume highly palatable food choices when motivated by reactivity within the BIS. The findings from this thesis contribute to understanding the role of psychological factors in weight management. The outcomes could be used when designing strategies to improve the effectiveness of weight loss and maintenance interventions and to tailor weight management prescriptions to individuals.

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List of Abbreviations

ATQ	Adult Temperament Questionnaire
BAS	Behavioural Activation System
BAS-DR	BAS – drive
BAS-FS	BAS – fun seeking
BAS-RR	BAS – reward responsiveness
BED	Binge eating disorder
BIS	Behavioural Inhibition System
BMI	Body mass index
DERS	Difficulties in Emotion Regulation Scale
BES	Binge Eating Scale
DEBQ	Dutch Eating Behaviour Questionnaire
D-KEFS CWIT	Delis-Kaplan Executive Function System color-word interference test
EC	Effortful Control
FFFS	Fight-Flight-Freeze System
HDHR	High Disinhibition, high Restraint
HDLR	High Disinhibition, low Restraint
HFSA	High-fat savoury
HFSW	High-fat sweet
LDHR	Low Disinhibition, high Restraint
LFPQ	Leeds Food Preference Questionnaire
NA	Negative Affect
PA	Positive Affect
PANAS	Positive Affect and Negative Affect Schedule
PSS	Perceived Stress Scale
QUT	Queensland University of Technology
RST	Reinforcement Sensitivity Theory
SCWIT	Stroop colour word interference test
SPSRQ	Sensitivity to Punishment and Sensitivity to Reward Questionnaire

STAI-T	State-Trait Anxiety Inventory- Trait Scale
STP	Sensitivity to punishment
STR	Sensitivity to reward
TFEQ	Three Factor Eating Questionnaire
UHREC	University Human Research Ethics Committee
VAS	Visual Analogue Scales

Statement of Original Authorship

The work contained in this thesis has not been previously submitted to meet requirements for an award at this or any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

QUT Verified Signature

Signature:

Date: 10/01/2017

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If I was going to finish with a quote, it would be this one from Christopher Columbus, "You can never cross the ocean until you have the courage to leave the shore."…….. I also can't leave out Piglet's Poem from the *Tao of Pooh and the Te of Piglet* "…..and the pride you'll feel inside is not the kind that makes you fall – it's the kind that recognizes the bigness found in being small."

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Chapter 1: Introduction

1.1 THE SIGNIFICANCE OF THE PROBLEM

1.1.1 The obesity statistics: The current Australian environment

The successful management of body weight is a problem in Australia. Over the last three to four years, the prevalence of overweight and obesity has increased by 2.1% with the number of individuals either overweight or obese reaching 63.4% during the period of 2011 to 2012. Of these individuals, approximately 35% are overweight and 28.3% are obese. This marks an overall increase in obesity of 7.1% over the last 17 years (Australian Bureau of Statistics, 2012) and the trend is expected to continue (Walls et al., 2012). It has been predicted that the prevalence of overweight and obesity will increase to 70% by the year 2025 in Australian adults aged 25 to 65 and above (Walls et al., 2012). In addition, it has also been reported that levels of overweight and obesity are increasing disproportionately: there is a greater increase in the prevalence of severe obesity relative to mild obesity (Peeters, Gearon, Backholer, & Carstensen, 2015). Furthermore, these findings are not solely constrained to Australia. The United States has also shown an increase in the prevalence of morbid relative to moderate obesity between 2000 and 2010 (Sturm & Hattori, 2013).

1.1.2 Energy intake within an obesogenic environment

The evidence suggests that humans are becoming more susceptible to weight gain. Therefore, it is perhaps not surprising that, within an environment where there is an overabundance of readily-available, inexpensive and highly palatable foods, i.e. one that has been labelled as ‘obesogenic’ (Swinburn & Egger, 2002), not only do people gain weight but, furthermore, they struggle to achieve and successfully maintain weight loss (Queensland Health, 2010).

Failure to manage those eating behaviours that contribute to weight gain appear to exist on a continuum that is anchored at one end by surgical intervention and, at the other, dietary prescription. Comparatively, individuals who fail to lose the most amount of weight post-surgery and who fail to attend follow up sessions have been shown to possess higher levels of emotional, disinhibited and binge eating behaviour than their more successful counterparts (Canetti, Berry, & Elizur, 2009; Chesler, 2012; Dodsworth, Warren-Forward, & Baines, 2010; Poole et al., 2005). A similar pattern also exists at the non-clinical level, whereby a failure to reduce levels of these eating behaviours is also linked to a reduced likelihood of successful weight management outcomes (A. Blair, Lewis, & Booth, 1990; Elfhag & Rössner, 2005; Kayman, Bruvold, & Stern, 1990; Mc Guire, Wing, Klem, Lang, & Hill, 1999; Ohsiek & Williams, 2011; Teixeira et al., 2010; Wing & Phelan, 2005). Subsequently, high levels of emotional, binge and disinhibited eating behaviour can lead to less successful outcomes whether the intervention is surgically managed or delivered via dietary prescription, which serves to highlight their debilitating effect on the success of weight management interventions in general.

The literature indicates that access to an increased supply of readily available, highly palatable and energy dense food is contributing to the current obesogenic environment (Berthoud, 2012; C. O. Stubbs & Lee, 2004; Swinburn et al., 2011). However, not everyone within this environment fails in their weight management efforts: individuals who successfully reduce their level of eating behaviours do achieve long-term weight management success (A. Blair et al., 1990; Teixeira et al., 2010; Wing & Phelan, 2005). The factors that lead to overconsumption in some but not others have been suggested to reflect individual differences in fundamental psychological and biological processes (Blundell & Finlayson, 2004; Dalton & Finlayson, 2014; Davis, 2009). In order to manage increasing obesity levels, a greater understanding of the psychobiological factors that motivate eating behaviour and overconsumption in response to the environment has been recommended (Davis, 2009; Dietrich, Federbusch, Grellmann, Villringer, & Horstmann, 2014). Therefore, in line with these recommendations, an approach that links psychobiological temperament with those eating behaviours associated with weight management failure and over-consumption has guided the focus of this thesis.

1.2 PSYCHOBIOLOGICAL PROCESSES THAT REGULATE BEHAVIOUR

The identification of these psychobiological factors may be achieved by determining an individual’s constitutional temperament phenotype. The model of psychobiological temperament investigated within this thesis in encompassed within

Rothbart and Bates definition of temperament (Rothbart & Bates, 2006; Rothbart, Sheese, & Posner, 2013), which provides a psychobiological basis for trait behaviours that are influenced by both genetic inheritance and the environment (Rothbart et al., 2013). According to Rothbart, Sheese and Posner (2013), temperament represents the psychobiological basis of personality, which reflects individual differences in dispositional traits, cognitions and coping strategies. Temperament traits represent a subset of these dispositional traits and give rise to trait behaviours that are influenced by an individual's level of emotional reactivity and their capacity to self-regulate their thoughts and emotions through attentional processes. Therefore an investigation into temperament provides an excellent opportunity to determine whether a psychobiological link exists between it and trait eating behaviours that have been associated with overconsumption. If such a link was found, it could provide a practical phenotypic model that is capable of predicting who may be at risk of exhibiting trait-eating behaviours that lead to overconsumption, weight gain and increased BMI.

As described by Carver (2008), Rothbart and Bates' definition of temperament may be conceptualised within a two-mode model of self-regulation. This model encompasses a hierarchical interrelationship between "lower order", reactivity of Reinforcement Sensitivity Theory's (RST) behavioural inhibition system (BIS), fight/flight/freeze system (FFFS) and behavioural activation system (BAS) (Gray & McNaughton, 2003) and the "higher order" executive attention system underlying the construct of effortful control (Bijttebier, Beck, Claes, & Vandereycken, 2009; Derryberry & Rothbart, 1997; Rothbart & Bates, 1998, 2006). Consequently, this model of temperament has the capacity to outline how trait behaviours will be influenced by levels of activation within subcortical affective-motivational systems that are represented by Gray and McNaughton's recently revised Reinforcement Sensitivity Theory (RST) (Gray & McNaughton, 2000). Importantly however, it also reflects how an individual's capacity to regulate the reactivity of these systems and the resulting expression of trait behaviours will be determined by the efficiency of an executive attention network, which has been conceptualised by Rothbart and Bates as the temperament construct of effortful control (Carver & Scheier, 2001; Derryberry & Rothbart, 1997; Rothbart & Bates, 1998). The components of this temperament model are briefly introduced in the next section.

1.2.1 The components of the psychobiological model: The ‘reactive’ affective-motivational systems of RST’s BIS/FFFS and BAS

Reinforcement Sensitivity Theory (RST) describes how the affective-motivational systems of Gray’s BIS, FFFS and BAS elicit a state of affect and a corresponding behavioural action when an individual interacts with their environment. In their revised RST, Gray and McNaughton (Gray & McNaughton, 2000) named these basic emotional and motivational systems the BAS, reflecting reward sensitivity and approach behaviour, the FFFS, reflecting sensitivity towards threat, punishment and withdrawal behaviour, and the BIS, which is responsible for managing conflict between the BAS and the FFFS (Corr, 2008).

The BAS is activated in response to appetitive rewards and promotes approach behaviours. On activation, it generates the emotions of hope and positive affect (Corr, 2008). The FFFS is activated in response to aversive stimuli and promotes avoidance behaviours. On activation, it generates the negative emotions of fear and frustration (Corr, 2008). Finally, the BIS is activated in response to conflict between the FFFS and the BAS. On activation, it generates feelings of negative affect and anxiety. The BIS’s main action is to resolve conflict between the BAS and the FFFS. When conflict cannot be resolved, the default physiological and psychological position within the BIS is to increase arousal and feelings of anxiety until resolution ensues via the engagement of the FFFS and avoidance behaviours. The BIS and the FFFS represent independent systems in the revised RST (Gray & McNaughton, 2000). However, activation within these systems promotes a negativity bias and corresponding feelings of negative affect, which can be encompassed within an overarching factor that is sensitive to punishment (Corr, 2004, 2008). Therefore, for ease of ongoing discussion, both systems (BIS and FFFS) will be combined to represent a system that is ‘sensitive to punishment’ (STP) and it will be referred to as the one BIS factor, when discussing the literature.

Individual differences exist at the level of the BIS and the BAS. Therefore, different individuals will possess different levels of BIS reactivity relative to BAS reactivity. Furthermore, the systems may not only exert independent effects on an individual, they may also interact to jointly influence emotion and behaviour, as described by Corr’s Joint Subsystems Hypothesis (2002b). Testing the joint subsystems hypothesis has shown different levels of these systems do interact (Corr, 2002b; Kambouropolous & Staiger, 2004); interactions between the BIS and the BAS have predicted the experience of emotional symptoms, mixed anxiety-depression, general distress and anhedonic depression (Dinovo & Vasey, 2011; Hundt, Nelson-Gray, Kimbrel, Mitchell, & Kwapil, 2007; Kambouropolous & Staiger, 2004; Knyazev & Wilson, 2004). Moreover, an inability to regulate the experience of these negative affective states can lead to symptoms of psychopathology (Gross, 2013): higher levels of BIS sensitivity are diagnostic for a range of emotional disorders, among them anxiety and depression; whilst weak BAS sensitivity is more specific to depression (Bijttebier et al., 2009; Clark & Watson, 1991; Zinbarg & Yoon, 2008).

Gray's earlier work suggested an interaction between these temperament dimensions and their resultant psychopathological states should be expected. He conceptualised that, as an individual's level of sensitivity to punishment (STP), which is synonymous with reactivity within the BIS, increases, so does their level of anxiety. However, he also demonstrated how the BIS might interact with an individual's level of sensitivity to reward (STR), which is synonymous with BAS reactivity, as anxiety levels increase. As depicted in Figure 1 below, at lower levels of BIS reactivity and higher levels of BAS reactivity an individual will experience the least amount of anxiety. As levels of BIS and BAS reactivity increase to similar levels of moderate reactivity, the individual will experience moderate levels of anxiety. Finally, when BIS reactivity is at its highest and BAS activity is at its lowest, the individual will experience the greatest level of anxiety (Gray, 1970).

The relevance of this relationship, between varying levels of the BIS and the BAS, and the experience of these negative affective states, is that the experience of these negative emotional states has been linked to eating behaviour and increased BMI (Alexander & Siegel, 2013; Haghighi et al., 2016; Keranen, Rasinaho, Hakko, Savolainen, & Lindeman, 2010; Ostrovsky, Swencionis, Wylie-Rosett, & Isasi, 2013; Ouwens, van Strien, & van Leeuwe, 2009; R. Peterson, Latendresse, Bartholome, Warren, & Raymond, 2012; Schneider, Appelhans, Whited, Oleski, & Pagoto, 2010; Stunkard, Faith, & Allison, 2003).

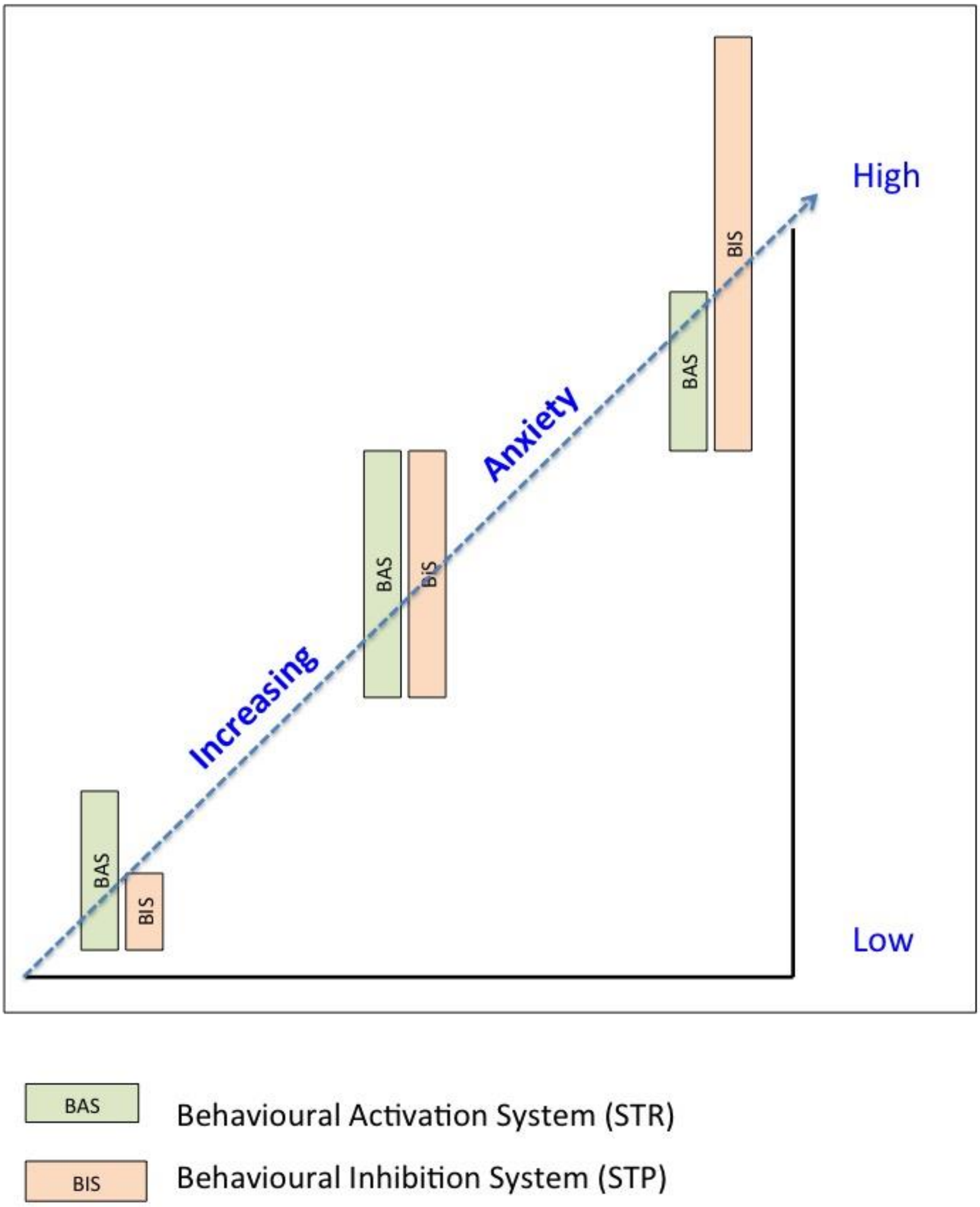

Figure 1.1. An adaptation of Gray's proposed relationships of reactivity within the BIS, which is synonymous with an individual's level of sensitivity to punishment (STP), and the BAS, which is synonymous with an individual's level of sensitivity to reward (STR), in relation to the dimension of anxiety.

The height of each column for each system represents their level of reactivity relative to the other. For example, at the lowest level of anxiety, an individual's level of BAS reactivity is greater than their level of BIS reactivity. Adapted from "The psychophysiological basis of introversion-extraversion", by J. A. Gray, 1970, *Behaviour Research and Therapy*, 8, 249-266. Copyright 1970 by Elsevier.

1.2.2 The components of the psychobiological model: The 'self-regulatory' attentional system of effortful control

The level of reactivity within the 'lower order' systems, especially the activity within the BIS, is important when one considers an individual's capacity to self-regulate or 'effortfully control' their behaviour. Effortful control is defined as the ability to inhibit a dominant response in order to carry out a subdominant response (Rothbart, Ellis, & Posner, 2010) and it has been linked to dysregulated eating behaviour. Lower levels of effortful control have been associated with dysregulated eating behaviour in eating disorders and in individuals awaiting pre-bariatric surgery (Claes, Bijttebier, Mitchell, de Zwaan, & Mueller, 2011; Claes, Mitchell, & Vandereycken, 2012; Claes, Robinson, Muehlenkamp, & Vandereycken, 2010; Müller et al., 2012; Müller, Claes, Wilderjans, & de Zwaan, 2014). However, besides successfully inhibiting dominant behaviour, effortful control also regulates the experience of negative affect (Derryberry & Rothbart, 1997; Rothbart et al., 2013; Rueda, Posner, & Rothbart, 2005)

The relationship between an individual's level of effortful control and their capacity to regulate negative affect may be important when considering their capacity to successfully manage eating behaviour and body weight. This is because effortful control is a limited resource that can be disrupted by high levels of activation within the BIS (Eysenck, Derakshan, Santos, & Calvo, 2007; Rothbart & Rueda, 2005). When attention is directed towards the BIS, it cannot be used to effortfully regulate emotion (Heatherton & Wagner, 2011; C. M. MacLeod & MacDonald, 2000). Consequently, an individual's capacity to regulate the negative affective states of anxiety and depression is directly proportional to the extent to which attention is diverted by activation within the BIS (Derryberry & Rothbart, 1997; Rothbart et al., 2013). Therefore, an individual with a high level of BIS reactivity, and a limited capacity to regulate it, may remain at 'the mercy' of unregulated negative affective states (Gratz & Roemer, 2004; Gross, 2013; Wallace & Newman, 1997). This process is particularly relevant to this thesis, because an inability to regulate negative affect has been associated with binge eating (Aldao, Nolen-Hoeksema, & Schweizer, 2010), emotional eating behaviour (Evers, Stok, & de Ridder, 2010; Ouwens, van Strien, & van Leeuwe, 2009), and self-regulatory failure (Heatherton and Wagner 2011, Wagner and Heatherton, 2013).

1.3 TEMPERAMENT AND A CONCEPTUAL RELATIONSHIP WITH FOOD REWARD AND THE REGULATION OF AFFECT

The intake of highly palatable food during the experience of stress and negative affect is negatively reinforcing. It decreases physiological arousal (Adam & Epel, 2007; Dallman, 2010; Gibson, 2006; Pecoraro, Reyes, Gomez, Bhargava, & Dallman, 2004; Tomiyama, Dallman, & Epel, 2011) and psychological discomfort (Gibson, 2006; Kampov-Polevoy, Alterman, Khalitov, & Garbutt, 2006; Macht, 2008), which reinforces and ensures the continuation of the behaviour (Carlson, 2007). Therefore, it is possible that, through a habitual process of using food to regulate affect, susceptible individuals will have learnt not only to want highly palatable foods, they may also have learnt to like them due to their perceived potential to provide pleasure during a time of discomfort and general distress (Dalton & Finlayson, 2013; Mela, 2006).

Human appetite is controlled by a synergistic relationship between hedonic (reward-based) and homeostatic (energy-based) drives that are designed to meet biological needs (Finlayson, King, & Blundell, 2007a). The act of acquiring and consuming food is a neurologically rewarded behaviour that can be separated into two distinct psychological components of wanting and liking (Dalton & Finlayson, 2014). These components describe the outcome of two distinct neurological systems that define the structure of neurologically rewarded, ingestive behaviour (Berridge, 1996). Wanting represents the motivational value, the ‘incentive salience’, desire or craving that is attributed to a rewarding object such as a highly palatable food item (Berridge, 2007; Dalton & Finlayson, 2013). The act of consumption and the perceived hedonic sensation of pleasure and positive affect are attributed to liking (Berridge, 1996; Dalton & Finlayson, 2014; Pecina, 2008).

The rewarding component of ingestive behaviour can be separated from homeostatic appetite and an uncoupling of this relationship is believed to contribute towards weight gain and obesity (Dalton & Finlayson, 2013, 2014; Finlayson et al., 2007a). Recent investigations have uncovered a relationship between hedonic reward and trait eating behaviour, which leads to a loss of control over appetite (Dalton, Blundell, & Finlayson, 2013a; Dalton & Finlayson, 2014; Dalton, Hollingworth, Blundell, & Finlayson, 2015; Finlayson & Dalton, 2012; Finlayson, King, & Blundell, 2007; Finlayson et al., 2007a; Finlayson, King, & Blundell, 2008).

Individuals defined by higher levels of trait binge or disinhibited eating behaviour have been reported to exhibit enhanced levels of psychological reward responsiveness, i.e. wanting and liking, attenuated satiety levels and a loss of control over appetite and subsequent intake.

These findings have been interpreted to suggest that, in the presence of highly palatable food, individuals with these eating behaviour traits will have enhanced sensitivity to its rewarding properties, particularly wanting, which places them at risk of over-consumption and weight gain (Dalton & Finlayson, 2013, 2014). However, individuals with affect regulation difficulties choose highly palatable sweet and fatty foods as one way to regulate mood (Macht, 2008). Furthermore, such an habitual pattern of behaviour is assumed to create a process whereby foods that promote positive affect, i.e. those high in fat and sugar, are 'learnt' to be 'liked' for the positive and psychologically rewarding feelings they promote (Mela, 2006). Given that food is used to regulate affect, in both emotional and binge eating behaviour (Greeno, Wing, & Shiffman, 2000; Kampov-Polevoy et al., 2006; Macht, 2008), and that liking has been significantly correlated with Disinhibition scores in a community sample, whilst wanting has not (French, Mitchell, Finlayson, Blundell, & Jeffery, 2014); it is surprising that an association between psychological food reward and a predisposition towards the experience of negative emotional states has not been intensely investigated. Therefore, a reasonable progression to expand these recent findings, which also links a process of dysregulated appetite to disinhibited eating behaviour, overconsumption and increased BMI, is to determine whether a reactive BIS, in association with a low level of effortful control, also motivates food intake at the level of psychological reward.

1.4 THE LINK BETWEEN PSYCHOLOGICAL REWARD (WANTING AND LIKING) AND A DYSREGULATED APPETITE (SATIETY)

It has been suggested that a state of satiety may be weakened by enhanced levels of psychological reward, such as wanting, which increase motivation or desire to snack on highly palatable food items (Dalton & Finlayson, 2013). However, it is also possible that the habitual use of food, as an affect regulation strategy, may be associated with an attenuated satiety response and enhanced liking. Although the current evidence suggests that enhanced psychological wanting for food is responsible for overriding satiety signals (Dalton & Finlayson, 2013, 2014); it is theoretically possible that an enhanced liking response may also be linked to an attenuated satiety response. For example, emotional eating behaviour has been linked to the misattribution of the stress response to feelings of hunger (van Strien, 2002). Therefore, the habitual use of comfort foods to regulate affect may be linked to an enhanced liking and an attenuated satiety response in susceptible individuals because the individual has learnt to ‘like’ foods that have been associated with feelings of comfort and calm (Gibson, 2006; Macht, 2008; Mela, 2006). Furthermore, a low satiety phenotype, which has been linked to chronic stress, anxiety and a high level of disinhibited eating behaviour, has been identified within the literature (Dalton et al., 2015; Drapeau et al., 2013; Drapeau & Gallant, 2013). Activation within the BIS underlies the experience of anxiety (Gray, 1970). Therefore, it is also possible that a reactive and poorly regulated temperament is associated with an attenuated satiety response, further compounding risk of overconsumption, overweight and obesity (Herbert & Pollatos, 2014). However, whether the BIS is associated with the psychological rewards of wanting and liking, an attenuated satiety response, overconsumption, and BMI is not currently known.

1.4.1 Current conceptual relationships between psychobiological temperament and eating behaviour

As introduced above, it is plausible that a temperament phenotype that consists of a reactive BIS and a low level of effortful control, which contributes towards a deficit in emotion self-regulatory skill and subsequent negative affect and the experience of anxiety, could predict eating behaviour and over-consumption. Therefore, prior knowledge of an individual’s psychobiological temperament and their capacity to regulate their emotional state could provide insight into their likelihood to experience negative affective states, such as stress, anxiety and depression, and difficulty managing eating behaviour. However, research into the relationship between temperament, eating behaviour and psychological reward, suggests that emotional, disinhibited and binge-eaters show evidence of a loss of control over eating behaviour that is motivated by high or low levels of reactivity within Gray’s BAS (Davis, 2013b; Davis et al., 2009; Davis & Loxton, 2014; Davis, Patte, et al., 2007; Dawe & Loxton, 2004; Dietrich et al., 2014; Gray & McNaughton, 2000).

Temperament research tends not to actively consider a relationship between an individual's risk for increased BMI and over-consumption that may be linked to increased levels of reactivity within Gray's BIS (Gray, 1970; Gray & McNaughton, 2000). Nor has it simultaneously considered an individual's level of effortful control. Therefore, the next step towards understanding the motivation behind those eating behaviours that lead to increased BMI is to consider whether a reactive BIS that is poorly regulated could feasibly be associated with eating behaviours that have been linked to increased BMI.

1.5 EATING BEHAVIOUR

1.5.1 Trait disinhibited eating behaviour

Disinhibited eating behaviour measures a loss of control over eating (Stunkard & Messick, 1985). It has more recently been conceptualised as an eating behaviour trait of Disinhibition that describes opportunistic eating behaviour (Bryant, King, & Blundell, 2008). It represents an enduring trait that increases the risk of weight gain and does not describe transitory indiscretions in weight management (Bryant, Kiezebrink, King, & Blundell, 2010; Bryant et al., 2008). Trait Disinhibition has been empirically associated with BMI (French, Epstein, Jeffery, Blundell, & Wardle, 2012), and eating in response to stress and the experience of negative emotional states (Bryant et al., 2008; Fay & Finlayson, 2011; Haynes, Lee, & Yeomans, 2003; Yeomans & Coughlan, 2009).

Individuals who possess high levels of disinhibited eating behaviour are overly responsive to the hedonic allure of highly palatable and tasty food (Bryant et al., 2008; Haynes et al., 2003; Yeomans & Coughlan, 2009). They also show an enhanced sensitivity towards the hedonic rewards of wanting and liking (Bryant et al., 2008; Finlayson, Bordes, Griffioen-Roose, de Graaf, & Blundell, 2012; French et al., 2014), an attenuated satiety response, and increased risk for over-consumption (Barkeling, King, Näslund, & Blundell, 2007; Dalton et al., 2015; Finlayson et al., 2012). High levels of Disinhibition have also been linked to binge eating disorder and binge-eating behaviour in individuals who simultaneously possess low levels of dietary restraint (C. B. Peterson et al., 1998; Wadden, Foster, Letizia, & Wilk, 1993; Yeomans & Coughlan, 2009).

Binge-eating disorder is defined as the consumption of a large amount of food in a short period of time that is accompanied by a sense of a loss of control over intake by the *Diagnostic and Statistical Manual for Mental Disorders*, fifth edition, (American Psychiatric Association, 2013). Trait binge-eating behaviour has been linked to a preference for highly palatable snack foods (Dalton, Blundell, & Finlayson, 2013b), enhanced sensitivity towards the psychological rewards of wanting and liking and increased risk for reward-driven over-consumption (Dalton et al., 2013a, 2013b; Finlayson, Arlotti, Dalton, King, & Blundell, 2011). Individuals who possess high levels of Disinhibition and concurrently low levels of dietary restraint (the HDLR eating behaviour subtype) are of special interest to this thesis. These individuals are suggested to possess a dysregulated appetite, to be prone to overeating and to have a tendency towards the highest levels of BMI (Bryant et al., 2008; Lawson et al., 1995; Provencher, Drapeau, Tremblay, Despres, & Lemieux, 2003; Williamson et al., 1995; Yeomans & Coughlan, 2009). Therefore, given the easy access to cheap and highly palatable food within the community (Swinburn et al., 2011), it is possible that this particular disinhibited eating behaviour style (HDLR) actively contributes to rising obesity levels.

1.5.2 Components of disinhibited eating behaviour: Emotional and external eating behaviour

In considering the influence of trait Disinhibition on the obesity epidemic, it is important to understand two eating behaviours that contribute towards its manifestation: emotional and external eating behaviour. Bruch, who is a proponent of The Psychosomatic Theory of Emotional Eating (van Strien, 2002), asserts that people eat emotionally when they experience certain emotionally aroused states such as anger, fear or anxiety (Bruch, 1961; van Strien, 2002). Emotional eaters are thought to have confused their internal perception of their emotionally aroused state with a physiological feeling of hunger and a subsequent lack of satiety (Bruch, 1961; van Strien, 2002). In comparison, external eating behaviour is based upon Externality Theory (Schachter & Rodin, 1974; van Strien, 2002), which attributes overeating to a heightened sensitivity to external influences, salient food cues and a lack of sensitivity to internal sensations of satiety, such as hunger and fullness (Schachter & Rodin, 1974; van Strien, 2002).

It is particularly noteworthy that a high degree of emotionality has been described as a characteristic of the trait of externality (van Strien & Schippers, 1995). This information is highly relevant to this thesis because a high level of negative emotionality such as the experience of uncontrollable anxiety, has been suggested, and shown, to enhance reactivity to external and highly salient food cues, and lead to a greater level of consumption in the obese (Berridge, 2009a; Slochower, 1983). The importance of these findings is they suggest that obese individuals, who are susceptible to the experience of negative emotional states, will be susceptible to emotional and external eating behaviour. Therefore, it is feasible that either an engagement in both emotional and external eating behaviours, or an enhanced engagement in external eating behaviour by individuals with a propensity to experience negative affect, will serve to increase disinhibited eating behaviour and opportunistic consumption. Relative to a link with a reactive BIS, trait disinhibited eating behaviour has been linked to eating in response to stress and negative affect (Bryant et al., 2008; Haynes et al., 2003; Yeomans & Coughlan, 2009) and both emotional and external eating behaviours have been recently linked to the BIS (Hennegan, Loxton, & Mattar, 2013; Matton, Goossens, Braet, & Vervaet, 2013; Stapleton & Whitehead, 2014). However, to the best of my knowledge, no studies have determined whether an individual's propensity towards enhanced negative emotionality, which is indicative of BIS sensitivity (Gray, 1970), is associated with disinhibited eating behaviour.

1.5.3 An inverse association between the BAS and higher levels of BMI

Two independent research groups have shown that there is an inverted U relationship between the BAS and BMI in adults. Within a sample of adult males and females, the association between the BAS and BMI has been shown to increase positively and linearly until a BMI of approximately 30kg/m^2. However, as BMI increases above 30 kg/m^2 the relationship reverses to an inverse linear relationship (Davis & Fox, 2008; Dietrich et al., 2014); it is also noted that a similar relationship has been reported in children (Verbeken, Braet, Lammertyn, Goossens, & Moens, 2012). Subsequently, at moderate levels of obesity, individuals have moderate to high levels of BAS reactivity and when morbidly obese, they experience low levels of BAS reactivity. Furthermore and, importantly, recent research has established for the first time that BMI is linearly and positively associated with the BIS in adult females, with a BMI range of 18.1 kg/m^2 to 46.5 kg/m^2 (Dietrich et al., 2014). However in this same study, there was no evidence of a relationship between disinhibited eating behaviour and the BIS.

Given the finding of an association between the BIS and BMI, the lack of an association between the BIS and disinhibited eating behaviour is surprising, as disinhibited eating behaviour is empirically associated with BMI (French et al., 2012) and the HDLR eating behaviour subtype has shown evidence of attaining the highest levels of BMI (Lawson et al., 1995; Provencher et al., 2003; Williamson et al., 1995). However, the findings from Dietrich et al (2014) and the reported relationship between disinhibited eating behaviour and BMI encourage the conceptualisation that, as BMI increases beyond 30, a temperament phenotype characterised by high levels of BIS reactivity, low levels of BAS reactivity and HDLR eating behaviour, could become prominent in females. Within the temperament-based, eating behaviour literature, individuals with high levels of disinhibited and binge eating behaviours are characterised as eating to satisfy a high level of sensitivity to reward or BAS reactivity (Davis & Loxton, 2014; Davis, Patte, et al., 2007; Dawe & Loxton, 2004). As BMI increases beyond 30 eating behaviour is reported to become more compulsive (and addictive) as evidenced by the practice of binge eating behaviour, despite the negative consequences that this type of behaviour brings (Davis & Fox, 2008; Davis & Loxton, 2014). However, evidence also suggests that as Disinhibition increases, these individuals are likely to have increasing degrees of psychopathology (Bryant et al., 2008; Provencher et al., 2007; Wadden et al., 1993). Consequently, it is intuitive to consider that there may be a link between rising levels of psychopathology, levels of disinhibited and restrained eating behaviour and BMI, as poor mood is an antecedent to binge episodes (Fuller-Tyszkiewicz et al., 2014; Greeno et al., 2000).

If the experience of a negative mood state can disinhibit eating behaviour in susceptible individuals, there may also be an alternative way to explain eating behaviour from a temperament-based perspective that considers BIS as well as BAS reactivity. For example, when Gray's schematic (Figure 2) is considered together with the inverse U relationship between the BAS and BMI and the positive linear relationship between the BIS and BMI in adult females reported by Dietrich et al. (2014), an alternative relationship can be conceptualised. It is possible that two temperament phenotypes become prominent at increasing levels of BMI in females who use food as a psychological reward (e.g. to regulate affect). As depicted in Figure 1.2, a high level of BIS and a high level of BAS (HBIS_HBAS) reactivity may exist in females with a moderate level of BMI, and a high level of BIS and a lower level of BAS reactivity (HBIS_LBAS) may exist in females with higher levels of BMI.

In addition to these proposed relationships, recent research has indicated that at higher levels of BMI an individual will have a high level of unrestrained disinhibited eating behaviour (Dietrich et al., 2014; Löffler et al., 2015). Furthermore these results support earlier findings in the literature, whereby individuals with a combination of high disinhibited and unrestrained eating behaviour (HDLR) were shown to have the highest levels of BMI, when compared to individuals with highly disinhibited and highly restrained eating behaviour (HDHR) (Bryant et al., 2008; Lawson et al., 1995; Provencher et al., 2003; Williamson et al., 1995). The results of Dietrich et al. (2014) and Löffler et al. (2015) are also in agreement with the disinhibited eating behaviour literature that the HDLR eating behaviour subtype has a propensity to binge eat and tends to have a higher level of BMI than the HDHR eating behaviour subtype (Bryant et al., 2008; Yeomans & Coughlan, 2009). Finally, anxiety and depressive disorders occur comorbidly with a diagnosis of binge eating disorder (American Psychiatric Association, 2013; Bulik, Sullivan, & Kendler, 2002; Grucza, Przybeck, & Cloninger, 2007; Robertson & Palmer, 1997). However, a relationship between the BIS and disinhibited eating behaviour has not yet been reported in the literature. Therefore, it is not yet known whether the BIS is associated with disinhibited eating behaviour, or whether a reactive temperament that is poorly regulated increases risk for higher levels of BMI, through higher levels of disinhibited eating behaviour that are inadequately restrained.

Image removed for copyright reasons (Dietrich et al, 2014, *Frontiers in Psychology, 5*. doi: 10.3389/fpsyg.2014.01073)

Figure 1.2. A conceptual interactive relationship between the BIS, BAS, anxiety and BMI.

As anxiety levels increase (B), moderate levels of BMI (A) are hypothesised at moderate levels of anxiety, when levels of both BIS and BAS are moderately high (B). The highest levels of the BIS and the lowest levels of the BAS are hypothesised to exist at the highest levels of BMI (A).
A: The schematic of Gray's proposed relationships of susceptibility to reward (BAS) and susceptibility to punishment (BIS) relative to the dimension of anxiety was adapted from "The psychophysiological basis of introversion-extraversion", by Gray, J. A., 1970, *Behaviour Research and Therapy*, 8, 249-266. Copyright 1970 by Elsevier. B: The reproduction of the quadratic relationship between the BAS Scale from the BIS/BAS Scales and BMI was reprinted from "Body weight status, eating behavior, sensitivity to reward/punishment, and gender: relationships and interdependencies", by Dietrich et al, (2014) p. 8.

1.6 THE GAP IN THE LITERATURE

Disinhibited and binge-eating behaviours have been linked to enhanced levels of psychological food reward, attenuated levels of satiety, overconsumption, and weight management failure. Moreover, disinhibited eating behaviour has been empirically associated with BMI. These eating behaviours are linked via an assumed shared diathesis to experience negative affective states such as anxiety and depression and to the use of food as an affect regulation strategy. In order to manage those eating behaviours, which are contributing towards rising obesity levels, a psychobiological approach to weight management has been suggested. However, it is pertinent that individual differences in BIS and BAS reactivity can arise and that these affective-motivational systems may interact to produce negative affective states, which have been linked to eating behaviour and BMI. It is also relevant that an individual's level of BIS reactivity can undermine their ability to regulate these negative affective states, and that this inability has been linked to the use of food as an affect regulation strategy. However, whether a psychobiological model of temperament, specifically a high level of reactivity within the BIS and a low level of effortful control, is associated with disinhibited eating behaviour, psychological food reward, an attenuated state of satiety and overconsumption is currently not known.

1.7 SUMMARY

In order to clarify why an individual is characterised by eating behaviours that place them at risk of weight gain and weight management failure, it is critical to determine whether their motivation is based solely upon the incentive salience inherent to the obesogenic environment that the current evidence base assumes (Dalton & Finlayson, 2013; Davis et al., 2009; Davis & Loxton, 2014), or whether it could additionally be based upon a need to manage the experience of acute or chronic negative affect that is associated with psychobiological temperament. In order to explore a mechanism of facilitated negative reinforcement that may be promoted via activity within the BIS, it is important to determine *why* an individual is motivated to consume food by determining *which* affective-motivational system is associated with eating behaviour, psychological reward responsiveness, attenuated satiety levels and overconsumption.

1.8 RESEARCH AIMS

The objective of this thesis was to better understand why some individuals are susceptible to weight gain and simultaneously unable to restrain their intake, in order to improve the outcome of weight gain prevention strategies. The primary aims were to determine whether a reactive BIS and a low level of effortful control was associated with eating behaviour and whether eating behaviour was in turn associated with BMI. The secondary aim was to determine whether this process was associated with a dysregulated appetite in an overweight and obese sample of adults

1.9 THESIS OUTLINE

The next chapter (Chapter 2) reviews the current literature that has investigated the relationships between temperament, eating behaviour and BMI. The Reinforcement Sensitivity Theory (Corr, 2008; Gray, 1987a; Gray & McNaughton, 2000) offers an insightful way for understanding the development of an emotional response via reactivity within the BIS and the BAS. Together with Rothbart and colleague's psychobiological model of temperament (Rothbart, Derryberry, & Posner, 1994), it provides a suitable base from which to hypothesise a model of self-regulatory failure that may lead to increased eating behaviour. Therefore, when required and in order to support the research questions, related literature, such as the relationship between the BIS and BAS, and the experience of negative emotional states, such as anxiety and depression, were also reviewed. Additionally, a conceptual relationship between temperament and the use of food to regulate affect will be described. Finally, a relatively recent body of knowledge that has accumulated around the use of a novel measure capable of measuring the psychobiological components of reward, the Leeds Food Preference Questionnaire (LFPQ) will be described. Chapter 3 is a description of the methodologies used. Chapters 4 to 6 are the experimental studies and describe the aims, methods, results, discussion and conclusion of each study. Findings from the three experimental studies, study limitations, and the implications of these findings are discussed in detail in Chapter 7. Chapter 7 concludes by considering the broader implications of the application of a psychobiological model of temperament to weight management strategies and the contributions this thesis makes to the current body of knowledge.

Chapter 2: Literature Review

2.1 OVERVIEW

The successful management of body weight is a problem in Australia. At present, approximately 35% of Australia adults are overweight and 28.3% are obese (Australian Bureau of Statistics, 2012). These figures are continuing to rise (Walls et al., 2012) and, by the year 2025, it is expected that the prevalence of overweight and obesity will increase to 70%. What is contributing to these obesity levels? Modern societies are living within an environment that offers an abundance of readily available and energy-dense foods and promotes sedentary behaviour (Caballero, 2007). The current environment has been labelled 'obesogenic' (Swinburn & Egger, 2002) and within it consumers must consciously choose between eating for pleasure (reward-based hedonic processes) or to maintain energy balance (homeostatic processes) (Dalton & Finlayson, 2013). A report from the United States has estimated that, in order to return to the average body weights of the 1970s, adults would need to decrease their dietary intake by 500 kcal/d (Swinburn, Sacks, & Ravussin, 2009). Presumably, a failure to manage eating behaviours that lead to over-consumption is also contributing to obesity levels in Australians (Australian Bureau of Statistics, 2012).

There is evidence that some individuals overeat in a reward-driven manner in response to palatable food cues within this environment (Blundell, Finlayson, & Halford, 2009; Dalton & Finlayson, 2013, 2014; Stice, Spoor, Ng, & Zald, 2009) and that eating behaviour may also driven by an attempt to alleviate stress, negative affect and increased levels of emotional arousal (Adam & Epel, 2007; Cools, Schotte, & McNally, 1991; Dallman, 2010; Epel, Lapidus, McEwan, & Brownell, 2000; Greeno & Wing, 1994; Greeno et al., 2000; Hepworth, Mogg, Brignell, & Bradley, 2010). Furthermore, Australian data also indicate that consumer eating behaviours, which increase the risk of obesity, are coupled to a reluctance to implement those behaviours that would lead to healthier choices (Queensland Health, 2011). A reluctance to incorporate healthy lifestyle messages into behavioural actions, i.e., to make the most appropriate behavioural choice, may be reflected in current food consumption data. For example, only one in ten Australians eat the recommended five serves of vegetables per day (Australian Bureau of Statistics, 2012). Moreover, those individuals who do gain weight subsequently struggle to lose and then maintain their loss (Queensland Health, 2010). Therefore, an individual's inclination towards hedonic (reward-based) eating, their use of food as an affect regulation strategy, difficulty changing habitual behaviours, and limited success at managing bodyweight, are all likely to be contributing towards the prevalence of obesity in Australia.

These factors may also be influencing the prevalence of severe obesity (BMI > 40 kg/m^2), relative to mild obesity (BMI 30 – 34.9 kg/m^2), within Australia. Within the current environment, severe obesity is increasing disproportionately to mild obesity (Peeters et al., 2015). These findings are prevalent for both sexes, although there is a trend for a greater increase in females over time. Further disturbing findings indicate that those individuals in the top 10 to 25% category of obesity are increasing in BMI from one generation to the next and it has been estimated that, if these trends continue, more than 10% of men and 15% of women will have a BMI that is greater than $35kg/m^2$ by the time they reach middle age (Peeters et al., 2015). Collectively, these findings suggest that Australian adults are taking in more energy than they are expending and indicate that, if eating behaviours do not change and over-consumption continues unabated, obesity levels in this country will continue to rise (Walls et al., 2012).

Whilst access to highly palatable and energy-dense foods contributes towards an obesogenic environment (Berthoud, 2012; C. O. Stubbs & Lee, 2004; Swinburn et al., 2011), not everyone within this environment gains weight or is unsuccessful in their weight management attempts. For example, although emotional and disinhibited eating behaviours have been associated with weight management failure (A. Blair et al., 1990; Elfhag & Rössner, 2005; Kayman et al., 1990; Mc Guire et al., 1999; Ohsiek & Williams, 2011; Teixeira et al., 2010; Wing & Phelan, 2005), reduced levels of these eating behaviours have been associated with long-term weight management success (A. Blair et al., 1990; Teixeira et al., 2010; Wing & Phelan, 2005).

Factors that lead to the susceptibility of over-consumption in some and not others have been suggested to reflect individual differences in fundamental psychological and biological processes (Blundell & Finlayson, 2004; Dalton &

Finlayson, 2014; Davis, 2009) and recent evidence has highlighted the need to identify traits that predispose some and not others to over-consume from the perspective of an individual's psychobiological temperament (Davis, 2009; Dietrich et al., 2014). The main body of research, which has investigated the relationship between temperament, emotional and binge-eating behaviour, describes those who over-consume as eating to satisfy a high level of sensitivity to reward when they are overweight, and eating in response to a down-regulated reward system, as part of an addictive process, when they are moderately to morbidly obese (Davis & Fox, 2008; Davis & Loxton, 2014; Davis, Strachan, & Berkson, 2004).

This body of research provides a temperament-based rationale to explain overeating behaviour and risk for obesity to date. However, it has only considered psychobiological temperament from the perspective of the system that is sensitive to reward (STR), i.e., arising from activity within Reinforcement Sensitivity Theory's BAS (Gray & McNaughton, 2000). By comparison, as proposed by Carver (2008), Rothbart and Bates' psychobiological model of temperament may be conceptualised as a two-layered system of behaviour management encompassing 'bottom-up' reactivity, from Reinforcement Sensitivity Theory's BIS, FFFS and BAS, and 'top-down' self-regulation via the executive function of effortful control (Carver, 2008; Derryberry & Rothbart, 1997; Rothbart & Bates, 1998, 2006). Therefore, the main body of research has not considered an individual's ensuing risk for over-consumption and obesity from this holistic psychobiological perspective.

This thesis will suggest that it is critical to understand eating behaviours from a holistic perspective because a high level of reactivity within the BIS, FFFS and BAS can overwhelm self-regulatory capacity and lead to negative emotional outcomes and ensuing maladaptive behavioural responses. Therefore, in direct comparison to the main body of research, Rothbart and Bates' temperament model has the capacity to determine whether an individual's level of BIS and FFFS reactivity interacts with their level of BAS reactivity to dysregulate appetite and increase consumption. Moreover, it offers insight into an individual's capacity to realistically manage their behaviour via a process of effortful self-regulation, when reactivity within the BIS, FFFS and BAS is apparent. Therefore, in order to understand the trait behaviours that motivate eating behaviour, appetite dysregulation and over-consumption, a complete psychobiological approach has guided the focus of this thesis. It is from such a perspective that the following literature review has been structured.

Part one of the literature review is structured to provide an evidence base for a conceptual relationship between psychobiological temperament, the experience of associated negative affective states and difficulties in emotion regulation, which lead to impairments in cognitive control. Evidence for the use of food as an emotion-regulation strategy is briefly reviewed and eating behaviours that have been associated with affect regulated eating behaviour and obesity are identified. Following this, evidence linking eating behaviour, BMI and the experience of the negative affective states, such as anxiety and depression, is presented; and evidence, which highlights the role of psychobiological temperament in the experience and prediction of these negative affective states, is considered. Part two of the literature review presents the current evidence, which has investigated the relationship between temperament, eating behaviour and BMI and highlights eating behaviour subtypes that are of interest to this thesis. Next a review of related research into impulsivity, psychological reward and a conceptualisation, which links temperament to hedonic (reward-based) eating behaviour and a dysregulated appetite, is presented. This conceptualisation and the available evidence is then considered in relation to a disinhibited eating behaviour subtype that has been noted to have an increased risk for severe BMI and a compulsive style of overeating behaviour. Part three concludes the review by considering evidence of an association between behavioural measures of cognitive impairment, notably a lack of cognitive inhibition and flexibility, in relation to eating behaviour and BMI. The review is then briefly summarised in part four.

PART ONE

2.2 ROTHBART AND BATES' PSYCHOBIOLOGICAL MODEL OF TEMPERAMENT

As previously introduced, as conceptualised and indicated by Carver (2008), Rothbart and Bates' definition of temperament (Rothbart & Bates, 2006; Rothbart et al., 2013) describes a hierarchical model (see Figure 2.1) of individual differences in the expression of affective-motivationally driven, reactive behaviours, which arise from reactivity within the behavioural inhibition system, fight/flight/freeze system

(BIS, FFFS) and behavioural activation system (BAS) (Bijttebier et al., 2009; Carver, 2008; Claes, Vertommen, Smits, & Bijttebier, 2009; Corr, 2008; Derryberry & Rothbart, 1997; Gray & McNaughton, 2000; Rothbart, Ahadi, & Evans, 2000), which are regulated by the executive attentional system of effortful control to influence the expression of emotion and behaviour (Rothbart et al., 2000).

Image removed for copyright reasons (C.S. Carver, 2008, *European Journal of Personality*, 22, 385-409.)

Figure 2.1. A schematic representation of the hierarchical interrelationship between the reactive lower order systems of Gray and McNaughton's BIS/FFFS and BAS and the regulative executive attentional system underlying Rothbart and Bates' construct of Effortful Control, adapted from C.S. Carver, 2008 p. 389.

Within this model, an individual's level of reactivity reflects the physiological and psychological response of the BIS, FFFS and the BAS to the perception of threat and reward and the ensuing motor and emotional responses (Corr, 2008). The capacity to self-regulate the reactivity of these systems is determined by the strength of the attentional process of effortful control, which regulates the reactivity within these lower order, reactive, subcortical systems and thereby determines an individual's emotional state and ultimately their behavioural response to the internal and external environment (Rueda et al., 2005). Individual differences in reactivity exist at the level of the BIS, the FFFS and the BAS, which are also subject to the influence of effortful control. Therefore, individuals will possess different dispositional traits, cognitions and coping strategies that will give rise to the subjective experience of various emotional states (Rothbart et al., 2013) and it is assumed, the subsequent expression of varying levels of trait eating behaviour. The components of this hierarchical model will be described separately below and then bought together to conceptualise how this model of psychobiological temperament may be linked to eating behaviour and risk for increased BMI.

2.3 THE COMPONENTS OF PSYCHOBIOLOGICAL TEMPERAMENT

2.3.1 Reinforcement Sensitivity Theory

The Reinforcement Sensitivity Theory (RST) of Gray (1970) and Gray and McNaughton recently revised in 2000 (2000), describes how three conceptual neural systems generate the emotions of hope, anxiety and fear, which serve to motivate behaviour when an individual interacts with stimuli within their environment. A major revision in the new theory is that the FFFS is activated in response to aversive stimuli and that the BIS is no longer activated in response to aversive stimuli. Instead, it is now responsible for resolving goal conflict between the FFFS and the BAS and for generating the aversive emotional state of anxiety. One limitation for assessing reactivity within these systems is that the current instruments in use were not developed to assess the strength of the FFFS independently of the BIS. Although investigators have been able to successfully isolate a factor of FFFS within the original BIS Scale of Carver and White (Carver & White, 1994; Heym, Ferguson, & Lawrence, 2008). All of the studies reviewed here have investigated the BIS from the perspective of the old theory. However, this limitation does not affect the integrity of this research as the BIS Scale was originally created to measure reactivity within a system that is activated in response to aversive stimuli.

A major conceptualisation within this thesis is that individuals in possession of a reactive BIS and FFFS will use food to regulate the experience of an aversive emotional state. The occurrence of these states will arise from both an activated BIS and/or an activated FFFS, which have both been linked to a higher order factor of negative affect (Corr, 2004). Therefore, the BIS Scale from Carver and White (1994) is still suitable for identifying a reactive BIS and FFFS that is associated with the experience of aversive emotions and negative affect and, for the ease of the ensuing discussion, the independent measures of the FFFS and the BIS will be referred to as the BIS from now on. It will be measured by the original BIS Scale of the Carver and

White BIS/BAS Scales (1994) and will encompass the combined factors of the BIS and FFFS as an overarching factor that is sensitive to punishment as suggested by Corr (2004). Additionally, some studies have also used an alternative scale, The Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ) from Torrubia, Avila, Molto and Caseras (2001), to assess reactivity within Gray's affective-motivational systems. Where this scale has been used, the related measures will be also identified as reflecting reactivity within the BIS and BAS.

2.3.2 The Reinforcement Sensitivity Theory systems

The Behavioural Activation System (BAS)

The BAS has been linked to the personality trait of impulsivity and the state of positive affect (Corr, 2008). It is sensitive to conditioned and unconditioned appetitive stimuli and activates automatic approach behaviours in response to stimuli that are associated with the receipt of reward or the omission/escape from punishment (Mc Naughton & Corr, 2008). When activated, it generates the emotion of hope and anticipatory pleasure and it is capable of reinforcing an active escape or avoidance response that is generated by the FFFS (Gray, 1991). The modulatory system of the BAS is the mesolimbic dopamine system and dopamine neurotransmitter (Mc Naughton & Corr, 2008).

The Fight/Flight/Freeze and the Behavioural Inhibition Systems (BIS/FFFS)

The FFFS has been linked to the personality factors of fear-proneness, avoidance and negative affect (Corr, 2004, 2008). It is sensitive to conditioned and unconditioned aversive stimuli and activates escape/avoidance behaviours in response to aversive stimuli, threat and the receipt of punishment. When activated, it increases physiological arousal and generates the emotions of fear and frustration (Corr, 2008). The BIS has been linked to the personality factors of worry-proneness, anxious rumination and negative affect and is best described as a conflict detection, risk assessment and appraisal system (Corr, 2004, 2008). It is activated upon the experience of an approach-avoidance conflict as would occur when both the BAS and the FFFS are activated equally. However, it can also be activated in response to conflict that is approach – approach or avoidance – avoidance in orientation (Mc Naughton & Corr, 2008). When activated, it inhibits all ongoing behaviour and directs an individual's attention to the resolution of conflict (Mc Naughton & Corr, 2008). Activation of the BIS may promote cautious, 'risk assessment', approach behaviour or passive avoidance behaviour.

Simultaneous activation of the BAS, FFFS and BIS, as would occur in an approach-avoidance conflict, increases physiological arousal and, furthermore, biases thought towards negative outcomes that are designed to keep the individual safe, thus biasing the use of escape/avoidance behaviours. During conflict, activation within the BIS promotes feelings of negative affect, anxiety, rumination and worry. When a conflict cannot be resolved, the default physiological and psychological position within the BIS is to increase levels of arousal and feelings of negative affect until resolution ensues via activation of the FFFS and the engagement of escape/avoidance behaviours. However, if attention to the environment or memory identifies a source of safety, the BIS can also activate BAS approach behaviours (Corr, 2008).

A conceptualisation for the intake of highly palatable food and the BIS/FFFS as negative feedback systems

Of interest to this thesis, both the BIS and the FFFS have been described as negative feedback systems (Corr, 2008). Within this description, the FFFS is so-called because it is designed to remove the individual from an undesired state of threat, which is felt as fear, to a desired state of safety; the BIS is so-called because it is designed to return the individual from a state of conflict, which is felt as anxiety, to a state of non-conflict (Corr, 2008). The successful avoidance of conflict or a threat is signaled when the individual engages in an alternative form of behaviour that reduces their level of conflict, threat and potential for harm and signals a state of 'safety' (Gray, 1987c; Levita, Hoskin, & Champi, 2012).

Highly palatable food is neurologically rewarding (Berridge, 1996). Its consumption is capable of down-regulating both psychological and physiological distress and has been linked to increased feelings of positive affect and calm (Adam & Epel, 2007; Dallman, 2010; Gibson, 2006; Macht, 2008). Therefore, it is conceptualised that the achievement of a state of safety or non-conflict could be signaled via the receipt of neurologically rewarding stimuli, such as highly palatable food (Berridge, 1996; Gray, 1991), which is anticipated to either increase a state of positive affect or alternatively reduce a state of high negative affect to a state of low negative affect, which has been linked to feelings of calm and relaxation (Carver, Sutton, & Scheier, 2000; Watson & Tellegen, 1985). Consequently, if an individual who is under threat or in conflict lacks sufficient self-regulatory skill to down-regulate a negative affective state and they have learnt to associate the receipt of a neurological reward from food with an increase in positive affect or feelings of calm, it is conceptualised that, over time, they will have learnt to regulate their negative affective state with food and, further, that this behavioural choice will have become habitual.

2.3.3 Self-regulation: Effortful control

The overarching construct of effortful control represents an individual's capacity to override a dominant, automatic response in order to enact a subdominant response during the experience of conflict (e.g., BIS activation). The construct is made up of subcomponents that define an individual's capacity to: motivate themselves to perform a less desired action, i.e., finish a tedious task on time, shift attention from punishing or rewarding stimuli, and inhibit inappropriate behaviour as desired (Evans & Rothbart, 2007). It is a higher-order, executive function that is theoretically linked to the successful management of emotion through its involvement in various emotion regulation processes such as distraction, suppression and reappraisal (Eisenberg, Hofer, Sulik, & Spinrad, 2013). Importantly, the capacity to exert effortful control over emotion enables the enactment of the most appropriate behavioural response or course of action when faced with conflict and discomforting levels of emotion, such as the suppression of disappointment or frustration and the activation of smiling upon the receipt of a disappointing gift (Rothbart et al., 2013). Higher levels of effortful control have been empirically associated with the regulation of emotion and cognition and lower levels with the experience of negative affect and the enactment of anti-social behaviours in infants, children, adolescents and adults (Cromheeke & Mueller, 2013; De Panfilis, Meehan, Cain, & Clarkin, 2013; Eisenberg et al., 2013; Eysenck et al., 2007; Heatherton & Wagner, 2011; Jones, Fazio, & Vasey, 2012; Kanske & Kotz, 2013; Morillas-Romero, Tortella-Feliu, Balle, & Bornas, 2015; Mueller, 2011; Müller et al., 2012; Müller et al., 2014; Posner & Rothbart, 2007, 2009; Rothbart et al., 2010; Rothbart et al., 2013). Therefore, a low level of effortful control or an inefficient use of effortful control may lead to emotion regulation difficulties, symptoms of negative affect and inappropriate behavioural responses.

An individual's ability to exert effortful control, can be disrupted by reactivity within the BIS. High levels of negative emotionality have been negatively associated with low levels of effortful control in adults (Evans & Rothbart, 2007; Rothbart & Rueda, 2005), and the experience of negative affect has been shown to weaken self-regulatory resolve (Heatherton & Wagner, 2011; Wagner & Heatherton, 2013a). Therefore, an individual with a reactive BIS is likely to possess reduced levels of effortful control and a reduction in their capacity to manage both their emotions and their subsequent behavioural responses. The Attentional Control Theory of Eysenck, Derakshan, Santos and Calvo (2007) was developed to explain how the experience of anxiety within non-clinical populations could impact cognitive performance. According to Attentional Control Theory, an individual's capacity to exert effortful control over reactivity within the BIS is limited. Upon BIS activation, the Theory asserts that the stimulus-driven attentional system underlying the BIS will divert attention *away* from the attentional network underlying effortful control and *towards* threatening stimuli that are either external (e.g., a threatening environment) or internal (e.g., worrying thoughts), in origin. Because attention is diverted towards the automatic processing of threat-related stimuli, less attentional resources are available to the executive function of effortful control, i.e., to regulate emotion and to inhibit a dominant pre-potent response in favour of a subdominant response. Consequently, individuals with higher levels of BIS reactivity will be less adept at regulating their emotional state or their subsequent behavioural actions if the attentional resources of effortful control are simultaneously diverted or deficient. Subsequently, Attentional Control Theory suggests that higher levels of the BIS, lower levels of effortful control and associated emotion regulation difficulties could predict the use of dominant or habitual behaviours and that, critically, these effects will be more noticeable at higher levels of anxiety. This conceptualisation will be explored in greater detail in the following section.

2.4 A CONCEPTUAL PSYCHOBIOLOGICAL MODEL OF A FAILURE TO MANAGE EATING BEHAVIOUR

To successfully change behavior, one must be able to deliberately interrupt, prevent or suppress the enactment of cued habitual behaviours (E. K. Miller & Cohen, 2001; Nigg, Silk, Starvo, & Miller, 2005). The achievement of goal-directed behaviour (e.g., such as enacting a new behaviour to enable weight loss) is reliant on one’s capacity to overcome the interference that arises when one chooses to enact a new behavioural pattern that is in direct competition with a fixed established and resistant behavioural pattern (E. K. Miller & Cohen, 2001). According to Attentional Control Theory, the experience of anxiety undermines the attentional resources available to effortfully regulate emotion and control behaviour, thereby increasing the likelihood that reactive, habitual, response patterns will override the enactment of a new behavioural response. Therefore, it is possible that, individuals with a reactive BIS and a low level of or inefficient use of effortful control, will have trouble overriding habitual behaviours in order to enact new and desired behaviours.

The prefrontal cortex model of cognitive control of Miller and Cohen (2001), describes how an efficient use of executive attention is required to achieve goal-directed behaviour. According to this model, the pre-frontal cortex must maintain its attentional focus on the task at hand to achieve a desired outcome. In the schematic depicted below (see Figure 2.2), the task at hand is to go for a walk instead of eating when feeling anxious or depressed, thereby achieving the desired longer-term outcome of weight loss. However, as conceptualised by Attentional Control Theory, a lack of attentional focus may arise due to the BIS diverting attention to the automatic management of a threat. Critically, the more reactive the BIS, the more attention will be diverted to the automatic processing of threat-related stimuli and the more negative affect will be experienced, as attentional resources are diverted away from the anterior attentional system that underlies effortful control. Therefore, for individuals with a high level of BIS reactivity and a low level of effortful control, there will be *even less* attentional resources available to regulate the experience of negative affect and to maintain the focus on the goal at hand, which is to go for a walk, instead of eating, upon the perception of a threat and experience of the ensuing negative emotional state.

An individual with emotion regulation difficulties is inefficient at down-regulating the effect of their aversive emotional state (Gratz & Roemer, 2004; Gross, 2013). As a result they remain ‘at the mercy’ of their emotional experiences. As one way of coping with an inability to regulate affect, it has been suggested that individuals with emotion regulation deficits engage in the use of maladaptive coping behaviours (Wallace & Newman, 1997). Indeed, research has shown that individuals who binge-eat have difficulty regulating their emotional state (Aldao et al., 2010;

Gianini, White, & Masheb, 2013; Munsch, Meyer, Quartier, & Wilhelm, 2012; U. Whiteside et al., 2007) and, further, that such difficulty predicts emotional eating, eating pathology and binge-eating behaviour (Gianini et al., 2013; U. Whiteside et al., 2007).

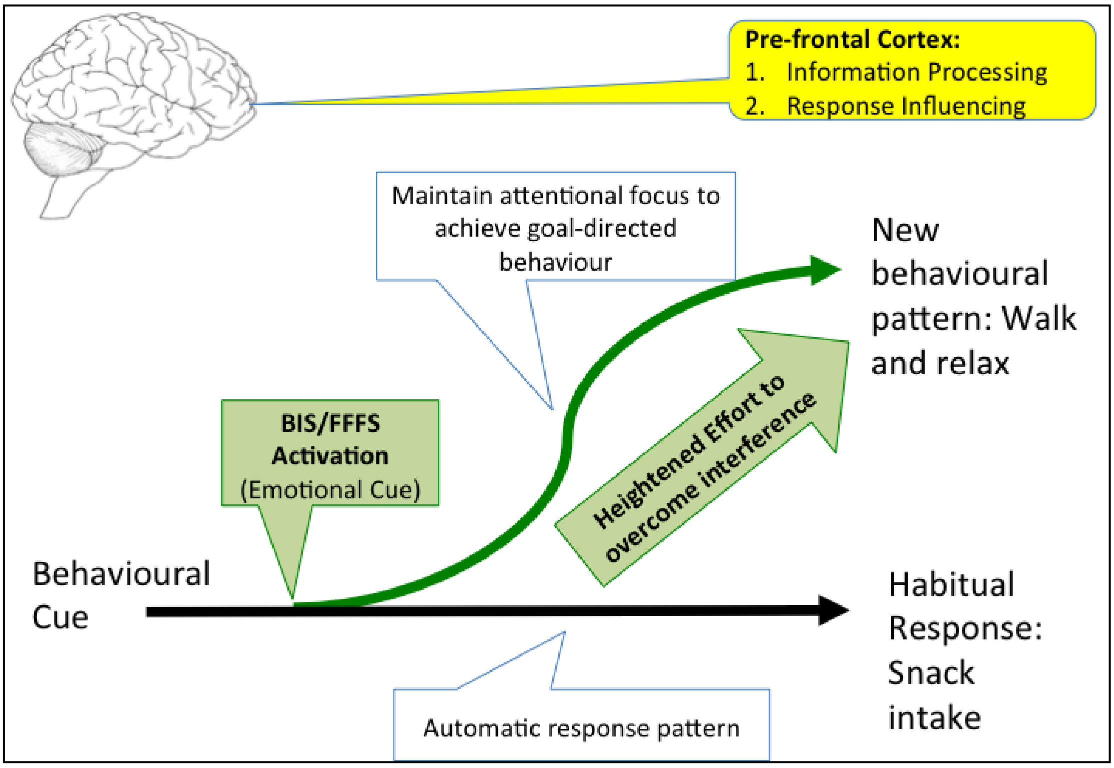

Figure 2.2. A diagrammatic representation of the Prefrontal Cortex Model of Cognitive Control of E. K. Miller and J. D. Cohen, 2001, *Annual Review of Neuroscience, 24, 167-202.*

In this diagram, the subject has learnt to respond to feelings of negative affect arising from reactivity within the BIS/FFFS (i.e., the emotional cue) by snacking on highly palatable food (i.e., the habitual response). In order to create a new behavioural pattern, the individual must override the interference that arises from their habitual response in order to enact their new behavioural cue of walking and relaxing the next time they feel anxious or depressed. However, it is conceptualised that an individual with a high level of BIS/FFFS reactivity will be unable to exert the required effort to overcome their competing habitual response, due to an increase in focus on an external threat and the associated feelings of negative affect that depletes the attentional resource of effortful control. In this scenario, the individual is not only competing against the interference inherent to their habitual response, they are also competing against their desire to escape from their negative emotions. As a result, it is conceptualised that the individual will be unable to maintain their focus on their new behavioural goal. Therefore, they will continue to rely upon their habitual behavioural response of snacking.

Therefore, it is suggested that, if the individual is not able to down-regulate their negative affective state by an efficient use of effortful control, they will seek to do so by other means, i.e., by the impulsive intake of highly palatable food. Subsequently, a reactive BIS that is ineffectively regulated could predict the failure to override dominant habitual behaviours (such as eating when experiencing a degree of negative emotionality). Consequently, the less dominant response, of going for a walk instead, will not be acted upon. Instead the individual may find him or herself once again reaching impulsively for that second slice of pie, even though they don't really want it. Therefore, the ability to regulate reactivity within the BIS and BAS, via the executive attentional system of effortful control, is critical for the achievement of goal-directed behaviours, successful behaviour change and successful weight management outcomes (Derryberry & Rothbart, 1997; Heatherton & Wagner, 2011; E. K. Miller & Cohen, 2001; Rothbart & Rueda, 2005; Wagner, Altman, Boswell, Kelley, & Heatherton, 2013; Wagner, Boswell, Kelley, & Heatherton, 2012; Wagner & Heatherton, 2013a).

It has been suggested that the level of arousal generated as the BIS and BAS interact (Corr & Mc Naughton, 2008) will contribute towards the enhanced facilitation of a behavioural response and, it is assumed, a degree of impulsivity (Carver, Johnson, & Joorman, 2009; Corr, 2008; Newman & Wallace, 1993; Patterson & Newman, 1993; Wallace & Newman, 1997). The personality trait of impulsivity has been linked to a heightened level of physiological and psychological arousal that is associated with activation within both the BIS and the BAS of Gray's RST (Carver et al., 2009; Newman & Wallace, 1993; Patterson & Newman, 1993; Wallace, Newman, & Bachorowski, 1991) and enhanced levels of arousal have been linked to a reliance on automatic and well-learned behaviours (Newman & Wallace, 1993; Schwabe & Wolf, 2009, 2011). Therefore, an interaction between the BIS and the BAS supports the expected action of anxious and impulsive behaviours on the failure to carry out goal-directed behaviours as described previously.

A failure to maintain goal-directed behaviour in the face of a high level of arousal has been used to explain the inappropriate responding portrayed by disinhibited individuals (Newman & Wallace, 1993). Moreover, interactions between the BIS and the BAS have predicted the experience of emotional symptoms, mixed anxiety-depression, general distress and anhedonic depression (Dinovo & Vasey, 2011; Hundt et al., 2007; Kambouropolous & Staiger, 2004; Knyazev & Wilson, 2004). Furthermore, the experience of negative affect and enhanced levels of physiological arousal have been linked to highly palatable food intake (Adam & Epel, 2007; Dallman, 2010) and to a reduction in the efficient use of executive functioning (Arnsten, 2009; Arnsten & Goldman-Rakic, 1998; C. Blair & Ursache, 2010; Heatherton & Wagner, 2011; Mueller, 2011; Wagner & Heatherton, 2013a, 2013b). Therefore, it is feasible that individuals who lack the attentional resources required to shift automatic, habitual, dominant behavioural patterns, as a result of a reactive BIS (E. K. Miller & Cohen, 2001), will maintain their reliance upon the use of maladaptive eating behaviours to regulate the experience of a negative affective state.

In the eating behaviour and temperament research, lower levels of effortful control and higher levels of the BIS and BAS have been linked to the experience of dysregulated emotions and dysregulated eating behaviour in obese individuals and in individuals with binge-type eating disorders and eating disorder symptoms (Claes et al., 2011; Claes et al., 2012; Claes et al., 2010; Müller et al., 2014; Nijs, Muris, Euser, & Franken, 2010). These findings provide support for the assumption that a low level of effortful control and reactivity within the BIS and BAS are linked to difficulty in regulating emotions and eating behaviours that have been linked, in turn, to higher levels of BMI. The review of this section has indicated that the relationship between an individual's capacity to regulate their emotions and eating behaviour via effortful control may be of importance when considering their capacity to manage eating behaviour and body weight. Specifically, prior knowledge of an individual's level of their reactive and self-regulative temperament might provide insight into their capacity to manage reactivity within the lower order systems, their level of emotional vulnerability, and their subsequent risk for failure to successfully manage eating behaviour and body weight.

2.5 THE USE OF FOOD AS AN AFFECT REGULATION STRATEGY

A review of the literature on the use of food as an emotion regulation strategy has identified that individuals eat emotionally to relieve and escape from negative affect (Macht, 2008). Using a five-way model to explain how emotions effect eating, Macht identified that a moderate level of negative affect and arousal promotes the intake of highly palatable, i.e., high-fat and sweet foods, as an emotion-regulation strategy in emotional and binge eaters, which places them at increased risk of obesity (2008).

Why do people eat emotionally? Emotional eating theory, which originated from psychosomatic theory, suggests that some individuals eat in response to highly aroused negative emotional states, such as fear and anxiety (van Strien, 2002). Furthermore, as suggested by van Strien (2002), these individuals may not even be consciously aware that they are eating to regulate the experience of an aversive state. However, Macht extended a core assumption of emotional eating theory that "negative emotions induce eating and are, as a result reduced" (2008, p. 6) to more recent theories, which suggest that consumption is also driven by a conscious attempt to improve mood (Thayer, 1989, 2001), to mask stress (Polivy & Herman, 1999), and to escape from aversive self-awareness (Heatherton & Baumeister, 1991). Therefore, although psychosomatic theory suggests that some emotional eaters may lack conscious awareness of their current emotional state, others appear to be highly aware of their current emotional state and subsequently seek to actively regulate it with food. Despite this distinction, however, the outcome for both types of individuals, i.e., those who are aware or unaware of their emotional state, is to consume highly palatable food as an affect regulation strategy.

The consumption of food has been described as a neurologically rewarding experience that has the capacity to change mood (Gibson, 2006). Experimentally, the consumption of sweet and fatty foods has been shown to immediately improve mood after a negative mood induction in emotional eaters (Macht, 2008; Macht & Mueller, 2007) and the taste of energy-dense foods, high in fat and sugar, has been shown to create a positive affective response that has been linked to activation within neurological reward centres (Berridge, 2003). Therefore, as suggested by Macht, eating immediately in response to the experience of negative affect is likely to be based upon hedonic (reward-based) and not homeostatic mechanisms (Macht, 2008). Of interest to the population under study in this thesis, Macht concluded his review by speculating that because the intake of highly palatable food has the capacity to create an immediate change in state, this style of hedonic eating behaviour could be commonly expressed within the general population. It is interesting that his conclusion supports other research that has linked trait binge-eating to enhanced levels of hedonic reward and over-consumption (Dalton & Finlayson, 2014; Finlayson et al., 2011; Finlayson & Dalton, 2012) and the observation by Dalton and Finlayson that trait binge-eating and the use of food as an affect regulation strategy is prevalent in10 to 20% of the general population (2014).

As described in section 2.3, it is likely that an individual in possession of a reactive temperament, which is ineffectively regulated, may experience increased levels of negative affect, which they are unable to regulate. Consequently, the possession of a reactive temperament phenotype, i.e., a high level of BIS reactivity and a low level of effortful control, could place them at risk of emotional and trait binge-eating behaviour, enhanced levels of hedonic reward, over-consumption and increased BMI. This information highlights the importance of understanding the temperament characteristics of individuals with higher levels of emotional, binge and disinhibited eating behaviours. These individuals could possess temperament characteristics, such as a reactive BIS and reduced levels of effortful control, which predispose them to experience negative affective states that they lack the skills to regulate.

2.6 EATING BEHAVIOUR

2.6.1 Emotional and external eating behaviour

Emotional eating behaviour is based upon psychosomatic theory (van Strien, 2002). Psychosomatic theory evolved from the observation that obese individuals ate when they were emotional, i.e., angry, fearful, anxious, lonely or depressed (Ouwens, van Strien, & van der Staak, 2003; van Strien, 2002). As described by van Strien (2002), a normal appetitive response to stress and emotional arousal is a reduction in appetite and satiety, as the physiological stress response inhibits gastric motility and releases glucose into the blood stream in preparation for the fight or flight response. However, despite these physiological signals, it has been observed that some individuals still increase their food intake (van Strien, 2002). Interestingly, individuals who eat emotionally are believed to lack sufficient interoceptive awareness of their internal physiological and emotional states (Bruch, 1961; van Strien, 2002). Consequently, it is thought that they have confused their emotionally-aroused state with hunger and a lack of satiety, which results in their eating in response to emotions that they may or may not be aware of (Bruch, 1964; van Strien, 2002).

Externality theory is an alternative theory of obesity, which attributes overeating behaviour to a heightened sensitivity to external influences, salient food cues, and a lack of interoceptive awareness towards a state of satiation (Schachter, 1971; van Strien, 2002). In contrast to emotional eating behaviour, which is initiated in response to emotional arousal, external eating behaviour is initiated in response to cues from the external environment (Schachter, 1968, 1971). Subsequently, external eaters may be induced to eat simply because they smell or see a delectable food item or even see others eating (van Strien, 2002).

As outlined here, the theories of emotional and external eating clearly describe two distinct aetiologies of over-eating behaviour. However, they also converge on two areas that are of interest to this thesis. Firstly, that an individual’s inability to perceive their internal state prior to intake is a causal factor in overeating (van Strien & Schippers, 1995). For example, psychosomatic theory proposes a misattribution of sensations of hunger to physiological sensations arising from the stress response (Bruch, 1961; van Strien, 2002) whilst externality theory advances that a heightened sensitivity towards external food cues is responsible for intake, irrespective of feelings of hunger or satiety (Schachter & Rodin, 1974; van Strien, 2002). Secondly: it has been suggested that both theories assume a strong relationship with overeating behaviour that is influenced by their level of emotionality (van Strien & Schippers, 1995). The latter relationship is quite straightforward for emotional eaters; i.e., they are assumed to eat in response to the experience of negative affective states. However, there is a more indirect route for external eaters. For example, external eaters as described by van Strien and Schippers, are susceptible to heightened states of emotional arousal, which are thought to influence their level of eating behaviour (1995). Van Strien and Schippers (1995), highlight evidence of this relationship in earlier research undertaken by Slochower (1983). Upon subsequent investigation, Slochower’s research indicated that obese individuals paid more attention to salient food cues and consumed more snack-type food when they were induced into a state of uncontrollable anxious arousal, in comparison to when they were in a state of calm (Slochower, 1983).

These findings led Slochower to suggest that consumption in obese individuals may result from an interaction between external and emotional factors (1983). Her interpretation suggests that a degree of emotional arousal potentiates the reward value of salient foods, which is responsible for an increased intake in overweight and obese individuals. Subsequently, these findings indicate that overweight or obese individuals are at risk of both emotional and external eating behaviour and that one trigger for overconsumption may be the experience of an uncontrollable, emotionally aroused state. These findings suggest that, not only will emotional eating behaviour be linked to external eating behaviour in the obese (van Strien & Schippers, 1995), it also suggests individuals who are susceptible to negative affect and to emotional eating may also be responsive to external eating, via enhanced responsiveness towards external food cues.

The Disinhibition Scale from the Three Factor Eating Questionnaire (TFEQ) (Stunkard & Messick, 1985) encompasses both emotional and external eating behaviours that can be superimposed either on a failure of or failure to exercise restraint (Ouwens et al., 2003; van Strien, 1997; Westenhoeffer, 1991; Yeomans & Coughlan, 2009). Subsequently, obese individuals who are at risk of emotional and external eating behaviour are also likely to be at increased risk of disinhibited eating behaviour. Therefore, it is feasible that a predisposition towards the experience of negative emotional states may not only lead to an increase in emotional and/or external eating behaviour, it is also likely to lead to an increase in disinhibited eating behaviour (van Strien & Schippers, 1995) and, subsequently, opportunistic over-consumption (Bryant et al., 2008).

2.6.2 Emotional and external eating behaviours and their relationship to disinhibited eating behaviour and obesity

Australian adults are continuing to gain weight (Australian Bureau of Statistics, 2012) and prospective studies have shown that those individuals who are at the higher levels of normal weight and who are already overweight are likely to gain weight during stress (Dallman, 2010). Although stress-induced eating is not a universal response (Greeno & Wing, 1994), it has been estimated that at least 40% of individuals have this response (Dallman, 2010). In light of these findings, it is interesting that research by van Strien, Herman and Verheijden (2009) has suggested that, over the last 20 years, the hedonic response to the obesogenic environment via external eating has plateaued, whilst an ‘emotional’ response ‘within’ an obesogenic food environment has increased. These findings led the authors of this study to suggest that the global increase in the obesity epidemic may be attributed to an increase in the consumption of highly palatable food as a result of emotional and not external eating (van Strien et al., 2009).

Emotional eating occurs in response to the experience of negative emotional states (Macht, 2008). Therefore, the results, from van Strien et al. (2009) suggest that an individual’s level of susceptibility to over-consumption, i.e., their level of disinhibited eating behaviour (Bryant et al., 2008), may not only be driven by a strong motivation to take advantage of the current obesogenic environment but may also be driven, in part, by the experience of an aversive affective state that is poorly regulated (Macht, 2008). In summary, the results from van Strien et al. highlight that the use of food as an emotion regulation strategy, i.e., emotional eating, may have a stronger influence on disinhibited eating behaviour, weight gain and obesity than an eating behavioural style that is driven solely by an individual’s responsiveness to their external food environment.

2.6.3 Disinhibited eating behaviour characteristics

Disinhibited eating behaviour has been traditionally measured with the Three Factor Eating Questionnaire (TFEQ) Disinhibition Scale (Stunkard & Messick, 1985), which measures a loss of control over food intake. It has been empirically associated with BMI (French et al., 2012), more recently described as an eating behaviour trait of opportunistic overconsumption (Bryant et al., 2008), and linked to weight management outcomes. Research into the levels of disinhibited eating behaviour of individuals who have successfully lost weight and maintained this loss over the longer-term have shown that reduced levels of trait Disinhibition are associated with weight management success (Wing & Phelan, 2005), whilst increasing Disinhibition levels are associated with weight regain (Elfhag & Rössner, 2005; Mc Guire et al., 1999; Wing et al., 2008). High levels of disinhibited eating behaviour can also be concurrently measured with the Restraint Scale of the TFEQ (Stunkard & Messick, 1985), which measures the cognitive intent to diet, to define two subtypes of disinhibited eaters at risk of weight gain (Bryant et al., 2010; Lawson et al., 1995).

When individuals are characterised by both high levels of disinhibited and restrained eating behaviours (HDHR); high levels of Restraint mark a cognitive intent to control weight. However, these individuals have been shown to increase intake in response to acute stress (Haynes et al., 2003), negative affect (Fay & Finlayson, 2011; Yeomans & Coughlan, 2009) and after a food preload (Westenhoeffer, Broeckmann, Munch, & Pudel, 1994). Furthermore, their attempts to restrain weight are associated with higher levels of dysregulated eating behaviour, body image concern and low levels of self-esteem (Bryant et al., 2010). According to Lawson et al. (1995), this eating behaviour subtype may describe a current and frequent dieter who is successful in their weight management attempts, yet still struggles to maintain their weight due to frequent periods of opportunistic eating. However, despite their ongoing eating behaviour failures, these individuals exhibit a reduced weight gain trajectory and level of BMI (Bryant et al., 2010; Lawson et al., 1995). Their tendency towards a constrained BMI has been hypothesized to reflect their high levels of restrained eating behaviour (Bryant et al., 2010; Lawson et al., 1995; Williamson et al., 1995).

In comparison to HDHR eating behaviour, a high level of Disinhibition on a background of low Restraint (HDLR) appears to characterise opportunistic eating behaviour that is not actively restrained (Bryant et al., 2010; Lawson et al., 1995; Yeomans & Coughlan, 2009). Subsequently, this subtype is suggested to have an increased risk for obesity as a consequence of their high level of hedonic responsiveness, dysregulated appetite and unrestrained eating behaviour (Bryant et al., 2010; Lawson et al., 1995). According to Lawson et al. (1995), this eating behaviour subtype may describe an individual who is a frequent, although not current, dieter who is very unsuccessful in their weight management efforts. It is of interest to this research, that these individuals have also been found to have the highest levels of BMI in their respective samples (Bellisle et al., 2004; Dykes, Brunner, Martikainen, & Wardle, 2004; Williamson et al., 1995).

In relation to eating to regulate affect, the HDLR eating behaviour subtype has been shown to reduce their intake during acute stress and the experience of negative affect and to increase their intake in response to experiencing positive affect (Haynes et al., 2003; Yeomans & Coughlan, 2009). As a result, it has been suggested that they are at risk of increased intake during a positive mood state, because the experience of positive affect interacts with and enhances their already high levels of psychological reward responsiveness to further elevate mood (Yeomans & Coughlan, 2009). Subsequently, these findings suggest that these individuals exhibit an external eating behavioural style and a loss of control over intake that is linked to positive and not negative affect. However, they do not offer insight into whether the HDLR subtype may increase their intake in response to feelings of negative affect that are less acute and more chronic in nature.

A tendency towards the enjoyment of highly palatable food has also been reported for both disinhibited eating behaviour subtypes (Bryant, 2006). However, the HDLR subtype has been reported to be more responsive to the hedonic properties of palatable food than their HDHR counterparts (Yeomans, Tovey, Tinley, & Haynes, 2004) and to have a propensity for over-consumption (Yeomans & Coughlan, 2009). Furthermore, this propensity has been attributed to a tendency to binge-eat (Yeomans & Coughlan, 2009) and there is evidence of a relationship between individuals with high levels of Disinhibition, low levels of Restraint, and binge-eating behaviour and binge-eating disorder (BED) in the literature (Ardovini, Caputo, Todisco, & Dalle, 1999; Lawson et al., 1995; Wadden et al., 1993; Yanovski & Sebring, 1994). Subsequently individuals with a HDLR eating behaviour subtype are also expected to show evidence of trait binge-eating behaviour.

Binge-eating behaviour has been defined as the consumption of a large amount of food in a short period of time that is accompanied by a sense of a loss of control over intake in the *Diagnostic and Statistical Manual for Mental Disorders* (5th ed.; DSM-5; American Psychiatric Association, 2013). It is a common pattern of eating behaviour that is found in the obese population (Stunkard, 1959) and it is of interest to this thesis that the negative emotional states and cognitions associated with the tendency to binge-eat have been estimated to occur in 10 to 20% of the general population (Dalton & Finlayson, 2014). Furthermore, these tendencies have been suggested to represent a psychometric trait of binge eating that can be measured along a continuum using the Binge Eating Scale (BES) (Dalton & Finlayson, 2014; Gormally, Black, Daston, & Rardin, 1982). These findings suggest that individuals with high levels of disinhibited eating behaviour may show similar dispositional trait characteristics to individuals with binge-eating behaviour.

At first glance, the HDLR eating behaviour subtype appears to have no desire to exercise restraint when confronted with highly palatable food. However, anecdotal evidence suggests otherwise. For example, individuals with BED, who were also high in Disinhibition and low in Restraint, have been reported to be “so overwhelmed by repeated failures that they had given up all efforts to diet” (Marcus, Smith, Santelli, & Kaye, 1992, p. 254). Moreover, the HDLR subtype’s tendency towards a higher BMI and low level of restraint have also been suggested to reflect their having “given up the struggle against obesity” (Lawson et al., 1995, p. 160). Collectively, these characteristics suggest that not only will trait binge-eating behaviours be found within the HDLR eating behaviour subtype, it is also possible that these anecdotal descriptions could reflect the characteristics of an individual with depressive tendencies. These findings serve to highlight the importance of understanding those factors that disenable this subtype to restrict their eating behaviour and body weight.

In summary, highly disinhibited eaters are at risk for over-consumption, weight gain and weight regain. Furthermore, a highly disinhibited individual’s level of restraint differentiates between two different over-eating subtypes, which differ in their weight-gain trajectories and penchant for highly palatable food. The HDHR subtype appears to have a slower and more contained weight gain trajectory when compared with the HDLR subtype, who appears to find highly palatable food more rewarding than the HDHR subtype. In light of the evidence presented here, both eating behaviour subtypes are likely to contribute towards increasing levels of overweight and obesity in Australia. However, it is also possible that the HDLR subtype may be contributing proportionately more towards the prevalence of severe obesity in Australia.

The review of this section on eating behaviour supports that an individual’s level of susceptibility towards over-consumption may not only result from a strong motivation to take advantage of a highly palatable food environment, which is inherent to the concept of external eating. Importantly, it also suggests that a high level of palatable food intake may also serve a particular purpose. It supports a view that one pathway to over-consumption could reflect a response to the experience of an aversive affective state that is not well regulated and that it may be linked to enhanced levels of psychological reward, over-consumption and the attainment of higher levels of BMI. Therefore, this information highlights the importance of determining whether certain aspects of temperament, i.e., such as an underlying predisposition towards experiencing greater levels of general distress may lead to greater levels of disinhibited eating behaviour, enhanced levels of psychological food reward, dysregulated appetite and consumption, which have been linked to an increased risk for obesity.

2.7 NEGATIVE AFFECTIVE STATES

2.7.1 Eating behaviour

The following section briefly outlines the relationships between the negative affective states of anxiety, depression and eating behaviour. The experience of negative affect, anxiety and depression has been associated with emotional (Alexander & Siegel, 2013; Keranen et al., 2010; Ostrovsky et al., 2013; Ouwens, van Strien, & van Leeuwe, 2009; Schneider et al., 2010; Schulz & Laessle, 2010), disinhibited (Fay & Finlayson, 2011; Haynes et al., 2003; Yeomans & Coughlan, 2009) and binge-eating behaviours (Goldschmidt et al., 2014; Keranen et al., 2010; Ostrovsky et al., 2013; Paxton & Diggens, 1997; Schulz & Laessle, 2010; Skinner, Haines, Austin, & Field, 2012). Emotional, disinhibited and binge-eating behaviours have been reported in individuals who have a higher level of depressive symptomatology (Camilleri et al., 2014; Goldschmidt et al., 2014; Grave, Todisco, Oliosi, & Marchi, 1996). Furthermore, the experience of anxiety and depression is co-morbid with binge-eating disorder (American Psychiatric Association, 2013) and the experience of negative affect has been found to precede binge-eating behaviour (Greeno et al., 2000) and to maintain eating pathology (Stice, 2002), whilst depressive symptoms have been found to predict binge-eating behaviour (Pearson, Zapolski, & Smith, 2015; Skinner et al., 2012). These findings highlight the interrelationships that exist between the experience of these negative affective states, eating behaviour and their ability to predict eating behaviour in susceptible individuals.

It is also noted that the relationship with anxiety is likely to be complex, with partial support in the literature for a curvilinear relationship between the experience of anxiety and eating behaviour in the obese (Robbins & Fray, 1980; Ruderman, 1983). For example, when induced into a state of high anxiety, highly anxious, obese individuals were noted to eat significantly less than when mildly anxious. Moreover, when induced into a state of relaxation, they did not eat significantly less than when mildly anxious (Ruderman, 1983). These results would appear to suggest that obese individuals tend to eat less at high compared to low levels of anxiety and that they eat similar amounts regardless of their level of anxiety or relaxation. These results serve to highlight the complex nature of eating behaviour in response to the experience of anxiety. When considered against the results which were earlier discussed in section 2.6.3, relative to the HDHR and the HDLR eating behaviour subtypes from the research by Yeomans and Coughlan (2009), Yeomans, Blundell and Lesham (2004) and Haynes, Lee and Yeomans (2003), they also serve to highlight the importance of considering an individual differences approach when studying these relationships.

2.7.2 Body mass index

The following sections outline a brief review of the relationships between the negative affective states of anxiety and depression and body mass index. The experience of anxiety and depression has been associated with BMI (de Wit et al., 2010; Petry, Barry, Pietrzak, & Wagner, 2008; Scott, McGee, Wells, & Oakley Browne, 2008; Simon et al., 2008; Strine et al., 2008) and, prospectively, with weight gain (Brumpton, Langhammer, Romundstad, Chen, & Mai, 2013; Gaysina et al., 2011; Lasserre et al., 2014). However, the literature is unable to draw a causal relationship between the experience of these states and BMI and these relationships appear to be complex. For example, one study has recently shown an inverted U relationship between anxiety and BMI: lower scores were associated with lower and very high BMI values and higher scores were associated with medium to high BMI values (Haghighi et al., 2016). Moreover, when considering the causal relationships that exist between depression and obesity, some researchers suggest a bi-directional relationship (Luppino et al., 2010; Markowitz, Friedman, & Arent, 2008), whilst others suggest stronger evidence of a causal relationship from obesity to depression than from depression to obesity (Faith et al., 2011). However, those studies and reviews that take into consideration moderating variables such as stress and mediating variables such as binge-eating behaviour provide support of a causal pathway between symptoms of anxiety and depression, eating behaviour and obesity (Markowitz et al., 2008; R. Peterson et al., 2012; Stunkard et al., 2003). Collectively, these findings highlight not only the complex relationships that exist between BMI and the negative affective states of anxiety and depression. They also highlight a causal pathway that may link affect-regulated eating behaviour to increased BMI in susceptible individuals.

2.8 TEMPERAMENT AND ITS RELATIONSHIP TO THE NEGATIVE AFFECTIVE STATES OF ANXIETY AND DEPRESSION

2.8.1 "Reactive" temperament: The BIS and BAS

The experience of negative affect is linked to self-regulatory failure (Heatherton and Wagner 2011, Wagner and Heatherton 2013) and an inability to regulate negative affect is linked to eating behaviour, weight regain and weight management failure (Aldao et al., 2010; Evers et al., 2010; Mc Guire et al., 1999; Ohsiek & Williams, 2011; Ouwens, van Strien, & van Leeuwe, 2009). As outlined in section 2.3, an individual's capacity to regulate negative affect is assumed to be directly proportional to their ability to regulate a reactive BIS and to subsequently down-regulate their experience of negative affect (Derryberry & Rothbart, 1997; Eysenck et al., 2007; Rothbart et al., 2013). Therefore, the possession of an emotionally reactive predisposition that is not well regulated, and the subsequent experience of negative affect is likely to lead to the use of food as an affect-regulation strategy and the failure to maintain healthy eating behaviours.

It is therefore important to understand that an individual's susceptibility to experience these states of negative affect is linked to their level of BIS and BAS reactivity. However, within this relationship, an individual's level of BIS reactivity appears to be the most important factor. For example, a reactive BIS is suggested to contribute towards a non-specific component of 'general distress' (Clark & Watson, 1991) and subsequently has been described as a 'shared diathesis' for the experience of both anxiety and depression (Bijttebier et al., 2009). The level of the BAS in relation to the BIS, on the other hand, appears to reflect a risk for either anhedonic or mixed-anxiety depression. For example, a lower level of BAS reactivity, which is believed to represent a trait vulnerability marker of depression, is characteristic of anhedonic depression, whilst higher levels of BAS reactivity are thought to characterise symptoms of mixed-anxiety depression (Bijttebier et al., 2009; Clark & Watson, 1991; Hundt et al., 2007). Therefore, both theory (Gray, 1970) and research suggest that reactivity within the BIS will be associated with anxiety and depressive disorders (Bijttebier et al., 2009; Zinbarg & Yoon, 2008). These relationships underscore the importance of including the BIS when investigating an individual's level of risk for eating behaviours that have been associated with the experience of these negative affective states and increased BMI.

It would appear from this literature that a reactive BIS represents a shared diathesis to experience the negative affective states of both anxiety and depression. As a consequence of this underlying predisposition, individuals with high levels of BIS and varying levels of BAS reactivity are likely to experience various states of negative affect and general distress (Clark & Watson, 1991) and psychological stress (McEwan & Stellar, 1993). As the experience of these negative affective states have been linked to eating behaviour (section 2.7.1), hedonic intake, consumption (Adam & Epel, 2007; Dallman, 2010; Gibson, 2006; Macht, 2008) and BMI (section 2.7.2); it is possible that a high BIS and varying levels of BAS reactivity will influence the expression of eating behaviour, psychological food reward, and the consumption of highly palatable foods during the experience of negative affective states, which share a common diathesis of BIS reactivity.

2.8.2 A psychobiological model of temperament: The BIS, BAS and effortful control

The following review will add to the literature reviewed in section 2.8.1 by exploring the relationship between an individual's level of effortful control and their level of BIS and BAS reactivity, relative to their producing of states of negative affect and psychopathology, which have been previously linked to eating behaviour and increased BMI.

An investigation into Rothbart's model of temperament by Lonigan and Vasey (2009) suggested that the relationship between negative affect and anxiety would be moderated by the quality of attentional control, as well as the level of negative affect, that is experienced in children prone to emotional distress. Similar to the assumptions of Attentional Control Theory (Eysenck et al., 2007), their results led them to propose that the level of affect a child experiences will be related to their ability to control both their attention to threatening stimuli and to their capacity to regulate their emotional response (Lonigan & Vasey, 2009). In support of their findings, a similar moderator effect of attentional control on the BIS, or the associated measure of negative affect, has been found in adolescents with symptoms of anxiety and depression (Sportel, Nauta, de Hullu, de Jong, & Hartman, 2011; Verstraeten, Vasey, Raes, & Bijttebier, 2009). In both studies, higher levels of negative affect (Verstraeten et al., 2009) or reactivity within the BIS (Sportel et al., 2011), were associated with higher symptoms of anxiety and depression when attentional control was low. These results provide evidence that reactivity within the BIS is not linked to the experience of these states in isolation. Rather, the evidence suggests it is the combined effect of a reactive temperament that is poorly regulated (i.e., a high BIS and a low level of effortful control (EC)) that will lead to an increased risk for an anxiety or depressive disorder. In support of these findings, similar results have now been reported in adolescents and adults and will be reviewed below.

In an extension of Lonigan and Vasey's work, research from Dinovo, Vasey and colleagues (Dinovo & Vasey, 2011; Vasey et al., 2014; Vasey et al., 2013) has demonstrated, across a series of studies, that a three-way interaction between low levels of EC and high levels of the BIS, or related measures of negative emotionality (NE) and high or low levels of the BAS, or related measures of positive emotionality (PE) (i.e., EC x BIS x BAS), predict symptoms of general distress and depression in children, adolescents and adults (Dinovo & Vasey, 2011; Vasey et al., 2014; Vasey et al., 2013). These studies are also the first to show that a high level of NE could overcome a high level of EC when PE is low. In a study design that interacted PE and NE against EC in a three way interaction, i.e., PE x NE x EC; an interaction between high levels of EC, low levels of PE, and high levels of NE was shown to significantly predict depression in one study (Vasey et al., 2013) and to narrowly miss significance in another (Vasey et al., 2014). However, the results were unequivocal when EC was low: both studies showed a significant interaction between low levels of EC, low levels of PE, and high levels of NE to predict depression (Vasey et al., 2014; Vasey et al., 2013). These results support the findings reviewed in the previous section and extend them by showing that an interaction between high levels of the BIS and high and low levels of the BAS will lead to the experience of negative affective states, when effortful control is low. They also introduce the concept that an individual may be at increased risk of persistent depressive symptomatology when the BIS is high and the BAS is low, despite their possessing a *high* level of EC (Vasey et al., 2014; Vasey et al., 2013).

Another interesting finding that has relevance to this thesis is that, across two separate studies, a low level of EC in combination with high levels of BIS or NE and high levels of BAS or PE were associated with increased levels of general distress, depression and non-specific arousal (assessed via the DASS-Stress Scale (Lovibond & Lovibond, 1995)) (Dinovo & Vasey, 2011; Vasey et al., 2014). These findings were explained by referring to the results of Hundt, Nelson-Gray, Kimbrel, Mitchell and Kwapil (2007), whereby an interaction between high levels of both the BIS and BAS was found to predict symptoms of mixed anxiety-depression. As per the results and conclusions drawn by Hundt et al. (2007), the higher levels of general distress and non-specific arousal found by Dinovo and Vasey (2011) and Vasey et al. (2014) were interpreted as reflecting the combined activation of the BIS and the BAS that is expected to occur in response to frequent approach-avoidance conflicts. This interpretation is theoretically in line with RST's assumed effects of BIS activation, which is expected to lead to increased levels of physiological arousal, negative affect and anxiety (Corr, 2008). However, it is also of interest that Vasey et al. suggested high levels of PE may even contribute to the experience of these symptoms.

These results are of interest because they can be theoretically linked to emotional eating behaviour via the Psychosomatic Theory of Emotional Eating (van Strien, 2002). As previously introduced, higher levels of physiological arousal are assumed to lead to emotional eating behaviour during the experience of negative affect and non-specific arousal (van Strien, 2002). Therefore, according to the findings of Dinovo and Vasey and Vasey et al. (Dinovo & Vasey, 2011; Vasey et al., 2014), emotional eating behaviour could occur when an individual's level of BIS and BAS are high and their level of effortful control is concurrently low. When this information is considered together with Attentional Control Theory (Eysenck et al., 2007) and the literature reviewed in section 2.3, emotional eating behaviour should be the most pronounced at high levels of anxiety and psychological stress.

The review of section 2.8.1 and the evidence presented from Dinovo, Vasey and colleagues introduces the concept that individuals with low levels of effortful control, who possess a temperament phenotype that is simultaneously high in BIS and BAS reactivity (i.e., HBIS_HBAS) or high in BIS and low in BAS reactivity (i.e., HBIS_LBAS), could show enhanced susceptibility towards emotional, binge and disinhibited eating behaviour via temperament-based predisposition to experience general distress, non-specific arousal and depression. Moreover, when this evidence is considered in relation to section 2.4, it is also theoretically possible that these individuals will lose control over their eating behaviour (e.g., show higher levels of eating behaviour) at higher levels of stress and anxiety.

PART TWO

2.9 EVIDENCE OF AN ASSOCIATION BETWEEN TEMPERAMENT AND EATING BEHAVIOUR IN THE TEMPERAMENT-BASED SELF-REPORT LITERATURE

2.9.1 Evidence for a relationship between the BAS and emotional, binge and external eating behaviour

Studies that have measured activation within RST'S BAS (Gray & McNaughton, 2000) in isolation, using either the SPSRQ from Torrubia et al. (Torrubia et al., 2001) or the BIS/BAS Scales from Carver and White (1994), will be reviewed here. A reactive BAS has been found to predict emotional eating when overweight individuals felt depressed (Davis, Strachan, et al., 2004). It has also been positively associated with emotional (Davis, Patte, et al., 2007) and external eating behaviour, using the Dutch Eating Behaviour Questionnaire (DEBQ) (Davis, Patte, et al., 2007; van Strien, Frijters, Bergers, & Defares, 1986), binge eating (Davis, Patte, et al., 2007), binge eating in carriers of the Taq1 A allele (Davis, Levitan, Kaplan, et al., 2008), food craving (Franken & Muris, 2005) a preference for the intake of sweet and fatty foods (Davis, Patte, et al., 2007), a preference for fatty foods and a tendency to underestimate portion sizes (Davis, Curtis, Tweed, & Patte, 2007; Tapper, Baker, Jiga-Boy, Haddock, & Maio, 2015), activation in brain regions that motivate food intake in response to images of palatable foods (Beaver et al., 2006) and an attentional bias for appetising food cues (Tapper, Pothos, & Lawrence, 2010).

Collectively these results suggest that the BAS demonstrates a relationship with emotional, external and binge-eating behaviours, the intake of foods that are high in fat and sugar and that, furthermore, it may promote a bias towards and motivate intake in response to palatable food cues. These findings suggest that individuals with a high level of BAS reactivity may be eating opportunistically in response to the obesogenic environment and that the BAS may also be contributing to rising obesity levels within Australia. However, although the BAS was found to be associated with emotional eating, when feeling depressed; emotional eating was found not to mediate the association between an individual's level of STR and BMI (Davis, Strachan, et al., 2004). A similar result was also found in a study that investigated the impact of food cravings associated with a reactive BAS on BMI, in a sample of normal weight females. Although the BAS was associated with a measure of food craving and BMI (Franken & Muris, 2005), the relationship between it and BMI was not mediated by craving. The body of literature to date seems to indicate that a reactive BAS, although associated with behaviours that lead to increased BMI, may not by itself, be a major risk factor for an increasing BMI, in a non-clinical, normal weight population.

This body of literature has not investigated whether the BIS is also associated with eating behaviour, food cravings and food preference however. This is despite earlier research from Loxton and Dawe, which considered a relationship between dysfunctional eating behaviour and temperament and found that activation within the BIS and BAS in adolescent girls and women, was associated with and additionally predicted dysfunctional eating behaviour (Loxton & Dawe, 2001, 2006). Therefore, although a relationship between the BIS and eating behaviour has not been considered in the research reviewed above, there is evidence to show that a relationship does exist. Importantly, this relationship may provide insight into an eating behaviour that has been empirically associated with opportunistic over-consumption and BMI: disinhibited eating behaviour.

2.9.2 Evidence for a relationship between the BIS and emotional, binge and external eating behaviour

It is timely that the most recent literature, which has started to appear since 2013, has begun to explore whether a relationship exists between emotional, external, binge and disinhibited eating behaviour, food preference, and the BIS. This literature will now be reviewed. Two recent studies have investigated the relationship between the BIS and BAS and emotional and external eating behaviour using the Dutch Eating Behaviour Questionnaire (DEBQ) (van Strien et al., 1986). Within these studies, clear associations between the BAS, emotional and external eating behaviour were demonstrated. However, the evidence was mixed for an association between emotional eating and the BIS. One study by Stapleton and Whitehead (2014), which used the BIS/BAS Scales (Carver & White, 1994), showed no evidence of a relationship between the BIS and emotional eating behaviour in a mixed gender sample. However, a study by Hennegan, Loxton and Mattar (2013), which used the SPSRQ (Torrubia et al., 2001) and a recently developed measure of the revised RST, the Jackson-5 (Jackson, 2009), in a female only sample did show evidence of a relationship between emotional eating behaviour and both BIS Scales.

In consideration of a possible link between the BIS and disinhibited eating behaviour, via the experience of negative emotionality (Slochower, 1983; van Strien & Schippers, 1995), it is noteworthy that both studies also showed evidence of an association between the BIS and external eating behaviour. Furthermore, the most recent research by Davis (2013b) has shown that both the BIS and the BAS (measured with the SPSRQ (Torrubia et al., 2001)), predict binge-eating behaviour. Further, a recent study that considered the influence of both the BIS and the BAS on self-reported dietary intake has shown evidence of a differential relationship between the BIS and BAS and intake of fat and sugar (Tapper et al., 2015). Using the Carver and White BIS/BAS Scales (Carver & White, 1994), higher BAS scores predicted higher fat intake and higher BIS scores predicted higher sugar intake (Tapper et al., 2015). Collectively, with the exception of some variables, these findings are similar to the associations that have been previously reported in those studies that measured the BAS in isolation. Therefore, in addition to the BAS, the BIS has now also demonstrated an association with emotional, external and binge-eating behaviour and a preference for sweet foods.

2.9.3 Evidence of an interaction between the BIS and the BAS and their relationship with emotional, external eating behaviour and risk for obesity

The evidence reviewed above provides the first tier of evidence to suggest that an interaction *between* the BIS and BAS could increase eating behaviours that lead to opportunistic consumption and weight gain as conceptualised in section 2.4. In support of this suggestion, the research team of Matton, Goosens, Braet and Vervaet (2013), investigated the relationship between emotional and external eating behaviour and four temperament phenotypes, with a cluster analysis, in an adolescent sample using both the Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ) (Torrubia et al., 2001) and the BIS/BAS Scales (Carver & White, 1994).

When comparing levels of emotional and external behaviour between these phenotypes, their results were significant when using the SPSRQ (Torrubia et al., 2001), whilst findings were not significant, yet showed similar trends using the BIS/BAS Scales (Carver & White, 1994). The results from their cluster analysis revealed the following four temperament phenotypes: a high BIS x high BAS (HBIS_HBAS); high BIS x low BAS (HBIS_LBAS); low BIS x high BAS (LBIS_HBAS) and finally, a low BIS x low BAS phenotype (LBIS_LBAS) (Matton et al., 2013). Using the SPRSQ, their results determined that both the HBIS_HBAS and HBIS_LBAS phenotypes exhibited the highest levels of emotional eating behaviour and that the HBIS_HBAS phenotype had the highest levels of both emotional and external eating behaviour. By comparison, the HBAS_LBIS phenotype had low levels of emotional eating and high levels of external eating, whilst the LBIS_LBAS phenotype had the lowest levels of both emotional and external eating behaviour.

The relevance of these findings, to this review, is that they provide a second tier of evidence that supports the importance of investigating an interaction between the BIS and BAS and eating behaviour, which has been linked to the regulation of emotions. Particularly, when these results are considered in conjunction with the findings of Dinovo, Vasey and colleagues (reviewed in section 2.8.2) who demonstrated that the same temperament phenotypes, i.e., HBIS_HBAS and HBIS_LBAS, predicted higher levels of general distress, physiological arousal and depression, when effortful control was low. Therefore, as outlined in section 2.4, it is theoretically possible that both the HBIS_HBAS or HBIS_LBAS phenotype could lose control over their eating behaviour, during the experience of these negative affective states, if they simultaneously lacked sufficient attentional resources to regulate them.

It is also interesting that the results from Matton et al. (2013), when considered together with the results from Dinovo and Vasey and Vasey et al. (Dinovo & Vasey, 2011; Vasey et al., 2014; Vasey et al., 2013), align with the results from van Strien et al. (2009) reported upon earlier in section 2.6.2. Van Strien et al. suggested that an individual's level of emotional eating behaviour may make a greater contribution to the obesity epidemic than their level of external eating behaviour. Matton et al. (2013) showed that emotional eating was highest in HBIS_HBAS and HBIS_LBAS individuals, whilst levels of emotional eating were lowest and levels of external eating were the highest in LBIS_HBAS individuals. Therefore, when considered together with the results of Dinovo and Vasey, and Vasey et al. (Dinovo & Vasey, 2011; Vasey et al., 2014; Vasey et al., 2013) and the results of van Strien et al. (2009) the results of Matton et al. (2013) would appear to indicate that the temperament phenotypes most likely to be associated with risk for increased BMI are HBIS_HBAS and HBIS_LBAS, as they both show high levels of emotional eating behaviour. On the other hand, the phenotype with the least risk for obesity is the LBIS_HBAS phenotype, as it shows low levels of emotional eating behaviour.

These findings appear to contradict the current conceptualisation of a highly reactive BAS and a weak action of the BIS, which has been suggested to lead to impulsive overeating behaviours as a driver of obesity (Davis, 2009). However, these findings may not be contradictory, but rather complimentary; when one considers the emotional characteristics that could arise when a reactive BIS interacts with a reactive BAS when effortful control is low, as shown by Dinovo and Vasey and Vasey et al. (Dinovo & Vasey, 2011; Vasey et al., 2014; Vasey et al., 2013), particularly for the temperament phenotype that is HBIS_HBAS. As previously introduced in section 2.8.2, this phenotype has been linked to higher levels of physiological arousal. Emotional eating has been suggested to occur in individuals with lower levels of interoceptive awareness who have misinterpreted the physiological stress response as a feeling of hunger (van Strien, 2002). Therefore, the HBIS_HBAS phenotype may potentially represent a temperament phenotype at high risk of emotional eating behaviour. However, it was also reported by Vasey et al. (2014) that a high BIS may even overcome a high level of EC when the BAS is low, which may lead to the persistence of depressive symptoms. Therefore, a HBIS_LBAS phenotype may also represent a phenotype at risk of emotional eating behaviour. Collectively, these findings support the conceptualisation that, when effortful control is ineffectively utilised, an interaction between high levels of BIS and high or low levels of the BAS, during the experience of a negative affective state such as anxiety or depression, could successfully predict levels of emotional eating behaviour and BMI. However, to the best of my knowledge, this effect has not been investigated in a non-clinical adult sample.

It is important to acknowledge that there could be a limited capacity to show evidence of an association between the Carver and White BIS Scale (1994) and the Dutch Eating Behaviour Questionnaire Emotional Eating Scale (van Strien et al., 1986) as evidenced by a lack of an association between the BIS Scale and the Emotional Eating Scale in the study by Stapleton and Whitehead (2014) and also by the weak and non-significant associations found by Matton et al. (2013). This lack of an association may be due to the fact that the Carver and White BIS/BAS Scales (1994) were designed to measure an individual's predisposition towards the experience of trait as opposed to state affect. As a result, these scales may be more distal predictors of emotional eating behaviour, as suggested in a study by Hasking and others (Corr & Mc Naughton, 2008; Hasking, 2006; Jackson & Francis, 2004). For example, in Hasking's study (2006) the BIS was initially found to predict disordered eating behaviour in a hierarchical linear regression model. However, when the variable non-productive coping was entered into the model, the effect of the BIS on disordered eating lost significance. These findings suggest that the BIS is likely to be a more distal indicator of disordered eating symptoms, whilst non-productive coping behaviours are a more proximal indicator of behaviour. Subsequently, an association between emotional eating and the BIS/BAS Scales may be difficult to find. In order to add to this body of literature, an effect of the BIS on emotional eating will be investigated. The research questions are:

- Do the BIS, the BAS and effortful control predict emotional eating behaviour and BMI?
- Does effortful control interact with the BIS and BAS to predict emotional eating and BMI?
- Does trait anxiety interact with temperament in a three-way interaction (i.e., BIS x BAS x STAI-T) to predict emotional eating behaviour and BMI when effortful control is low?

2.9.4 Evidence of an association between the BIS, BAS and disinhibited eating behaviour in the self-report literature.

As previously introduced, emotional, external and binge-eating behaviours have all been linked to disinhibited eating behaviour, which has demonstrated an empirical association with BMI (French et al., 2012). The evidence reviewed thus far has also shown that both the BIS and the BAS have been associated with emotional, external and binge-eating behaviour. Therefore, it is reasonable to assume that, in combination, the BIS and BAS may also be linked to disinhibited eating behaviour. However, within the current literature, which links temperament to disinhibited eating behaviour, it is assumed that an individual with a reactive BAS will be the most susceptible towards a disinhibition of intake (Dawe & Loxton, 2004). Therefore, it is of interest that the two independent studies of Stapleton and Whitehead (2014) and Hennegan et al. (2013) have provided direct evidence of a relationship between the BIS and external eating behaviour and that Hennegan et al. demonstrated evidence of a cognitive link between the BIS and external eating behaviour via the following eating expectancies: that eating is rewarding and pleasurable, and eating alleviates boredom and helps to manage negative affect. However, no evidence of an association between either of the BIS and BAS Scales and disinhibited eating behaviour was found in a recent study from Dietrich et al. (2014). Yet, despite this lack of an association, further results from Dietrich et al. do suggest that a reactive BIS is likely to be associated with disinhibited eating behaviour, which has been empirically associated with BMI (French et al., 2012), as their study is the first to report a positive association between the BIS and BMI in adult women.

To support this line of conjecture, additional results from Dietrich et al. (2014) and those from another independent study by Löffler et al. (2015), have reported evidence of an inverse U relationship between BMI and restrained eating behaviour that is moderated by an individual's level of disinhibited eating behaviour. The outcome of this relationship is that both studies suggest that at the highest levels of BMI, an individual will have a high level of disinhibited eating behaviour that is combined with a low level of dietary restraint (Dietrich et al., 2014). Furthermore, these findings are also supported by earlier studies, which have shown that individuals with highly disinhibited eating behaviour and low levels of dietary restraint (HDLR) tend to have the highest levels of BMI in the sample under investigation (Bryant et al., 2008; Lawson et al., 1995; Provencher et al., 2003; Williamson et al., 1995).

Therefore, it is possible that a lack of finding in the study by Dietrich et al. (2014) may reflect their low average sample BMI of 26.4 (*SD* = 6.6), which places the average BMI at the lowest level of overweight. Their lack of finding suggests that if there is to be an influence of the BIS on disinhibited eating behaviour, it is possible that it may show evidence of its greatest influence within a BMI range from overweight (BMI 25.0 kg/m^2) through to severe obesity (BMI $\geq$ 40.0 kg/m^2). Additional evidence to support this conceptualisation will be considered in the following section. The body of temperament research has not identified whether the BIS is associated with, or predicts, disinhibited eating behaviours that occur within a community sample of overweight and obese adults. Subsequently, a research question is:

- Does a reactive temperament, high BIS, and low effortful control predict disinhibited eating behaviour in an overweight and obese sample?

2.10 EVIDENCE OF AN ASSOCIATION BETWEEN TEMPERAMENT AND BMI IN THE TEMPERAMENT-BASED SELF-REPORT LITERATURE

When considering temperament's relationship to BMI, the results in the literature are clearly complex, as both high and low levels of the BAS are associated with BMI, albeit in opposite directions. Franken and Muris (2005) reported evidence of a positive linear association between BMI and the BAS in female students, with a mean BMI of 21.3 (SD = 2.6), using the SPSRQ from Torrubia et al. (Torrubia et al., 2001). However, other researchers who have investigated the association between the BAS and BMI, with BMIs that range from normal weight through to severe obesity, have found evidence of both a positive and a negative relationship. For example, one study of females found that individuals who were overweight had a higher level of BAS reactivity than individuals who were obese (Davis, Strachan, et al., 2004). Further, studies that investigated higher levels of obesity in mixed gender samples that ranged from a BMI of approximately 20 kg/m^2 through to 50 kg/m^2 (Davis & Fox, 2008; Dietrich et al., 2014) found evidence of an inverted U relationship between an individual's level of BAS and BMI.

The inverted U relationship, which occurs across gender, shows a positive association between the BAS, measured either with the SPSRQ (Torrubia et al., 2001) or the BIS/BAS Scales (Carver & White, 1994); from a BMI of normal weight (25.0 kg/m^2) to mild obesity (30.0 kg/m^2). However, as the level of BMI increases from a mild to a severe level of obesity (30.0 kg/m^2 to > 40.0 kg/m^2), the relationship changes direction and becomes negatively associated with BMI (Davis & Fox, 2008; Dietrich et al., 2014). In the study by Dietrich et al. (2014), it was reported that this relationship changed direction at a BMI of approximately 30kg/m^2, which is similar to the results of Davis and Fox (2008). Evidence for the existence of this inverted U relationship has now been found across two separate investigations in adults (Davis & Fox, 2008; Dietrich et al., 2014) and in one study in children aged 10 to15 years (Verbeken et al., 2012).

A dual-process model of addiction has been proposed to explain this variation in BAS reactivity (Davis, 2013b; Davis & Fox, 2008; Davis & Loxton, 2014). Within this model, it has been hypothesized that, over time, chronic levels of palatable food intake lead to an overstimulation of the mesolimbic dopamine reward pathways (Wang, Volkow, Thanos, & Fowler, 2004). Subsequently, it is suggested that this overstimulation leads to a down-regulation of the associated brain reward circuitry. The inverted U relationship between obesity and an individual's level of sensitivity to reward has been hypothesized to characterise this process (Davis & Loxton, 2014). Importantly, the dual-process model describes an addictive process (Davis & Loxton, 2014). Therefore, it is expected that such down-regulation, in turn, will lead to enhanced levels of craving and overconsumption (Davis, 2013b). The cravings are assumed to arise because the individual has become sensitised to the rewarding properties of highly palatable foods (Davis & Carter, 2009).

There is an alternative model to the dual-process model (Davis, 2013b; Davis & Fox, 2008) and it is one that postulates the existence of a 'reward deficiency syndrome' (Blum et al., 2000; Wang et al., 2001). The reward deficiency model suggests that, instead of a functional down-regulation in D2 receptor levels as a result of addictive eating behaviour, the eating behaviour results from a pre-morbid dopamine deficit. The rewarding effects of dopamine are transmitted when dopamine binds with its receptor: the dopamine D2 receptor (Blum et al., 2000). Subsequently, proponents of the reward deficiency syndrome hypothesise that highly palatable foods are consumed to compensate for this deficit. It is believed that the increase in palatable food intake will increase dopamine levels, as a form of self-medication (Wang et al., 2001).

Davis (2009) has countered the argument for the reward deficiency syndrome model of obesity by noting that the evidence has primarily been drawn from studies that have used morbidly obese participants. As a consequence, it is suggested that the existence of the reward deficiency syndrome in obesity may only be relevant for individuals who are morbidly obese and, furthermore, that this model may also be too simplistic to explain compulsive over-eating behaviour (Davis & Loxton, 2014). As an alternative, the dual-process model is offered to explain the process that is proposed to lead to the reward deficit, i.e., as reflecting a down-regulation of the mesocorticolimbic pathways (Davis & Loxton, 2014). Furthermore, as a consequence of such down-regulation, individuals who restrict their intake have been suggested to suffer the negative affective states of the withdrawal process, such as anxiety and depression (Davis, 2013a). Hence, the overeating behaviour that occurs in these individuals is suggested to reflect, in part, an attempt to counter the experience of the resultant levels of negative affect (Davis, 2013a). However, within the dual-process model of addiction, it is critical now to consider that the BIS has also been positively associated with BMI in adolescents (Delgado-Rico, Rio-Valle, Gonzalez-Jimenez, Campoy, & Verdejo-Garcia, 2012) and more recently in adult females (Dietrich et al., 2014).

As a result of finding a positive linear association between the BIS and BMI, it now becomes theoretically conceivable that, rather than a dual-process model of obesity whereby a single susceptible group of individuals are assumed to pass through varying stages of reward sensitisation, reflecting up- and then down-regulation of the neural reward pathways. It is also possible that the dual-process model is capturing the eating behaviour characteristics of *two* completely different groups. According to the model of psychobiological temperament that is investigated within this thesis (Section 2.2), it is conceivable that two broadly different groups may possess two different constitutional temperament phenotypes. Therefore, two completely different underlying trait dispositions may contribute towards eating behaviour, over-consumption and increasing BMI. Moreover, given the evidence reviewed previously, it is also possible that the BAS in isolation may not have as strong an effect on eating behaviour and levels of craving that were initially hypothesised to lead to obesity. This statement is supported by research, which has shown that, although a reactive BAS can be linked to both emotional eating behaviour (Davis, Strachan, et al., 2004) and food craving in a normal weight sample (Franken & Muris, 2005), these variables were shown not to mediate a relationship between a reactive BAS and BMI. The BAS in isolation may also not have as strong an effect on an individual's level of trait impulsivity and eating behaviour, which will be reviewed in section 2.11.

It was reported earlier that Dietrich et al. (2014) were unable to find an association between the BIS and disinhibited eating behaviour. However, it was reported above that lower levels of the BAS have consistently been associated with higher levels of BMI and that the BIS has also been positively associated with BMI in adolescents and adult females. Therefore, if the BIS does contribute to disinhibited eating behaviour as hypothesised herein, it is feasible that it will be most strongly associated with Disinhibition at the highest levels of BMI when BAS is low. Therefore, the BIS may be most strongly associated with disinhibited eating behaviour at the higher and not the lower levels of BMI, where it may be less confounded by an interaction with the BAS. Consequently, it may be difficult to find evidence of an association between the BIS and disinhibited eating behaviour when the average BMI is less than 30 kg/m^2. This conceptualisation may explain why Dietrich et al. (2014) were unable to find a relationship between the BIS and disinhibited eating behaviour, as their average BMI was only 26.42 kg/m^2. Subsequently, it is conceptualised that a relationship between disinhibited eating behaviour and the BIS will be found at higher levels of average BMI. Furthermore, given the finding of a linear association between the BIS and BMI in women by Dietrich et al. (2014), it is feasible to suggest that the literature reviewed in this section may indicate that the BIS could also be associated with high levels of the BAS as BMI increases from overweight through to mild obesity and that it may also be associated with declining levels of the BAS as BMI increases from mild obesity through to severe obesity.

2.10.1 The relevance of investigating the HDHR and the HDLR eating behaviour subtypes

The literature suggests that, as an individual's level of Disinhibition increases, so does their degree of psychopathology (Bryant et al., 2008; Provencher et al., 2007; Wadden et al., 1993). Therefore, it is informative that the HDLR eating behaviour subtype has been reported in individuals with BED, who are susceptible to both anxiety and depressive disorders (American Psychiatric Association, 2013; Bulik et al., 2002; Grucza et al., 2007; Robertson & Palmer, 1997). Moreover, when this literature is considered together with the results from Dinovo, Vasey and colleagues (section 2.8.2), which linked low levels of effortful control and higher levels of negative affect such as general distress and depression to the HBIS_HBAS and HBIS_LBAS temperament phenotypes, it is also intuitive to consider that rising levels of psychopathology, binge and disinhibited eating behaviours, consumption and BMI could be associated with these temperament phenotypes. Davis and Davis and Carter suggest that this relationship may reflect an addictive process (Davis, 2013a; Davis & Carter, 2009). However, the current temperament-based literature has not yet determined whether disinhibited eating behaviour is associated with the experience of negative emotionality that is inherent to a low level of effortful control and an individual's level of BIS reactivity in relation to their level of BAS reactivity (Gray, 1970). Therefore, a research question is:

- Does a three-way interaction between BIS x BAS x trait anxiety (STAI-T) (i.e., BIS x BAS x STAI-T), a low level of effortful control and associated emotion regulation difficulties predict disinhibited eating behaviour?

The literature has also not yet established whether specific disinhibited eating behaviour subtypes, which have been identified in the non-temperament-based literature, are linked to psychobiological temperament. Critically, the HDHR and HDLR eating behaviour subtypes can be differentiated by their distinct eating behaviour styles and level of BMI (section 2.6.3). Therefore, despite the fact that a relationship between disinhibited eating behaviour and the BIS has not yet been established (Dietrich et al., 2014), the results of Dinovo, Vasey and colleagues (section 2.8.2) and evidence of the inverted U relationship between the BAS and BMI encourages the conceptualisation that a high level of BIS reactivity, in combination with a low level of effortful control, may contribute towards a high level of disinhibited eating behaviour and a high level of restraint (HDHR) resulting in overweight and mild obesity in individuals with high BAS reactivity (HBIS_HBAS). On the other hand, it may also contribute towards a high level of disinhibited eating behaviour that is inadequately restrained (HDLR) in individuals with mild to severe obesity and low BAS reactivity (HBIS_LBAS). If a relationship between psychobiological temperament and these disinhibited eating behaviour subtypes could be established, it would enrich the current understanding of differential trait behaviours that lead to over-consumption and increased BMI. Therefore the research question is:

- Does the proportion of HBIS_HBAS and HBIS_LBAS phenotypes differ according to their HDHR and HDLR eating behaviour subtype in an overweight and obese sample and can they be further differentiated according to BMI?

2.11 EVIDENCE OF AN ASSOCIATION BETWEEN TEMPERAMENT AND IMPULSIVITY IN THE TEMPERAMENT-BASED SELF-REPORT LITERATURE

The original RST predicted that highly impulsive individuals were motivated to seek rewards (Gray, 1987b). There were no changes to this conceptualisation of the BAS in the recently revised RST and the BAS continues to be associated with an orientation to rewarding stimuli and the expression of appetitive and impulsive sensation-seeking traits (Corr, 2008; Corr & Mc Naughton, 2008), which have been linked to binge-eating behaviour (Davis, 2009, 2013b; Davis & Carter, 2009; Dawe & Loxton, 2004; Guerrieri, Nederkoorn, & Jansen, 2008). Moreover, as BMI increases beyond 30 kg/m^{2,} eating behaviour is reported to become more compulsive as evidenced by the practice of binge-eating behaviour, despite the negative consequences this type of behaviour brings (Davis & Fox, 2008; Davis & Loxton, 2014). In the temperament and eating behaviour research, these findings have been linked to a heightened level of sensitivity to reward (e.g., as a result of BAS activation), which is believed to place an individual at increased risk of overeating and weight gain (Davis, 2009; Davis, Curtis, et al., 2007; Davis, Patte, et al., 2007).

The type of individual who exhibits this type of eating behaviour has been described as high in risk and fun-seeking behaviour (Davis, 2009). It is believed that they act in this manner because they possess a heightened level of sensitivity to reward that is not adequately constrained by their level of sensitivity to punishment (Avila, 2001; Davis, 2009; Newman & Wallace, 1993). Therefore, it has been suggested that they are at risk of reward-driven impulsive eating behaviour (Davis, 2009). However, it is important to discriminate impulsive behaviours that are expressed through sensation or novelty seeking traits (i.e., as a result of BAS activation) (Davis, 2009) from impulsive behaviours that are expressed through trait negative urgency (S. Whiteside & Lynam, 2001).

The construct of negative urgency describes trait impulsive behaviours that occur in response to the experience of intense negative affect (S. Whiteside & Lynam, 2001). It is noteworthy that this trait is linked to the personality domain of Neuroticism and its associated impulsivity facet (S. Whiteside & Lynam, 2001). Given the strong correlations reported between Gray and McNaughton's BIS/FFFS (Gray & McNaughton, 2000) and the NEO-PI-R Five Factor Model's (P. T. Costa & Mc Crae, 1992) Neuroticism Scale and the weak to moderate correlation with its impulsivity facet (Keiser & Ross, 2011), trait negative urgency is also likely to be linked to activation within the BIS/FFFS. Furthermore, the scale that measures this trait includes items that measure an individual's likelihood to experience cravings, to binge eat and to act rashly whilst experiencing negative emotions (S. Whiteside & Lynam, 2001). Therefore, it is also likely that trait negative urgency and impulsive behaviours could also be linked to eating behaviour as a result of a reactive BIS. This conceptualisation is interesting in light of findings, which suggest that an individual's degree of trait negative urgency may be a stronger predictor of binge-eating pathology than their level of trait sensation seeking.

It may seem counterintuitive that an individual with a high level of BIS reactivity and a low level of BAS reactivity could exhibit disinhibited behaviour. According to Reinforcement Sensitivity Theory the action of the BIS is to restrain the behavioural approach system during times of conflict (Corr, 2008). Therefore, its job is to halt forward motion and to constrain what could potentially be inappropriate or risky behaviour. However, a collection of findings suggest that, whilst trait sensation seeking is linked to the frequency of binge episodes, it is an individual's level of trait negative urgency, which not only increases one's vulnerability for binge eating, it also initiates the binge and then reinforces the behaviour over and above trait sensation seeking (Michael D. Anestis, Selby, & Joiner, 2007; Smith et al., 2007). Moreover, these are not isolated findings. A meta-analysis exploring the relationship between trait negative urgency, trait sensation seeking and their association with the binge eating and purging behaviours of bulimia nervosa, reported a moderate effect size of 0.38 for negative urgency and a small effect size of 0.16 for sensation seeking. (Fischer, Smith, & Cyders, 2008). Following this trend, another study has demonstrated that negative urgency significantly predicted bulimic symptoms after controlling for sensation seeking, as well as symptoms of anxiety and depression (M. D. Anestis, Smith, Fink, & Joiner, 2009). Therefore, the trait of negative urgency may have a stronger impact on the occurrence of binge eating than trait sensation seeking.

A similar relationship has been found in a community sample of obese/overweight participants in a study by Mobbs, Crepin, Thiery, Glay and Van der Linden (2010), which determined how Whiteside and Lynam's (2001) four facets of impulsivity were related to obesity and eating disorder symptoms. Supporting the evidence reported in the eating disorder literature above, they demonstrated that overweight/obese individuals have higher levels of negative urgency than normal weight controls. Furthermore, evidence for an association between impulsive sensation seeking traits and overweight/obesity was not reported on. Yet, the results indicated that overweight/obese individuals were higher in both BIS and BAS reactivity than normal weight controls. However, in support of a theorised association between trait negative urgency, eating behaviour and the BIS, Mobbs et al. (2010) did report that a loss of control over eating was associated with the BIS and not with the BAS.

The evidence reviewed above provides further support for a role of the BIS in the expression of impulsive and uncontrolled eating behaviour as BMI increases from overweight through to severe obesity. It is possible that an individual with a reactive BIS and an inefficient use of effortful control will respond to an emotional state, which they are unable to regulate, with an impulsive behavioural style that culminates in increased emotional eating behaviour, as has been conceptualised in section 2.4. This section critically highlights the need to consider an effect of the BIS, concurrently with the BAS, in models of compulsive overeating that have only considered an individual's level of predispositional BAS sensitivity. Therefore, a research question is:

- Does trait negative urgency predict emotional eating and BMI when psychobiological temperament interacts with trait anxiety (i.e., BIS x BAS x STAI-T), when effortful control is low?

2.12 EVIDENCE OF AN ASSOCIATION BETWEEN TEMPERAMENT AND PSYCHOLOGICAL REWARD IN THE TEMPERAMENT-BASED SELF-REPORT LITERATURE

Within the main body of temperament and eating behaviour literature, an individual's hedonic inclination and tendency to binge eat is believed to rest on their predisposition towards a high level of sensitivity to reward (i.e., BAS reactivity) (Davis, 2009; Dawe & Loxton, 2004). Moreover, in a review by Aldao, Nolen-Hoeksema and Schweizer (2010) individuals who have been shown to use a maladaptive emotion regulation strategy, such as rumination, and who have difficulty using adaptive emotion regulation strategies, such as re-appraisal, have also been suggested to turn to highly palatable food because they are high in sensitivity to reward. However, this suggestion is based on a body of research in which individuals who are sensitive to reward have been found to display disordered, dysregulated or emotional eating behaviour (Davis, Strachan, et al., 2004; Kane, Loxton, Staiger, & Dawe, 2004; Loxton & Dawe, 2001, 2007). Therefore, when individuals with high levels of BAS reactivity experience negative affect, due to the conceptualisation that they are highly susceptible to the rewarding properties of food (Davis et al., 2009; Davis & Loxton, 2014; Davis, Patte, et al., 2007; Davis, Strachan, et al., 2004; Dawe & Loxton, 2004; Stice et al., 2009), the literature suggests that they will turn to the use of food, i.e., as a maladaptive affect regulation strategy (Aldao et al., 2010; Davis, 2013a). Nevertheless, it is important to point out that an individual's propensity to seek rewards that may result from a simultaneously high level of BIS reactivity has not been considered in this body of research.

This thesis maintains that it is critically important to consider an individual's level of BIS reactivity in such interactions. It is important to remember that individuals high in BIS reactivity are also likely to experience distress in response to stressful circumstances (Heponiemii, Keltikangas-Jarvinen, Puttonen, & Ravaja, 2003) and to experience negative affective symptoms such as non specific arousal, general distress, anxiety and depression (Bijttebier et al., 2009; Dinovo & Vasey, 2011; Vasey et al., 2014; Vasey et al., 2013). Relative to the review by Aldao et al. (2010), the BIS has also been positively and strongly associated with the maladaptive emotion regulation strategy of rumination (Keune, Bostanov, Kotchoubey, & Hautzinger, 2012; Randles, Flett, Nash, McGregor, & Hewitt, 2010). It has also been positively and strongly associated with various difficulties in emotion regulation subscales (DERS), such as a lack of emotional awareness and a lack of access to emotion regulation strategies (Tull, Gratz, Latzman, Kimbrel, & Lejuez, 2010), which have also been associated with eating pathology and binge, emotional and disordered eating behaviours (Gianini et al., 2013; Lafrance Robinson, Kosmerly, Mansfield-Green, & Lafrance, 2013).

Without concurrently measuring the BIS against the BAS, it cannot be determined that individuals who have been classified as 'sensitive to reward' are motivated to obtain food to regulate affect on the basis that they have a high level of reward sensitivity that is motivated by reactivity within the BAS (Davis, 2009; Davis, Patte, et al., 2007). It is possible that an individual with enhanced reactivity within the BIS, reduced levels of effortful control and subsequent emotion regulation difficulties may also increase their emotional eating behaviour, when experiencing emotional states that they are unable to regulate, as has been conceptualised in section 2.4. This section critically highlights the need to consider an effect of the BIS, concurrently with the BAS, in models of addiction that posit an enhanced level of reward seeking behaviour as a result of an individual's level of predispositional BAS reactivity. It also raises the question:

- Do emotion regulation difficulties predict emotional eating behaviour and BMI when psychobiological temperament interacts with trait anxiety (i.e., BIS x BAS x STAI-T), when effortful control is low?

A conceptual link between the BIS, BAS and hedonic reward

The acquisition and consumption of food is a neurologically rewarded behaviour that can be separated into two distinct psychobiological food reward constructs of wanting and liking (Dalton & Finlayson, 2014). These constructs are based upon two distinct neurological systems that define the process of neurologically rewarded ingestive behaviour: wanting and liking (Berridge, 1996). Wanting represents the motivational value, the 'incentive salience', desire or craving that is attributed to a rewarding object such as a highly palatable food item, which is mediated by the rewarding effects of dopamine (Berridge, 2007; Dalton & Finlayson, 2013). The perception of pleasure and positive affect experienced upon its ingestion is attributed to liking, which is mediated by the rewarding effects of the opioid neurotransmitter (Berridge, 1996; Dalton & Finlayson, 2014; Pecina, 2008).

The regulation of appetite is balanced between hedonic (reward-based) and homeostatic (energy-based) processes that are attuned to biological requirements (Finlayson et al., 2007a). An enhanced sensitivity towards the rewarding effects of ingestive behaviour can override homeostatic appetite, and the dysregulation of homeostatic appetite is believed to contribute towards weight gain and obesity (Dalton & Finlayson, 2013, 2014; Finlayson & Dalton, 2012; Finlayson et al., 2007a). The available evidence suggests that trait binge eating is linked to a dysregulated appetite via enhanced implicit wanting for high-fat sweet foods. Enhanced implicit wanting for high-fat sweet foods has also been linked to a susceptibility to overeating (which is also a feature of trait disinhibited eating behaviour (Bryant et al., 2008; van Strien, Cleven, & Schippers, 2000). Subsequently, trait binge-eating behaviour has been proposed to represent an ecologically valid phenotype of obesity that is susceptible to reward-driven overeating (Dalton & Finlayson, 2014).

How might Reinforcement Sensitivity Theory's BIS and BAS (Corr, 2008; Gray & McNaughton, 2000) fit into a model of enhanced psychological reward and over-consumption? The BAS activates automatic approach behaviours in response to appetitive rewards and safety signals (Gray, 1987a; Mc Naughton & Corr, 2008). Therefore, it has the potency to motivate approach behaviours and, by extension, the expression of food-seeking behaviours in anticipation of a desired reward (Berridge, 2003; Corr, 2008). Consequently, a reactive BAS might place an individual at risk of appetite dysregulation via enhanced levels of the psychological reward of 'wanting'.

Unlike the BAS, however, the BIS cannot be explicitly linked to psychological reward processes. However, it is plausible that an association may exist between a reactive BIS and the psychological reward of liking via a process of negative reinforcement. For example, activation within the BIS induces the experience of fear, frustration, anxiety and negative affect (Corr, 2008). In direct contrast to the experience of these negative affective states, liking mediates the "core process of hedonic pleasure" (Berridge, 2009b, p. 385). Neurologically, the intake of palatable food stimulates opioid release and the experience of pleasurable affect as the opioid neurotransmitter binds with its receptor in brain-based reward centres (Berridge, Ho, Richard, & Difeliceantonio, 2010; D. Costa, Tschop, Horvath, & Levine, 2006). The fact that liking creates a change in affect (Berridge, 2003) and has been linked to the experience of pleasure in response to food intake in anxious individuals (Appleton & McGowan, 2006) provides support for the conceptualization that the intake of palatable food under aversive circumstances may be negatively reinforced via the action of these rewarding neuropeptides. Furthermore, opioids enhance the palatability of food, which encourages greater intake (Pecina & Berridge, 2000). Thus, when highly palatable sweet and fatty foods are consumed, they have the capacity to increase feeding, even when animals are satiated (Berridge et al., 2010; Olszewski, Alsio, Schioth, & Levine, 2011). Collectively, these findings provide support for the conceptualisation that the intake of highly palatable food during the experience of distress may have the potential to potentiate the liking response and perpetuate a cycle of negative reinforcement (Drolet et al., 2001). They also suggest that a reactive BIS might place an individual at risk of appetite dysregulation via enhanced levels of the psychological reward of 'liking'.

Relative to an individual's level of hedonic inclination and their choosing to eat in response to the pleasure that this brings, i.e. in the absence of homeostatic need and in response to an enhanced level of sensitivity to reward (Davis et al., 2009), it has been suggested that what is liked is generally wanted (Berridge, 1996) and that foods which are highly liked, i.e., because they promote feelings of reward, such as pleasure, may precipitate approach behaviours (Pecina, 2008). In the temperament and eating behaviour field, the nature of a reactive BAS has been assumed to promote approach behaviours in response to cues of reward, such as highly palatable food (Davis, 2009; Davis, Patte, et al., 2007). However, Mela has also indicated that a 'liking' response to highly palatable foods, which are eaten in response to the experience of negative affect, can be learned (Mela, 2000) and, as conceptualised above, a reactive BIS could theoretically be associated with the psychological reward of liking. Therefore, it is feasible that an individual with a reactive and poorly regulated BIS may also have learnt to want these highly liked foods because they alleviate the feeling of an aversive state. Subsequently, enhanced levels of psychological reward could also be associated with a reactive BIS and not only with a reactive BAS.

The available evidence

If an individual has learnt to like and desire foods that have been associated with the improvement of negative affect, it is possible that a pathway to disinhibited eating behaviour, which is motivated by reactivity within the BIS, will be associated with enhanced levels of wanting and liking food reward behaviour. Therefore, it is helpful that the BIS has recently been associated with binge-eating behaviour (Davis, 2013b), because evidence for the occurrence of this response under the conceptualisation described herein may already have been indirectly reported upon. In an earlier study by Davis et al. (2009) enhanced levels of the psychological rewards of wanting and liking were reported in individuals with BED, relative to the occurrence of genetic markers that have been associated with enhanced levels of reactivity within the dopamine and opioid-based reward pathways. In this study, self-report levels of hedonic motivation were also determined via endorsement on a self-report measure of appetitive responsiveness. The results of this study suggested that, relative to these genetic markers, individuals with BED had enhanced levels of wanting and liking food reward behaviour, when compared to obese individuals without BED. Additionally, appetitive responsiveness, measured with the Power of Food Scale (Cappelleri et al., 2009) indicated that individuals with BED had significantly higher scores relative to obese controls, indicating a high level of appetitive approach towards food.

The results of Davis et al. (2009), which suggest that enhanced levels of wanting and liking are present in obese individuals with BED, are similar to the findings reported by Dalton, Blundell and Finlayson (2013a). However, in this study, instead of using genetic markers to highlight reactivity within the food reward pathways that have been associated with wanting and liking food reward behaviours, Dalton et al. (2013a) quantified these psychological markers of reward, using the Leeds Food Preference Questionnaire (LFPQ) (Finlayson et al., 2007). The LFPQ is a computerised, behavioural measure that has conceptually separated the dopamine and opioid-based food reward systems into the psychologically related constructs of wanting and liking (Dalton & Finlayson, 2014; Finlayson et al., 2007, 2008). Recent research using this behavioural tool has determined that these psychological markers of reward can define an individual's risk for over-consumption (Dalton et al., 2013a; Dalton & Finlayson, 2014; Finlayson et al., 2011; Finlayson et al., 2012; Finlayson & Dalton, 2012).

Within this line of research, an individual's susceptibility to over-consumption has been determined by investigating trait disinhibited and binge-eating behaviours, the psychological rewards of implicit wanting (which measures an unconscious response) and explicit liking (which measures a conscious response towards food images), satiety and food intake in normal weight to obese females. Trait binge-eating behaviour has been associated with explicit liking for all foods, an increased implicit wanting for high-fat sweet foods, a reduced suppression of hunger and increased intake of high-fat sweet foods in normal weight subjects, after a preload (Finlayson et al., 2011). Similar results were found when disinhibited eating behaviour was examined in normal weight subjects. Similarly to trait binge-eating behaviour, higher Disinhibition scores were also associated with explicit liking for all foods and enhanced implicit wanting for high-fat sweet foods, a reduction in levels of satiety and greater energy intake after a sweet but not savoury preload (Finlayson et al., 2012). Both these studies show that normal weight individuals with higher trait binge and disinhibited eating behaviours have a higher explicit liking for foods and an enhanced implicit wanting for high-fat sweet foods after a preload. Moreover, enhanced levels of implicit wanting coincided with a reduced suppression of hunger and the increased consumption of a test meal in individuals with higher levels of trait binge-eating behaviour. These findings have been interpreted to suggest that enhanced levels of psychological reward, i.e., wanting and liking, represent markers of reward-driven over-consumption that may lead to an increased risk of weight gain through a loss of appetite control (Finlayson et al., 2011).

The results of Finlayson, Arlotti, Dalton, King and Blundell (2011) and Finlayson, Bordes, Griffioen-Roose, de Graff and Blundell (2012) were extended in an additional study that sought to examine the differences in the psychological rewards of liking and wanting relative to trait binge-eating behaviour in individuals who were overweight and obese by Dalton, Blundell and Finlayson (2013a). In this study, individuals were classified according to their scores on the Binge Eating Scale (Gormally et al., 1982), into lean- binge (LB) or lean – non-binge (L-NB) or overweight or obese binge (OB) or overweight or obese-non binge (O-NB) groups. Similar to the findings in normal weight individuals, both binge types had a greater preference and enhanced explicit liking for high-fat sweet foods when compared to non-binge types. However, obese binge types had higher levels of implicit wanting for high-fat sweet foods after the preload, compared to O-NB individuals, and consumed more energy during the ad libitum test meal when compared to the O-NB and both lean types. In contrast, the opposite pattern was seen in the O-NB individuals. However, no differences in levels of hunger or satiety were found between the groups.

In this study by Dalton et al. (2013a) there was evidence of a dissociation between explicit liking and implicit wanting for high-fat sweet foods, according to hunger, and increased levels of consumption in the OB, which did not appear in the O-NB type. As a result, it was suggested that the increased motivation for high-fat sweet foods in the fed state, which was evident in the O-B type, may represent a marker of reward sensitization in these individuals, which could convey risk for weight gain. Consequently, similar to the conclusions drawn by Davis et al. (2009), individuals with trait binge-eating behaviour have shown an enhanced level of reward-driven over-consumption (Dalton & Finlayson, 2014). However, similarly to the results presented by Davis et al. (2009), it is currently unknown whether enhanced levels of implicit wanting and explicit liking are associated with enhanced reactivity within self-reported measures of the BIS. Therefore, research questions include:

- Is the BIS or the BAS associated with mean implicit wanting and liking of high-fat foods?
- Does the BIS or BAS and effortful control predict implicit wanting and explicit liking, in overweight and obese?

2.13 APPETITE DYSREGULATION

A state of satiety describes a lack of motivation to eat in between meals (Chapelot, 2013). Subsequently, the interoceptive awareness of this state describes one way in which the human body regulates homeostatic intake (Chapelot, 2013). An enhanced level of psychological reward, such as implicit wanting, has the capacity to override homeostatic appetite and lead to a loss of appetite control (Finlayson et al., 2007a), i.e., by increasing one's motivation or desire to snack on highly palatable foods mid-meals (Dalton & Finlayson, 2013). Recent evidence suggests that this process could be exacerbated in individuals who possess a low satiety phenotype.

In a recent study by Dalton, Hollingworth, Blundell and Finlayson (2015), females identified as low in a psychological marker of satiety were classified with a low satiety phenotype. In this study, females classified with a low satiety phenotype were shown to possess weak appetitive responses to ingested food, higher levels of disinhibited eating behaviour, to consume significantly more energy during an ad libitum lunch and to demonstrate greater wanting for high-fat foods when hungry, in comparison to females classified with a high satiety phenotype. These findings highlight that normal weight females with higher levels of disinhibited eating behaviour and a low satiety phenotype may be at risk of over-consumption as a result of an attenuated capacity to be sensitive to satiety signals that is accompanied by enhanced levels of wanting.

An activated BIS underlies the experience of anxiety (Gray, 1970; Gray & McNaughton, 2000) and the experience of anxiety is a psychological stressor (McEwan & Stellar, 1993). Consequently, it is of relevance to this thesis that the experience of anxiety and stress has also been linked to a reduced sensitivity to satiety signals in individuals who have been classified with a low satiety phenotype (Drapeau et al., 2013; Drapeau & Gallant, 2013). It is also interesting that the BIS has recently been associated with emotional and external eating behaviours (Hennegan et al., 2013; Matton et al., 2013; Stapleton & Whitehead, 2014), which are both linked to a low level of interoceptive awareness via either a lack of awareness of a state of satiation (external eating) or to a misinterpretation of the physiological stress response as hunger (emotional eating) (Schachter, 1971; van Strien, 2002; van Strien & Schippers, 1995). Moreover, the Disinhibition Scale from the Three Factor Eating Questionnaire (Stunkard & Messick, 1985) contains items that measure both emotional and external eating behaviours (Ouwens et al., 2003; van Strien, 1997; Westenhoeffer, 1991; Yeomans & Coughlan, 2009). Therefore, it should not be surprising that disinhibited eating behaviour is linked to an attenuated satiety response (Dalton et al., 2015; Drapeau et al., 2013; Drapeau & Gallant, 2013; Finlayson et al., 2012) or that research has identified that obese individuals with high levels of disinhibited eating behaviour have difficulty identifying their feelings of hunger and fullness relative to their habitual intake or that they show a weaker suppression of hunger and reduced levels of fullness after the consumption of a meal (Barkeling et al., 2007).

What is surprising, however, is that a link between an individual's temperament-based predisposition to experience trait anxiety, which has been linked to an inability to regulate emotions or behaviour as outlined in section 2.4, has not been intensely investigated within this relationship. Therefore, it is unknown if an individual with a reactive BIS temperament and a low level of effortful control will show evidence of a disruption to the homeostatic control of eating behaviour via enhanced psychological reward and attenuated levels of satiety. Evidence of such a finding could provide another perspective to the link that has already been made between the experience of anxiety and stress in individuals with high levels of disinhibited eating behaviour who have been classified with a low satiety phenotype. Subsequently, the research questions are:

- Is the BIS and a low level of effortful control associated with psychological food reward in highly disinhibited individuals, in the fed state?
- Is the BIS associated with an attenuated satiety response?

2.14 THE RELEVANCE OF THESE FINDINGS FOR THE HDLR EATING BEHAVIOUR SUBTYPE

As previously described in section 2.6.3, the HDLR eating behaviour subtype has been characterised as disinhibiting their intake in response to hedonic cues (Yeomans, Tovey, et al., 2004) and in response to the experience of positive affect (Yeomans & Coughlan, 2009). In direct contrast, they have been shown to inhibit their intake in response to acute stress and negative affect (Haynes et al., 2003; Yeomans & Coughlan, 2009). However, it is not known how the HDLR subtype reacts to the experience of chronic stress and chronic as opposed to acute negative affect. This lack of information has been highlighted because the experience of chronic stress may lead to the psychopathological states of anxiety and depression (K.-S. Kim & Han, 2006; McEwan & Stellar, 1993), which have been found in obese binge eaters with high levels of disinhibited eating behaviour and low levels of dietary restraint (HDLR) (Wadden et al., 1993).

The link between the experience of depression and binge-eating behaviour in the HDLR subtype is important because a diagnosis of major depressive disorder has been linked to impulsively reacting to emotions in general, including the experience of positive emotions (Carver, Johnson, & Joorman, 2013). Subsequently, as has been reported in the study by Yeoman and Coughlan (Yeomans & Coughlan, 2009), these findings support the conceptualisation that the HDLR subtype, which has been shown to lose control over intake in response to the experience of positive affect, could also lose control in response to the experience of chronic stress and the associated states of anxiety and depression, if they lacked a sufficient level of effortful control. This conceptualisation is supported by Bruch, a supporter of the psychosomatic theory of emotional eating, who has suggested that obese individuals who eat emotionally may also overeat in response to the experience of any emotionally aroused state (Bruch, 1961).

Therefore, the current characterisation of the HDLR eating behaviour subtype, which is to increase intake in order to enhance the effects of an already positive affective state, could place these individuals at risk of misclassification (Yeomans & Coughlan, 2009). Individuals with this eating behaviour subtype could be mistakenly classified as being highly motivated to approach highly palatable food, solely because they are highly sensitised to its rewarding properties as a result of reactivity within the BAS (Davis, 2009). Consequently, it may not have been considered that they could also be motivated to approach food to down-regulate the negative affect of a reactive BIS. This distinction is important. However, it is currently unknown whether a relationship exists between the highly disinhibited eating behaviour subtypes (HDHR or HDLR) and the HBIS_HBAS, HBIS_LBAS temperament phenotypes and a low level of effortful control. Specifically, it is currently not known if the HDLR eating behaviour subtype may be linked to a HBIS_LBAS phenotype, which Dinovo and Vasey, and Vasey et al. have shown predicts the experience of general distress and depression (Dinovo & Vasey, 2011; Vasey et al., 2014; Vasey et al., 2013).

2.15 THE IDENTIFICATION OF ENHANCED LEVELS OF WANTING, LIKING AND AN ATTENUATED SATIETY RESPONSE IN THE HDLR EATING BEHAVIOUR SUBTYPE

It is acknowledged that the identification of an association between the BIS, enhanced levels of psychological reward and an attenuated satiety response, which have been identified as placing an individual at risk of over-consumption and increased BMI, would be novel. Therefore, in order to determine whether this relationship exists, its investigation may be best identified in the HDLR eating behaviour subtype. This eating behaviour subtype is highlighted because it has been associated with the highest levels of BMI when compared with the HDHR individual

(Bellisle et al., 2004; Dykes et al., 2004; Williamson et al., 1995). Moreover, research findings thus far have shown a positive association between the BIS and BMI in women and a negative association between the BAS and BMI at the highest levels of BMI (Davis & Fox, 2008; Dietrich et al., 2014). Subsequently, the HDLR subtype may have reduced levels of BAS reactivity. The relevance of a lower level of BAS reactivity is that it may increase the likelihood of obtaining evidence of an effect of the BIS on psychological food reward and a loss of appetite control, such as an attenuated level of satiety, should one exist.

The HDLR eating behaviour subtype has been suggested, in the non-temperament eating behaviour literature, to reflect a subtype that is at risk of obesity due to a high level of hedonic responsiveness not inhibited by an appropriate level of restraint (Bryant et al., 2010; Yeomans & Coughlan, 2009). It is noted that a link between the BIS and enhanced levels of psychological reward would appear to contradict the current conceptualisation, within the temperament and eating behaviour literature, that this eating behaviour subtype is reflective of a temperament phenotype characterised by an enhanced level of BAS activation that is not adequately constrained by an appropriate level of BIS activation (Davis, 2009). However, the evidence reviewed thus far does question the utility of considering the effect of the BAS without concurrently measuring activation within the BIS. The nature of the relationship between the HDLR eating behaviour subtype, psychological reward and psychobiological temperament is not currently known.

It is also important to note that some individuals are successful in their attempts at weight management. Individuals who have low levels of Disinhibition and concurrently high levels of Restraint (LDHR) have been characterized as frequent dieters who succeed in their weight loss attempts (Lawson et al., 1995; Westenhoeffer, 1991). Critically, they are less responsive to highly palatable foods than the HDLR subtype (Yeomans, Tovey, et al., 2004) and do not lose control of their intake after induced stress (Haynes et al., 2003). Therefore, these individuals are able to maintain control over their eating behaviour in a manner that is contrary to both their HDHR and HDLR counterparts. Importantly, such an outcome suggests their engagement with, as yet unknown, weight management processes that *enable* this subtype to cognitively control their intake to highly palatable food, despite living within an obesogenic environment and amongst the accompanying stressors of life (Yeomans, Tovey, et al., 2004).

The LDHR subtype represents a successful dieter who is able to resist the allure of highly palatable foods, which suggests that the dispositional temperament traits of these individuals relative to the dispositional temperament traits of the HDLR subtype are worth investigating. If these characteristics are found to differ between the groups, it may suggest a temperament-based way forward to manage over-consumption and Australia's rising incidence of obesity, within an obesogenic environment (Peeters et al., 2015; Swinburn et al., 2011). Therefore, a research question is:

- Do individuals with a HBIS_LBAS temperament phenotype who are simultaneously high in Disinhibition and low in Restraint (HDLR) possess a psychological phenotype that is higher in reward and lower in satiety when compared to individuals with a LBIS_LBAS temperament phenotype who are simultaneously low in Disinhibition and high in Restraint (LDHR)?

PART THREE

2.16 COGNITIVE INHIBITION

Relevance to a cognitive model of control

According to the prefrontal cortex model of cognitive control of Miller and Cohen (E. K. Miller & Cohen, 2001) described earlier in section 2.4, to achieve goal-directed behaviour the pre-frontal cortex must be able to maintain its attentional focus on the task at hand. For example, in the face of distraction from either competing external stimuli such as an appetizing treat or internal stimuli such as negative self-referent thoughts. However, the capacity to maintain attentional focus, e.g., in the service of goal-directed behaviour, is reliant on an ability to disregard stimuli that are not currently relevant (C. M. MacLeod & MacDonald, 2000). Subsequently, the achievement of goal-directed behaviour is reliant on a capacity to overcome the interference that arises when a person chooses to enact a new behavioural pattern that is in direct competition with a fixed established and resistant behavioural pattern (E. K. Miller & Cohen, 2001).

The process of achieving goal-directed behaviour is encompassed within Rothbart's definition of effortful control (Rothbart, Ellis, Rueda, & Posner, 2003), which refers to an individual's ability to override a dominant response in order to achieve a subdominant response and, additionally, in Nigg's (2000) definition of interference control, which refers to the "ability to suppress a stimulus that pulls for a competing response so as to carry out a primary response". According to Nigg (2000), Rothbart, Ellis and Posner (2010), Rothbart and Rueda (2005) and MacLeod and MacDonald (2000), the Stroop task, which has the capacity to indicate whether an individual has difficulty controlling their level of attentional focus (C. M. MacLeod & MacDonald, 2000; E. K. Miller & Cohen, 2001), represents an appropriate measure of effortful/interference control. Subsequently, the Stroop task may be one way to capture evidence of an association between effortful control, eating behaviour and BMI.

2.16.1 Body mass index

A systematic review, which explored evidence of impaired executive function in obese adults, demonstrated that the evidence of an association between BMI and the Stroop task is mixed (Fitzpatrick, Gilbert, & Serpell, 2013). One study, which investigated differences between obese individuals with and without BED, failed to find a difference between the groups in the Stroop task (Galioto et al., 2012). Nonetheless some studies do show a relationship (Allan, Johnston, & Campbell, 2010; Fagundo et al., 2012; Gunstad et al., 2007) and, when compared with a lean control group, overweight individuals have been shown to perform worse on the Stroop task (J. Cohen, Yates, Duong, & Convit, 2011; Fagundo et al., 2012). The failure to find a significant difference between groups has been suggested to reflect small sample sizes and a lack of sufficient power (Fitzpatrick et al., 2013).

2.17 COGNITIVE FLEXIBILITY

Relevance to a cognitive model of control

To override an habitual behavioural pattern, an individual must be able to achieve the following three tasks: 1) they must maintain activity within the pre-frontal cortex; 2) they must be able to maintain their focus on the task at hand, despite interference from salient external and internal distractors; and, 3) they must be able to deliberately interrupt, prevent or suppress the enactment of cued habitual behaviours (Nigg et al., 2005). Response perseveration, or the tendency to enact repetitive behaviours across time, has been linked to states of high arousal (Robinson, Wilkowski, Kirkeby, & Meier, 2006) and reduced levels of cognitive flexibility (Vainik, Dagher, Dubé, & Fellows, 2013). Therefore, as outlined in section 2.4, this process may not efficiently occur in individuals whose attention is captured by salient stimuli and who subsequently experience emotional distress that they are unable to regulate.

2.17.1 Body mass index

Evidence for a tendency towards a deficit in cognitive flexibility in the obese, although still mixed, is stronger than the evidence for cognitive inhibition (Fitzpatrick et al., 2013), with overweight and obese individuals performing worse on measures of cognitive flexibility when compared to their leaner counterparts (J. Cohen et al., 2011; Fagundo et al., 2012). Interestingly, in contrast to cognitive inhibition, there was evidence of a group difference in a measure of cognitive flexibility between obese individuals with binge-eating disorder (BED) and obese individuals without BED (Fitzpatrick et al., 2013). Moreover, BMI has also been associated with a reduction in cognitive flexibility in overweight and obese adolescents, using the Delis-Kaplan Executive Function System colour word interference test (D-KEFS CWIT) switching task (Delgado-Rico et al., 2012). Subsequently, these findings indicate that obese individuals with or without BED may have a reduced capacity to exert the cognitive control that is needed to flexibly change established maladaptive behaviour patterns. Specifically, overweight and obese individuals with or without BED may have trouble overriding dominant and automatic, i.e., habitual eating behaviour patterns that are associated with the maintenance of a high level of BMI.

2.18 COGNITIVE INHIBITION AND FLEXIBILITY AND EATING BEHAVIOURS

In support of this conceptualisation, poor Stroop performance has been associated with a higher Disinhibition score that was positively associated with BMI in adolescents (Maayan, Hoogendoorn, Sweat, & Convit, 2011). Poor Stroop performance has also been associated with frequency of fatty food consumption (Hall, 2012), tendency towards unintentional eating (Allan et al., 2010) and a higher than intended snack intake (Allan, Johnston, & Campbell, 2011). Moreover, higher snack intake was shown to occur at the expense of fruit and vegetable intake. The gap between the intended behaviour of eating more fruits and vegetables and the actual behaviour of eating more snack foods was partially explained by a deficit in cognitive flexibility (Allan et al., 2011). Furthermore, individuals who were less successful at maintaining their desired intake had a higher BMI than those who were more successful (Allan et al., 2010).

2.19 EVIDENCE FOR A TEMPERAMENT-BASED MODEL OF COGNITIVE INHIBITORY CONTROL

When considered at the individual difference level of temperament, Mueller, Claes, Wilderjans and de Zwaan (2014) failed to find evidence of a Stroop interference effect between two clusters of morbidly obese individuals using Rothbart and Bates' (2006) psychobiological temperament model. One cluster, characterised as emotionally dysregulated, was reported to be low in effortful control and high in both BIS and BAS dimensions. Another cluster was described as emotionally resilient. They were reported to be high in effortful control and low in both BIS and BAS dimensions. However, a lack of a Stroop interference effect may not be due to a null finding. The lack of difference was not explained in this study. However, it could be due to an inability to find a difference in cognitive inhibition between groups, when BMI is at the high level that it was in this study. For example, 79.5% of the resilient high functioning cluster had a mean BMI of 47kg/m2, whilst 77.9% of the emotionally dysregulated cluster had a mean BMI of 47 kg/m2.

Evidence in support of an inability to find a difference between groups due to similarly high levels of BMI comes from another team, which investigated whether there was evidence of a Stroop interference effect between morbidly obese individuals with and without BED. This team were also unable to find evidence of group differences (Galioto et al., 2012). The lack of a Stroop interference effect occurred despite the fact that both groups, when compared with normative values, were found to be impaired in Stroop performance (Galioto et al., 2012). Within this sample, the obese group without BED had an average BMI of 37 kg/m2, whilst those with BED had an average BMI of 45 kg/m2. As a result, it was suggested that the higher levels of obesity, which were associated with neuro-cognitive dysfunction, might have masked subtle group differences (Galioto et al., 2012).

In summary, the evidence reviewed suggests that there might be a difference between how lean and obese individuals exert cognitive control and flexibility over habitual eating behaviours, which may increase the likelihood of weight gain. Therefore, it is possible that susceptible individuals with a reactive and inefficiently regulated temperament have learnt to eat in response to the emotions arising from an interaction between the BIS and BAS. Can this difference be discriminated via the developmental model of reactive and regulative temperament, such as Rothbart has conceptualised? Evidence of an association between cognitive inflexibility in this particular phenotype would invite the suggestion that relapses associated with problematic eating behaviours, such as disinhibited and binge-eating behaviour, may reflect an underlying deficit in the dimension of effortful control that is mediated by reactivity within the BIS. Therefore, the following questions are relevant to this thesis.

- Is Stroop performance associated with effortful control?
- Is Stroop performance associated with disinhibited eating behaviour and BMI?
- Does a high BIS phenotype have a deficit in cognitive inhibitory control?
- Does a high BIS phenotype show a reduced level of cognitive flexibility?

PART FOUR

2.20 SUMMARY

Whilst it is clear that over-consumption over the last 30 years has contributed towards obesity (Swinburn, Sacks, Lo, et al., 2009), what remains unclear are the drivers of over-consumption and why not everyone is susceptible. Overweight and obese individuals have been shown to obtain heightened pleasure from the highly palatable foods that they select and ingest (Berthoud, 2012; Davis, Levitan, Carter, et al., 2008; Mela, 2001). However, how or why these individuals may be motivated via temperament to maximise their hedonic experience within an obesogenic environment has not yet been clarified on two fronts. A complete model of psychobiological temperament (Rothbart & Bates, 2006; Rothbart et al., 1994), which includes the BIS and the self-regulatory measure of effortful control has not been investigated. Nor has this model of temperament been considered in relation to the psychological rewards of wanting and liking, which have been linked to appetite dysregulation and trait eating behaviours that increase risk for obesity (Berridge, 2009b; Dalton & Finlayson, 2014; Finlayson et al., 2007; Finlayson et al., 2007a; Finlayson et al., 2008).

In order to clarify why an individual might be motivated to over consume, it is important to determine whether their motivation is based purely upon the incentive salience inherent in the food items themselves or based upon a need to manage the experience of acute or chronic negative affect arising from an underlying temperament predisposition. One way to determine *why* an individual is motivated towards over-consumption is to determine *which* temperament dimension is associated with eating behaviour and then to determine *whether* this dimension is associated with hedonically motivated food reward behaviours that lead to appetite dysregulation via an attenuated satiety response and, consequently, increased levels of consumption. In order to consider a mechanism of facilitated negative reinforcement that is motivated by a reactive BIS that is poorly regulated, it is important to determine whether there is an association between high levels of the BIS and low levels of effortful control, eating behaviour, enhanced food reward behaviours, an attenuated capacity to be sensitive to satiety signals and over-consumption. This thesis aims to investigate these relationships.

The overarching aim of this thesis is to *extend* the literature by presenting across a series of three experimental studies *the evolution of* a phenotypic model of temperament-based eating behaviour. The current literature has predominantly theorised that an individual's level of temperament reactivity, sensitivity to reward (BAS), is linked to uncontrolled eating behaviour and obesity. However, according to the constitutional model of temperament developed by Rothbart and colleagues an individual's level of reactivity reflects their innate level of BIS as well as their BAS reactivity. It also reflects their level of emotional reactivity, which is regulated by the later developing temperament construct of effortful control. However, the relationships between constitutional temperament, eating behaviour, psychological reward and the energy intake of high-fat foods, as well as the expected theoretical links to emotion regulation difficulties and an attenuated satiety response, has not been previously determined. Therefore, these relationships were explored, using a variety of experimental tools as shown in Figure 2.3.

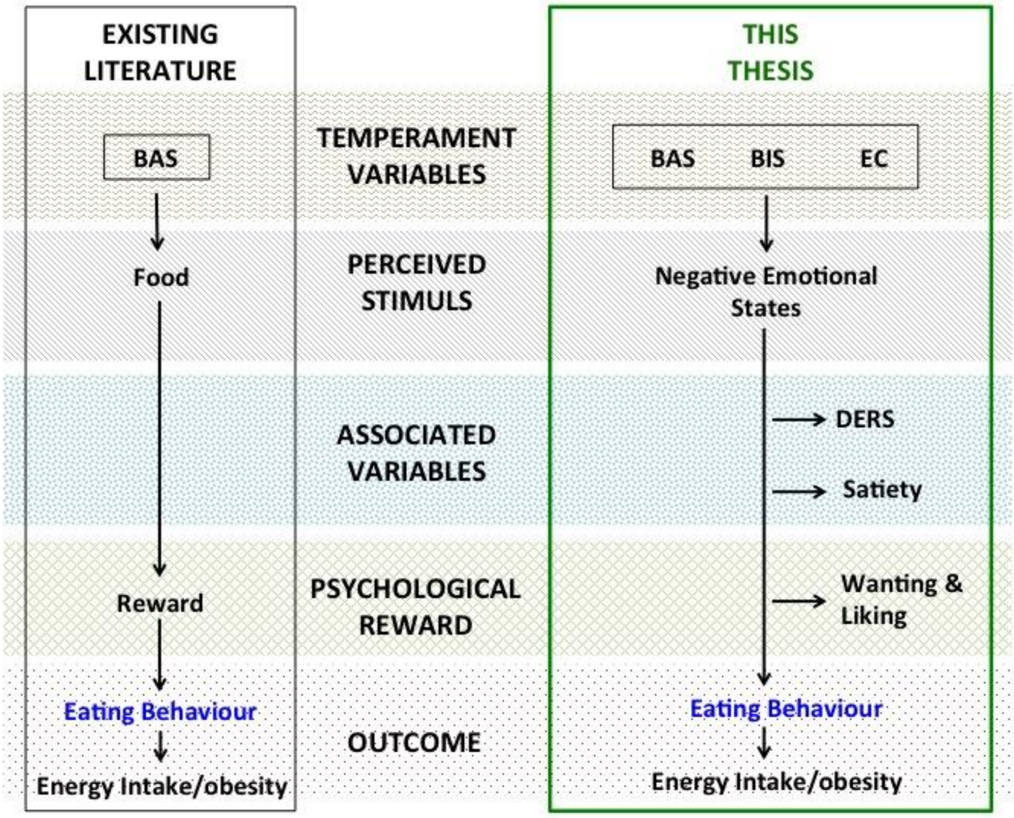

Figure 2.3. The evolution of a phenotypic model of temperament across studies one, two and three.

The evolution of this model was investigated by determining the relationships between temperament and the outcome measures of eating behaviour, energy intake and obesity. The relationships between temperament, psychological reward and the associated variables of ‘difficulties in emotion regulation’ (DERS) and satiety were also explored, given their conceptualised and theoretical links to negative emotional states, eating behaviour and obesity.

Chapter 3: General Methodology

3.1 ETHICAL CONSIDERATIONS

Ethical approval was sought for each study. In study one, ethical approval was granted from The Central Queensland Health Services District Health Research Ethics Committee and the Queensland University of Technology (QUT) University Human Research Ethics Committee (UHREC) (Approval number 12/QCQ/6). In studies two (Approval number 1400000275) and three (Approval number 1500000100), ethics approval was granted by the QUT UHREC. Prior to participation, informed consent was obtained from each participant.

3.2 RESEARCH DESIGN

A cross-sectional exploratory study design was employed in studies one and two. Study three, which was also exploratory, employed a mixed design. The between factors were participant group (high BIS, HDLR subtype and low BIS, LDHR subtype), and the within factors were condition (fed or fasted state) and time (baseline, 0min, 30min, 60min, 90min). The dependent variables were explicit liking according to four categories of fat and taste (high-fat sweet, low-fat sweet, high-fat savoury, low-fat savoury), implicit wanting (appeal bias) for high-fat or low-fat foods, two measures of subjective appetite sensations (hunger and fullness) and three measures of energy intake (total energy intake, energy intake of high-fat sweet foods and energy intake of high-fat non-sweet foods).

The rationale for choosing an exploratory design for studies one and two was based on the paucity of evidence showing a relationship between the BIS and effortful control with emotional and disinhibited eating behaviour and BMI in an adult, non-clinical, community-based setting at the time of planning. The exploratory design of the third study was based upon the following results of study two: that females with a HBIS_LBAS phenotype and HDLR eating-behaviour subtype occurred in significantly greater numbers in the obese category than did females who simultaneously possessed a LBIS_LBAS phenotype and LDHR eating-behaviour subtype; and that the BIS significantly predicted explicit liking and implicit wanting for high-fat sweet foods. Studies two and three were conducted in the absence of any direct evidence that has previously linked the BIS with hedonic food reward behaviours, measures of satiety and energy intake.

3.3 PARTICIPANTS

3.3.1 Sample size

Sample size calculations were performed prior to each study. For study one, sample size calculations indicated 146 participants were required for the primary analysis to examine the relationship between the BIS and BMI, assuming a medium effect size, power of 0.8 and probability of 0.05, using a multiple-linear regression analysis with 12 predictor variables. A medium effect size was based on the finding of a small to medium effect between the BIS and BMI (r = 0.36, $p < .05$) in an overweight/obese sample of male and female adolescents (Delgado-Rico et al., 2012) and a small to medium effect between the BAS and BMI in a sample of female adults (r = 0.31, $p < .005$) (Franken & Muris, 2005). The sample size estimate was determined using the formula of Tabachnick and Fidell (2013, p. 123). Using these numbers, interaction effects between the BIS and BAS and Trait anxiety (STAI-T) on emotional eating behaviour were also explored as a secondary analysis.

For study two, sample size calculations indicated that between 152 to 205 participants were required to examine an interaction between the BIS and BAS and STAI-T on disinhibited eating behaviour, using an effect size estimate between R^2 = .03 and R^2 = .04, respectively (both indicative of a small to medium effect size; r = .17 to .20). This was based on power of 0.8 and probability of 0.05. The sample size was calculated using the Power Analysis and Sample Size Software (PASS) procedure for multiple regression (Hintze, 2011). The final sample size of 170 should therefore have provided a power of .08 to detect the effect at approximately R^2 = .035 (i.e., still a small sized effect; r = .19).

For study three, sample size calculations indicated that 42 participants were required to examine the relationship between the BIS, effortful control and psychological reward (implicit wanting). This was based on the finding of a medium effect between the correlation of effortful control and implicit wanting (r = -.35, $p <$ .05) in a combined sample of 42 high BIS low BAS and low BIS low BAS individuals, from the candidate's second study.

3.3.2 Inclusion and exclusion criteria

Table 3.1 outlines the selection criteria across the three studies

Table 3.1

Inclusion and Exclusion Criteria across Studies One, Two and Three.

Selection Criteria	Study 1	Study 2	Study 3
Inclusion Criteria			
Gender			
Male and Female	Y	Y	N
Female only	N	N	Y
Age			
18 - 65	Y	Y	Y
BMI			
Lean, Overweight, Obese	Y	N	N
Overweight and Obese only	N	Y	Y
Eating Behaviour			
1) D ≥ 12 , BIS ≥24, BAS <41	N	N	Y
2) D < 12, BIS < 24, BAS <41	N	N	Y
Exclusion criteria			
Male	N	N	Y
Use of anti-depressants	N	N	Y
Use of anxiolytics	N	N	Y
Eating disorder	Y	Y	Y
BMI < 25	N	Y	Y
Communication difficulty, i.e. intellectual impairment	Y	Y	Y
Poor English skills, i.e. inability to read, write in English	Y	Y	Y
Physical impairment, inability to undertake anthropometry	Y	Y	Y
Cognitive deficit impairing the ability to read and write	Y	Y	Y
Pregnancy, up to 12 months post-partum	Y	Y	Y
Breastfeeding	Y	Y	Y
Smoking	Y	Y	Y

1) High BIS group; 2) Low BIS group
Y: yes; N: no
D: Disinhibited eating behaviour, BIS: Behavioural Inhibition System, BAS: Behavioural Activation System, BMI: Body Mass Index

Gender: The decision to include both males and females in studies one and two was due to the limited number of studies that have included males, when examining relationships between temperament, eating behaviour and BMI (Davis, 2013b; Dietrich et al., 2014; Stapleton & Whitehead, 2014). The decision to include women only in the third study was based upon the findings of study two. In study two, there was a statistically significant difference in the proportion of BIS_BAS phenotypes and level of disinhibited eating behaviour in females but not males. Specifically, females with a combined HBIS_LBAS phenotype, who were simultaneously higher in disinhibited eating behaviour and lower in restrained eating behaviour had a proportionately higher level of BMI than females with a combined LBIS_LBAS phenotype who were also lower in disinhibited eating behaviour and higher in restrained eating behaviour. These differences were investigated in greater detail in study three as they were of clinical importance, given the theoretical underpinnings of RST and disinhibited eating behaviour.

Age: The age group of 18 to 65 years was selected to investigate the relationship between temperament and eating behaviour and appetite in adults as opposed to children, adolescents or the elderly.

BMI: Study one (Chapter 4) was designed as an exploratory study to determine whether a relationship existed between eating behaviour, BMI and temperament within a sample of males and females. Subsequently individuals with a range of BMIs of 18.5 to 45 kg/m^2, were recruited to explore whether eating behaviour and varying levels of BMI were associated with temperament. The decision to investigate a sample consisting of only overweight and obese individuals in study two (Chapter 5) and study three (Chapter 6) was based upon the findings of study one.

Eating behaviour and temperament levels: Based upon the results of study two (Chapter 5), two groups of females with high and low levels of disinhibited eating behaviour that were combined with either HBIS_LBAS or LBIS_LBAS temperament phenotypes were recruited into study three. Individuals were recruited into a high BIS group if they had a high level of Disinhibition classified with a score of 12 to 16, a high level of BIS classified with a score of 24 to 28, and a low level of BAS classified with a score of 24 to 40. Individuals were recruited into a low BIS group if they had a low level of disinhibited eating behaviour classified with a score of 2 to 11, a low level of BIS classified with a score of 12 to 23, and a low level of BAS classified with a score of 24 to 40.

Eating disorders: As part of the recruitment process, it was written into the exclusion criteria that individuals would not be eligible for the study if they had been diagnosed with an eating disorder. Individuals with eating disorders were excluded from all of the studies, because they were designed to measure non-eating disordered, community-dwelling adults.

Communication difficulties: Individuals with communication difficulty such as an intellectual impairment, poor English skills (e.g. as an inability to read and write in English) and any cognitive deficit that impaired the participants' ability to read and write were excluded. These individuals were excluded because participants were required to complete patient-reported outcome measures and to undertake computer-based tests that required a basic ability to understand, read and write the English language.

Pregnancy and Breastfeeding: Individuals who were either pregnant or breastfeeding were also excluded due to the expected weight gain of pregnancy (Queensland Health, 2013) and the higher energy requirements and appetite changes that are associated with both of these states (Queensland Health, 2013) (Butte & King, 2005; Douglas, Johnstone, & Leng, 2007; Sichieri, Field, Rich-Edwards, & Willett, 2003).

Smoking: Individuals who were smokers were excluded due to the effect of smoking on appetite suppression (Chiolero, Faeh, Paccaud, & Cornuz, 2008), BMI (Chiolero et al., 2008; Kimokoti et al., 2010), and a reduction in the perceived reward value of palatable food (Kroemer, Guevara, Vollstädt-Klein, & Smolka, 2013; Machulska, Zlomuzica, Adolph, Rinck, & Margraf, 2015).

3.4 PROCEDURES

3.4.1 Data collection

In the first study (Chapter 4), demographic and self-report data were collected in paper and pencil format from participants. For studies two (Chapter 5) and three (Chapter 6), data were collected electronically by the use of the KeySurvey web-based survey management system. A number of patient-reported outcome measures were utilised within this study: two measured reactive and regulative temperament, three measured eating behaviour, four measured the experience of negative affective states and two measured associated impulse and emotion regulation difficulties. The patient-reported outcome measures are discussed below. Two behavioural tasks measuring executive function were also employed. One version of the Stroop procedure was presented electronically in study two and is described in detail in Chapter 5; another version was presented in a paper and pencil format in study three and is described in detail in Chapter 6.

Three behavioural tasks were also utilised within this study to determine the following outcome measures: a computer-based behavioural task measured the psychological components of reward (e.g. wanting and liking) in studies two and three and is outlined below; a standardised caloric preload was employed to measure appetite and satiety (specifically hunger and fullness) from a set of four visual analogue scales (VAS) in study three and six ad libitum portions of high-fat sweet and high-fat non-sweet snack items as a measure of acute energy intake. The details of these last two data collection instruments are presented in Chapter 6.

3.4.2 Anthropometric data

Height and weight were measured with subjects standing barefoot or in socks, with pockets emptied. Body weight was measured to the nearest 0.1 kg on a digital scale. Height was measured to the nearest 0.1 cm using a portable stadiometer. BMI was calculated as weight in kilograms divided by the square of height in meters (BMI = kg/m^2) (World Health Organization, 2015). Waist circumference was measured at the midpoint between the iliac crest and bottom of the last rib and hip circumference, and hip circumference at the midpoint of the buttocks (ISAK, 2001). Participants were classified by BMI, as lean, overweight or obese. These classifications followed the BMI weight categories defined by the World Health Organisation: as normal weight greater than or equal to $18.5kgm^2$ to $24.9kgm^2$, overweight $25.0kgm^2$ to $29.9kgm^2$ and obese greater than or equal to $30.0kgm^2$ (World Health Organization, 2015).

3.4.3 Demographic data and characteristics of the participants

Socio-demographic data collected included the following: Data was collected on the following: socio-demographic variables (e.g. age, gender, indigenous status, marital status, highest level of occupation, home ownership), lifestyle variables (e.g. physical activity and drinking frequency), and general health (number of health conditions, mental health diagnoses, self-reported height, weight and dieting history).

3.5 SELF-REPORT MEASURES

3.5.1 Reactive and regulative temperament

Reactive temperament

The BIS/BAS Scales (Carver & White, 1994) were used to measure an individual's dispositional degree of sensitivity or reactivity within Gray's Behavioural Inhibition System (BIS) and Behavioural Activation System (BAS) (Gray, 1970) in response to signals of reward and punishment in all studies. The BIS/BAS Scales (Carver & White, 1994) are a 20-item measure, which assess an individual's level of dispositional behavioural inhibition or sensitivity to punishment, and their dispositional level of behavioural approach or sensitivity to reward. These scales have been specifically designed to measure an individual's trait levels of emotional response to external circumstances assumed to activate Gray's BIS or BAS (Carver & White, 1994).

The scales are scored on a four-point response scale (1 = very true for me, to 4 = very false for me) and measure agreement to statements that describe emotional reactions to potentially harmful or rewarding scenarios. All items, except two items that reflect sensitivity to punishment, are reverse scored. The BIS Scale contains seven items measuring reactions to the anticipation of punishment (e.g. "I feel pretty worried or upset when I think or know somebody is angry at me."). Higher scores indicate higher levels of BIS reactivity or sensitivity and the total score is calculated by summing the total of all of the items, after taking into account reverse-scored items, and scores range from 7 to 28. The total BAS Scale contains 13 items. It consists of three subscales: BAS reward responsiveness (BAS-RR) (five items), which captures the intensity of the response to the occurrence or anticipation of reward (e.g. "When I'm doing well at something, I love to keep at it."); BAS-drive (BAS-DR) (four items), which measures the intensity with which an individual will persist in their pursuit of a desired goal (e.g. "When I want something I usually go all-out to get it.") and BAS-fun seeking (BAS-FS) (four items), which measure both a desire to experience new rewards and a willingness to spontaneously approach a potentially rewarding event (e.g. " I will often do things for no other reason than they might be fun."). Higher scores on all BAS subscales represent a higher level of temperament reactivity or sensitivity. The BAS total score can be calculated by summing the totals of the three subscale scores and ranges from 13 to 52.

The BIS/BAS Scales (Carver & White, 1994) have been described as the most often used scale to measure and evaluate Gray's Reinforcement Sensitivity Theory (RST) systems (Torrubia, Avila, & Caseras, 2008). However, it is acknowledged that Gray's theory (Gray, 1970) was recently revised to include the Fight/Flight/Freeze System (FFFS) (Gray & McNaughton, 2000), which the BIS Scale was not designed to measure. Whilst some authors have re-examined the BIS Scale and successfully separated a BIS (four items) and FFFS factor (three items) from the original BIS Scale of seven items, such as Heym et al. (2008), caution has been recommended in following this lead due to the limited number of items in each scale (Dissabandara, Loxton, Dias, Daglish, & Stadlin, 2012). Furthermore, the concepts underpinning the hypotheses are based upon evidence that has accumulated from the use of the BIS Scale as a single factor. Therefore the original BIS Scale was chosen for this research. Other reasons for choosing the BIS/BAS Scales are outlined on pp. 87 - 88.

Psychometric findings support the reliability and the four-factor structure of the BIS/BAS Scales. The BIS Scale has been shown to possess good reliability (Portney & Watkins, 2009) ranging from 0.74 (Carver & White, 1994) to 0.83 (Cooper, Perkins, & Corr, 2007) and moderate to good reliability for the BAS subscales of: BAS-Drive (BAS-DR) 0.76 (Carver & White, 1994) to 0.83 (Heubeck, Wilkinson, & Cologon, 1998), BAS-Reward responsivity (BAS-RR) 0.65 (Jorm et al., 1999) to 0.73 (Carver & White, 1994) and BAS-Fun-seeking (BAS-FS) 0.66 (Carver & White, 1994) to 0.76 (Meyer, Johnson, & Winters, 2001). The three BAS subscales have been shown to load onto a single BAS factor (Carver & White, 1994). Independent studies have also supported the one-dimensional nature of the BAS Scale. The BAS has been shown to reflect a higher-order behavioural activation factor, with strong loadings of all three BAS subscales (.59 to .77) on a single higher-order BAS factor (Campbell-Sills, Liverant, & Brown, 2004). Furthermore, studies using the single BAS Scale have reported good reliability coefficients, ranging from 0.81 (Dietrich et al., 2014) to 0.88 (Davis, Patte, et al., 2007). The BIS/BAS Scales (Carver & White, 1994) have demonstrated good test-retest reliability over an 8-month period in both depressed and non-depressed individuals, with coefficients ranging from .62 to .92 (Kasch, Rottenberg, & Arnow, 2002).

The validity of the scales' four-factor structure, of one BIS Scale and 3 BAS subscales was originally reported by Carver and White (1994) and has since been independently validated via confirmatory factor analysis by other studies (Campbell-Sills et al., 2004; Gomez & Gomez, 2005; Heubeck et al., 1998). This four-factor structure has also been supported across cultures (Leone, Perugini, Bagozzi, Pierro, & Mannetti, 2001). The BIS/BAS Scales show good convergent and discriminant validity (Carver & White, 1994; Jorm et al., 1999).

The BIS/BAS Scales are not the only scales that have been developed to measure sensitivity or reactivity within Gray's RST (Gray, 1970). Another popular scale in use is the Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ) developed by Torrubia et al (Torrubia et al., 2008; Torrubia et al., 2001). While there is some debate in the literature about which is the more appropriate measure (Caseras, Àvila, & Torrubia, 2003), a review of the results of purposely-constructed BIS and BAS measures has found that both the BIS/BAS Scales (Carver & White, 1994) and the SPSRQ (Torrubia et al., 2001) have predictive capability in the laboratory setting (Torrubia et al., 2008). Therefore, both the BIS/BAS Scales and the SPSRQ were deemed suitable for assessing reactivity within Gray's BIS and BAS (Gray, 1970; Torrubia et al., 2008). Given support for the use of either measure, the BIS/BAS Scales were selected in this study as a measure of RST traits in order to make comparisons with previous studies, which have predominantly used the BIS/BAS Scales. Further support for the use of the BIS/BAS Scales was found in the following three areas.

Firstly, the scales developed by Carver and White (1994) have been designed to capture the emotional consequence of BIS or BAS activation. This aspect of these scales is critical to this thesis because the subjective experience of negative emotional states assumed to arise from reactivity within these systems underpins the investigations within this thesis. Secondly, the investigation of hypotheses that have been designed to investigate an individual's capability to self-regulate affect using the BIS/BAS Scales has been supported (Leone et al., 2001). Thirdly, a review by Torrubia, Avila and Caseras (2008), which investigated the predictive capability of both scales in the laboratory setting has reported that both Carver and White's BIS and BAS Scales are 'very good' at predicting self-reported affect in the laboratory setting, whilst there was 'insufficient data' to report on the predictive ability of the SPSRQ. Moreover, this research will be undertaken in an Australian population; the BIS/BAS Scales have been validated in an Australian population and normative scores have been generated (Jorm et al., 1999). It is for these reasons that the BIS/BAS Scales were chosen for this research instead of the SPSRQ. Finally, the single BIS Scale was used throughout as a combined BIS/FFFS factor representing an overarching factor of sensitivity to punishment (Corr, 2004). It is acknowledged that the BIS Scale from Carver and White measures both factors of the BIS and the FFFS from the revised RST (Gray & McNaughton, 2000); however, for ease of communication, the BIS/FFFS factors will be referred to as the one BIS factor from here on.

Regulative temperament

The short form Effortful Control (EC) Scale is a subscale from the Adult Temperament Questionnaire (ATQ) (Evans & Rothbart, 2007). It was employed as a measure of effortful control in all studies. The Effortful Control Scale is a 19-item measure that has been designed to assess a higher-order factor of temperament that defines an individual's capacity to exercise control over their behaviour and emotions as they interact with their external environment. The short form Effortful Control Scale is available at http://www.bowdoin.edu/faculty/s/sputnam/rothbart/pdf, upon request to the authors.

The Effortful Control Scale (Evans & Rothbart, 2007) is scored on a seven-point response scale (1 = extremely untrue of you to 7 = extremely true of you). It consists of three scales measuring attentional control, inhibitory control, and activation control. Attentional control (five items) measures the capacity to focus as well as to flexibly shift attention as needed; i.e., from punishing or rewarding stimuli (e.g. "It is very hard for me to focus my attention when I am distressed.") and scores range from 5 to 35. Inhibitory control (seven items) measures the capacity to inhibit inappropriate behaviour (e.g. "I usually have trouble resisting my cravings for food, drink, etc.") and scores range from 7 to 49. Finally, activation control (seven items) measures the capacity to perform an action that they would rather avoid (e.g. "When I am afraid of how a situation might turn out, I usually avoid dealing with it.") and scores range from 7 to 49. Higher scores indicate higher levels of effortful control.

The short-form Effortful Control Scale has been shown to be a reliable and valid measure. Construct validity of the short-form, Effortful Control Scale has been supported by exploratory factor analysis in a sample of 700 community-dwelling adults with a mean age of 58.7 years (Evans & Rothbart, 2007) and good test-retest reliabilities have been demonstrated over a two-week period for the total Effortful Control Scale (Moriya & Tanno, 2008).

3.5.2 Eating behaviour

The Dutch Eating Behaviour Questionnaire (DEBQ) (van Strien, 2002; van Strien et al., 1986) was used to measure emotional eating behaviour in study one. The 33-item DEBQ measures the three eating behaviours of external, emotional and restrained eating. Only the Emotional and External Eating Scales were utilised in study one.

The DEBQ Emotional and External Eating Scales (van Strien, 2002) were based upon two psychological theories of overeating: psychosomatic (Bruch, 1964) and externality theory (Schachter & Rodin, 1974). Psychosomatic theory has linked a lack of interoceptive awareness towards feelings of hunger and a lack of satiety to the physiological stress response; whereby emotionally aroused individuals ‘feel hungry” and eat in response to feelings of fear or anxiety. On the other hand, externality theory has linked a lack of responsiveness to physiological feelings of hunger and satiety and a hyper-responsiveness to external food cues, to overeating. Therefore, in contrast to emotional eaters, these individuals are believed to be under-responsive to internal cues and over responsive to external food cues (van Strien, 2002). In summary: the trigger for emotional eaters is the level of physiological arousal inherent to their emotionally aroused state, whilst the triggers for external eaters are salient cues within their external environment.

Whilst there are other self-report measures available to measure emotional eating, for example, the Emotional Overeating Questionnaire (Masheb & Grilo, 2006) and the more frequently used Emotional Eating Scale (EES) of Arnow, Kenardy and Agras (1995), there were two reasons why the DEBQ Emotional Eating Scale was chosen for inclusion in the first study. The first study of this thesis was an exploratory study. Therefore, at this exploratory level, a more general relationship between emotional eating and the Carver and White BIS/BAS Scales (1994) was investigated across a broad range of BMI and gender. A more specific investigation into a relationship between the BIS/BAS Scales and emotional eating relative to specific emotional states was not a part of the study design. The EES has been designed with three scales that measure emotional eating in response to three different emotional states. This is in direct contrast to the DEBQ Emotional Eating

Scale that contains items pertaining to these mood states on a unitary scale, which does not discriminate between them. Therefore, given the exploratory design of the first study, the DEBQ Emotional Eating Scale was deemed to be the most suitable due to its more general nature.

The most important reason for the use of the DEBQ Emotional Eating Scale over other alternatives, however, is the following: besides measuring emotional eating behaviour, the DEBQ also contains a scale that measures external eating behaviour. As outlined previously (section 2.6.1), the theories of emotional and external eating converge on two areas that are of interest to this thesis an individual's level of emotionality and their attenuated capacity to be sensitive to satiety signals. Therefore, both emotional and external eating behaviours may be present in overweight or obese individuals who are in possession of a reactive temperament that is not well regulated. For example, it is possible that a high degree of emotionality, such as would be expected from an individual with a reactive BIS and a low level of effortful control, would be associated with both emotional and external eating behaviours. By including the DEBQ in the first study as the questionnaire of choice, the strength of these relationships could be explored. However, given the relationship between the experience of negative affect and emotional eating, it was anticipated that the DEBQ Emotional Eating Scale would show the strongest relationship with the BIS Scale. Subsequently, whilst the DEBQ External Eating Scale was also included in the first study for exploratory purposes, the DEBQ Emotional Eating Scale was the scale upon which hypotheses were based.

The DEBQ has been reported as a reliable, stable and valid instrument (van Strien et al., 1986; Wardle, 1987). Cronbach's alpha has been shown to range from .80 to .90 for the External Eating Scale (Royal & Kurtz, 2010; van Strien et al., 1986) to 90 (van Strien, Herman, & Anschultz, 2012) and from .94 to .95 for the Emotional Eating Scale (Bekker, van de Meerendonk, & Mollerus, 2004; Royal & Kurtz, 2010; van Strien et al., 1986; van Strien, Herman, & Anschultz, 2012).

The DEBQ provides three different scales using a five-point response scale (1 = never, to 5 = very often). The Emotional Eating Scale (13 items) measures eating in response to emotionally aroused states (e.g. "Do you have the desire to eat when you are irritated?") and scores range from 13 to 65; the External Eating Scale (ten items) measures eating in response to external food cues (e.g. "If food smells and looks good, do you eat more than usual?") and scores range from 10 to 50; finally, the restrained eating scale (ten items) measures overeating behaviour that is attributed to dieting (e.g. "When you have put on weight, do you eat less than you usually do?") and scores range from 10 to 50 (van Strien et al., 1986). Raw scores for each subscale are calculated and then divided by the total number of items on each scale to provide scale scores (van Strien, 2002). The scale score from each scale provides a level of eating behaviour for each scale: higher scores indicate higher levels of eating behaviour. Normed-scale scores, for normal, overweight and obese males and females, are available from a sample of 1170 subjects studied in 1983 (van Strien, 2002).

The Three Factor Eating Behaviour Questionnaire (TFEQ) (Stunkard & Messick, 1985) is a 51-item questionnaire designed to measure eating behaviour in relation to the following three dimensions: Disinhibition (TFEQ-D), Restraint (TFEQ-R) and Hunger (TFEQ-H). The Hunger Scale was designed to measure subjective feelings of hunger. Only the Disinhibition and Restraint Scales were used in studies two (Chapter 5) and three (Chapter 6). Restraint (21 items) measures the cognitive control of eating behaviour and is considered to be a valid measure of an individual's intent to diet to control body weight by limiting intake (Williamson et al., 2007) (e.g. "How likely are you to consciously eat less than you want?"), and scores range from 0 to 21. Disinhibition (16 items) measures a loss of control over food intake (e.g. "Do you go on eating binges though you are not hungry?"), and scores range from 0 to 16. Of interest to this thesis, is that Disinhibition has more recently been defined as a measure of trait behaviour that describes the opportunistic eating behaviour of an individual with a readiness to eat (Bryant et al., 2008). Hunger (14 items) measures feelings of hunger (e.g. How frequently do you skip dessert because you are no longer hungry?"), and scores range from 0 to 14. The questionnaire is divided into two parts. The first part consists of 36 items divided into a forced choice, true/false format, whilst the second part contains 14 items that are answered with a four-point Likert Scale and one item that is answered with a five-point Likert Scale. Responses are given either a zero or a one score and then summed. Higher scores denote higher levels of Disinhibition, and Restraint and were used as continuous measures in this research. The Disinhibition and Restraint Scales have been shown to have adequate to high internal consistency, in a combined sample of males and females, with Cronbach's alpha ranging from .75 to .91 and .84 to .93, respectively (Dietrich et al., 2014; Stunkard & Messick, 1985).

As a result of findings from Study one (Chapter 4), the Disinhibition scale was chosen to determine if there was a relationship between Gray and McNaughton's BIS (Gray & McNaughton, 2000) and disinhibited eating behaviour in study two. Similarly to the two distinct DEBQ Emotional Eating and DEBQ External Eating Scales, the single TFEQ-D Scale contains items that measure both external and emotional eating behaviour (Ouwens et al., 2003; Stunkard & Messick, 1985; Wardle, 1987; Westenhoeffer et al., 1994). There were other reasons for using it. The original TFEQ-D Scale has been linked to additional factors that are of interest to this research, such as BMI, eating in response to stress and negative affect, food choice, psychological food reward (e.g. wanting and liking) (Bryant et al., 2008; Finlayson et al., 2012), and an attenuated capacity to be sensitive to satiety signals (Barkeling et al., 2007; Blundell et al., 2005; Dalton et al., 2015; Drapeau et al., 2013; Drapeau & Gallant, 2013). A further goal of this research was to follow the methodology of previously published research to determine whether specific eating behaviour subtypes, which have been previously characterised by interacting high and low levels of the original TFEQ-D and TFEQ-R Scales, were associated with high BIS and high BAS (HBIS_HBAS) and high BIS and low BAS (HBIS_LBAS) temperament phenotypes.

These eating behaviour subtypes are of interest because one subtype, which has been characterised as high in Restraint and high in Disinhibition (HDHR) loses control of eating behaviour during the experience of stress and negative affect (Haynes et al., 2003; Yeomans & Coughlan, 2009), shows evidence of disordered eating behaviour (Bryant et al., 2010) and a constrained level of BMI (Williamson et al., 1995). On the other hand, the second subtype, which has been characterised as high in Disinhibition and low in Restraint (HDLR), is susceptible to overconsumption in response to palatability (Yeomans, Tovey, et al., 2004) and attains the highest levels of BMI in the sample under investigation (Lawson et al., 1995; Williamson et al., 1995). As can be seen, these studies, which have used the original TFEQ-D and TFEQ-R Scales to characterise these eating behaviour subtypes, relative to their levels of Disinhibition and Restraint, have provided clinically informative results. These studies have shown that distinct eating behaviour subtypes, which are a function of their TFEQ-D and TFEQ-R Scale scores, can be discerned relative to their level of body mass index, disordered eating behaviour, consumption in response to stress and negative affect, and consumption in response to perceived palatability.

It is acknowledged that, based upon psychometric results, the original TFEQ presents some disadvantages in terms of its psychometric precision. Whilst factor analysis has shown evidence of construct validity for the Restraint Scale (Ganley, 1988; Hyland, Irvine, Thacker, Dann, & Dennis, 1989; Karlsson, Persson, Sjostrom, & Sullivan, 2000; Löffler et al., 2015; Stunkard & Messick, 1985), the same cannot be said for either of the TFEQ-D and the TFEQ-H Scales. (Hyland et al., 1989; Karlsson et al., 2000; Löffler et al., 2015) (Ganley, 1988; Hyland et al., 1989; Karlsson et al., 2000; Löffler et al., 2015). Based on these factor-analytic results, alternative and shortened versions of the original TFEQ have been recommended, such as the TFEQ-18 (Karlsson et al., 2000; Löffler et al., 2015). However, at the start of study two, no association between the BIS and the TFEQ-D Scale, in any of its possible forms had been reported in the literature. Subsequently, there was concern that by reducing the number of items on the TFEQ-D Scale or the TFEQ-R Scale to improve psychometric performance, as has been recommended (Karlsson et al., 2000; Löffler et al., 2015), that valuable information may be lost.

In light of the wealth of evidence that has accumulated with the use of the TFEQ in its original form and, despite the potential for a loss of precision, (i.e., it is acknowledged that an emotional eating factor remains nested within the original TFEQ-D Scale and that the number of items on both the TFEQ-D and the TFEQ-R Scale will not be reduced), it was determined it would be more informative to investigate whether a relationship existed between the BIS and the original TFEQ-D Scale as it is currently conceptualised: as a trait that shows a disposition towards opportunistic eating behaviour. Therefore, in order to add to the current body of literature, to allow for the best possible interpretation of outcome, and to explore the results of other researchers who have used the original TFEQ-D Scale relative to associations of interest, the original TFEQ was used in studies two (Chapter 5) and three (Chapter 6). It was anticipated that doing so would allow for the exploration of any possible associations that may be found, relative to either trait Disinhibition or the eating behaviour subtypes (e.g. of HDHR or HDLR).

The Binge Eating Scale (BES) (Gormally et al., 1982) was used as a measure of binge-eating severity in study one and study three. The BES was developed to measure severity of binge-eating amongst obese persons (Gormally et al., 1982). It is a 16-item scale containing three to four numbered statements per item. It contains eight items that assess binge-eating behaviour (e.g. “I have the habit of bolting down my food, without really chewing it. When this happens I usually feel uncomfortably stuffed because I’ve eaten too much.”), and eight items that assess feelings around binge-eating episodes (e.g. “Because I feel so helpless about controlling my eating I have become very desperate about trying to get in control.”). Participants are requested to read each statement in each item and to choose the response that best describes the way they feel about the problems they have controlling their eating behaviour. Scores are summed to produce a total measure of binge-eating tendency and range from 0 to 46. Higher scores indicate higher levels of binge-eating severity. It is considered a valid measure for determining the severity of uncontrolled eating behaviour (Timmerman, 1999), has the capacity to identify problematic eating behaviour in individuals not meeting the criteria for BED (Greeno, Marcus, & Wing, 1995), and has recently shown excellent performance in discriminating between clinically significant cases of binge-eating behaviour in a sample of non clinical females (Duarte, Pinto-Gouveia, & Ferreira, 2015). Moreover, the following cut-offs to determine binge-eating severity in obese individuals have been recommended: mild < 17, moderate 18 to 26 and severe ≥ 27 (Marcus, Wing, & Hopkins, 1988). In related research, the measure has been used to identify a normal weight and obese phenotype that is susceptible to over-consumption (Dalton et al., 2013a; Finlayson et al., 2011). It was chosen for use in studies one and three to determine if any level of binge-eating behaviour was detectable in the sample under investigation.

The Binge Eating Scale has sound psychometric properties. The internal consistency of the scale has been shown to range from 0.88 in a general sample of women (Duarte et al., 2015) to .89 in a clinical sample of obese women seeking treatment for obesity (Freitas, Lopes, Appolinario, & Coutinho, 2006), and it has recently demonstrated very good construct reliability and convergent validity in a general population of females (Duarte et al., 2015).

3.5.3 Determinants of negative affective states

Emotional eating is based on the psychosomatic theory of overeating, which purports that emotional eating occurs as an inappropriate response to the experience of negative, emotionally-aroused states such as stress or anxiety (Bruch, 1961; van Strien, 2002). In support of this conceptualisation, the intake of highly palatable food has been shown to occur in individuals during the experience of negative emotional states ranging from the experience of stress/negative mood through to symptoms of anxiety and depression (Fay & Finlayson, 2011; Konttinen, Mannisto, Sarlio-Lahteenkorva, Silventoinen, & Haukkala, 2010; Schneider et al., 2010; Wallis & Hetherington, 2004).

The following measures have been associated with the BIS and emotional eating behaviour. However, none of these measures have been previously interacted with the BIS/BAS Scales to determine if higher levels of reactivity within the BIS and the subsequent experience of negative emotionality will predict eating behaviour. Therefore, the following scales, which capture the strength of an individual's level of negative emotionality, were used to determine if they would interact with Carver and White's BIS/BAS Scales (1994) to predict emotional eating behaviour in study one. The scale that was shown to have the strongest association with the DEBQ Emotional Eating Scale (van Strien et al., 1986) in study one was used in the analysis. Consequently, the analysis in study one was designed to determine if an individual who was predisposed to experience negative emotionality (arising either from trait anxiety, negative affect or perceived stress) would show higher levels of emotional eating behaviour.

The State-Trait Anxiety Inventory Trait Scale (STAI-T) was used to measure trait anxiety (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1977). The STAI-T is a 20-item measure designed to assess a personality disposition towards the experience of state anxiety during stressful experiences. The scale is scored on a four-point response scale (1 = almost never to 4 = almost always). Instructions for the Trait format request that participants indicate how they feel in general to scale items (e.g. "I feel nervous and restless", "I feel like a failure"). Higher scores indicate higher levels of trait anxiety and the total score is calculated by summing the totals of all of the items, after taking into account reverse-scored items. The STAI-T provides a continuous score of trait anxiety that ranges from 20 to 80. The STAI-T is a well validated, reliable, stable and widely-used measure of trait anxiety, which has good validity and test-retest reliability over a two week period (McDowell, 2006). Cronbach's alpha for the STAI-T scale has been shown to range from .89 (Slessareva & Muraven, 2004) to .92 (Gomez & Gomez, 2005), in related research.

A positive correlation is expected between the Carver and White BIS Scale (1994) and the Trait Anxiety Scale, given the theoretical and empirical relationship between the BIS and anxiety (Corr, 2008; Gray, 1970; Zinbarg & Yoon, 2008) and the knowledge that this measure has been used to measure reactivity within the BIS (Torrubia et al., 2008). However, it is not synonymous with this RST dimension (Torrubia et al., 2008), nor can it be considered an equivalent measure to Carver and White's BIS Scale (Carver & White, 1994). Amongst other reasons, the STAI-T taps an individual's general level of anxiety (e.g. "I am happy" (reversed-scored)) as opposed to the Carver and White BIS Scale, which assesses their predisposition to experience anxiety (e.g. "I feel worried when I think I have done poorly at something important"). In the literature, it has been significantly associated with the BIS Scale (Hofmann & Kim, 2006; Slessareva & Muraven, 2004), shown to predict greater food intake in response to the induction of an anxious state in obese individuals, when compared to lean individuals (Schneider et al., 2010), and it has been associated with low self-control in individuals high in RST's BIS (Slessareva & Muraven, 2004).

The Perceived Stress Scale (PSS) was used to measure psychological stress. The PSS 10 item scale was used in this research. It measures the degree to which situations in an individual's life are perceived as stressful during the last month (S. Cohen, Kamarck, & Mermelstein, 1983). Instructions for the PSS request that participants indicate how often they felt or thought in a certain way over the last month (e.g. "In the last month, how often have you been upset because of something that happened unexpectedly?"). Answers are scored on a five-point response scale (0 = never to 4 = very often). The PSS provides a continuous score of perceived stress that ranges from 0 to 40. The total score is calculated by summing the totals of all of the items, after taking into account reverse-scored items, and higher scores indicate higher levels of perceived stress. The PSS has been reported to have acceptable reliability (Cronbach's alpha of .78) and construct validity in a large U.S. community sample (S. Cohen & Williamson, 1988). Other related studies have reported

Cronbach's alpha ranging from .87 (Groesz et al., 2012) to .89 (Grossniklaus, Gary, Higgins, & Dunbar, 2010).

Although the BIS Scale has not been directly associated with the Perceived Stress Scale, individuals with a high level of BIS sensitivity have been shown to experience a greater level of unpleasant affect when engaged with stressful aversive tasks (Heponiemii et al., 2003) and the experience of anxiety is a psychological stressor (McEwan & Stellar, 1993). Moreover, perceived stress has been associated with BMI, higher palatable food intake, and disinhibited eating behaviour in women of normal to obese weight (Groesz et al., 2012). Furthermore, individuals with high levels of emotional eating have been shown to consume more energy dense foods in response to a stressful manipulation, when compared to individuals with low levels of emotional eating (Oliver, Wardle, & Gibson, 2000) Therefore, it is feasible that individuals with a high level of BIS sensitivity may react to the perception of a stressful situation with a higher level of emotional eating.

The Brief Positive Affect and Negative Affect Schedule (PANAS) was used to measure symptoms of positive and negative affect (Watson, Clark, & Tellegen, 1998). The PANAS consists of two scales that measure positive affect (PA) and negative affect (NA). The scales are scored on a five-point response scale (1 = very slightly or not at all to 5 = extremely). Each PA and NA scale consists of 10 items (e.g. 'interested' indicating a measure of positive affect and 'irritable' indicating a measure of negative affect). Measures of positive and negative affect were recorded using the 'trait' measure of positive and negative affectivity. Participants were asked to read each item and then to indicate to what extent they generally feel this way, e.g. how they felt on the average. The PANAS provides a continuous score of both positive and negative affect that ranges from 10 to 50. The total score for each scale is calculated by summing the totals of each corresponding item. Higher scores indicate higher levels of affect.

Psychometrically, it has acceptable reliability, with Cronbach's alpha ranging from 0.86 to 0.90 for PA and from 0.84 to 0.87 for NA, excellent factorial, convergent and discriminate validity and appropriate levels of stability over a two-month period (Watson et al., 1998). The experience of negative affect has been positively associated with both emotional eating behaviour (Spoor, Bekkerb, Van

Strien, & van Heck, 2007), and the Carver and White BIS Scale (Carver & White, 1994; Jorm et al., 1999).

3.5.4 Impulsive behaviour and emotion regulation difficulties

The UPPS Impulsive Behaviour Scale was developed from the conceptualisation by Whiteside and Lynam (2001) that various personality traits give rise to a general factor of impulsive behaviour. In developing the scale, their desire was to clarify whether the multifaceted construct of impulsivity, which is currently measured by various instruments, can be separated into different personality pathways that lead to impulsive responding.

An aetiology of interest to this research is trait negative urgency, which was linked to the personality domain of Neuroticism and its associated impulsivity facet by Whiteside and Lynam (2001). Given the strong correlations reported between Gray and McNaughton's BIS/FFFS, and the NEO-PI-R Five Factor Model's (P. T. Costa & Mc Crae, 1992) Neuroticism Scale and the weak to moderate correlation with its impulsivity facet (Keiser & Ross, 2011), it is conceivable that impulsive eating behaviours, which arise from trait Neuroticism, may stem from a reactive BIS. However, this possibility has not yet been explored in the literature; therefore, it is of interest to this thesis that Whiteside and Lynam (2001) developed the trait Urgency subscale, which measures the extent to which the experience of intense negative affect leads to impulsive behaviours that serve an emotion-regulatory function.

The UPPS is a 46-item inventory measuring four different personality pathways to impulsive behaviour and it was used in study one (S. Whiteside & Lynam, 2001). It contains four scales, which are scored on a four-point response scale (1 = agree strongly, to 4 = disagree strongly), and evaluates four facets of impulsivity: Urgency (12 items) measures "the tendency to experience strong impulses, frequently under conditions of negative affect" (e.g. "I have trouble resisting my cravings for food, cigarettes, etc", or "when I feel bad, I will often do things I later regret in order to make myself feel better now", or "when I am upset, I often act without thinking") and scores range from 4 to 48; (lack of) Premeditation (11 items) measures "the tendency to think and reflect on the consequences of an act, before engaging in the act" (e.g. "I have a reserved and cautious attitude towards life.") and scores range from 4 to 44; (lack of) Perseverance (10 items), measures "an individual's ability to remain focussed on a task that may be boring or difficult" (e.g.

“I generally like to see things through to the end.”) and scores range from 4 to 40; and finally, Sensation Seeking (12 items) measures “a tendency to enjoy and pursue activities that are exciting and an openness to trying new experiences that may or may not be dangerous” (e.g. “I generally seek new and exciting experiences and sensations.”) and scores range from 4 to 40. Higher scores indicate higher levels of impulsivity.

Exploratory factor analysis in the original validation study produced a robust four-factor solution and good convergent (0.38 to 0.70, *M* = 0.58) and divergent (.05 to .33, *M* = .17) validity of the four subscales was reported, alongside moderate to high internal consistency coefficients ranging from 0.82 (Sensation seeking) to 0.91 (Urgency) (S. Whiteside & Lynam, 2001). Subsequent independent studies have validated the four-factor structure via confirmatory factor analysis, with evidence that the four-factor solution displayed acceptable and good fit to the data in a French and German sample (Kämpfe & Mitte, 2009; Van der Linden et al., 2006). Finally, convergent, discriminative and differential validity has been demonstrated in two independent studies of undergraduate students (J. Miller, Flory, Lynam, & Leukefeld, 2003) and a community sample (S. Whiteside, Lynam, Miller, & Reynolds, 2005). The internal consistency of the scale of interest to this study, the Urgency subscale, has been shown to have Cronbach’s alpha that ranges from .88 in a non-clinical sample of overweight/obese (Mobbs et al., 2010) to .92 in a clinical outpatient sample of individuals attending a mental health clinic (M. D. Anestis et al., 2009).

The Urgency subscale was the only measure used in this research for the following reasons: it has been found to be the strongest predictor of eating problems in a study designed to test the convergent and discriminant validity of the UPPS measure (J. Miller et al., 2003) and subsequent studies have confirmed its capacity to predict the occurrence of bulimic symptoms, when controlling for the other UPPS impulsivity scales (Michael D. Anestis et al., 2007; M. D. Anestis et al., 2009). Importantly, the Urgency subscale reflects a tendency to commit “rash or regrettable actions as a result of intense negative affect” (S. Whiteside & Lynam, 2001, p. 677). Therefore, items on the Urgency subscale reflects its utility to tap behaviours related to an inability to regulate emotion and simultaneously manage behaviours, e.g. “When I am upset, I often act without thinking”, and it also includes items that reflect the engagement with impulsive behaviours that provide an emotion regulatory effect, e.g. "When I feel bad, I will often do things I later regret in order to make myself feel better now". Consequently, the Urgency subscale captures an individual's difficulty to control behaviours during the experience of an aversive state.

As outlined previously, an individual's level of BIS sensitivity will be assessed relative to an overarching hypothesis that unregulated affect from a reactive BIS may motivate 'maladaptive' eating behaviours, such as emotional and disinhibited eating. Alongside the interpretation that a reactive BIS may lead to maladaptive behaviour is the theoretical assumption that an individual will also show a reduced capacity to exert effortful control and, furthermore, experience difficulty regulating their emotions. However, it is not known which combination of constructs will predict eating behaviours that may serve an emotion-regulatory function; i.e., it is not known if the Urgency subscale will predict eating behaviour beyond the BIS, Effortful Control Scales, the Difficulty in Emotion Regulation Scale (DERS) (Gratz & Roemer, 2004) and pertinent DERS subscales, such as the DERS-Impulse or DERS-Goals subscales, which measure a similar construct. The findings from study one determined if this measure was to be used in future studies.

The Difficulties in Emotion Regulation Scale (DERS) (Gratz & Roemer, 2004). The DERS was developed to comprehensively assess emotion dysregulation within the following interrelated dimensions of emotion regulation: the understanding of emotions, the awareness and acceptance of emotions, a capacity to engage in goal-directed behaviour and to abstain from acting impulsively when experiencing negative emotions, and access to effective emotion-regulation strategies. It was employed to measure difficulty in emotion regulation in all studies.

The DERS is a 36-item scale with a five-point option response scale 1 = almost never (0 - 10%) to 5 = almost always (91 – 100%). It measures general emotion regulation difficulties (total score, range from 36 to 180) as well as six sub factors that are interrelated and assesses emotion dysregulation across the following six domains: Non-acceptance of emotional responses (Non-Acceptance six items), measures "the tendency to have negative secondary emotional responses to one's negative emotions or non-acceptance in reactions to one's distress" (e.g. When I'm upset, I feel like I am weak") and scores range from 6 to 30; Difficulties engaging in goal-directed behaviour when upset (one item reversed scored) (Goals, five items) measures "difficulties concentrating and accomplishing tasks when experiencing negative emotions" (e.g. "When I'm upset, I have difficulty thinking about anything else") and scores range from 5 to 25; Lack of emotional awareness (All reverse-scored) (Awareness, six items) measures "the tendency to attend to and acknowledge emotions" (e.g. "I pay attention to how I feel") and scores range from 6 to 30; Limited access to emotion-regulation strategies (one item reversed scored) (Strategies, eight items) measures "the belief that there is little that can be done to regulate emotions effectively, once an individual is upset" (e.g. "When I'm upset, I believe that I'll end up feeling very depressed", and scores range from 8 to 40; Impulse control difficulties (one item reverse scored) (Impulse, six items) measures "difficulties remaining in control of one's behaviour when experiencing negative emotions" (e.g. "When I'm upset, I lose control over my behaviours") and scores range from 6 to 30; and, finally, a lack of emotional clarity (two items reversed scored) (Clarity, five items), measures "the extent to which individuals know (and are clear about) the emotions they are experiencing (e.g. I have no idea how I am feeling") and scores range from 5 to 25 (Gratz & Roemer, 2004). A higher score on the subscales and total scales indicates greater difficulty in regulating emotion.

In the original study using common factor analysis, the measure showed an interrelated six-factor structure, which reflects the multidimensional nature of the emotion-regulation dimensions upon which this scale is based. The DERS Scale showed high internal consistency with a Cronbach's alpha of 0.93, and all subscales had adequate internal consistencies with Cronbach's alpha all greater than 0.80. The DERS scale demonstrated good test-retest reliability, ($r = 0.88$), whilst the six subscales showed adequate test-retest reliability with Pearson's r ranging from .57 to .89, and adequate construct and predictive validity in a non-clinical sample (Gratz & Roemer, 2004). In independent studies the DERS has shown good construct validity (Fowler et al., 2014; Ritschel, Tone, Schoemann, & Lim, 2015). The DERS Scale has shown high internal consistency (Cronbach's alpha ranging from .93 to .95) and the subscales moderate to high internal consistencies (Cronbach's alpha that ranges from .74 to .90) in male and female samples (Fowler et al., 2014; Lafrance, Kosmerly, Mansfield-Green, & Lafrance, 2014; Ritschel et al., 2015). Although there has been mixed research findings about the utility of a six- vs. five-factor structure, where the latter removes the Awareness subscale (Bardeen, Fergus, & Orcutt, 2012), recent research suggests continued use of the six-factor structure (Fowler et al., 2014). In light of these findings and the caution recommended by Fowler not to discard information until there is stronger evidence to do so, the DERS-Awareness subscale will be included within this research.

The construct of effortful control has been linked to the use of effective emotion regulation strategies and behavioural outcomes, as evidenced by its inverse association with measures of negative emotionality (Rothbart & Rueda, 2005) and its positive association with self-regulatory behaviours (Rothbart et al., 2010). Moreover, it is noteworthy that the construct of effortful control has been related to an individual's capacity to control their attention whilst they are emotional (Evans & Rothbart, 2007). Therefore, as discussed in Chapter 2 section 2.4, an individual's capacity to control their behaviour will be limited by their capacity to control their attention. Subsequently, the administration of the DERS scale, and its six subscales in this research, alongside the measure of effortful control and its three subscales, provides an opportunity to determine where an individual's perceived deficit in eating behaviour control will be found, relative to a reactive BIS. For example, which type of emotion regulation or effortful-control deficit do they possess? Furthermore, given effortful control's theoretical relationship to emotion regulation, which measure is more predictive of eating behaviour: effortful control or emotion regulation difficulties? Including both scales in studies one and two allowed for the teasing apart of these relationships.

3.5.5 Appetite measures

The Leeds Food Preference Questionnaire (LFPQ) (Finlayson et al., 2007) was used in studies two (Chapter 5) and three (Chapter 6) to measure the psychological components of food reward and preference. The LFPQ is a validated, computerised, behavioural task measuring preference for specific food categories and the psychological components of food reward: wanting and liking (Finlayson et al., 2007, 2008).

The terms 'wanting' and 'liking' are conceptualised as psychological constructs that are interrelated and together describe an individual's hedonic response towards food. The term 'explicit liking' describes an individual's conscious perception of sensory pleasure or expected pleasure that a food will provide and it establishes the motivational value of food. The term explicit wanting on the other hand, describes a conscious, subjective feeling of attraction or desire triggered by the perception of a particular food item or food cue in the environment. This component of food reward may also operate on an automatic, unconscious or implicit level. The construct of implicit wanting reflects unconsciously motivated food-reward behaviour. This psychological construct is thought to explain why an individual who likes a wide variety of foods may be unconsciously motivated to consume one food over another (Dalton & Finlayson, 2013, 2014).

In combination, the psychological components of wanting and liking provide a measure of the reward value of food. However, it is also possible to measure these components separately to determine if they differ by degree or even dissociate when investigating eating behaviour or levels of BMI. For example, using the LFPQ, Finlayson, King and Blundell (2008) found that implicit wanting could be dissociated from homeostatic hunger and more recent research has shown that higher levels of wanting and liking are linked to food choice, food intake (Griffioen-Roose, Finlayson, Mars, Blundell, & de Graaf, 2010; Griffioen-Roose, Mars, Finlayson, Blundell, & de Graaf, 2011; Verschoor, Finlayson, Blundell, Markus, & King, 2010), a dysregulated appetite (Dalton et al., 2013a; Finlayson et al., 2011) and an increased risk for obesity (Dalton & Finlayson, 2014).

The LFPQ has been used to successfully uncouple wanting and liking in trait binge normal weight, obese (Dalton et al., 2013a; Finlayson et al., 2011), and disinhibited eaters (Finlayson et al., 2012). These findings support its suitability for identifying which food reward behaviours may be enhanced in individuals with higher levels of these eating behaviours. The LFPQ has also been shown to discriminate between individuals rated as high and low in anxiety relative to their levels of liking (Verschoor et al., 2010). Psychometrically, it has acceptable test-retest reliability ($r = 0.61$ to 0.95) measured upon immediate repetition and up to one week later (Finlayson et al., 2011), and its concurrent validity with other measures of food reward has been reported as satisfactory (Finlayson et al., 2011).

The behavioural task: To measure explicit liking and implicit wanting, participants were presented with a total of 16 visual images of common food items. The visual images provided represent four different taste and fat categories. Foods rated as high in fat provide greater than 50% of energy from fat whilst foods low in fat provide less than 20% of their total energy from fat. There are four food categories in the experiment: high-fat savoury (HFSA), high-fat sweet (HFSW), low-fat savoury (LFSA) and low-fat sweet.

The foods used in this experiment can be found in Table 3.2 and in Appendix B. Participants' responses to the visual images are recorded and provide the mean scores for explicit liking and implicit wanting of these four food categories.

Table 3.2

Photographic Food Stimuli used in the Leeds Food Preference Questionnaire in the assessment of Explicit Liking and Implicit Wanting

Savoury		Sweet	
High Fat	Low fat	High Fat	Low Fat
Potato crisps	Pasta: tomato sauce	Cheese Cake	Nectarine
Hamburger	Green capsicum	Apple Strudel	Strawberries
French fries	Broccoli	Milk chocolate	Jelly Beans
Fried drumsticks	Tomato	Choc chip biscuits	Apple

Motivation for the foods presented is assessed by a forced choice methodology whereby each image of a food are paired so that each image from each of the four food categories is compared to every other food category over a total of 96 trials. Participants are instructed to respond as quickly and as accurately as they can by a key press to the prompt "Which food do you most want to eat now (Figure 3.1)?"

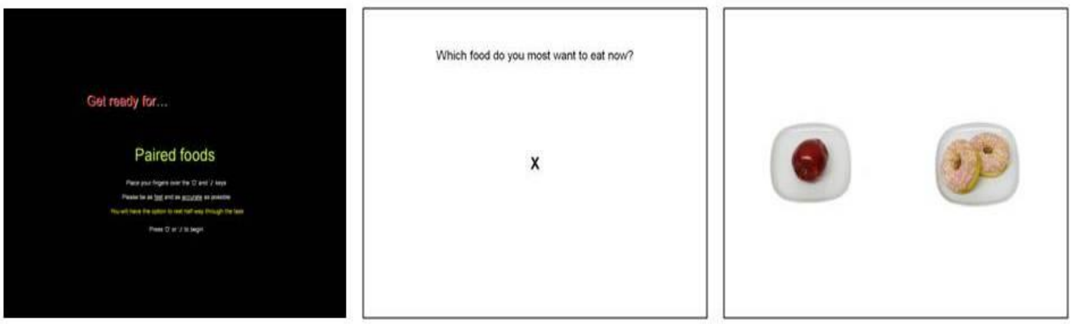

Figure 3.1. Schematic of the implicit wanting trials in the LFPQ.

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The parameters for this part of the experiment are configured to provide 96 randomised food-pair trials that are conducted over three blocks. In this forced-choice paradigm, implicit wanting is assessed covertly by measuring the time taken to choose a particular food category. The reaction time for food selection is measured in milliseconds and responses for each food contribute towards the mean response for each food. In order to adjust for the total variability in reaction time and the speed and frequency with which each food is chosen, a 'Frequency Weighted Algorithm' has recently been developed (Dalton & Finlayson, 2014). The algorithm allows for the implicit wanting score to be adjusted for both selection, which positively contributes towards the score, and non-selection, which negatively contributes towards the score of the food chosen. A positive score indicates a faster reaction time towards the preferred food category and a negative score indicates the opposite. A score of zero indicates that both paired categories are preferred equally.

An appeal-bias score, as an alternative to the frequency-weighted algorithm score, can also be used to measure implicit wanting (Dalton & Finlayson, 2014; French et al., 2014). To calculate the appeal bias for high-fat foods; mean low-fat implicit wanting scores are subtracted from mean high-fat implicit wanting scores. In this manner, an appeal bias for high-fat versus low-fat foods is indicated by a positive value; whilst, a negative value indicates a bias for low-fat foods. A score of zero indicates equal preference. The inter-correlations for both implicit wanting measures have been rated as very high ($r = > .9$) (Dalton & Finlayson, 2014).

Explicit liking and explicit wanting are measured with 100mm visual analogue scales. Participants are requested to respond to the prompts "How pleasant would it be to taste some of this food now?" and "How much do you want some of this food now?" by mouse click on a visual analogue scale presented beneath each food item. The scales are anchored at either end with 'not at all' and 'extremely', to provide a measure of liking and wanting, respectively (Figure 3.2). Foods are presented in a randomized order. To calculate scores, category means are obtained by averaging the ratings of each food within its particular category; i.e. high-fat sweet (HFSW) or high-fat savoury (HFSA) for each participant. A higher score indicates a higher level of explicit liking and wanting for each category measured.

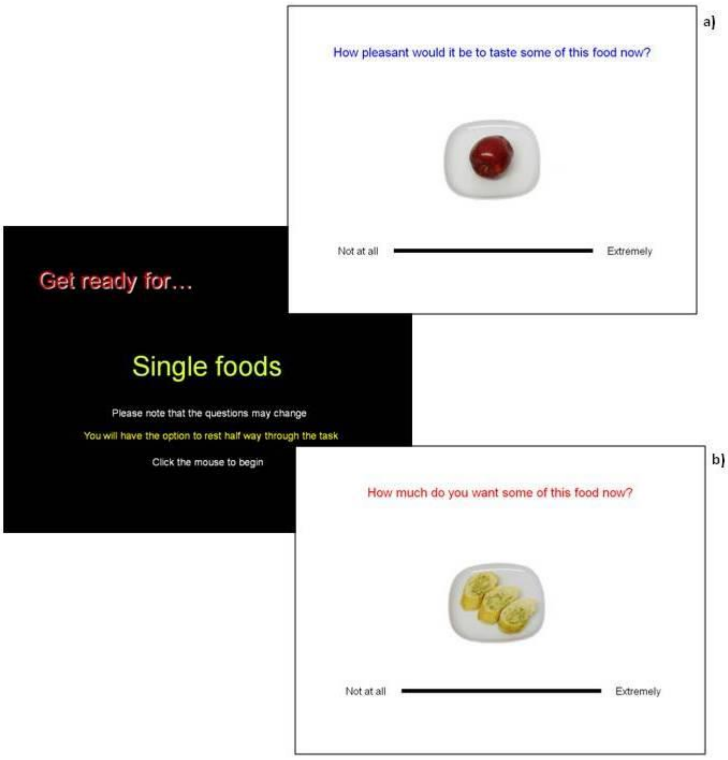


Figure 3.2. Schematic of the explicit liking (a) and explicit wanting (b) trials in the Leeds Food Preference Questionnaire.

Reprinted from "Psychobiological examination of liking and wanting for fat and sweet taste in binge-eating females", by M. Dalton and G. Finlayson, 2014, Physiology & Behavior, 136 (2014), 128 – 134. Copyright 2014 by Elsevier.

3.6 DATA ANALYSIS

This section outlines the data analysis procedures for outcome measures and statistics that were undertaken in more than one study. When a data analytic procedure was unique to a single study, the details of its analysis are reported in the relevant chapter. All data were analysed using SPSS (IBM SPSS Statistics for Windows, Version 22.0, Armonk, NY: IBM Corp, released 2013). Outcome data from the LPFQ in studies two and three were collected using the experimental software E-prime (v.2.10.242 (200), Psychology Software Tools, ND) and exported to Microsoft Excel via E-Data Aid. Data from the online surveys in studies two (Chapter 5) and three (Chapter 6) were exported from the KeySurvey platform to Microsoft Excel and then imported to SPSS.

Across all three studies, the normality of data, prior to conducting t-tests was assessed using a z score to screen for normality. The z score was obtained by dividing the values for skewness and kurtosis by their standard errors. A value +/- 1.96 was used to indicate that the data was not normally distributed (H.-Y. Kim, 2013) and such data were analysed using suitable non-parametric tests.

In all three studies, associations between the dependent and predictor variables were examined for linear relationships using scatter plots. The strength of associations were determined using Pearson's correlation coefficient or Spearman's correlation coefficients, depending upon the linearity of the data. Effect sizes were reported as small: r = .10 - .29, medium: r = .30 - .49 and large: r = .50 – 1.0, following the recommendation of Cohen (J. Cohen, 2013). Categorical variables were summarised and presented as counts and percentages and continuous variables were presented as means (*M*) and standard deviations (*SD*), or medians (*Mdn*) and inter-quartile ranges (*IQR*), when assumptions of normality were not met.

In all three studies, independent sample t-tests were used to assess the differences between groups on variables of interest, or the non-parametric alternative where appropriate (e.g. the Mann-Whitney U test). Effect sizes for the independent t-tests were reported as small (d =0.2), medium (d = .50) and large (d = 0.80); for the Mann-Whitney U test as small (r = .10), medium (r = .30) and large (r = .50), following the recommendation of Cohen (J. Cohen, 2013).

Hierarchical, multiple-linear regression in studies one (Chapter 4) and two (Chapter 5) was used to assess the strength of the effect of predictors on the dependent variable. The regression models were run and subsequently checked for violation of assumptions. Violation of the assumptions of normality, linearity, outliers, homoscedasticity and independence of residuals was checked via visual inspection of the normal probability plot and the scatter plot of the residuals. An absence of multicollinearity was checked by establishing that the variance inflation factor was less than 10 (Pallant, 2013). In the analyses that investigated an interaction or mediation effect in studies two and three, all continuous variables were centred following the method of Aiken and West (1996). When investigating the effect of an interaction, independent variables were entered into the model in a series of steps, following the methodology of Dinovo and Vasey (2011). Interactions were probed using the PROCESS Macro Plug-in for SPSS from Hayes (2013). When investigating the effects of mediation, the following criteria were used according to the statistical procedures of Baron and Kenny (1986): 1) the independent variable significantly predicts the mediator; 2) the mediator significantly predicts the dependent variable; and 3) the independent variable significantly predicts the dependent variable, but this relationship is reduced and/or loses significance when the mediator is entered as an independent variable in a multiple regression model. The Sobel test from the Preacher and Leonardelli (2010 - 2015) internet-based utility was used to determine if the mediation effect was statistically significant: http://www.quantpsy.org/sobel/sobel.htm).

3.7 DATA MANAGEMENT

3.7.1 Data cleaning

To minimize errors within the data set, all variables, including all of the individual items that made up the scales, were inspected using the frequency distribution and the explore function within SPSSS, prior to analysis (Pallant, 2013). Any outliers and errors found were checked against the original data.

3.7.2 Missing data

Missing data were managed in two steps: the first step determined if there was a pattern to the missing data; i.e. whether the data were missing completely at random (MCAR) or missing not at random (MNAR), using Little's MCAR Chi-Square statistic (Tabachnick & Fidell, 2013). The second step was to manage missing data according to the findings of the first step.

Study one was the only dataset to have missing data, as participants filled out their self-report questionnaires by hand. In studies two (Chapter 5) and three (Chapter 6) participants completed the self-report questionnaires on a desktop computer. If any items were missed, the computer program prompted them to make a response. When a large number of items were missed (i.e. due to 50 percent or more of the items being missed on one questionnaire), the participant was removed from the data set.

Chapter 4: Psychological markers of susceptibility to weight gain: what is the role of temperament in the aetiology of obesity?

4.1 EXECUTIVE SUMMARY OF MAIN OUTCOMES

1. BAS was not significantly associated with emotional eating behaviour in males or females
2. Higher levels of BIS were significantly associated with higher levels of emotional eating in males and external eating in females
3. High trait anxiety predicted higher emotional eating when both BIS and BAS were concurrently high but not when BIS levels were high and BAS levels were low.
4. High BIS attenuated high effortful control when BAS was low, and predicted higher emotional eating behaviour.

4.2 INTRODUCTION

When this study was conducted, no studies had investigated whether a relationship existed between the BIS, emotional and external eating behaviour. Research that had considered the psychobiological characteristics of emotional eating behaviour had done so with a focus on the BAS (Davis, Curtis, et al., 2007; Davis, Patte, et al., 2007; Davis, Strachan, et al., 2004; Dawe & Loxton, 2004; Franken & Muris, 2005; Nederkoorn, Van Eijis, & Jansen, 2004). It is only recently that the BIS has been linked with BMI, emotional and external eating behaviours (Delgado-Rico et al., 2012; Hennegan et al., 2013; Matton et al., 2013; Stapleton & Whitehead, 2014) and, whilst findings have been consistent for a relationship between the BIS and external eating behaviour, they have been mixed for a relationship between the BIS, emotional eating (Hennegan et al., 2013; Stapleton & Whitehead, 2014) and BMI (Delgado-Rico et al., 2012; Stapleton & Whitehead, 2014).

Derryberry and Rothbart (1997) have conceptualised temperament as arising from the integration of regulative and reactive brain processes that collectively describe individual differences in reactivity and self-regulation (Rothbart et al., 2013). Within this psychobiological model of temperament, an individual's capacity to self-regulate their emotions and their resultant behavioural outcomes is determined by their capacity to exert the attentional processes of effortful control over reactivity within the BIS and the BAS. An inability to regulate the reactivity within these systems has been linked to an inability to regulate emotion (Rothbart et al., 2013). Low levels of effortful control in the HBIS_HBAS and HBIS_LBAS temperament phenotypes has been shown to predict general distress-increased autonomic arousal and depression, (Dinovo & Vasey, 2011; Vasey et al., 2014). Similarly, a high level of BIS reactivity when the BAS is low is also capable of overcoming high levels of effortful control to predict depressive symptoms in the HBIS_LBAS phenotype. Subsequently, when the BIS is high and an individual is unable to exert effortful control over their emotions, regardless of their level of BAS, they might be unable to regulate their emotional experience, which could increase their risk of emotional eating behaviour and obesity.

Emotional eating behaviour has been suggested to occur in response to the experience of negative affect, i.e., as an affect regulation strategy (Macht, 2008), and high levels of anxiety have been theoretically and empirically linked to cognitive impairment in non-clinical individuals (Eysenck et al., 2007; Mueller, 2011). Therefore, a reactive BIS and a low level of effortful control, in combination with high or low levels of the BAS, may predict impulsive, avoidance-based behaviours, such as emotional eating, in a maladaptive attempt to down-regulate the experience of a negative emotional state (Wallace & Newman, 1997). Subsequently, it is feasible that an individual with a trait predisposition to experience negative affect and trait anxiety, i.e., one who possesses either a HBIS_HBAS or HBIS_LBAS phenotype and who is also unable to efficiently exert effortful control over their emotions, may eat emotionally during the experience of a negative affective state that they are unable to otherwise regulate.

To the best of my knowledge, no studies, outside of the eating-disordered and bariatric populations (Claes et al., 2012; Claes, Nederkoorn, Vandereycken, Guerrieri, & Vertommen, 2006; Claes et al., 2010; Müller et al., 2014), have considered a dual-process relationship between effortful control and reactivity within the BIS and BAS (Bijttebier et al., 2009; Carver, 2008; Carver et al., 2009; Derryberry & Rothbart, 1997). Subsequently, there is a paucity of literature considering a dual-process approach within a non-eating disordered and non-clinical, community-based sample. As a result, it was not known whether both effortful control and the BIS would predict emotional eating behaviour and BMI in community-based adults or whether a three-way interaction between the BIS x BAS x effortful control or the BIS x BAS x trait anxiety (STAI-T) would predict emotional eating behaviour and BMI.

As highlighted above, a failure to regulate heightened emotional states may lead to the experience of negative affective states such as anxiety and depression (Atherton, Nevels, & Moore, 2015; Brockmeyer et al., 2012; Cisler, Olatunji, Feldner, & Forsyth, 2010; Gross, 2013). Subsequently, without the regulatory capacity of effortful control to inhibit the attention that is allocated to these states, it should not be surprising that the use of maladaptive emotion regulation strategies has been related to the expression of impulsive (Smith et al., 2007) and emotional eating behaviour (Evers et al., 2010; Ouwens, van Strien, & van Leeuwe, 2009); that difficulties dealing with the experience of a depressed state has been shown to mediate emotional eating (Ouwens, van Strien, & van Leeuwe, 2009); or that emotional eating behaviour has been found to mediate the link between depression and weight gain (van Strien, Konttinen, Homberg, Engels, & Winkens, 2016). However, how much a deficit in emotion regulatory ability and/or impulsive behaviour contributes to emotional eating behaviour beyond the influence of a reactive temperament that is inefficiently regulated is unknown. Therefore, this research also explored whether a deficit in emotion regulation ability and the enactment of urgent impulsive behaviour contributes towards the prediction of emotional eating behaviour, beyond the contribution of the BIS, BAS and effortful control.

4.3 STUDY AIMS

The study aimed to determine whether the reactive temperament dimensions of BIS and BAS and the regulative temperament dimension of effortful control were associated with BMI and emotional eating behaviour and to determine whether these variables, in association with an inability to regulate emotion and impulsive behaviour, predicted emotional eating behaviour. Two further aims were to determine if an interaction between BIS x BAS x trait anxiety predicted emotional eating behaviour; and to determine if a three-way BIS x BAS x effortful control interaction predicted emotional eating behaviour.

4.3.1 Hypotheses

- The BIS and the BAS would be positively associated with emotional eating behaviour and BMI.
- Effortful control would be inversely associated with emotional eating behaviour and BMI.
- The BIS and effortful control, but not the BAS, would predict emotional eating behaviour and BMI and difficulties regulating emotion and negative urgency would also contribute towards the prediction of emotional eating behaviour and BMI.
- The interaction term of BIS x BAS x STAI-T would predict emotional eating behaviour and BMI, when effortful control is low.
- The interaction term of BIS x BAS x EC would predict emotional eating and BMI.
- Difficulties regulating emotion and negative urgency would contribute towards the prediction of emotional eating behaviour and BMI after accounting for the contribution of the BIS x BAS x STAI-T interaction term.

4.4 METHODS

4.4.1 Participants

Participants were recruited from General Practice Clinics, community groups and government and non-government organisations in a regional community. Facility managers were approached and consent was obtained to recruit from their client base. From approximately 420 individuals approached, 146 participants were recruited into the study. Time was cited as the most common reason for non-participation. A total of eight participants were excluded from the data set. Four participants were excluded due to a large number of missing items on one or more scales, i.e. half of one questionnaire not filled out due to being on a back page. One participant was excluded as a result of self-reported increased appetite from a steroid-based medication. Three other participants were excluded due to outliers on either the dependent variable of BMI or on the key independent variable of the BIS Scale. A total of 138 participant data sets were analysed. Inclusion and exclusion criteria can be found in the general methodology (Chapter 3).

4.4.2 Measures

The study involved administration of ten self-report questionnaires that have been previously described in the general methodology (Chapter 3). Two measured temperament: The BIS/BAS Scales (Carver & White, 1994) and the Effortful Control Scale from Evans and Rothbart's Adult Temperament Questionnaire (2007). Two measured eating behaviour: the DEBQ (van Strien et al., 1986) and the BES (Gormally et al., 1982). Three measured the experience of negative affective states: The Perceived Stress Scale, The Trait version of the STAI-T (S. Cohen et al., 1983; McDowell, 2006) and the PANAS (Watson et al., 1998). Two other self-report questionnaires that captured other factors associated with over-eating behaviour were included: the Difficulties in Emotion Regulation Scale (DERS) (Gratz & Roemer, 2004) and the Urgency subscale from the UPPS Impulsive Behaviour Scale (S. Whiteside & Lynam, 2001). In addition, the anthropometrical measures of weight, height, waist and hip circumference were taken. The Binge Eating Scale (BES) was not included in subsequent analyses due to a large number of missed items across study participants as reported below.

4.4.3 Procedures

On receiving informed consent, participants were taken to a room where the anthropometrical measures were completed, as previously described. They were then provided with the battery of questionnaires to be completed.

4.4.4 Data analysis

Categorical variables were summarized and presented as counts and percentages for the total sample and according to a three-group classification of BMI. Participants were divided into three groups according to their BMI (lean, BMI 18.5 to 24.99 kg/m^2; overweight, BMI 25.00 to 29.99 kg/m^2, and obese, BMI 30 kg/m^2 and above) (World Health Organization, 2015). Descriptive statistics were used to describe the dependent variables of BMI and emotional eating behaviour and the independent variables of trait anxiety (STAI-T), total effortful control score (EC-T), reactivity within the BIS (BIS Scale), reactivity within the BAS (BAS Scale) and negative urgency (UPPS-U). These variables were all continuous variables and were presented as means and standard deviations or median with interquartile range, depending upon the normality of the independent and dependent variables.

Australian females have a higher mean BIS scores than males, and females have been hypothesised to possess a greater vulnerability to develop an anxiety disorder (Catuzzi & Beck, 2014; Jorm et al., 1999). A primary hypothesis in this study was that the BIS would be associated with emotional eating behaviour and BMI. Therefore, in order to determine if gender differentiates an association between the BIS, emotional eating, and BMI, the sample was split by gender. Independent sample t-tests were used to assess the differences between gender and the BIS_BAS phenotypes when data were normally distributed. When data were not normally distributed; the non-parametric alternative, the Mann-Whitney U test, was used to assess whether groups differed significantly from each other. Mean differences between BMI categories on the independent variables were assessed using a one-way analysis of variance. Post-hoc analyses were conducted on significant interactions using the Tukey honest significant difference test. Effect sizes for the ANOVA were reported as small; $\eta^2 = .01$, medium; $\eta^2 = .06$ and large; $\eta^2 = 0.14$, following the recommendation of Cohen (J. Cohen, 2013).

Associations between the independent and dependent variables were determined using Pearson's correlation coefficient for linear data. The following correlational analyses were run, both across the total sample and between the genders, to examine the relationship between total effortful control, emotional eating, and BMI; the BIS and BAS temperament dimensions, emotional and external eating behaviour and BMI.

The regression series investigated a three-way interaction between BIS x BAS x STAI-T and emotional eating behaviour. Prior to running these analyses, it was determined that the STAI-T ($r = .382$, $p < .01$) variable was the most strongly correlated with the DEBQ Emotional Eating Scale, when compared to the PSS ($r = .279$, $p < .01$), and the NA Scale ($r = .358$, $p < .01$). As a result, it was chosen as the negative affective variable of choice to interact with the BIS x BAS interaction term in the regression model. Furthermore, the DERS-T Scale was highly correlated with the STAI-T Scale (r = .823, p < .01). To avoid multicollinearity, the DERS-Goals subscale was included as an alternative DERS variable in the analysis with the three-way BIS x BAS x STAI-T interaction term, as it was not as strongly associated with the STAI-T (r = .581, p < .01).

The following analyses describe a series of hierarchical, multiple, linear regression models (HRLM) that were run to determine whether the following independent variables significantly predicted emotional eating behaviour and BMI: **a)** BIS, BAS, EC-T, DERS-T and UPPS-U; **b)** three-way BIS x BAS x EC interaction; **c)** three-way BIS x BAS x STAI-T interaction, DERS-G and UPPS-U. Prior to the analyses, it was noted that the dependent variable of emotional eating behaviour (DEBQ-EM) was positively skewed. Subsequently, DEBQ-Em was square-root transformed prior to inclusion in the models. Gender was dummy-coded prior to entry, to allow a comparison of gender effects, by allocating males with a code of 0 and females a code of 1 (Aiken & West, 1996). In those analyses that investigated the interaction term, all continuous variables were centred (Aiken & West, 1996).

The independent variables were entered stepwise into the HRLM. Within the model, an individual's level of BIS reactivity was assessed relative to an overarching hypothesis that unregulated affect from a reactive BIS may motivate 'maladaptive' eating behaviours, such as emotional eating behaviour. A primary hypothesis of this study was that both the BIS and effortful control would predict emotional eating behaviour and BMI. Although it was not known whether the BIS or effortful control would be a stronger predictor of emotional eating behaviour, effortful control has been inversely related to measures of negative emotionality (Evans & Rothbart, 2007) and research findings by Hasking (2006) and others (Jackson & Francis, 2004) suggest that the BIS would be a distal predictor of behavioural outcomes. Therefore, in order to determine if the BIS does predict emotional eating and whether that association is then mediated by a low level of effortful control, the BIS was entered prior to the variable of effortful control in a series of hierarchical linear regression models (HLRM). As discussed in section 2.4, an inefficient use of effortful control (EC) would lead to emotion regulation difficulties when reactivity in the BIS is high. Therefore, the DERS-T Scale was administered after the EC-T Scale. The personality trait of impulsivity has been linked to a heightened level of psychological and physiological arousal, as would be expected to occur in response to a high level of BIS reactivity that is not well regulated, as discussed in section 2.4. Therefore, an individual is expected to react with urgent impulsivity or negative urgency to the experience of unregulated negative affect, which is expected to occur in individuals who have difficulty regulating their emotional state. Therefore, the UPPS Urgency subscale was entered into the HRLM after the DERS-T Scale. However, it is not known whether the Urgency subscale would predict eating behaviour beyond the DERS-T Scale. The inclusion of these variables in this order would determine each scale and subscales' contribution beyond a reactive BIS. It also provided the opportunity to uncouple their interrelationship with emotional eating behaviour.

Significant interactions were probed using the PROCESS Macro Plug-in for SPSS from Hayes (Hayes, 2013). Prior to running the Macro, gender was recoded using unweighted effects coding. Males were assigned a code of -1 and females a code of 1. Unweighted effects coding provides a grand mean for both groups and it does not change the simple regression equation for either group (Aiken & West, 1996). Subsequently, the coding was changed to allow a more meaningful visual interpretation of the three-way interaction on the dependent variable of emotional eating. For all analyses, an α-level of 0.05 was employed to determine significance, unless otherwise specified.

4.5 RESULTS

Prior to analysing the data, Little's MCAR Chi-Square statistic was employed to determine whether the data were missing completely at random or missing not at random. The Chi-Square statistic indicated that the data were missing completely at random, $\chi^2(df = 6086) = 148.05$, $p = 1.000$, $n = 142$. In addition, the BES was completely removed from the data set as 14% of its items were missing. In study one, missing data were handled as per each scale's instructions. Across the raw data set ($n = 146$), the number and percentage of items missed for each self-report questionnaire was reported (Table 4.1).

4.5.1 Participant characteristics

Total Sample

One hundred and thirty eight participants aged between 18 and 65 years (*M* = 46.5, *SD* = 12.1 years) were recruited and their characteristics can be found in Table 4.2. To gain a greater understanding of how participant characteristics were related to BMI, the groups were classified into either a Lean (BMI: 18.5 to 24.99 kg/m^2), Overweight (BMI: 25.00 to 29.99 kg/m^2) or Obese (BMI: 30.00$^+$ kg/m^2) category (Table 4.3).

BMI Classification

There were a greater number of females, across every BMI category. The majority of the lean, overweight and obese groups were not currently dieting. As the weight category increased across the three groups, their weight management characteristics either rose or fell in the expected direction. For example, the obese group had the highest number of weight loss attempts, relative to the lean group and the overweight group had more attempts than the lean group. Furthermore, the lean group considered themselves to be more successful at weight loss than either the overweight group or the obese group. One-quarter of the obese group (25%, *n* =12) considered themselves to have failed at weight loss, whilst only 6% (*n* = 3) of the overweight group considered themselves to be failures, with no-one in the lean group rating themselves as a weight loss failure. The descriptive statistics of the key variables of interest are presented for the total sample (Table 4.4) and by gender (Table 4.5).

Table 4.1

The Number and Percentage of Items Missed for Each Questionnaire and Their Associated Subscales in Study One.

Scale and subscale	Total number of items missed	% missing
DEBQ		
Emotional Eating	5	3%
External Eating	2	1%
Restrained Eating	3	2%
PANAS		
PA	1	< 1%
NA	1	< 1%
STAI-T	5	3%
PSS	2	1%
BIS/BAS	0	0%
UPPS		
Urgency	1	< 1%
EC		
Activation	2	1%
Attention	1	< 1%
Inhibition	2	1%
BES	20	14%
DERS		
Non Acceptance	1	< 1%
Goals	1	< 1%
Impulsivity	1	< 1%
Awareness	1	< 1%
Strategies	1	< 1%
Clarity	1	< 1%

DEBQ: Dutch Eating Behaviour Questionnaire; PANAS: Positive and Negative Affect Schedule; UPPS: UPPS Impulsive Behaviour Scale; EC: Effortful Control Scale, BES: Binge Eating Scale; DERS: Difficulties in Emotion Regulation Scale.

Table 4.2

Demographic, Mood and Weight Management Characteristics of Participants (n=138)

Characteristics		*n*	%	*Mdn (IQR)*
Age (years)				49.00 (39.00 – 56.00)
BMI				27.63 (24.62 – 33.67)
Gender				
Female		81	58.7	
Male		57	41.3	
Marital Status				
Never married		17	12.3	
Widowed		1	0.7	
Divorced		11	8.0	
Separated		4	2.9	
Married		105	76.1	
Educational Attainment				
Post - school degree or higher		51	37.0	
Post-school diploma		14	10.1	
Post-school certificate		15	10.9	
Year 12		18	13.0	
Year 11		5	3.6	
Year 10		29	21.0	
Year 9		5	3.6	
Year 8		1	0.7	
Home Ownership				
Own outright		51	37.0	
Mortgage		52	37.7	
Renting		27	19.6	
Other		8	5.8	
Mood disorder				
Depression		21	15.2	
Anxiety		8	5.8	
Mixed anxiety-depression		1	0.7	
Obsessive compulsive		3	2.2	
Currently dieting				
Yes		23	16.7	
No		115	83.3	
Weight loss attempts	*n* = 123			
0-5		89	72.4	
6-10		15	12.2	
11+		19	15.4	
Weight loss success	*n* = 134			
Very		22	16.4	
Somewhat		32	23.9	
Not very		32	23.9	
Failed		15	11.2	
Never attempted		33	24.6	

Table 4.3

Selected Demographics, Mood Disorders and Weight Management Characteristics of Participants, Classified by BMI Category

Characteristics	**Lean** (*n* = 38)		**Overweight** (*n* =5 2)		**Obese** (*n* =48)	
	n	%	*n*	%	*n*	%
Age (years) (M, SD)	45.03	13	45.21	13	49.08	37
BMI (M, SD)	22.86	2	27.28	1	36.90	5
Gender						
Male	13	34	25	48	19	40
Female	25	66	27	52	29	60
Mood disorder						
Depression	5	13	7	13	10	21
Anxiety	2	5	3	6	3	6
Anxiety/Depression	-		-		1	2
Obsessive compulsive	-		1	2	1	2
Currently dieting						
Yes	7	18	7	14	9	19
No	31	82	44	85	39	81
Weight loss attempts						
0-5	27	72	33	64	28	58
6-10	4	11	3	6	8	17
11+	4	11	6	12	9	19
Previous weight loss success						
Very	13	34	8	15	1	2
Somewhat	11	29	10	19	10	21
Not very	2	5	9	17	21	44
Failed	-		3	6	12	25
Never attempted	11	31	18	35	4	8

Note percentages have been rounded

Table 4.4

Descriptive Statistics of Main Study Variables for the Total Sample

Variable	*M*	*SD*	*Mdn*	*IQR*
DEBQ-Em	2.31	1.00	2.15	1.46 – 2.85
DEBQ-Ext	2.87	0.59	-	-
STAI-T	38.83	10.96	38.00	30.00 – 45.25
DERS-T	77.93	22.03	72.00	61.75 – 90.00
EC-T	88.33	13.72	-	-
BIS	20.95	3.43	-	-
BAS	38.98	5.52	-	-
UPPS-U	2.33	0.57	-	-

BMI: Body Mass Index (kg/m^2); DEBQ-Em: Dutch Eating Behaviour Questionnaire Emotional Eating Scale; DEBQ-Ext: Dutch Eating Behaviour Questionnaire External Eating Scale; STAI-T: State Trait Anxiety Inventory Trait Anxiety Scale; DERS-T: Difficulties in Emotion Regulation Total Scale; EC-T: Effortful Control Total Scale BIS: Behavioural Inhibition System; BAS: Behavioural Activation System, UPPS-U: UPPS Urgency subscale

Table 4.5

Descriptive Statistics of Main Study Variables by Gender

	Females n = 81			Males n = 57		
Variable	*M*	*SD*	*Mdn (IQR)*	*M*	*SD*	*Mdn (IQR)*
Age	47.59	11.97	49.00 (39.50-55.00)	47.51	12.33	-
BMI	29.75	7.40	27.27 (23.37-35.87)	28.94	4.88	27.74 (25.60 – 32.37)
DEBQ-Em	2.62	1.03	-	1.86	0.80	1.92 (1.12 – 2.31)
DEBQ-Ext	2.89	0.60	-	2.85	0.58	-
STAI	39.99	10.71	-	37.19	11.21	37.00 (28.00 – 43.50)
DERS-T	79.44	21.41	74.00 (62.50-94.00)	75.79	22.90	70 .00 (61.00 – 87.50)
EC-T	88.25	13.21	-	88.44	14.53	-
BIS	21.70	3.25	-	19.88	3.43	-
BAS	38.35	5.40	-	39.88	5.61	-
UPPS-U	2.33	0.53	-	2.33	0.61	-

DEBQ-Em: Dutch Eating Behaviour Questionnaire Emotional Eating Scale; DEBQ-Ext: Dutch Eating Behaviour Questionnaire External Eating Scale; STAI-T: State Trait Anxiety Inventory Trait Anxiety Scale; DERS-T: Difficulties in Emotion Regulation Total Scale; EC-T: Effortful Control Total Scale; BIS: Behavioural Inhibition System; BAS: Behavioural Activation System; UPPS-U: UPPS Urgency subscale

Gender Differences

Independent samples t-tests for normally distributed data and Mann-Whitney U test, for non-normally distributed data was conducted to compare the following variables by gender: BIS, BAS, DEBQ-Em, DEBQ-Ext, STAI, DERS-Total score (DERS-T), EC-Total score (EC-T), and UPPS Urgency (UPPS-U). There was a statistically significant difference in BIS scores between males and females, with females having a higher level of the BIS than males t (136) = 3.18, p = .002. The magnitude of this difference, using Cohen's d, was moderate (d = 0.55). A significant difference in the level of emotional eating, U = 1278.00, z = -4.46, p < .001, and a trend towards significance in trait anxiety, U = 1913.50, z = -1.71, p = .087, was found, with females reporting higher levels of emotional eating and anxiety than males. The magnitude of these differences was moderate for emotional eating (r = -.38, p < .001), but small for anxiety (r = -.15, p = .087). There were no other statistically significant differences by gender for any other variable. Tables, reporting the non-significant results can be found in Appendix C1, Mean differences are reported in Table C.1 and median differences in Table C.2.

BMI category

The Descriptive Statistics of the independent variables per BMI classification are presented in Table 4.6. A one-way between-groups analysis of variance was conducted to compare the following variables across BMI categories: DEBQ-Em, DEBQ-Ext, STAI, DERS-Total score (DERS-T), EC-Total score (EC-T), BIS, BAS and UPPS Urgency (UPPS-U) were compared across the BMI categories. There was a statistically significant difference in DEBQ-Em scores for the three BMI groups: F (2, 135) = 8.19, p < .001, in DEBQ-Ext scores: F (2, 135) = 3.70, p < .05 and in UPPS-U scores: F (2, 135) = 4.19, p < .05 (see Table 4.6). There were no other statistically significant differences between the BMI groups for any of the other variables. An ANOVA Table, reporting the non-significant results can be found in Appendix C, Table C.3.

Table 4.6

Descriptive Statistics of Main Study Variables by BMI Category

Variable	**Lean** (*n* =38)		**Overweight** (*n* = 52)		**Obese** (*n* = 48)		**ANOVA**
	M	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*p*
DEBQ-Em	1.93	(0.66)	2.18	(1.06)	2.74	(1.05)	.000
DEBQ-Ext	2.68	(0.52)	2.88	(0.65)	3.02	(0.55)	.027
STAI-T	37.55	(9.57)	37.65	(12.03)	41.13	(10.63)	.201
DERS-T	75.05	(20.52)	77.29	(22.59)	80.92	(22.65)	.458
EC-T	90.24	(13.24)	90.21	(14.56)	84.77	(12.67)	.380
BIS	20.92	(3.51)	20.56	(3.78)	21.40	(2.94)	.476
BAS	38.95	(5.36)	39.42	(6.13)	38.52	(4.99)	.718
UPPS-U	2.20	(0.55)	2.26	(0.61)	2.52	(0.48)	.017

DEBQ-Em: Dutch Eating Behaviour Questionnaire Emotional Eating Scale; DEBQ-Ext: Dutch Eating Behaviour Questionnaire External Eating Scale; STAI-T: State Trait Anxiety Inventory Trait Anxiety Scale; DERS-T: Difficulties in Emotion Regulation Total Scale; EC-T: Effortful Control Total Scale; BIS: Behavioural Inhibition System, BAS: Behavioural Activation System; UPPS-U: UPPS Urgency subscale

The difference in mean scores between the groups was large for DEBQ-Em (η^2= .11) and moderate for both DEBQ-Ext (η^2 = .05) and UPPS-U (η^2 = .06). Post-hoc comparisons using the Tukey honest significant difference (HSD) test indicated that the mean DEBQ-Em score for the obese group was significantly higher than the lean (p < .001) and overweight groups (p < .05) and that the overweight group means did not differ significantly from the lean group (p = .435). The mean DEBQ-Ext score for the obese group was significantly higher than the lean group (p < .05); however, the overweight group did not differ significantly from either the lean (p = .219) or the obese BMI group (p = .480). Mean UPPS-U scores for the obese group were significantly higher than the lean group ($p < .05$) and there was a trend towards significantly higher means scores in the obese group, compared to the overweight group ($p < .056$).

In summary, the obese group reported a higher level of emotional eating than both lean and overweight groups. The overweight and obese share similar levels of external eating. However, the obese group reported a significantly higher level of external eating behaviour than the lean group, and the obese group can be further differentiated in terms of expressing urgent, impulsive behaviour when compared to the lean group. There were no differences between the groups in total emotion-regulation difficulties or in symptoms of trait anxiety.

4.5.2 Relationships between temperament (BIS, BAS and effortful control), emotional eating behaviour and BMI

BIS and BAS

The relationship between the BIS and BAS, BMI and emotional eating behaviour was investigated both across the sample (Table 4.7) and by gender (Table 4.8), using Pearson's product-moment correlation coefficients.

Table 4.7

Means, Standard Deviations and Intercorrelations Between Temperament, (BIS, BAS and Effortful Control), BMI and Emotional Eating, Total Sample

Measure	*M*	*SD*	1	2	3	4	5
1.BMI	29.41	6.47	---				
2.DEBQ-Em	2.31	1.00	.414**	---			
3.BIS	20.95	3.43	.131	.302**	---		
4.BAS	38.98	5.52	-.024	-.053	-.043	---	
5.EC-T	88.33	13.72	-.172*	-.415**	-.171*	.014	---

BMI: Body Mass Index (kg/m^2); DEBQ-Em: Dutch Eating Behaviour Questionnaire Emotional Eating Scale; BIS: Behavioural Inhibition System; BAS: Behavioural Activation System; EC-T: Effortful Control Total Scale.
*$p < .05$, **$p < .01$,

Table 4.8

Means, Standard Deviations, and Intercorrelations between Temperament (BIS, BAS and Effortful Control), BMI and Emotional Eating, by Gender

Male (*n* = 57)	*M*	*SD*	1	2	3	4	5	6
1.BMI	28.94	4.88	---					
2.DEBQ-Em	1.86	0.80	.331*	---				
3.DEBQ-Ext	2.85	0.58	.281*	.476**	---			
4.BIS	19.88	3.41	-.065	.395**	.149	---		
5.BAS	39.88	5.61	.045	.071	.254	.081	---	
6.EC-T	88.44	14.53	-.084	-.537**	-.552**	-.218	.012	---
Female (*n* = 81)	*M*	*SD*	1	2	3	4	5	6
1.BMI	29.75	7.40	---					
2.DEBQ-Em	2.62	1.03	.456**	---				
3.DEBQ-Ext	2.89	0.60	.192	.588**	---			
4.BIS	21.70	3.25	.213	.137	.305**	---		
5.BAS	38.35	5.39	-.046	-.043	-.156	-.075	---	
6.EC-T	88.25	13.21	-.398**	-.398**	-.371**	-.141	.014	---

BMI: Body Mass Index (kg/m^2); DEBQ-Em: Dutch Eating Behaviour Questionnaire Emotional Eating Scale; DEBQ-Ext: Dutch Eating Behaviour Questionnaire External Eating Scale; BIS: Behavioural Inhibition System; BAS: Behavioural Activation System; EC-T: Effortful Control Total Scale
*$p < .05$, **$p < .01$

Emotional eating behaviour

Across the sample, there was a significant, moderate and positive correlation between DEBQ-EM and the BIS ($p < .01$), with higher levels of DEBQ-Em associated with higher levels of the BIS. However, there was no association between the BAS and DEBQ-Em. When a relationship between the BIS, BAS and behaviour by gender was examined, there was evidence of a significant, positive relationship between the BIS and emotional eating in males ($p < .01$), with higher levels of BIS associated with higher levels of DEBQ-Em. However, unexpectedly, there was no evidence of an association between the BIS and DEBQ-Em in females and neither gender showed an association between the BAS and DEBQ-Em scores.

On the basis of not finding an association between the BIS, BAS and emotional eating in females, the association between the BIS, BAS and the DEBQ External Eating Scale (DEBQ-Ext) was explored by gender (Table 4.8). There was evidence of a significant, positive association between the BIS and DEBQ-Ext in females ($p < .01$); however, this relationship was absent in males, suggesting that higher levels of external eating behaviour are associated with higher levels of the BIS in females but not males. There was also no evidence of an association between the BAS and

DEBQ-Ext in females, although there was evidence of a trend towards a weak-to-moderate association in males (p = .057).

BMI

Across the sample there was no association between the BIS or the BAS and BMI. Moreover, no significant correlations between the BIS, BAS and BMI were found when males and females were examined separately. However, females did show a trend towards a positive association between the BIS and BMI (p = .056). This suggests that the BAS temperament is not associated with BMI in either gender and that there is a trend for an association between the BIS and BMI in females, but not males. On the basis of not finding a linear association between the BIS and BMI in either gender, the hypotheses that temperament (i.e., BIS, BAS and effortful control) would predict BMI were not investigated further. Instead, a supplementary analysis was undertaken to determine whether a relationship between BIS, BAS and BMI may be found when the genders were stratified by their BIS_BAS phenotypes (i.e., HBIS_LBAS, HBIS_HBAS, LBIS_HBAS, LBIS_LBAS) and BMI category (i.e., lean, overweight and obese). This information can be found in Appendix C1.

Effortful Control

The relationship between effortful control, BMI and emotional eating was investigated both within the total sample (Table 4.7) and by gender (Table 4.8), using Pearson's product-moment correlation coefficient.

Emotional eating behaviour

A significant, inverse correlation between effortful control and emotional eating ($p < .01$) was found across the sample, with low levels of effortful control associated with higher levels of emotional eating. There was also evidence of a significant, inverse correlation between EC-T and DEBQ-Em in females ($p < .01$), with low levels of EC-T associated with higher levels of DEBQ-Em. In males there was evidence of a significant, inverse correlation between EC-T and DEBQ-Em ($p <$ .01), with lower levels of EC-T associated with higher levels of DEBQ-Em.

BMI

Across the sample, there was a significant, inverse correlation between effortful control and BMI ($p < .05$), with low levels of effortful control associated with higher levels of BMI. In females, there was a significant, inverse correlation between effortful control and BMI (*p* < .01), with low levels of EC-T associated with higher levels of BMI. In contrast, there was no association between effortful control and BMI in males.

4.5.3 Temperament (BIS, BAS and effortful control): A predictor of emotional eating behaviour.

A hierarchical, multiple, linear regression was run to investigate whether the BIS, BAS and effortful control significantly accounted for the variance in emotional eating behaviour. In addition, the contribution of these temperament dimensions to the variance in emotional eating behaviour was determined, when associated variables, such as difficulty in emotion regulation and urgent-impulsivity, were added to the model. As the DEBQ-Em variable was positively skewed, it was transformed using a square root transformation, prior to running the regression analysis. The means and standard deviations and intercorrelations for DEBQ-Em are presented in table 4.9. Table 4.10 presents the regression model.

Table 4.9

Means, Standard Deviations, and Intercorrelations between DEBQ-Em (transformed) and Temperament (BIS, BAS and Effortful Control), Total Sample

Variables	*M*	*SD*	1	2	3	4	5	6	7
1.DEBQ-Em (transformed)	1.48	0.33	---						
2.BMI	29.41	6.47	.405**	---					
3.BIS	20.95	3.43	.309**	.131	---				
4.BAS	38.98	5.52	-.049	-.024	-.043	---			
5.EC-T	88.33	13.72	-.426**	-.172*	-.171*	.014	---		
6.DERS-T	77.93	22.03	.393**	.122	.369**	-.044	-.507**	--	
7.UPPS-U	2.33	0.57	.432**	.222**	.247**	.211*	-.633**	.471**	---

DEBQ-Em: Dutch Eating Behaviour Questionnaire Emotional Eating Scale; BMI: Body Mass Index (kg/m^2); BIS: Behavioural Inhibition System; BAS: Behavioural Activation System; EC-T: Effortful Control Total Scale; DERS-T: Difficulties in Emotion Regulation Total Scale; UPPS-U: UPPS Urgency Scale

After controlling for age, gender and BMI in step 1, the addition of BIS and BAS in step 2 explained an additional 2.6% of the variance in emotional eating; however, this step was not significant, F change (2, 132) = 2.49, p = .087. Inspection of the BIS and BAS beta coefficients revealed that the BAS variable was not significant (β = -.007, p = .924); subsequently, the BAS variable was removed from the model. After removal of the BAS, the BIS variable explained 2.5% of the variance in emotional eating and the step was significant, *F* change (1,133) = 5.01, $p = .027$. To explore whether the addition of effortful control, total score (EC-T), difficulties in emotion regulation, total score (DERS-T), and negative urgency (UPPS-U) added significantly to the variance in emotional eating beyond the BIS, these variables were added sequentially. Effortful control, total score (EC-T) was added in the third step. The addition of EC-T explained an additional 11.1% of the variance in emotional eating and the change to the model was significant, *F* change (1, 132) = 25.89, $p < .001$. However, after the addition of EC-T, the contribution of the BIS was no longer significant ($p = .072$), which suggested that the dimension of effortful control mediated the effect of the BIS on emotional eating behaviour. Difficulties in emotion regulation total score (DERS-T) was added in a fourth step and significantly explained an additional 1.7% of the variance in emotional eating, *F* change (1,131) = 4.14, $p < .05$. Finally, UPPS-U was added in a fifth step and explained an additional 1.1% of variance in emotional eating; however, UPPS-U did not significantly add to the prediction of emotional eating, *F* change (1, 130) = 2.62, $p = .108$, and it was removed from the model.

The final model at step 4 was significant: *F* (6,131) = 1.11, $p < .001$, $R^2 = .45$. After the fourth step, gender, BMI, EC-T and DERS-T were all statistically significant. The final model predicted significantly higher levels of emotional eating in females ($\beta = .324$, $p < .001$). BMI recorded the highest beta value ($\beta = .304$, $p < .001$), followed by EC-T ($\beta = -.284$, $p < .001$) and DERS-T ($\beta = .162$, $p < .05$). Therefore, in addition to greater BMI, gender, a low level of effortful control, and difficulty regulating emotion predicted emotional eating behaviour. Collectively, the variables entered into the model explain 45% of the variance in emotional eating behaviour.

Table 4.10

Hierarchical Regression Analysis Predicting Emotional Eating Behaviour with Temperament, Difficulty Regulating Emotion and Urgency

Step and predictor variable	*B*	*SE B*	*β*	R^2	ΔR^2
Step 1:				.299***	
Age	-.003	.002	-.101		
Gender	.230	.048	.346***		
BMI	.020	.004	.390***		
Step 2:				.324*	.026
BIS	.016	.007	.169*		
Step 3:				.435***	.111
EC-T	-.008	.002	-.356***		
Step 4					
DERS-T	.002	.001	.162*	.452*	.017
Step 5					
UPPS-U	.092	.057	.159	.463	.011

BMI: Body Mass Index (kg/m^2); BIS: Behavioural Inhibition System; EC-T: Effortful Control Total Scale; DERS-T: Difficulties in Emotion Regulation Total Scale; UPPS-U: UPPS Urgency subscale
B: unstandardised coefficient; β:standardised coefficient. Gender coded as 0 = male.
**p* < .05, ***p* < .01, ****p* < .001

4.5.4 Predicting emotional eating behaviour via a three way interaction between BIS x BAS x STAI-T.

A hierarchical, linear, multiple regression was run to determine whether the interaction of BIS x BAS x STAI-T added significantly to the variance in emotional eating behaviour. Table 4.11 presents the intercorrelations between the independent and dependent variables. The regression model is presented in Table 4.12.

Age, BMI, gender, EC-T, BAS, BIS and STAI-T were controlled for in step 1. After entry of the two-way interaction terms of BIS x BAS, BIS x STAI-T and BAS x STAI-T in step 2, the variance explained by the model as a whole was 45.9%, *F* (10, 127) = 10.77, *p* < .001. The addition of the interaction terms in step 2 did not significantly change the model, *F* change (3, 127) = 1.36, *p* = .260. However, entry of the three way BIS x BAS x STAI-T, interaction term at step 3 explained an additional 2.6% of the variance in emotional eating and the change to the model was significant, *F* change (1, 126) = 6.36, *p* = .013.

To explore whether the addition of difficulties in emotion regulation, goals subscale, (DERS-G), and negative urgency (UPPS-U) added significantly to the variance in emotional eating, beyond the three way interaction, DERS-G was added in a fourth step. Addition of the DERS-G variable explained an additional 3.4% of the variance in emotional eating and the change to the model was significant, *F* change (1, 125) = 8.79, p = .004. Finally, UPPS-U was added in a fifth step; however, it did not significantly change the model's ability to predict emotional eating behaviour, *F* change (1, 124) = 3.29, p = .072. Subsequently, it was omitted from the final analysis.

The final model at step 4 was significant, *F* (12, 125) = 11.22, $p < .001$, R^2 = .51 and explained 51% of the variance in emotional eating behaviour. After the fourth step, there was a significant difference in the level of emotional eating scores by gender (β = .287, $p < .001$). BMI had the highest beta value (β = .340, $p < .001$), followed by EC-T (β = -.278, $p < .01$), DERS-G (β = .261, $p < .01$), and the BIS x BAS x STAI-T interaction term (β = .162, $p < .001$).

Table 4.11

Means, Standard Deviations, and Intercorrelations between Emotional Eating Behaviour, Temperament, Emotion Regulation Difficulties and Urgency, Total Sample

Variables	*M*	*SD*	1	2	3	4	5	6	7
1. DEBQ-Em-T	1.48	0.33	---						
2.BIS	20.95	3.43	.309**	---					
3.BAS	38.98	5.52	-.049	-.043	---				
4.EC-T	88.33	13.72	-.426**	-.171*	.014	---			
5.STAI-T	38.83	10.96	.376**	.397**	-.047	-.518**	---		
6.DERS-G	12.64	4.13	.438**	.436**	-.017	-.432**	.581**	---	
7.UPPS-U	2.33	0.57	.432**	.247**	.211*	-.633**	.663**	471**	--

DEBQ-Em-T: Dutch Eating Behaviour Questionnaire Emotional Eating Scale – Transformed; BIS: Behavioural Inhibition System; BAS: Behavioural Activation System; EC-T: Effortful Control Total Scale; STAI-T: State Trait Anxiety Inventory Trait Anxiety Scale; DERS-G: Difficulties in Emotion Regulation subscale; Difficulty in Following Goal Directed Behaviour When Distressed; UPPS-U: UPPS Urgency subscale
*p < .05, **p < .01

Table 4.12

Hierarchical Linear Multiple Regression Analysis Predicting Disinhibited Eating Behaviour with Three-Way BIS x BAS x STAI Interaction

Step and predictor variable	*B*	*SE B*	*β*	R^2	ΔR^2
Step 1:				.441***	
Age	.001	.002	.037		
BMI	.015	.003	.301***		
Gender	.215	.046	.324**		
BAS	.001	.004	.024		
BIS	.009	.007	.098		
EC-T	-.008	.002	-.315***		
STAI-T	.003	.002	.099		
Step 2:				.459	.017
BIS x BAS	-.002	.001	-.124		
BIS x STAI-T	.001	.001	.103		
BAS x STAI-T	.000	.000	.071		
Step 3:				.485**	.026**
BIS x BAS x STAI-T	.000	.000	.193*		
Step 4:				.519**	.034**
DERS-G	.021	.007	.262**		
Step 5:				.531	.012
UPPS-U	.107	.059	.185		

DEBQ-Em: Dutch Eating Behaviour Questionnaire Emotional Eating Scale; BIS: Behavioural Inhibition System; BAS: Behavioural Activation System; EC-T: Effortful Control Total Scale; STAI-T: State Trait Anxiety Inventory Trait Anxiety Scale; DERS-G: Difficulties in Emotion Regulation subscale; Difficulty in Following Goal Directed Behaviour When Distressed; UPPS-U: UPPS Urgency subscale
B: unstandardised coefficient; β:standardised coefficient. Gender coded as 0 = male.
*$p < .05$, **$p < .01$, ***$p < .001$

Probing the three-way BIS x BAS x STAI-T interaction

The interaction of high and low levels of BIS and BAS with trait anxiety (STAI-T) was explored to determine whether these variables moderated the effect of trait anxiety (STAI-T) to predict emotional eating behaviour. The following model, adapted from Hayes (Hayes, 2013) (Figure 4.1), presents trait anxiety as the predictor variable, with high and low levels of the BIS and BAS as its moderators.

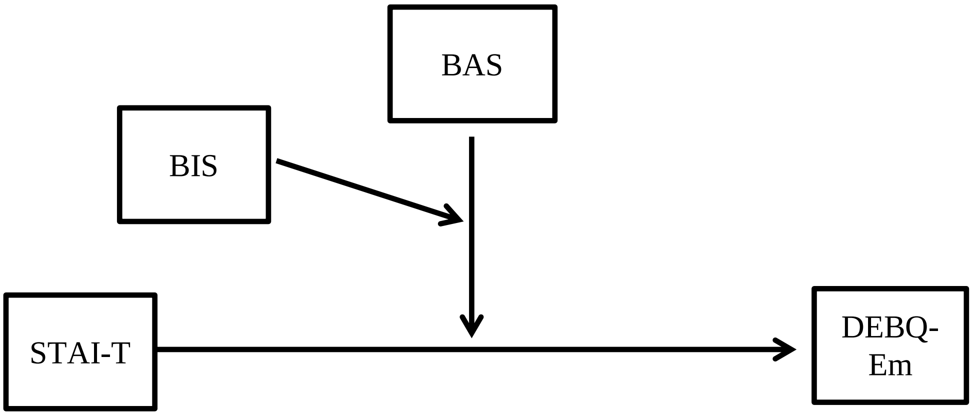


Figure 4.1. Three-way interaction of BIS x BAS x STAI-T on emotional eating behaviour: STAI-T as the predictor variable.

Further examination showed that STAI-T predicted emotional eating behaviour only at one level of BIS and BAS. The 'β' represents the unstandardised beta coefficient. Trait anxiety positively predicted emotional eating behaviour only when both BIS and BAS (HBIS_HBAS) levels were concurrently high (β = .0118, $p < .01$). It did not predict emotional eating behaviour when BIS was high and BAS was low (HBIS_LBAS) (β = -.0005, $p = .89$), when BIS was low and BAS was high (LBIS_HBAS) (β = -.0021, $p = .89$) or when both BIS and BAS were low (LBIS_LBAS) (β = .0049, $p = .39$). When this interaction was displayed as a graph, it was noted that the HBIS_LBAS phenotype had higher levels of emotional eating behaviour at lower levels of anxiety than did the HBIS_HBAS phenotype. This interaction is presented below at high and low levels of the BIS (Figure 4.2 and Figure 4.3). Figure 4.2 shows that, even at a low level of STAI-T, the HBIS_LBAS phenotype had a high level of emotional eating when compared to the HBIS_HBAS phenotype, whilst Figure 4.3 indicates that, even though the LBIS_LBAS individual increased their level of emotional eating when feeling anxious, it was not of the same magnitude.

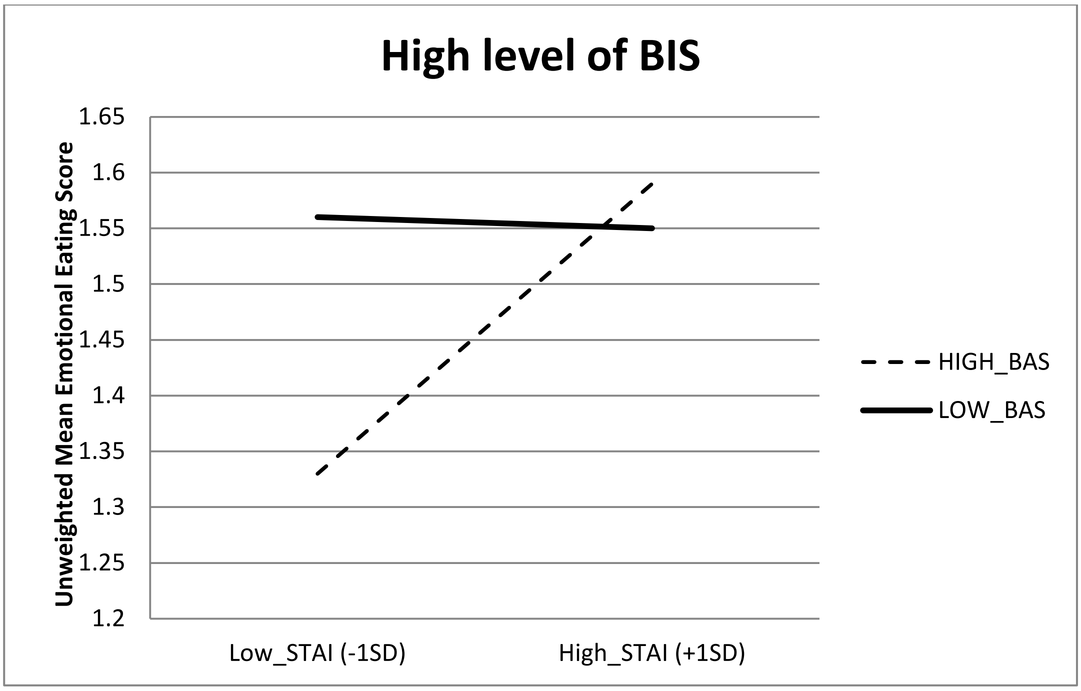


Figure 4.2. Graphic representation of the interaction between high levels of the BIS and high and low levels of the BAS when STAI-T is the predictor variable on emotional eating scores.

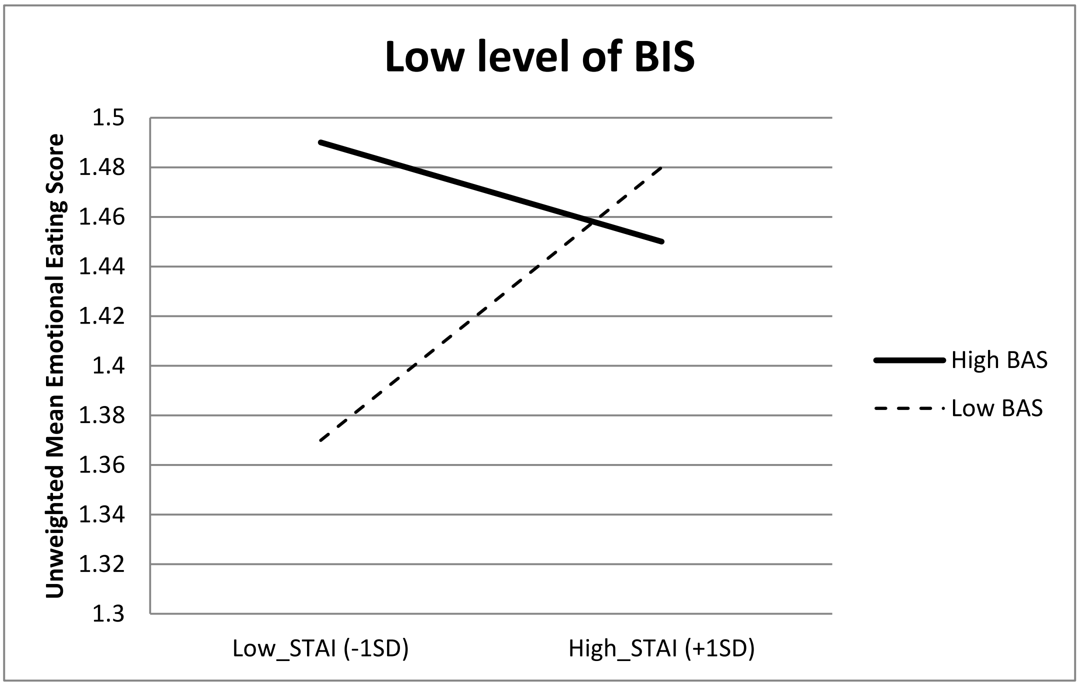


Figure 4.3. Graphic representation of the interaction between low levels of the BIS and high and low levels of the BAS when STAI-T is the predictor variable on emotional eating scores.

Figure 4.2 shows that, even when levels of trait anxiety were low, the HBIS_LBAS phenotype had a high level of emotional eating when compared to the HBIS_HBAS phenotype. To determine if the HBIS_LBAS phenotype may have greater difficulty in their perception of trait anxiety, the DERS lack of awareness and understanding of emotions and lack of clarity of emotions subscales were explored relative to the HBIS_HBAS phenotype. The phenotypes were also investigated for a difference in their level of trait anxiety (Table 4.13).

Table 4.13

Means and Standard Deviations of Trait Anxiety and a Lack of Awareness and Understanding of Emotions for the BIS_BAS Phenotypes

	HBIS_HBAS *n* = 15		HBIS_LBAS *n* = 17	
Variable	*M*	*SD*	*M*	*SD*
DERS-Awareness	14.87	1.08	18.59	1.31
STAI-T	43.13	2.59	45.65	2.82

DERS-Awareness: Difficulties in Emotion Regulation subscale - lack of awareness and understanding of emotions; STAI-T: State Trait Anxiety Inventory – Trait Anxiety Scale.

Independent t-tests revealed there was no difference between the phenotypes in their level of trait anxiety. However, the HBIS_LBAS phenotype had a significantly higher level of a lack of emotional awareness and understanding of their emotions when compared to the HBIS_HBAS phenotype, t (30) = -3.72, p = .039. Calculated with Cohen’s *d*, the magnitude of this difference was large, d = 0.78.

4.5.5 Predicting emotional eating behaviour via a three-way interaction of BIS x BAS x EC-T

A hierarchical, multiple, linear regression was performed to assess the ability of the EC-T x BIS x BAS interaction term to predict levels of emotional eating. Table 4.11 presents the intercorrelations between the independent and dependent variables. The regression model is presented in table 4.14. The following analysis was exploratory, and the significance value was adjusted accordingly ($p < .10$). Age, BMI, gender, BAS, BIS and EC-T were entered at step 1, explaining 43.5% of the variance in emotional eating. After entry of the two-way interaction terms of BIS x BAS, BIS x EC-T and BAS x EC-T in step two, the total variance explained by the model as a whole was 44.4%, F (9, 128) = 11.36, $p < .001$. However, the addition of the two-way interaction terms at step 2 did not significantly change the model's ability to predict emotional eating behaviour, *F* change (3, 128) = .66, p = .577. After entry of the three-way BIS x BAS x EC-T interaction term at step 3, the total variance explained by the model was 45.6%, *F*, (10, 127) = 10.65, $p < .001$. The addition of the three-way interaction term explained an additional 1.2% of the variance in emotional eating, R^2 change = .012, *F* change (1, 127) = 2.84, and there was a trend towards significance (p = .094). After the third step, there was a significant difference in the level of emotional eating scores by gender (β = .317, p < .001). Effortful control recorded the highest beta value (β = -.384, $p < .001$), followed by BMI (β = .304, $p < .001$), BIS (β = .127, $p < .10$) and the three-way BIS x BAS x EC-T interaction term (β = -.123, $p < .10$). The model was significant, *F*, (10, 127) = 10.65, $p < .001$, R^2 = .45 and explained 45% of the variance in emotional eating behaviour.

Table 4.14

Hierarchical Regression Analysis Summary for Temperament Variables Predicting Emotional Eating Behaviour

Step and predictor variable	*B*	*SE B*	*Β*	R^2	ΔR^2
Step 1:				.435***	
Age	.001	.002	.025		
BMI	.015	.003	.306***		
Gender	.217	.046	.327***		
BAS	.001	.004	.019		
BIS	.012	.007	.127*		
EC-T	-.009	.002	-.357***		
Step 2:				.444	.009
BIS x BAS	-.002	.001	-.093		
BIS x EC-T	.000	.000	.000		
BAS x EC-T	.000	.000	-.024		
Step 3:				.456*	.012*
BIS x BAS x EC-T	.000	.000	-.123*		

BMI: Body Mass Index (kg/m^2); DEBQ-Em: Dutch Eating Behaviour Questionnaire Emotional Eating Scale; BIS: Behavioural Inhibition System; BAS: Behavioural Activation System; EC-T: Effortful Control Total Scale; B: unstandardised coefficient; β: standardised coefficient. Gender coded as 0 = male.
*p < .1, **p < .05, ***p < .001

Probing the three-way BIS x BAS x EC interaction

To examine the effect of the interaction of the BIS x BAS x EC on emotional eating behaviour, the interaction of high and low levels of BIS and BAS against EC-

T was explored to determine if an interaction between these temperament dimensions moderated the prediction of effortful control on emotional eating behaviour. The following model, adapted from Hayes (Hayes, 2013) (Figure 4.4), presents EC-T as the predictor variable, with high and low levels of the BIS and BAS as its moderators.

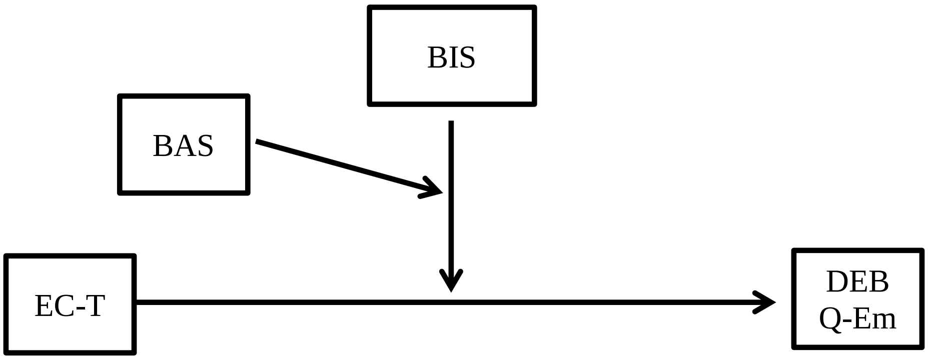


Figure 4.4. Three-way interaction of BIS x BAS x EC-T on emotional eating behaviour: EC-T as the predictor variable.

Further examination showed that effortful control inversely predicted emotional eating behaviour at three levels of BIS and BAS. The 'β' represents the unstandardised beta coefficient: 1) HBIS _HBAS ($\beta = -.005$, $p < .01$), 2) LBIS _LBAS ($\beta = -.010$, $p < .001$) and 3) HBAS_ low BIS ($\beta = -.008$, $p < .001$). Effortful control did not predict emotional eating behaviour in the HBIS_LBAS phenotype ($\beta = -.005$, $p = .179$). These results suggest that a low level of effortful control may predict high levels of emotional eating behaviour when the following temperament types are combined: HBIS and HBAS, LBIS_HBAS and LBIS_LBAS phenotypes. It also suggests that, conversely, a high level of effortful control may be able to overcome these same reactive temperament combinations to predict a low level of emotional eating behaviour. However, it does not predict emotional eating behaviour in the HBIS_LBAS phenotype (Figure 4.5). Subsequently, this analysis did not predict the effect that a HBIS_LBAS phenotype may have on emotional eating behaviour when effortful control was the predictor variable. Such a finding therefore suggests that another variable may moderate low levels of the BAS and high levels of effortful control to predict a higher level of emotional eating. This finding suggests that a high level of the BIS could attenuate a high level of effortful control to predict a higher level of emotional eating behaviour. Subsequently the interaction was probed again, this time positioning the BIS as the predictor variable (Figure 4.6).

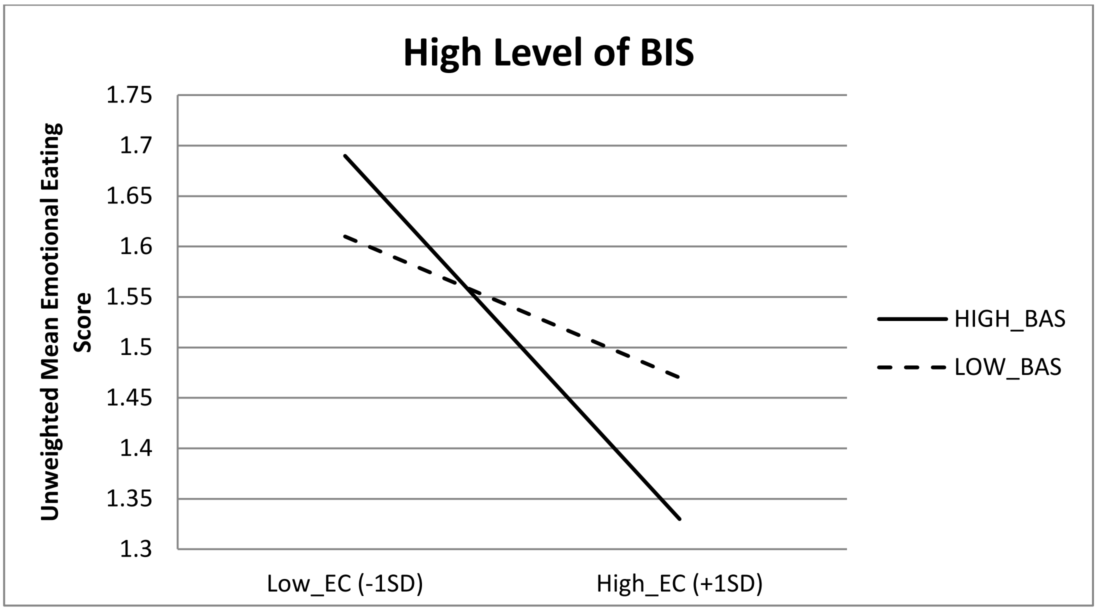


Figure 4.5. Graphic representation of a high level of EC-T significantly predicting low levels of emotional eating when BIS is high and BAS is high but not when the BAS is concurrently low.

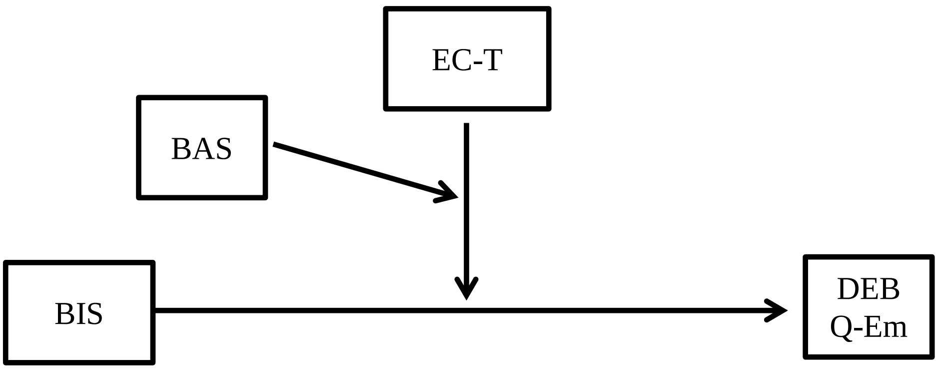


Figure 4.6. Three-way interaction of BIS x BAS x EC-T on emotional eating behaviour: BIS as the predictor variable.

When the BIS was positioned as the predictor variable (Figure 4.6), a high level of the BIS positively predicted emotional eating behaviour at a low level of the BAS, when effortful control was high (β = .029, $p < .05$). By contrast, when the BAS was high, a high level of effortful control did not predict high levels of emotional eating (β = -.005, p = .662). The graph of these interactions is presented at high levels of EC-T (Figure 4.7).

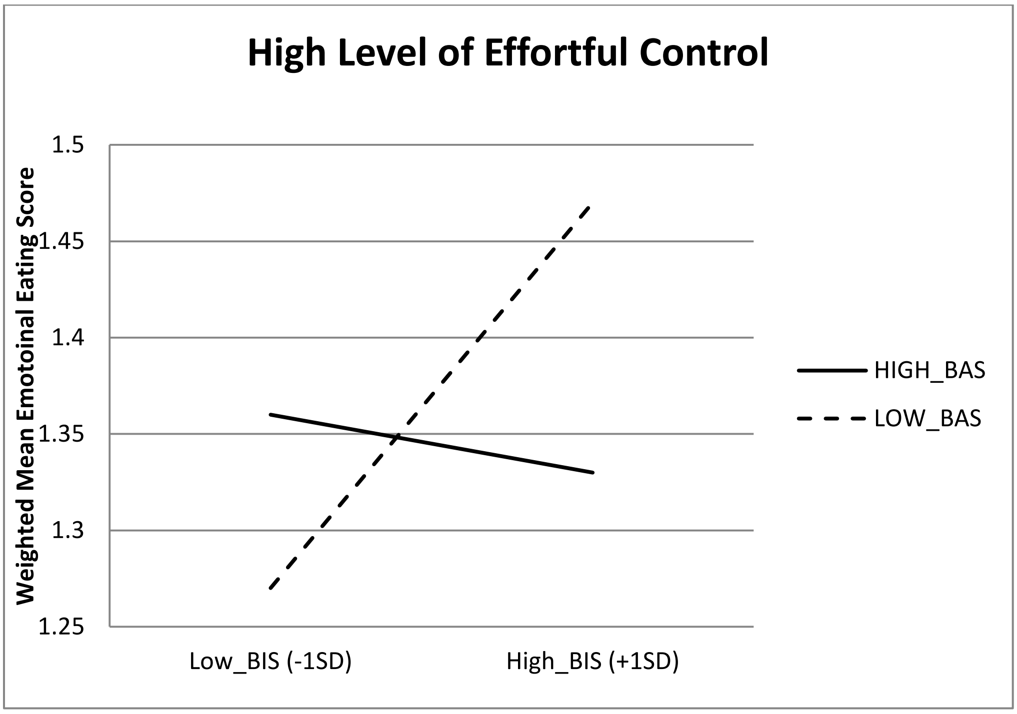


Figure 4.7. Graphic representation of high levels of the BIS interacting with low levels of the BAS to significantly predict emotional eating when EC-T is high.

This finding and the results presented in Figure 4.7 suggest that high levels of the BIS may attenuate high levels of effortful control when BAS levels are concurrently low but not when BAS levels are concurrently high, to predict higher levels of emotional eating behaviour.

4.6 DISCUSSION

The aim of this study was to determine whether the reactive temperament dimensions of BIS and BAS and the regulative temperament dimension of effortful control, in association with an inability to regulate emotion and negative urgency, predicted emotional eating behaviour and BMI in a community sample. Two further aims were to determine if the experience of anxiety in response to stressful situations, i.e., trait anxiety, and the regulative temperament dimension of effortful control interacted with high levels of the BIS and high and low levels of the BAS to significantly predict emotional eating behaviour.

4.6.1 Sample overview: Weight management characteristics and BMI category

An overview of the sample showed that the majority were not currently dieting. However, one-quarter of those who had attempted to lose weight had made from 6 to 11 or more attempts to lose weight. Moreover, one-third of those who had dieted considered themselves to be either not very successful at weight management or to have failed in their attempts. Not surprisingly, the obese category had the highest number of weight loss attempts, relative to the lean and overweight groups, and one-quarter of these individuals considered themselves to have failed in their weight management efforts.

The relationship between the levels of emotional and external eating behaviour in the obese group, compared to the overweight and lean group, is informative. Emotional eating behaviour has been associated with BMI and weight gain over time (Koenders & van Strien, 2011; van Strien, Frijters, Roosen, Knuiman-Hijl, & Defares, 1985; van Strien et al., 2009; van Strien, Herman, & Verheijden, 2012) and, in support of these findings, the obese group had the highest levels of emotional eating when compared with both lean and overweight groups. Moreover, it was interesting that the overweight and obese shared similar levels of external eating behaviour, whilst the obese group had significantly higher levels of external eating behaviour than the lean group and they could be further differentiated from the lean group by their level of negative urgency. These findings support the conceptualisation of van Strien and colleagues that an individual's level of emotional eating, within an obesogenic environment, may represent a more sensitive indicator of an individual's obesity risk than their level of external eating behaviour alone (van Strien et al., 2009). Moreover, it adds to this literature by indicating that an individual's level of negative urgency, which was shown to share an association with the BIS in this study and also in a study of overweight and obese adolescents (Delgado-Rico et al., 2012), may contribute towards this risk. Surprisingly, there were no significant differences between the obese and the lean category in their level of effortful control or in their ability to regulate emotion. However, this finding may indicate a need to further differentiate within the BMI groups, to determine whether, by doing so, any differences become apparent.

4.6.2 Relationships amongst BIS, BAS, effortful control and emotional eating behaviour

Women were higher in emotional eating and the BIS than men, which supports previous findings (Jorm et al., 1999; Keller & Siegrist, 2015; McLean, Asnaani, Litz, & Hofmann, 2011). These results were also not unexpected, as the mean Emotional Eating Scale scores from a community sample within the DBEQ manual (van Strien, 2002) show that a combined sample of obese and non-obese men (n = 449) had a mean emotional eating score of 1.72 (*SD* 0.57), whilst obese and non-obese women (n = 602) had a mean emotional eating score of 2.06 (*SD* 0.72). However, it is interesting that, in comparison to these findings, the mean level of emotional eating behaviour of females in study one is higher again than the level of emotional eating behaviour reported in van Strien's community sample of 1983, whilst the level of mean external eating behaviour was similar (2002).

This is an interesting finding in light of a report by van Strien et al. (2009) of an increase in emotional eating (Cohen's d = 0.92) to a greater extent than external eating (Cohen's d = 0.32) between the 1983 sample and a more recent sample of males and females (n =1342) (van Strien et al., 2009). The results of this study support the results of van Strien et al. (2009) and similarly suggest that an increase in levels of emotional eating in females may place them at greater risk of weight gain over time than an inclination to give in to the numerous opportunities to overeat that an obesogenic environment provides; i.e., as would be expected from a high level of external eating.

The BIS and emotional eating behaviour

The first part of the first hypothesis, that the BIS would be associated with emotional eating behaviour, was supported in the complete sample. These findings are different to the findings that have been recently reported by Stapleton and Whitehead (2014) whereby no association was found between the Carver and White BIS Scale (1994) and emotional eating behaviour in their mixed sample of males and females. However, the hypothesis was only partially supported, according to gender in study one. Interestingly, there was evidence of a significant association between the BIS and emotional eating in males but no evidence of a significant association in females. However, other authors (Hennegan et al., 2013) who used the SPSRQ (Torrubia et al., 2001) and the Jackson 5 (Jackson, 2009) in a female-only sample have shown evidence that the BIS (r = .29, p < .001) is associated with emotional eating behaviour. Subsequently, those results differ from the results obtained within this study. Stapleton and Whitehead (2014) did not separate the group by gender, so it is not known if they may have found a similar effect in males. Therefore, this study has reported the first evidence of an association between the BIS Scale from the Carver and White BIS/BAS Scales (1994) and emotional eating in a non-clinical and non-bariatric population of adult males but not females.

Given the finding of a relationship between the BIS and emotional eating in males, these results do not suggest what may have been identified is a lack of sensitivity of the Carver and White BIS Scale (1994) to identify a relationship with emotional eating behaviour in females. Rather, it is possible that, relative to the scales design, which captures the emotional response inherent to both BIS and BAS activation, the Carver and White BIS Scale is only distally associated with emotional eating behaviour in females. Therefore, it may always show evidence of a weaker association with emotional eating behaviour in this gender.

This line of conjecture is supported by the research of Evers et al. (2010), which has shown that emotional eating is not directly associated with an increase in eating behaviour in females but, rather, indirectly associated via an inability to regulate the effect of their current emotional state. For example, their findings showed that females increased their intake of comfort food when they used an ineffective emotion regulation technique, such as suppression, to a greater extent than those women who use an effective emotion regulation strategy, such as appraisal. Insightfully, their studies found it was not the induction of the negative event that resulted in the intake of ‘comfort food’ but the failure to effectively regulate the emotion associated with it. Subsequently, these results would support that a low level of effortful control and an inability to regulate emotions, rather than the BIS directly, would be a stronger predictor of emotional eating behaviour in females.

Besides explaining the lack of a finding in females, this evidence may also contribute towards explaining the positive association in males. For example, males have been found to use emotion regulation strategies less often than women (Nolen-Hoeksema & Aldao, 2011) and a difficulty in identifying emotions has been associated with a higher level of emotional eating in men (Larsen, van Strien, Eisinga, & Engels, 2006). Therefore, when faced with an aversive state that they may not even attempt to regulate, males may be more inclined to succumb directly, as opposed to indirectly, to emotional eating. Furthermore, although males in this sample did not have a significantly higher level of BAS, when compared to females, their level of BAS was higher than norms for Australian males (Jorm et al., 1999). This is relevant because activation within the BIS could also lead to emotional eating behaviour, via impulsive responding, in individuals with a high level of BAS.

As described in stage three of Patterson and Newman's model of disinhibition (1993), in response to the experience of an aversive event that serves as an input to the BIS (Corr, 2002a), an individual with high levels of BAS reactivity will experience an enhanced emotional state that motivates them to continue to actively seek reward. This implicates a response that may be enhanced by the level of motivation inherent to frustrative non-reward, i.e., from activation within the BIS (Corr, 2002a). Under these circumstances, as described by Corr (2002a), a feeling of frustrative non-reward would be caused by the thwarting of BAS-motivated expectations mediated by acute activation within the BIS. In support of this conceptualisation, emotional eating was associated with the BIS and emotional eating behaviour in males. Subsequently, activation of the BIS in males could lead to an increase in emotional eating behaviour during the experience of frustrative non-reward. This line of reasoning may also support the findings of a greater proportion of males with a LBIS_HBAS phenotype in the overweight and obese BMI category, when stratified by their level of BMI and BIS_BAS phenotype, as discussed below. It is possible that in LBIS_HBAS males, intermittent BIS activation on a background of a high level of BAS reactivity represents one pathway to enhanced emotional eating behaviour and increased risk for obesity.

An effect of the BIS on external eating behaviour

The relationship between the BIS and external eating behaviour in females but not in males was unexpected, as the most recent literature was not available when the first study in this thesis was completed. However, a level of high emotionality has been suggested to lead to a focus on external eating cues, which may disinhibit eating behaviour when the source of anxiety is diffuse or uncontrollable (Robbins & Fray, 1980; Slochower, 1983; van Strien & Schippers, 1995). Specifically, it has been suggested to result not only in emotional eating but also to increase external eating behaviour and both types of eating behaviour have been related to over-consumption and disinhibited eating behaviour (Ouwens et al., 2003; Robbins & Fray, 1980; Slochower, 1983; van Strien, 1997, 2000).

It is interesting that, since the completion of this study, two recent papers have also highlighted a similar association; one in a sample of males and females (Stapleton & Whitehead, 2014), whilst another (Hennegan et al., 2013) has shown evidence of an association in a female only sample. Collectively, the results from this study and the current literature suggest that, at least in women, this may be a reliable finding. Subsequently, a high BIS, which has been associated with the experience of negative affective states, (Dinovo & Vasey, 2011; Heponiemii et al., 2003; Hundt et al., 2007; Vasey et al., 2014; Vasey et al., 2013) could be associated with an increase in attention to external food cues as a learnt response to increased negative affect and arousal. Therefore, the association between the BIS and an association with the DEBQ External Eating Scale suggests that, in response to activation within the BIS, and similar to findings by Slochower (1983), an increase in negative emotionality, in those most susceptible to experience it, may lead to an orientation towards external food cues and disinhibited eating behaviour.

4.6.3 Relationships amongst the BAS, emotional eating behaviour and BMI

Unexpectedly and in contrast to other findings within the adult literature, there was no relationship between the BAS and BMI or the BAS and emotional eating behaviour in either gender (Davis, Patte, et al., 2007; Franken & Muris, 2005; Hennegan et al., 2013; Stapleton & Whitehead, 2014). One reason for this may be that the female sample from Franken and Muris (2005) had a mean BMI of 21.3 (*SD* 2.6) and the mixed sample from Stapleton and Whitehead (2014) had a mean BMI of 24.29 (*SD* 5.45), which is lower than the mean BMI of 29.41 (*SD* 6.47) obtained from the combined sample in this study. Two independent studies (Davis & Fox, 2008; Dietrich et al., 2014) suggest that a positive association exists between the BAS and BMI up until a level of mild obesity and that the relationship changes to an inverse association at a BMI of approximately 30 and that this occurs in both genders. Subsequently, a lack of a positive association, between the BAS and BMI may have been attributed to by this effect; i.e., the mean BMI of this sample may have placed them precisely at that aspect of a curvilinear trajectory where no association could be detected. This effect may also have contributed towards the lack of association between the BAS and emotional eating behaviour. Simply eyeballing the scatter plots did not show evidence of any association between the BAS and BMI, linear or otherwise, which suggests this association was not to be found within this sample. However, it was also surprising that a significant association was not found between the BIS and BMI.

Proportion of the BIS_BAS phenotype stratified by gender and BMI

Given the lack of a linear or curvilinear relationship between the BIS, BAS and BMI, a supplementary analysis was undertaken to determine if a relationship between temperament and BMI may be detected when the genders were stratified by their BIS_BAS phenotype; i.e., HBIS_HBAS, HBIS_LBAS, LBIS_HBAS and LBIS_LBAS and BMI category, of lean, overweight and obese. Subsequently, the proportion of BIS and BAS phenotypes were examined in a Chi square analysis, by gender and BMI category. Although the findings were not significant, the histograms presented in Appendix C1, Figures C1 and C2, suggest that a greater proportion of females who were overweight and obese had a temperament phenotype that was higher in BIS and either concurrently high or low in BAS. By comparison, the opposite pattern was found in men. In men, there appeared to be a greater proportion of the LBIS_HBAS phenotype in the overweight and obese category. Given the association between emotional eating behaviour and BMI across both genders, these results serve to highlight that the consideration of an interaction effect between the BIS and BAS on BMI, in the HBIS_LBAS and HBIS_HBAS phenotype in females, and the LBIS_HBAS phenotype in males could be fruitful.

Effortful control, emotional eating behaviour and BMI

The first part of the second hypothesis that lower levels of effortful control would be associated with higher levels of emotional eating behaviour was supported for both genders. However, lower levels of effortful control and higher levels of BMI were only apparent in females, not males Therefore, it would appear that the subsequent risk for higher levels of BMI is not linked to lower levels of effortful control in males. Females, on the other hand, do appear to have a more direct and enduring relationship, whereby a low level of effortful control is linked both to a higher level of emotional eating behaviour and a higher level of BMI. As suggested by the results in this study, females may be more susceptible to reactivity within the BIS undermining their capacity to exert effortful control over their eating behaviour.

4.6.4 A series of hierarchical, multiple, linear, regression analyses

As a result of the lack of association between the BIS and BMI, the hypotheses that were planned to explore whether the BIS and effortful control or the interaction terms of BIS x BAS x STAI-T and BIS x BAS x EC-T would predict BMI were not investigated. The ensuing discussion subsequently covers the series of hierarchical linear regression models investigating whether the BIS, EC-T, associated variables of DERS-T and UPPS-U, and the interaction terms of BIS x BAS x STAI-T and BIS x BAS x EC-T predicted emotional eating behaviour instead.

Temperament (BIS, BAS and effortful control) and its ability to predict emotional eating behaviour

The third hypothesis that the BIS, EC-T, DERS-T and UPPS-U would predict emotional eating behaviour was partially supported. The results show that the BIS significantly predicted emotional eating behaviour beyond the variance explained by age, BMI and gender. Furthermore, it contributed towards the prediction of emotional eating behaviour, whilst the BAS did not. The final model, which included the DERS-T and EC-T variables, was significant and explained 45% of the variance in emotional eating behaviour. This model subsequently demonstrated that a low level of effortful control and difficulties in emotion regulation significantly added to the prediction of emotional eating behaviour. These findings were similar to those of Stapleton and Whiteside (2014), who also showed that difficulties in emotion regulation, beyond the contribution of the BIS or the BAS, predicted emotional eating behaviour. However, they extended these findings by showing that a low level of effortful control also contributes to emotional eating behaviour.

These results suggested that the lack of a significant association between the BIS and emotional eating in females, found earlier, could be explained by it being a more distal predictor of emotional eating behaviour, as previously reported by Hasking (2006); as it appeared to be mediated by a low level of effortful control. As has been previously introduced, low levels of effortful control and high levels of the BIS or related variables have been shown to predict the experience of negative affective states (Dinovo & Vasey, 2011; Vasey et al., 2014; Vasey et al., 2013), which have been linked to emotional eating behaviour (reviewed in section 2.7.1). Moreover, it is possible that a high level of BIS reactivity would reduce the likelihood that an individual could successfully exert effortful control over both their emotions and their behaviour (reviewed in section 2.4). Therefore, it is possible that a high level of BIS reactivity and a consequent low level of effortful control would lead to emotion regulation difficulties (reviewed in section 2.3.3) and emotional eating behaviour. Furthermore, although UPPS-U was positively associated with the BIS and DERS and inversely associated with effortful control, it did not significantly add to the prediction, beyond the BIS, EC and DERS variables. This finding indicated that the Urgency subscale of the UPPS measures overlapping constructs, which do not extend beyond a reactive temperament, which is poorly regulated, and associated emotion regulation difficulties.

Overall, these findings suggested that a low level of effortful control appeared to mediate the effect of the BIS on emotional eating behaviour and together with emotion regulation difficulties predicted emotional eating behaviour. Moreover, as hypothesized, the BAS did not contribute towards the prediction of emotional eating behaviour. Therefore, these findings are not in agreement with the current conceptualisation of a highly reactive BAS as a driver of impulsive eating behaviour, which has been suggested to increase risk for obesity (Davis, 2009). Instead these results suggest that when the BIS is concurrently included in analyses investigating the effect of temperament on eating behaviour that it may be a stronger predictor of eating behaviour than the BAS.

Predicting emotional eating behaviour via three-way interaction of BIS, BAS and trait anxiety

Having highlighted the interest in this thesis of activation within the BIS and a subsequent increase in physiological and psychological arousal (reviewed in section 2.4 and 2.8.2), the aim of the first exploratory hypothesis was to determine whether a high BAS and high BIS (HBIS_HBAS) and/or a high BIS and a low BAS (HBIS_LBAS) phenotype would be predisposed to experience state anxiety during stressful experiences (i.e. trait anxiety), and whether such a predisposition would subsequently predict emotional eating behaviour. The addition of the three-way interaction term did add significantly to the prediction of emotional eating behaviour and the addition of DERS-G, although not UPPS-U, added to the prediction of emotional eating behaviour beyond the addition of the interaction term.

When this interaction was probed, it revealed that emotional eating behaviour was only predicted in individuals who possessed a HBIS_HBAS phenotype. It also highlighted a striking contrast between these individuals and those who possessed the HBIS_LBAS phenotype. Interestingly, there was a clear relationship between a significant increase in trait anxiety and a significant increase in emotional eating behaviour in the HBIS_HBAS, but not the HBIS_LBAS phenotype. However, the HBIS_LBAS phenotype appeared to already have a higher level of emotional eating behaviour at a low level of trait anxiety, when compared to the HBIS_HBAS phenotype. Supplementary analyses showed that, even though both BIS_BAS phenotypes were found not to differ significantly in their level of trait anxiety, they did differ significantly in their ability to regulate their emotions. When the emotion regulation strategies of these individuals were explored, the HBIS_LBAS phenotype had a significantly higher level of a 'lack of awareness' and understanding of their emotional state, with a large effect size (d = 0.78) when compared with the HBIS_HBAS phenotype.

These findings are interesting when compared to the results of Dinovo, Vasey and colleagues (literature review section 2.8.2), which predicted that, when effortful control was low, the HBIS_HBAS phenotype would experience high levels of general distress and an increase in autonomic arousal and that the HBIS_LBAS phenotype would experience depression. When considered together with the conceptual psychobiological model of a failure to manage eating behaviour, (reviewed in section 2.4 and the Psychosomatic Theory of Emotional Eating, which asserts that individuals eat emotionally in response to an increase in physiological arousal and psychological distress, which they have mistaken for feelings of hunger (van Strien, 2002). The ability of the BIS x BAS x STAI-T interaction term to predict emotional eating behaviour in the HBIS_HBAS phenotype could indicate that individuals in possession of a low level of effortful control and a HBIS_HBAS phenotype may be more susceptible to lose control over their behaviour and eat emotionally in response to stressful circumstances. Furthermore, a predisposition of the HBIS_LBAS phenotype to experience depressive symptoms, in combination with their reported deficit in emotional awareness, could explain their already higher level of emotional eating behaviour at a lower level of trait anxiety, when compared to the HBIS_HBAS phenotype.

These results are also interesting in light of the complex relationship reported on earlier between eating behaviour and the experience of anxiety (reviewed in section 2.7.1). Moreover, given the results showing that the BIS was significantly correlated with external eating behaviour in females and the expected relationship between emotional, external and disinhibited eating behaviour (reviewed in section 2.6.2), it is not inconceivable that these temperament phenotypes might underlie trait eating behaviours that have been shown to characterise the HDHR and HDLR eating behaviour subtypes (Haynes et al., 2003; Yeomans & Coughlan, 2009; Yeomans, Tovey, et al., 2004). When investigating the effect of stress and negative affect on consumption patterns between the HDHR and the HDLR subtypes (reviewed in section 2.6.3), results indicated that the HDHR subtype consumed more food in relation to the experience of stress and negative affect, whilst the HDLR subtype was found to consume more highly palatable food in the neutral state and to decrease their intake during the experience of stress and negative affect (Haynes et al., 2003; Yeomans & Coughlan, 2009).

These results highlight the importance of considering an interaction between the BIS and the BAS when investigating eating behaviour. They are also supported by the results of Matton, Goosens, Braet and Vervaet (Matton et al., 2013), which showed a relationship between two BIS and BAS clusters and emotional eating behaviour. Similarly to the results reported here, the HBIS_HBAS and HBIS_LBAS clusters of Matton et al. (2013) were shown to have higher levels of emotional eating behaviour when compared to the LBIS_HBAS and LBIS_LBAS temperament clusters. Relative to a link between emotional, external and trait disinhibited eating behaviour (reviewed in section 2.6.2), the results of Matton et al. also support the consideration of an investigation into the temperament traits of the HDHR and HDLR disinhibited eating behaviour subtypes, as their HBIS_HBAS cluster was also shown to have the highest levels of external eating behaviour.

Whilst exploratory, these results provide support for the consideration of a model of reward-driven affect-regulated eating behaviour that may arise from an interaction between the BIS and BAS. Importantly, these results introduce the action of the BIS, together with the BAS, when considering the influence of temperament on affect-regulated eating behaviour, which to date has only been considered in relation to individuals with a high level of BAS reactivity (Aldao et al., 2010). At present, the current conceptualisation is that the higher an individual's level of reward-seeking behaviour, which is described synonymously with their level of BAS reactivity, the greater their propensity to seek food as an affect-regulation strategy (Aldao et al., 2010; Davis & Loxton, 2014). The results of this analysis support the consideration of the conceptualisation that the BIS may also have a role to play in hedonically motivated food reward behaviour, e.g. via enhanced levels of wanting and liking (reviewed in section 2.12).

What is the relationship between a reactive temperament and effortful control in the prediction of emotional eating behaviour?

The aim of the second exploratory hypothesis was to determine whether effortful control either moderated or was moderated by the BIS and/or the BAS, and whether their interaction predicted emotional eating behaviour. Therefore, the effect of a three-way interaction, i.e., BIS x BAS x EC-T on emotional eating behaviour, was explored across the sample. Entry of the three-way interaction term into the model was significant and explained an additional 1.2% of the variance in emotional eating behaviour. It is acknowledged that this finding could be interpreted as insignificant, i.e., as it does not appear to contribute significantly to the model in a meaningful way. However, it is of interest to this research that a study by Dinovo and Vasey (2011), which investigated the effect of psychobiological temperament on the prediction of general distress, found a similarly small (2%) increase in their prediction of general distress after the addition of their BIS x BAS x EC-T interaction term. The most interesting finding from their study was that, when effortful control was low, high levels of the BIS predicted levels of distress that were significantly above average when BAS was high and low. Moreover, in an extension of this research, a later study (Vasey et al., 2013) also reported that a related three-way interaction term, which only added a significant 0.2% change to their model, predicted high levels of depressive symptoms when levels of effortful control were low, negative emotionality was high, and positive emotionality was low. Furthermore, they also showed that, even when effortful control was high, in combination, high levels of negative emotionality and low levels of positive emotionality may also give rise to depressive symptoms that even a high level of effortful control may fail to overcome. Collectively, these findings are of theoretical interest in relation to the use of food to regulate affect (reviewed in section 2.5), a psychobiological model of a failure to manage eating behaviour (reviewed in section 2.4) and the knowledge that the experience of negative affective states have been linked to eating behaviour (reviewed in section 2.7.1). The knowledge that low levels of effortful control and high levels of BIS, alongside high or low levels of BAS, can predict general distress and depression and that the experience of such negative affective states can be linked to eating behaviour (reviewed in section 2.7.1) supports the theoretical basis of this thesis.

In the final model a low level of effortful control significantly predicted higher levels of emotional eating behaviour, in a three-way EC-T x BIS x BAS interaction, in the HBIS_HBAS, LBIS_HBAS and LBIS_LBAS phenotypes. When these results are considered in relation to the prediction of emotional eating behaviour by the BIS x BAS x STAI-T interaction term, they could support a model of affect-regulated eating behaviour in individuals who possess a HBIS_HBAS phenotype and a low level of EC. Moreover, these results are supported by the research of Müller et al. (2014) who showed that obese individuals with a low level of effortful control and a HBIS_HBAS phenotype, identified via latent profile analysis, were more emotionally dysregulated and possessed more eating disordered and depressive symptoms than a temperament phenotype with a higher level of effortful control and lower BIS and BAS scores.

In the final model, it was also noted that when effortful control was positioned as the predictor variable, it did not predict a higher level of emotional eating behaviour when the BIS was high and the BAS was concurrently low (Figure 4.5), i.e., in the HBIS_LBAS phenotype. Therefore, this model was investigated further by positioning the BIS as the predictor variable, with BAS and EC-T as its moderators (Figure 4.6). Upon doing so, the subsequent analysis showed that high levels of the BIS predicted higher levels of emotional eating behaviour at a low level of the BAS, even when effortful control was high. Therefore, at low levels of the BAS, a high level of the BIS appeared to attenuate the effects of a high level of effortful control to predict emotional eating. This finding, although only exploratory, is worthy of further investigation. As previously reviewed (section 2.8.1 and 2.8.2), high levels of the BIS and low levels of the BAS have been linked to depressive psychopathology (Bijttebier et al., 2009) and research by Vasey et al. (Vasey et al., 2013) has indicated that the synergistic combination of a high level of negative emotionality and a low level of positive emotionality may overcome even a high level of effortful control, to result in the experience of depressive symptoms. Therefore, the results from this analysis suggest that the HBIS_LBAS phenotype may be at risk of increased emotional eating behaviour, regardless of their level of effortful control.

These results are also noteworthy when considered in relation to the prediction of emotional eating behaviour by the BIS x BAS x STAI-T interaction term. Although the HBIS_LBAS phenotype did not increase their level of emotional eating behaviour at a higher level of trait anxiety, they did have a higher level of emotional eating behaviour at a low level of trait anxiety, when compared to the HBIS_HBAS phenotype. Furthermore, supplementary analysis revealed that they had a reduced level of awareness of their emotional state in comparison to the HBIS_HBAS phenotype. Therefore, it is possible that individuals with a HBIS_LBAS phenotype and a low or high level of effortful control may eat emotionally in response to feeling depressed and they may be also less aware of their emotional state. This lack of emotional awareness could place them at greater risk of emotional eating and weight gain, at apparently lower levels of trait anxiety.

These results introduce the need to consider an individual's capacity to successfully manage their eating behaviour on the basis of a holistic psychobiological model of temperament. Specifically, the conceptualisations presented herein directly present the question: are these individuals eating because they have a high level of sensitivity to reward that is driven by a high level of BAS reactivity or are they eating because they have a high level of BIS reactivity and a corresponding low level of effortful control?

4.7 CONCLUSION

These findings highlighted that the level of reactivity within an individual's psychobiological temperament and their capacity to regulate their ensuing emotional state could be indicative of dispositional trait behaviours influencing emotional eating behaviour. Whilst highlighting that the HBIS_HBAS phenotype may be at risk of emotional eating in response to higher levels of trait anxiety when levels of effortful control are low, the findings also suggested that individuals with a HBIS_LBAS phenotype may exhibit a lack of awareness, and understanding of their emotional state. As such, it is possible that they will also eat emotionally, irrespective of their level of trait anxiety, because they have misinterpreted a heightened state of physiological arousal with a lack of satiety and a state of hunger. Moreover, as evidenced by their lack of awareness to their emotional state, it is possible that their predisposition to overeat emotionally may be less easily predicted by self-report measures of negative affect, i.e., such as the STAI-T.

The results also suggested that an individual's capacity to exert effortful control may be overcome by reactivity within the BIS. When these results are considered in relation to the prefrontal cortex model of cognitive control of Miller and Cohen(2001) they highlight the difficulty that a high BIS phenotype may experience when desiring to change their habitual eating behaviours, once their capacity to exert effortful control is exhausted (Muraven & Baumeister, 2000; Wagner & Heatherton, 2013a). Finally, the evidence from the male sample is informative and provides a basis for the consideration of how temperament may be associated with emotional eating behaviour and possibly disinhibited eating behaviour in this subgroup, which to date has been under-investigated within the temperament and eating behaviour literature.

Chapter 5: Temperament and its impact on psychological food reward and trait Disinhibition

5.1 EXECUTIVE SUMMARY OF MAIN OUTCOMES

1. The BIS but not the BAS was significantly associated with disinhibited-eating behaviour in both genders.
2. The BIS but not the BAS was significantly associated with implicit wanting and explicit liking for high-fat sweet and savoury foods
3. Effortful control significantly partially mediated the association between the BIS and disinhibited-eating behaviour. A low level of effortful control fully mediated the association between the BIS and implicit wanting of high-fat sweet foods.
4. A significantly greater proportion of females with a HBIS_LBAS phenotype were high in Disinhibition and low in Restraint (HDLR) when compared to females with a LBIS_LBAS phenotype, who were more prominent in the high Restraint and low in Disinhibition (LDHR) eating behaviour subtype.
5. The proportion of individuals with the HDLR eating behaviour subtype was significantly greater in the obese weight category than individuals with the LDHR eating behaviour subtype, who were more prominent in the overweight category.

5.2 INTRODUCTION

Disinhibited-eating behaviour, which has been described as a dispositional trait, has been linked to weight gain, poor weight loss success, weight regain after weight loss, unhealthy food choices, binge eating, and obesity. It has also been linked to a hedonic style of eating behaviour and the psychological rewards of wanting and liking (Bryant et al., 2008; Finlayson et al., 2012; French et al., 2014; Lawson et al., 1995; Provencher et al., 2003; Williamson et al., 1995).

A hedonic style of eating behaviour (Adam & Epel, 2007; Davis, Patte, et al., 2007; Finlayson et al., 2007a) drives a motivation towards consumption that is not based upon the requirement to satisfy homeostatic hunger but rather to satisfy a psychological expectation or desire (Bryant et al., 2008; Finlayson et al., 2007a; Finlayson et al., 2008; Lowe & Butryn, 2007). Disinhibited-eating behaviour, such as binge-eating behaviour, which represents a loss of control over intake and displays a disregard for long-term consequences, has been linked to a hedonically driven, addictive style of eating behaviour by some researchers within the temperament-based eating behaviour field (Davis & Carter, 2009). For example, binge-eating behaviour has been linked to BAS hyper-reactivity, which is believed to lead to disinhibition or loss of control over intake (Davis, 2009; Dawe & Loxton, 2004). Subsequently, individuals with high scores on self-report measures of BAS reactivity have been conceptualised as eating in response to a desire to further enhance an already high level of reward or to regulate the experience of a negative affective state (Aldao et al., 2010; Davis & Carter, 2009; Davis, Patte, et al., 2007). However, the field has not yet investigated whether a high level of BIS reactivity, which may be ineffectively regulated by effortful control and associated emotion regulation difficulties, is also linked to a psychobiological model of a failure to manage eating behaviour, enhanced levels of psychological reward, disinhibited-eating behaviour, and obesity.

The pleasure associated with the liking response creates a positive affective reaction (Berridge, 2003) and the intake of highly palatable foods has been linked to the self-regulation of mood (Macht, 2008). Moreover, foods that are liked are often wanted (Berridge, 1996) and enhanced levels of psychological reward are capable of overriding homeostatic appetite and disinhibiting eating behaviour (Dalton & Finlayson, 2013; Finlayson et al., 2007a). Interestingly, higher levels of trait disinhibited and binge eating behaviour have been linked to the psychological rewards of wanting and liking and to the experience of negative emotional states (Dalton & Finlayson, 2014; Finlayson et al., 2012; French et al., 2014). Similarly, a reactive BIS, a low level of effortful control, and emotion regulation difficulties have also been linked to the experience of negative emotional states (Bijttebier et al., 2009; Derryberry & Rothbart, 1997; Dinovo & Vasey, 2011; Gratz & Roemer, 2004; Gross & Muñoz, 1995; Rothbart et al., 2013; Vasey et al., 2014; Vasey et al., 2013).

Therefore, it is possible that an individual with a reactive temperament may possess pre-dispositional traits that lead to disinhibited-eating behaviour and enhanced levels of psychological reward. However, to the best of my knowledge, a relationship between a reactive BIS, beyond a reactive BAS, and a low level of effortful control, associated emotion regulation difficulties and disinhibited-eating behaviour has not been reported previously, nor have any studies investigated whether these constructs are associated with or predict the associated psychological rewards of wanting and liking (Dietrich et al., 2014). Therefore, Chapter 5 explores whether the BIS, BAS, EC-T and associated emotion regulation difficulties (DERS) predict disinhibited-eating behaviour and the hedonic rewards of wanting and liking.

The results from Chapter 4 suggested that a reactive BIS and a low level of effortful control, but not a reactive BAS, may disinhibit eating behaviour, either by an effect on emotional eating behaviour (in males) or via an effect on external eating behaviour (in females). Moreover, Chapter 4 also revealed that the BIS appeared to be mediated by a low level of effortful control, whilst both a low level of effortful control and emotion regulation difficulties predicted emotional eating behaviour beyond a reactive BIS. Therefore, it is possible that the BIS, but not the BAS, will also be a distal predictor of disinhibited-eating behaviour in Chapter 5. Chapter 5 determines whether effortful control mediates the effect of the BIS on disinhibited-eating behaviour. Furthermore, it is possible that an individual with a reactive BIS may also exhibit enhanced implicit wanting out of a desire or motivation to use highly palatable and 'liked' food as an affect-regulation strategy. Therefore, it is feasible that an individual with a poorly regulated reactive temperament might be susceptible to enhanced wanting because of difficulties with regulating emotion. Consequently, associated emotion-regulation difficulties may mediate the effect of the BIS, but not the BAS, on the implicit wanting of high-fat sweet foods (IW_HFSW). Therefore, Chapter 5 also explored whether DERS mediates the effect of the BIS on the implicit wanting of high-fat sweet foods.

Study one (Chapter 4) also identified the potential for a link between the HDHR and HDLR eating behaviour subtypes (Section 2.6.3), and the HBIS_HBAS and HBIS_LBAS temperament phenotypes. Although the analyses were only exploratory, an interaction between the BIS x BAS x STAI-T interaction term predicted an increase in emotional eating behaviour in individuals with a

HBIS_HBAS phenotype. These results identified that, when levels of trait anxiety increased in HBIS_HBAS females, similarly to findings of increased eating behaviour in response to the experience of stress and negative affect in the HDHR eating-behaviour subtype, so did their level of emotional-eating behaviour. Therefore, study 2 also investigated whether a psychobiological model of temperament is capable of predicting an individual's level of vulnerability to trait Disinhibition as trait anxiety increases.

Additional results, although not significant, also suggested that when the BIS_BAS phenotypes were stratified by gender and BMI classification that, as BMI increased in females, similarly to a finding of a propensity for higher levels of obesity in the HDLR eating-behaviour subtype, BMI also appeared to increase proportionately in females with the HBIS_LBAS phenotype. Moreover, further support for this latter result is reflected in the temperament-based research that was reviewed both prior to and upon completion of this study. There is evidence of an inverted-U relationship between the BAS and BMI in both adults and children as BMI increases from a normal body weight through to severe obesity (Davis & Fox, 2008; Dietrich et al., 2014; Verbeken et al., 2012). Whilst it was not possible to detect a relationship between the BIS and BMI, there is evidence that, as BIS reactivity increases, BMI also increases in adolescents (Delgado-Rico et al., 2012) and in adult females, (Dietrich et al., 2014). Collectively, the results from study one (Chapter 4) and the literature suggested it may be valuable to investigate the effect of an interaction between the BIS and the BAS by observing the outcome of a combination of BIS and BAS scores on BMI in the one study. For example, they suggested that, when an individual's level of BIS reactivity is considered alongside their level of BAS reactivity as BMI increases, the HBIS_HBAS phenotype may occur in proportionately greater numbers in the overweight to mildly obese BMI range, whilst a HBIS_LBAS phenotype may occur in proportionately greater numbers from the mildly obese to the severely obese range. However, there is no evidence of a link between these temperament phenotypes and increasing levels of BMI in the current literature and it is possible that an apparent relationship between the BIS and these disinhibited-eating behaviour subtypes only exists in samples with a higher mean BMI. Therefore, study 2 investigated whether the stratification of the BIS_BAS phenotypes by gender, disinhibited-eating behaviour subtype, and BMI classification significantly differentiates one BIS_BAS phenotype from another in a community sample of overweight and obese individuals.

The aim of this study was to determine whether temperament is associated with either of the aforementioned eating-behaviour subtypes. However, it also offers a novel way of conceptualising the trait dispositions of those who succeed and fail in their weight management attempts. Low levels of Disinhibition and high levels of Restraint (LDHR) have been shown to characterise successful (Westenhoeffer, 1991; Yeomans, Mobini, Bertenshaw, & Gould, 2009) and frequent dieters who succeed in their weight loss attempts (Lawson et al., 1995) (Section 2.15). This characterisation suggests that the dispositional traits of these individuals relative to their highly disinhibited counterparts are also worth investigating. For example, if the proportion of temperament phenotypes are found to differ between the successfully restrained and unsuccessfully restrained eating-behaviour subtypes, it may suggest a temperament-based way forward to manage rising obesity levels. Therefore, in addition to investigating whether temperament may be linked to those subtypes who fail to successfully restrain their eating behaviour, this study also explored whether temperament is linked to the LDHR subtype, which has been characterised as a successful dieter who successfully restrains intake.

Executive control processes such as effortful control are higher-order processes that promote the achievement of goal-directed outcomes (Allan et al., 2010). Evidence suggests that a reduced ability to direct attention and inhibit pre-potent cognitions is linked to disinhibited-eating behaviour, overconsumption and appetite in lean, overweight and obese individuals (Allan et al., 2010; Fitzpatrick et al., 2013; Hou et al., 2011; Maayan et al., 2011; Nijs et al., 2010; Vainik et al., 2013). However, it is not known if a self-reported measure of effortful control is associated with a behaviour-based test of executive function, such as the Stroop Colour Word Interference Test (SCWIT) (Stroop, 1935), or whether this measure is associated with disinhibited-eating behaviour in an adult, overweight and obese, non-clinical, community sample (Müller et al., 2014). Therefore study 2 explored the utility of the construct of effortful control by administering the SCWIT, which measures one of its core constructs: the ability to inhibit a pre-potent response. It determined whether a behaviourally-based cognitive deficit is associated with self-reported effortful control, disinhibited-eating behaviour and BMI.

5.3 STUDY AIMS

The primary aim of this study was to determine if the BIS, effortful control and difficulty regulating emotion predicted disinhibited-eating behaviour and the psychological rewards of wanting and liking. The secondary aims were to determine whether a particular BIS_BAS phenotype occurred in a significantly greater proportion in any of the disinhibited-eating behaviour subtypes, relative to gender and BMI, and to determine whether the three-way BIS x BAS x STAI interaction term predicted disinhibited eating behaviour.

5.3.1 Hypotheses

- o The BIS, but not the BAS, and a low level of effortful control would be associated with and significantly add to the prediction of disinhibited-eating behaviour in an overweight and obese community sample.
- o Effortful control would mediate the effect of the BIS on disinhibited-eating behaviour.
- o Stroop performance would be positively associated with disinhibited-eating behaviour and effortful control and inversely associated with BMI.

- Exploratory hypotheses
  - o The BIS, but not the BAS, would be associated with and predict implicit wanting and explicit liking of high-fat sweet foods.
  - o DERS would mediate the effect of the BIS on implicit wanting.
  - o The interaction of BIS x BAS x STAI would significantly add to the prediction of disinhibited-eating behaviour.
  - o The proportion of temperament phenotypes (HBIS_HBAS, HBIS_LBAS, LBIS_HBAS, LBIS_LBAS) would significantly differ from one another according to their disinhibited-eating behaviour subtype classification (HDHR, HDLR or LDHR). The resultant eating-behaviour subtypes would be further differentiated by their BMI classification.

5.4 METHODS

5.4.1 Participants

The study sample was obtained across metropolitan and regional areas. The majority of participants were sampled from metropolitan areas. Participants were staff and students from The Queensland University of Technology. Selected government employees (i.e. Brisbane City Council, Department of Main Roads), non-government employees (i.e. Rio Tinto), community groups (i.e. Rotary), patients from G.P surgeries and any organisation/group that assists individuals to manage their weight (i.e. Wesley LifeShape Clinic), in both metropolitan and regional areas, were also invited to participate.

After receiving permission from management, administrative authorities within each facility were requested to circulate an email and flyer that outlined the study. Those individuals who expressed an interest responded via email to the lead researcher, who then contacted the participants to discuss the study in more detail, either via email or telephone. Participants who expressed an interest to participate in the study and who met the inclusion criteria were invited to take part at a date and time that was convenient for them. Participants were provided with an online link to complete the survey component of the assessment within two weeks of their testing session.

A total of 184 participants completed the online survey. Thirteen individuals were lost to follow-up after survey completion, with reasons cited as clashing work schedules. In total, 174 assessments were carried out. However, three of these patricipants were not included in the data set due to failing to complete the online survey. A further case was excluded as she was breast-feeding and another case was removed as she reported an extremely high BMI of 66. A total of 169 participants remained.

5.4.2 Measures

The online self-report questionnaires consisted of the following: demographic, lifestyle and health questions, the Three-Factor Eating Behaviour Questionnaire (Stunkard & Messick, 1985), the Behavioural Inhibition and Behaviour Activation Scales (BIS/BAS Scales) (Carver & White, 1994), the Effortful Control Scale (EC-T) from the Adult Temperament Questionnaire (Evans & Rothbart, 2007), the trait measure of the State-Trait Anxiety Scales and The Difficulties in Emotion Regulation Scales (DERS) (Gratz & Roemer, 2004).

Behavioural task of executive function

The Stroop Colour Word Interference Test (SWCIT) (Stroop, 1935) is a reliable measure that has been reported as showing a consistent relationship with eating behaviour and BMI (Vainik et al., 2013). In order to successfully lose weight, a dieting individual must exercise restraint over their habitual eating behaviours that led to weight gain. Many individuals habitually choose high-fat foods to self-regulate a negative emotional state. Therefore, when placed on a diet, these individuals must learn to overcome the level of cognitive interference or conflict (Nigg, 2000) inherent to their choosing a less desired, 'healthier' response, whenever they experience the desire to eat to regulate affect. The construct of effortful control and the Stroop task measure an individual's capacity to overcome the level of conflict or 'cognitive interference' (Nigg, 2000) inherent to choosing a sub dominant over a dominant response (Rothbart & Rueda, 2005). Therefore, the Stroop task was chosen, as an operationalized measure of effortful control, over other attentional tasks such as the dot probe, which measures negativity bias (C. MacLeod, Mathews, & Tata, 1986), or a response inhibition task such as the stop go task, which measures the ability to inhibit a motor response (Nigg, 2000), as it specifically measures an individual's capacity to overcome cognitive interference

In this research, the Stroop test was administered individually to participants in a noise-free, well-lit, quiet and ventilated room via the E-Prime software program (E-prime v.2.10.242 (200), Psychology Software Tools, ND). Stimuli were presented on a laptop computer in Times New Roman font, size 72, on a 15-inch monitor, using a grey background. Following the methodology and a review of the literature by Macleod (2005) the task was set up with the following parameters: two blocks in total were run and in each block there was a proportion of 50% congruent and 50% incongruent stimuli. Four colours were chosen to represent these stimuli: red, green, blue and yellow. Within each block there was 48 congruent and 48 incongruent trials, making up a total of 96 trials per block. Within the congruent trials, the words were presented in their corresponding colour, whilst within the incongruent trials, the words were printed in a colour that was incongruent to its content; . for example, the word blue was printed in red ink. By configuring the blocks in this manner, the congruent words served as the control. This has been suggested to provide a more meaningful interpretation of the interference effect, as the difference between the time that it takes to complete the incongruent trials from the congruent trials provides its direct measure (C. M. MacLeod, 2005). Each of the 12 incongruent colour-word combinations was presented equally often for two repetitions, which bought the total number of incongruent stimuli in the trial to 48. The controlled trials were varied in the same manner, which bought the total number of trials in each block to 96. All stimuli were presented in a randomised order. In accordance with the methodology of MacLeod (2005) the following parameters were built into the E-Prime program (E-prime v.2.10.242 (200), Psychology Software Tools, ND): a fixation cross appeared in the middle of the screen for 500ms, followed by the stimulus for a total of 1500ms and a 500ms blank period whereby the participant still had an opportunity to make their response. This provided a total trial interval of 2500ms.

At the beginning of the test, participants were instructed they would be presented with a series of stimuli that would be presented in four colours (red, green, blue, and yellow). Their task was to press one of the four computer keys that corresponded to the four colours presented on the screen as quickly and as accurately as possible. Participants were guided through the following printed instructions that appeared on their screen upon the initiation of the testing procedure. “You will see words in the centre of the screen printed in blue, red, green or yellow ink. Your task is to press the blue-coloured key when the word is printed in blue ink.” These instructions continued until all of the colours had been described. At this point they were also prompted by the researcher to “not respond to the word, but instead to the colour of the ink”. The computer screen was advanced by space-bar click and the following prompt appeared: “You should attempt all trials and try to respond as quickly and as accurately as you can”. They were then informed that they would have the opportunity to practise the task. They were provided with the option to repeat the instructions or to move to the practice trials. The practice trial consisted of 16 trials: 12 incongruent and four congruent. If an incorrect response was made, participants were prompted with “Incorrect”. If participants did not move quickly enough through the trials, they were prompted with “No Response Detected”. Participants were provided with the opportunity to run through the practice trials again, if necessary. When they were ready, they proceeded to the test. After completing block one of the test, participants were allowed to rest until they were ready to proceed to the final block. The length of the rest time was self-selected. Excluding the practice trials and rest period, the total time to complete the test was eight minutes.

5.4.3 Procedures

Participants were requested to take part in the assessment after fasting for a minimum of two and a maximum of four hours. At QUT's Human Appetite Research Centre (HARC), participants were re-screened to ensure compliance with the selection criteria, i.e. total fasting time, and the following anthropometrical measures were taken: height, weight and waist circumference, as outlined in the general methods section. At the assessment session, participants completed two behavioural measures: the LFPQ and a computer-based version of the Stroop Colour Word Interference Test (SCWIT). The LFPQ has been described in more detail in the general methods section. Total assessment time was 30 minutes. See below for a schematic of the procedures (Figure 5.1).

TEST DESCRIPTION AND TIMING (mins)				
Arrival i.e. 12:00pm	12:05	12:15	12:25	Debrief Departure 12;30pm
Arrival, study familiarisation, rescreening & anthropometry	Stroop	LFPQ	Study completion	

Figure 5.1. Schematic of the study procedure.

5.4.4 Data analyses

Categorical variables were summarised and presented as counts and percentages for the total sample and according to gender. The results of these statistics are presented. However, they will not be discussed due to space constraints. Descriptive statistics were used to describe the dependent variables of BMI and disinhibited-eating behaviour and the independent variables of Behavioural Inhibition (BIS) and Behavioural Activation Scales (BAS), Effortful Control total score (EC-T), Difficulties in Emotion Regulation Scale total score (DERS-T), State-

Trait Anxiety Inventory-Trait anxiety (STAI-T), Implicit wanting for high-fat sweet foods (IW_HFSW), Implicit wanting for high-fat savoury foods (IW_HFSA), Explicit liking for high-fat sweet foods (EL_HFSW), Explicit liking for high-fat savoury foods (EL_HFSA), Stroop Colour Word Interference test (SCWIT). These variables were continuous variables and were presented as means and standard deviations or median with interquartile range, depending upon the normality of the independent and dependent variables, for both the total sample and between the genders.

Independent sample t-tests were used to assess the differences between gender on the independent variables of BIS and BAS, the subscales of the BAS Scale BAS-Fun Seeking (BAS-FS), BAS-Drive (BAS-DR) and BAS-reward Responsiveness (BAS-RR), with the dependent variables of BMI and disinhibited-eating behaviour. Associations between the variables were determined using Pearson’s Product Moment Correlation Coefficients for linear data. The following correlational analyses were performed, both across the total sample and between the genders, to examine the following relationships: total effortful control, BIS, BAS, disinhibited-eating behaviour with BMI; total effortful control, BIS, BAS with implicit wanting and explicit liking of high-fat sweet and savoury tastes; Stroop interference scores, Disinhibition and BMI.

A series of hierarchical, multiple linear regression models were run with the following independent and dependent variables: **a)** IV: BIS, EC-T, DERS-T with DV: EL_HFSW; **b)** IV: BIS, BAS, EC-T, DERS-T with DV: IW_HFSW; **c)** IV: BIS, BAS, EC-T, IW_HFS, EL_HFSW with DV: disinhibited-eating behaviour. To investigate whether EC-T mediated the association between the BIS and disinhibited-eating behaviour and whether DERS-T mediated the association between the BIS and implicit wanting of high-fat sweet foods, all continuous variables were centred (Aiken & West, 1996) and the statistical procedures of Baron and Kenny (Baron & Kenny, 1986) were followed. Finally, regression models were used to investigate whether a three-way interaction between BIS x BAS x STAI predicted disinhibited-eating behaviour.

A series of Chi-Square analyses were run in order to examine the following: **a)** the proportion of BIS_BAS phenotypes (i.e. HBIS_HBAS, HBIS_LBAS, LBIS_HBAS, LBIS_LBAS) in an overweight and obese sample; **b)** the proportion of males to females, relative to the disinhibited-eating behaviour subtypes (i.e. HDHD, HDLR, LDHR, LRLD); **c)** the proportion of BIS_BAS phenotypes that occur, relative to high or low levels of disinhibited-eating behaviour by gender; **d)** the proportion of BIS_BAS phenotypes that occur relative to high and low levels of disinhibited-eating behaviour in females; **e)** the proportion of BIS_BAS phenotypes that occur within the disinbited-eating behaviour subtypes (i.e. HDHD, HDLR, LDHR, LRLD) in females and finally; **f)** the proportion of HDLR and LDHR eating behaviour subtypes relative to an overweight and obese classification.

To conduct these analyses, the following categorical groups were created: two disinhibited-eating behaviour groups (High (HD) and Low (LD)), four disinhibited-eating behaviour subtypes (HDHR, HDLR, LDHR, HDHR), and four BIS_BAS phenotypes (HBIS_HBAS, HBIS_LBAS, LBIS_HBAS, LBIS_LBAS). The process for creating these groups for analysis was as follows: the sample was divided into four BIS_BAS phenotypes based on a median split of BIS, BAS scores. Across the sample, median splits were based upon the following levels of each BIS and BAS dimension: low BIS: 12 to 22, high BIS: 23 to 28, low BAS: 24 to 39 and high BAS: 40 to 52**.** Across the sample, median splits were based upon the following levels of disinhibited-eating behaviour and Restraint scores: high disinhibited-eating behaviour 10 to16**,** low disinhibited-eating behaviour 2 to 9**,** high Restraint10 to 21 and low Restraint 0 to 9. The sample was divided into **gender** and then divided again into four groups based on a gender-specific median split of BIS and BAS and disinhibited-eating behaviour. **Within males**, median splits for the BIS _BAS phenotypes were based upon the following: low BIS 16 to 20**,** high BIS 21 to 28**,** low BAS 24 to 38 and high BAS 39 to 52. Median splits for disinhibited-eating behaviour were based on the following levels of disinhibited-eating behaviour: high disinhibited-eating behaviour 7.6 to 16 and low disinhibited-eating behaviour 3 to 7.5. **Within females**, median splits for the BIS_BAS phenotypes were based on the following levels: low BIS 12 to 23**,** high BIS 24 to 28**,** low BAS 24 to 40 and high BAS 41 to 52**.** Median splits for disinhibited-eating behaviour were based upon the following: high disinhibited-eating behaviour 12 to 16 and low disinhibited-eating behaviour 2 to 11; e) a median split was carried out on the Restraint scores in order to categorise **females** into gender-specific eating-behaviour subtypes. Median splits were based upon the following Restraint scores: low Restraint 0 to 10 and high

Restraint 11 to 20; f) finally, **females** were divided into two groups according to their BMI (overweight, BMI 25.00 to 29.99 kg/m^2, and obese, BMI 30 kg/m^2 and above) (World Health Organization, 2015).

A Chi-square test for independence was used to explore the relationship between the proportion of BIS_BAS phenotypes that occur by gender and across the overweight and obese BMI categories by gender, with a Bonferroni adjustment for multiple analyses. When the expected frequency in any cell was less than 5, the data were re-run with the Monte Carlo estimation and Fisher's exact probability statistic for contingency tables was used to determine significance. An α-level of 0.05 was used to determine statistical significance.

5.5 RESULTS

5.5.1 Participant characteristics

Total sample

One hundred and sixty nine participants aged between 18 and 65 years (M = 45.83, SD = 12.14) were recruited. The sample contained a greater proportion of females (62%, n = 105). In terms of mood characteristics, less than one tenth of the sample had a diagnosis of anxiety or depression (8%, n = 13).

The sample contained a high number of frequent dieters and almost one-half of the sample was currently dieting (43%, n = 72). In relation to the sample's weight loss success, only ten percent considered themselves to be very successful at losing weight (11%, n = 18). Almost one-half of the sample classified themselves as 'somewhat' successful at losing weight (45%, n = 76), and over one third (39%, n = 65) rated themselves as 'not very' successful or to have 'failed' in their weight loss attempts. These results are summarised in Table 5.1

Gender

Weight management characteristics by gender are presented in Table 5.2. Females were more actively engaged with managing their weight. Half of the female sample (51%, n = 53) and less than one-third of the male sample were currently dieting (30%, n = 19). The majority of participants of both genders rated themselves as 'somewhat' successful at weight management (Males: 39%, n = 25; Females: 49%, n = 51). Interestingly, a greater proportion of males (28%, n = 18) than females

(22%, *n* = 23) considered themselves to be ‘not very’ successful at weight loss, whilst this trend reversed when weight loss failure was examined. A higher proportion of females (17%, *n* = 18) to males (9%, *n* = 6) considered themselves to have ‘failed’ in their weight loss attempts.

Table 5.1
Demographic, Mood and Weight Management Characteristics of Participants

Characteristics	*n*	%	*M* (*SD*)
Age (years)			45.83 (12.14)
BMI			33.33 (6.82)
Region			
Oceania	124	73.4	
Europe	12	7.1	
Americas	2	1.2	
Africa	6	3.6	
Asia	10	5.69	
Indigenous Status			
Aboriginal	3	1.8	
South Sea Islands	1	0.6	
Gender			
Female	105	62.1	
Male	64	37.9	
Marital Status			
Never married	37	21.9	
Widowed	4	2.4	
Divorced	16	9.5	
Separated	5	3.0	
Married	107	63.3	
Educational Attainment			
Post-school Degree or higher	80	47.3	
Post-school Diploma	39	23.1	
Post-school Certificate	22	13.0	
Year 12	17	10.1	
Year 10	8	4.7	
Other	3	1.8	
Home Ownership			
Own outright	44	26.0	
Mortgage	77	45.6	
Renting	41	24.3	
Other	7	4.1	
Mood disorder			
Depression	9	5.3	
Anxiety	2	1.2	
Mixed anxiety-depression	2	1.2	
Currently dieting			
Yes	72	42.6	
No	97	57.4	
Weight loss attempts			
0	13	7.7	
1-5	75	44.4	
6-10	34	20.1	
11+	47	27.8	
Weight loss success			
Never dieted	10	5.9	
Very	18	10.7	
Somewhat	76	45.0	
Not very	41	24.3	
Failed	24	14.2	

Table 5.2

Weight Management Characteristics of Participants Separated by Gender

Characteristic	Males (n = 64)		Females (n = 105)	
	n	%	*n*	%
Currently dieting				
Yes	19	30	53	51
Weight loss attempts				
0	10	16	3	3
1-5	37	58	38	36
6-10	7	16	27	26
11+	10	16	37	35
Previous weight loss success				
Zero attempts	8	13	2	2
Very	7	11	11	11
Somewhat	25	39	51	49
Not very	18	28	23	22
Failed	6	9	18	17

Note percentages have been rounded

5.5.2 Descriptive statistics of the main study variables for the total sample

Descriptive statistics of the sample's main variables of interest are presented in Table 5.3. The Stroop scores from two participants were removed as one score was an extreme outlier and one participant failed to arrive at testing in a fasted state and was not administered the Stroop task or the LFPQ.

5.5.3 Gender differences between main study variables

Independent Samples t-tests were conducted to compare differences between the main study variables for males and females. The full table is presented in Appendix D, Table D.1. Only the significant differences are presented (Table 5.4).

There was a significant difference in BMI (p < .05), disinhibited-eating behaviour (p < .001), BIS (p < .001), STAI-T (p < .001) and EL_HFSA between males and females, with females having higher mean values than males across all of these variables, except explicit liking for high-fat savoury foods. Males had higher values on explicit liking for high-fat savoury foods, when compared to females. There were no other significant differences between genders for any other variables

Table 5.3

Descriptive Statistics of Main Study Variables for the Total Sample

Variable	*M*	*SD*	*N*	*Mdn*	*(IQR)*
Age	45.83	12.14	169	-	-
BMI	33.33	6.82	169	31.30	28.11 – 36.70
Disinhibition	9.17	3.82	169	9.00	6.00-12.50
Restraint	9.42	4.35	169	-	-
BIS	21.41	3.70	169	-	-
BAS	38.86	5.75	169	-	-
EC-T	86.49	13.91	169	-	-
DERS-T	75.40	21.14	169	71.00	60 – 90.50
STAI-T	38.94	11.41	169	38.00	30.00 – 46.00
Stroop	80.35	49.52	167	68.26	6.29 – 246.12
IW_HFSW	-0.01	31.37	168	-	-
IW_HFSA	-18.42	36.24	168	-27.06	-74.41 – 59.03
EL_HFSW	42.30	23.51	168	-	-
EL_HFSA	34.29	24.01	168	28.50	15.44 – 51.69

BMI: Body Mass Index (kg/m^2); Disinhibition: Disinhibition Scale; Restraint: Restraint Scale; BIS: Behavioural Inhibition System; BAS: Behavioural Activation system EC-T: Effortful Control Total Scale; DERS-T: Difficulties in Emotion Regulation Total Scale; STAI-T: State Trait Anxiety Inventory-Trait Scale; Stroop: total reaction time Stroop interference score; IW_HFSW: Implicit wanting high fat sweet; IW_HFSA: Implicit wanting high fat savoury; EL_HFSW: Explicit liking high fat sweet; EL_HFSA: Explicit liking high fat savoury

Table 5.4

Gender Differences between BMI, Disinhibited Eating Behaviour, Mood and Liking for High-Fat Savoury Foods

	Males n = 64		Females n = 105					
Variable	*M*	*SD*	*M*	*SD*	*df*	*t*	*p*	Cohen's *d*
BMI	31.75	5.73	34.29	7.27	167	2.51	.013	0.38
Disinhibition	7.69	3.52	10.08	3.72	167	4.13	.000	0.66
BIS	19.78	3.81	22.40	3.26	167	4.75	.000	0.76
STAI-T	34.69	9.86	41.52	11.56	167	3.94	.000	0.63
EL-HFSA	39.88	27.52	30.85	20.98	166	-2.40	.026	0.38

BMI: Body Mass Index (kg/m^2), Disinhibition: Disinhibition Scale; Restraint: Restraint Scale; BIS: Behavioural Inhibition System; STAI-T: State Trait Anxiety Inventory-Trait Scale; EL_HFSA: Explicit liking high fat savoury

5.5.4 Relationships amongst temperament (BIS, BAS and effortful control), disinhibited-eating behaviour and BMI.

BIS and BAS

The relationship between BIS, BAS, EC-T, BMI and disinhibited-eating behaviour was investigated separately by gender: male (Table 5.5) and female (Table 5.6). There was evidence of significant associations between the BIS and disinhibited-eating behaviour in both males (p < .01), and females (p < .01), with higher levels of the BIS associated with higher levels of disinhibited-eating behaviour in both genders. However, none of the BAS Scales were significantly associated with disinhibited-eating behaviour in either gender. In addition, neither the BIS nor the BAS were significantly associated with BMI in either gender.

Effortful control

There was evidence of significant, inverse associations between EC-T and disinhibited eating behaviour in both males (p < .01) and females (p < .01), with low levels of EC-T associated with higher levels of disinhibited-eating behaviour. Effortful control was not significantly correlated with BMI in either gender.

Disinhibited-eating behaviour and BMI

Disinhibited-eating behaviour was significantly (p < .05) associated with BMI in females and significantly (p < .05) associated with BMI in males, with higher levels of Disinhibition associated with higher levels of BMI in both genders.

Table 5.5

Means, Standard Deviations, and Intercorrelations between Temperament, BMI and Disinhibition in Males

Males n = 64										
Measure	*M*	*SD*	1	2	3	4	5	6	7	8
1.EC-T	87.97	13.04	---							
2.BMI	31.75	5.73	-.123	---						
3.D	7.69	3.52	-.391**	.350*	---					
4.BIS	19.78	1.81	-.356**	-.093	.280**	---				
5.BAS	37.98	5.70	.083	-.179	-.012	.167	---			
6.BAS-FS	11.21	2.10	.035	-.067	-.139	.024	.805**	---		
7.BAS-DR	10.55	2.64	.159	-.157	.010	.094	.868**	.606**	---	
8.BAS-RR	16.22	2.28	-.009	-.204	.086	.285*	.753**	.389**	.452**	---

EC-T: Effortful Control Total Scale; BMI: Body Mass Index (kg/m^2), D: Disinhibition Scale; BIS: Behavioural Inhibition System. BAS: Behavioural Activation System; BAS-FS: BAS Fun Seeking subscale; BAS-DR: BAS Drive subscale ; BAS-RR: BAS Reward Responsiveness subscale

$^*p < .05$, $^{**}p < .01$

Table 5.6

Means, Standard Deviations, and Intercorrelations between Temperament, BMI and Disinhibition in Females

Females n = 105										
Measure	*M*	*SD*	1	2	3	4	5	6	7	8
1.EC-T	85.58	14.4	---							
2.BMI	34.29	7.27	-.173	---						
3.D	10.10	3.72	-.389**	.233*	---					
4.BIS	22.40	3.26	-.330**	.050	.352**	---				
5.BAS	39.39	5.75	-.197*	-.154	-.076	-.208*	---			
6.BAS-FS	11.62	2.44	-.224*	-.154	-.186	-.301**	-.786**	---		
7.BAS-DR	10.43	2.58	-.158	-.103	.051	-.077	.846**	.466**	---	
8.BAS-RR	17.34	2.10	-.086	-.118	-.055	-.126	.790**	.420**	.551**	---

EC-T: Effortful Control Total Scale; BMI: Body Mass Index (kg/m^2), D: Disinhibition Scale; BIS: Behavioural Inhibition System. BAS: Behavioural Activation System; BAS-FS: BAS Fun Seeking subscale; BAS-DR: BAS Drive subscale; BAS-RR: BAS Reward Responsiveness subscale

$^*p < .05$, $^{**}p < .01$

5.5.5 Relationships amongst temperament (BIS and BAS) and the psychological rewards (implicit wanting and explicit liking) by gender

The relationship between BIS, BAS and the psychological rewards of implicit wanting and explicit liking for high-fat sweet and savoury foods (implicit wanting for high-fat sweet: IW_HFSW, implicit wanting for high-fat savoury: IW_HFSA, explicit liking for high-fat sweet: EL_HFSW, explicit liking for high-fat savoury: EL_HFSA) was investigated by gender.

In males (Table 5.7), there was no evidence of a significant association between BIS and IW_HFSW, IW_HFSA or EL_HFSA. However, there was evidence of a significant association between BIS and EL_HFSW ($p < .01$), with higher levels of the BIS associated with higher levels of explicit liking for high fat sweet foods. There was also evidence of a significant, inverse association between the BAS and IW_HFSA ($p < .05$) and a significant inverse association between the BAS and EL_HFSA ($p < .05$), with higher levels of the BAS associated with lower levels of IW_HFSA and EL_HFSA. For IW_HFSA ($p < .05$), EL_HFSA ($p < .05$) and EL_HFSW ($p < .05$) there were significant positive associations with disinhibited-eating behaviour, with higher levels of IW_HFSA, and EL_HFSW and EL_HFSA associated with higher levels of disinhibited-eating behaviour.

In females (Table 5.8), there was no evidence of a significant association between BIS and IW_HFSW, although there was evidence of a significant association between the BIS and IW_HFSA ($p < .01$), with higher levels of BIS associated with higher levels of implicit wanting for these foods. The BIS was also found to be significantly associated with EL_HFSW ($p < .05$) and EL_HFSA ($p < .01$), with higher levels of the BIS associated with higher levels of EL_HFSW and EL_HFSA. There was no evidence of a significant association between the BAS and IW_HFSW, IW_HFSA or EL_HFSW, although there was evidence of a significant, inverse association between the BAS and EL_HFSA ($p < .05$) with higher levels of the BAS associated with lower levels of EL_HFSA. It was further noted that IW_HFSW ($p < .01$) and EL_HFSW ($p < .01$) were significantly associated with disinhibited-eating behaviour and that IW_HFSA ($p < .01$) and EL_HFSA ($p < .01$) were also significantly associated with disinhibited-eating behaviour. Therefore, higher levels of IW_HFSW, IW_HFSA, EL_HFSW and EL_HFSA were associated with higher levels of disinhibited-eating behaviour.

5.5.6 Relationships amongst Stroop reaction time, effortful control, disinhibited-eating behaviour and BMI by gender

The relationship between Stroop reaction time, effortful control, disinhibited-eating behaviour and BMI was investigated by gender. In males (Table 5.7), there was no evidence of a significant association between Stroop, effortful control, disinhibited-eating behaviour or BMI. In females (Table 5.8), there was no evidence of a significant association between Stroop, effortful control or disinhibited-eating behaviour, although there was evidence of a significant association between the Stroop and BMI ($p < .05$), with slower reaction times associated with higher levels of BMI.

Table 5.7

Intercorrelations between BMI, Eating Behaviour, Temperament, Mood, Cognitive and Food Reward Variables, in Males (n = 64)

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
1.BMI	---												
2.D	.350**	---											
3.R	-.216	-.063	---										
4.BIS	-.093	.280*	-.022	---									
5.BAS	-.179	-.012	.460**	.167	---								
6.EC-T	-.123	-.391**	.313*	-.356**	.083	---							
7.STAI-T	.221	.390**	-.300*	.573**	-.166	-.544**	---						
8.DERS-T	.275*	.384**	-.258*	.460**	-.042	.542**	.761**	---					
9.Stroop	-.062	.048	.155	.065	.297*	.019	-.190	-.175	---				
10.IW_ HFSW	.101	.156	-.137	.212	-.029	-.324**	.189	.131	-.065	---			
11.IW_ HFSA	.122	.286*	-.311*	.115	-.318*	-.191	.202	.384**	-.066	.070	---		
12.EL_ HFSW	.068	.257*	-.232	.332**	-.066	-.366**	.307*	.269*	-.049	.697**	.311*	---	
13.EL_HFSA	.040	.251*	-.330**	.167	-.282*	-.173	.149	.330**	-.060	.103	.851**	.510**	---

BMI: Body Mass Index (kg/m^2); D: Disinhibition Scale; R: Restraint Scale; BIS: Behavioural Inhibition System; BAS: Behavioural Activation System; EC-T: Effortful Control Total Scale; DERS-T: Difficulties in Emotion Regulation Total Scale; STAI-T: State Trait Anxiety Inventory-Trait Scale; Stroop: total reaction time Stroop interference score; IW_HFSW: Implicit wanting high fat sweet; IW_HFSA: Implicit wanting high fat savoury; EL_HFSW: Explicit liking high fat sweet, EL_HFSA: Explicit liking high fat savoury
*$p < .05$, **$p < .01$

Table 5.8

Intercorrelations between BMI, Eating Behaviour, Temperament, Mood, Cognitive and Food Reward Variables, in Females (n = 105)

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
1.BMI	---												
2.D	.233*	---											
3.R	-.151	-.200*	---										
4.BIS	.050	.352**	-.072	---									
5.BAS	-.154	-.076	.208*	-.208*	---								
6.EC-T	-.173	-.389**	-.001	-.330**	-.197*	---							
7.STAI-T	.221*	.344**	-.106	.612**	-.259**	-.449**	---						
8.DERS-T	.187	.402**	-.125	.475**	-.245*	-.533**	.809**	---					
9.Stroop	.224*	.117	-.021	.012	-.071	-.124	.124	.169	---				
10.IW_HFSW	.230*	.402**	-.117	.130	.020	-.236*	.227*	.258**	.150	---			
11.IW_HFSA	.043	.259**	-.216*	.325**	-.164	-.139	.266**	.219*	.046	.074	---		
12.EL_HFSW	.149	.461**	-.273**	.238*	-.045	-.272**	.287**	.327**	.026	.732**	.177	---	
13.EL_HFSA	.083	.341**	-.320**	.289**	-.196*	-.189	.008	.240*	-.027	.201*	.686**	.562**	---

BMI: Body Mass Index (kg/m^2); D: Disinhibition Scale; R: Restraint Scale; BIS: Behavioural Inhibition System; BAS: Behavioural Activation System; EC-T: Effortful Control Total Scale; DERS-T: Difficulties in Emotion Regulation Total Scale; STAI-T: State Trait Anxiety Inventory-Trait Scale; Stroop: total reaction time Stroop interference score; IW_HFSW: Implicit wanting high fat sweet; IW_HFSA: Implicit wanting high fat savoury; EL_HFSW: Explicit liking high fat sweet, EL_HFSA: Explicit liking high fat savoury
*$p < .05$, **$p < .01$

5.5.7 Temperament (BIS, BAS and effortful control) and its ability to predict disinhibited-eating behaviour

Hierarchical linear multiple regression assessed the ability of the BIS to predict disinhibited-eating behaviour. The variables entered into the regression model are presented in Table 5.9 and the regression model is presented in Table 5.10.

Table 5.9

Means, Standard Deviations, and Intercorrelations between Disinhibited Eating Behaviour, Temperament, Emotion Regulation Difficulties and Psychological Reward

Variables	*M*	*SD*	1	2	3	4	5	6	7
1. D	9.17	3.81	---						
2. BIS	21.41	3.69	.392**	---					
3. BAS	38.86	5.75	-.014	-.009	---				
4. EC-T	86.49	13.91	-.395**	-.345**	-.107	---			
5. DERS-T	75.40	21.14	-.412**	.475**	-.160*	-.540**	---		
6. IW_HFSW	0.21	31.99	.327**	.179*	.012	-.270**	.226**	---	
7. EL_HFSW	42.30	23.51	.351**	.235**	-.060	-.298**	.297**	.710**	---

D: Disinhibition Scale; BIS: Behavioural Inhibition System; BAS: Behavioural Activation System; EC-T: Effortful Control Total Scale; DERS-T: Difficulties in Emotion Regulation Total Scale; IW_HFSW: Implicit Wanting high fat sweet; EL_HFSW: Explicit liking high fat sweet
$^{*}p < .05$, $^{**}p < .01$

After controlling for age, gender and BMI at step 1. The addition of BIS and BAS in step 2 explained an additional 9.3% of the variance in disinhibited-eating behaviour and this final model was significant, F (5, 162) = 10.92, $p < .001$. However, BMI and the BIS, but not the BAS, were significant, with the BIS recording a higher beta value ($\beta = .325$, $p < .001$) than BMI ($\beta = .261$, $p < .001$). Subsequently, the BIS and not the BAS predicted disinhibited-eating behaviour to a greater extent than BMI and this was independent of both age and gender at step two F, (5, 162) = 10.92, $p < .001$, $R^2 = .25$.

To determine whether the addition of effortful control, total score (EC-T) and difficulties in emotion regulation, total score (DERS-T) added significantly to the variance in disinhibited-eating behaviour, beyond the BIS, EC-T was added in a third step. The addition of EC-T explained an additional 6.1% of the variance in disinhibited-eating behaviour and the change in the model was significant, R^2 change = .061; F change (1, 161) = 14.2, $p < .001$. After the addition of EC-T, it was noted that the beta coefficient of the BIS decreased from the second (β = .325, $p < .001$) to the third step, whilst still retaining significance (β = .227, $p = .003$), which suggested that EC-T partially mediated the effect of the BIS on disinhibited-eating behaviour. Difficulties in emotion regulation, total score (DERS-T), was added in a fourth step. Although the addition of DERS-T to the model explained an additional 1.4%, it did not add significantly to the prediction of disinhibited-eating behaviour, *F* change (1, 161) = 3.30, $p = .072$. Consequently, it was removed prior to further analyses. After the removal of DERS-T, the model explained 31.3% of the variance in disinhibited-eating behaviour.

After the removal of DERS-T from the model, IW_HFSW was added in a fourth step and EL_HFSW in a fifth step. The addition of IW_HFSW significantly explained an additional 2.8% of the variance in disinhibited-eating behaviour, *F* change (1, 161) = 6.70, $p = .011$ and the addition of EL_HFSW in the final step significantly explained a further 2.2% of the variance in disinhibited-eating behaviour, *F* change (1, 160) = 5.49, $p = .020$. However, the addition of EL_HFSW appeared to fully mediate the effect of IW_HFS on disinhibited-eating behaviour. This addition resulted in a loss of significance of the IW_HFSW variable (β = .023, $p = .806$). After this final step, the model was significant, *F*, (8, 159) = 11.30, $p < .001$, $R^2 = .362$ and explained 36.2% of the variance in disinhibited-eating behaviour.

In the final model, gender, BMI, BIS, EC-T and EL_HFSW were all significant predictors of disinhibited-eating behaviour. Interestingly, explicit liking for high-fat sweet foods was the strongest predictor of disinhibited-eating behaviour with the highest beta value (β = .226, $p = .020$), followed by a low level of EC-T (β = -.211, $p = .004$), BMI (β = .189, $p = .006$) and the BIS (β = .177, $p = .018$). Therefore, in this model, enhanced liking for high-fat sweet foods predicted disinhibited-eating behaviour, above implicit wanting for high-fat sweet foods, when effortful control was concurrently low. High levels of the BIS and BMI also contributed significantly, to this prediction. However, difficulty regulating emotion did not contribute to disinhibited-eating behaviour beyond the contribution made by effortful control.

Table 5.10

Hierarchical Regression Analysis Predicting Disinhibited Eating Behaviour with Temperament and Psychological Reward

Step and predictor variable	*B*	*SE B*	*β*	R^2	ΔR^2
Step 1:				.159***	
Age	0.011	.023	.037		
Gender	2.008	.571	.256**		
BMI	0.144	.041	.258**		
Step 2:				.252***	.093
BIS	0.336	.075	.325***		
BAS	0.006	.046	.009		
Step 3:				.313**	.061
EC-T	-0.074	.020	-.270***		
Step 4:				.340	.028
IW_HFSW	0.021	.008	.176*		
Step 5:				.362*	.022
EL_HFSW	0.037	.016	.226*		

BMI: Body Mass Index (kg/m^2); BIS: Behavioural Inhibition Scale; BAS: Behavioural Activation Scale; EC-T: Effortful Control Total Scale; IW_HFSW: Implicit wanting high fat sweet; EL_HFSW: Explicit liking high fat sweet; B: unstandardised coefficient; β: standardised coefficient. Gender coded as 0 = male.
$^*p < .05$; $^{**}p <. 01$; $^{***}p < .001$

It was noted earlier that there appeared to be partial mediation of the effect of the BIS by EC-T. Upon testing for a mediation effect, there was a significant indirect effect of the BIS via EC-T, Sobel's $z = 2.97$, $p = < .01$. This result suggested that a low level of EC partially mediates the effect of the BIS to result in higher levels of disinhibited-eating behaviour (Figure 5.2). The results and the full mediation table are presented in Appendix D1, Table D.2.

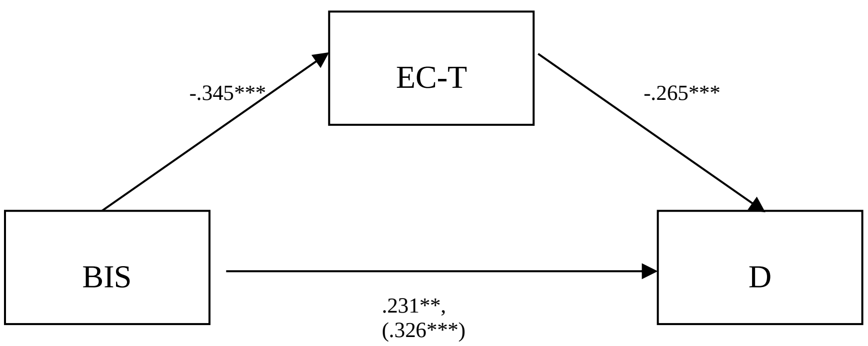


Figure 5.2. Mediation by EC-T on the association between the BIS and disinhibited-eating behaviour.

$^*p$ <.05, $^{**}p$ <.01, $^{***}p$ <.001

These findings suggested that the analysis, which planned to explore whether emotion-regulation difficulties mediated the effect of the BIS on IW_HFSW, required revision. The results clearly showed that EC-T partially mediated the BIS effect and furthermore, that the addition of DERS-T after the addition of EC-T, was redundant. Rather than a low level of effortful control leading to difficulty regulating emotions, which may subsequently predict implicit wanting or explicit liking for high-fat sweet foods, the stronger predictor may be a low level of effortful control. Therefore, the hypothesis that DERS-T would mediate the BIS to predict implicit wanting of high-fat sweet foods was not investigated. Instead a supplementary analysis investigated whether a low level of EC-T, and not DERS-T, mediated the association between the BIS and implicit wanting of high-fat sweet foods.

5.5.8 Temperament and its ability to predict implicit wanting and explicit liking of high-fat sweet foods

A series of hierarchical linear regressions were conducted to investigate whether the BIS, BAS, EC-T and DERS significantly added to the variance of the psychological rewards of explicit liking and implicit wanting. The means and standard deviations and inter-correlations for IW_HFSW and EL_HFSW are presented in Table 5.9, and the regression models are presented below.

Implicit wanting

In the first analysis (Table 5.11), hierarchical multiple regression assessed the ability of the BIS, BAS, EC-T and DERS-T to predict IW_HFSW. Age, gender and BMI were added as control variables in step 1. This step was not significant F (3,164) = 2.47, p = .064. The addition of BIS and BAS, at step 2 explained an additional 2.8% of the variance in IW_HFSW. However, this step did not increase the ability of this model to predict IW_HFSW, F change (2, 162) = 2.42, p = .092, although the model was significant, F (5,162) = 2.47, p = .034. Closer inspection of the beta values for the BIS (β = .175, p = .032) and BAS (β = .042, p = .590) revealed that the beta coefficient of the BAS was not significant. Subsequently the BAS was removed from the model prior to further analysis.

Table 5.11

Hierarchical Regression Analysis Predicting Implicit Wanting for High-Fat Sweet Foods with BIS and BAS

Step and predictor variable	*B*	*SE B*	*β*	R^2	ΔR^2
Step 1:				.043	
Age	-0.036	0.202	-.014		
Gender	3.272	5.110	.050		
BMI	0.907	0.364	.193*		
Step 2:				.071	.028
BIS	1.513	0.701	.175*		
BAS	0.233	0.431	.042		

BMI: Body Mass Index (kg/m^2), BIS: Behavioural Inhibition System BAS; Behavioural Activation System B: unstandardised coefficient; β: standardised coefficient. Gender coded as 0 = male.
$^*p < .05$,

After removal of the BAS only BMI and the BIS were significant, with BMI recording a higher beta value (β = .194, *p* = .013) than the BIS (β = .172, *p* = .034). Subsequently, BMI and the BIS but not the BAS predicted implicit wanting for high-fat sweet foods and this was independent of both age and gender, F (5, 162) = 3.89, p = .002, R^2 = .10. The regression was continued to determine whether the addition of effortful control and difficulties in emotion regulation significantly predicted IW_HFSW, beyond the addition of the BIS. The new regression model, omitting the BAS score, is presented in Table 5.12. The addition of EC-T explained an additional 3.8% of the variance in IW_HFSW, and the change to the model was significant, F change (1, 162) = 6.87, p = .011. DERS-T was added in a fourth step. Although the addition of DERS-T to the model explained an additional 0.1% to the variance in IW_HFSW, it did not add significantly to the prediction of IW_HFSW, F change (1, 161) = .201, p = .066, and it was omitted from the final model.

Table 5.12

Hierarchical Regression Analysis Predicting Implicit Wanting for High-Fat Sweet Foods with Temperament and Difficulties Regulating Emotion

Step and predictor variable	*B*	*SE B*	*β*	R^2	ΔR^2
Step 1:				.043	
Age	-0.036	0.202	-.014		
Gender	3.272	5.110	.050		
BMI	0.907	0.364	.193*		
Step 2:				.047*	.026
BIS	1.49	0.699	.172*		
Step 3:				.108*	.038
EC-T	-0.442	0.207	-.192*		
Step 4				.108	.001
DERS -T	0.068	0.151	-.045		

BMI: Body Mass Index (kg/m^2), BIS: Behavioural Inhibition System, EC-T: Effortful Control Total Scale, DERS-T: Difficulties in Emotion Regulation Total Scale
B: unstandardised coefficient; β: standardised coefficient. Gender coded as 0 = male.
**p* < .05

The final model was significant, F (5, 162) = 3.89, p = .002, R^2 = .108 and explained 10.8% of the variance in implicit wanting for high-fat sweet foods, with EC-T (β = -.211, *p* = .01) and BMI (β = .161, *p* = .037) adding to the prediction of IW_HFSW. However, the greater inverse beta coefficient of EC-T suggested that a low level of effortful control predicted implicit wanting for high-fat sweet foods to a greater extent than BMI and, further, that this was independent of age, gender, the BIS and difficulty regulating emotion. Furthermore, closer inspection of the regression revealed that after the addition of EC-T in the third step, the BIS became non-significant (β = .097, *p* = .250); suggesting that EC-T fully mediated the effects of the BIS to predict IW_HFSW. A test of mediation was undertaken and the mediation, mediation table and mediation model are presented in Appendix D2, Table D.3 and Figure D1.

Explicit liking

In the next analysis (Table 5.13), hierarchical multiple linear regression assessed the ability of the BIS, BAS, EC-T and DERS-T to predict EL_HFSW. Age, gender and BMI were added as control variables in step 1. This step was not significant, F (3,164) = 1.70, p = .170. The addition of BIS and BAS at step 2 significantly predicted an additional 8.0% of the variance in EL_HFSW, F change (2, 162) = 7.27, p = .001, and the model was significant, F (5,162) = 4.00, p = .002. Closer inspection of the beta values for the BIS (β = .299, p < .001) and BAS (β = -.025, p = .739) revealed that the beta coefficient of the BAS was not significant. Subsequently, the BAS score was removed from the model prior to further analysis.

Table 5.13

Hierarchical Regression Analysis Predicting Explicit Liking for High-Fat Sweet Foods with BIS and BAS

Step and predictor variable	B	$SE\ B$	β	R^2	ΔR^2
Step 1:				.030	
Age	-0.200	0.149	-.103		
Gender	-3.987	3.774	.083		
BMI	0.452	0.271	.131		
Step 2:				.110**	.08
BIS	1.902	0.504	.299***		
BAS	-0.103	0.309	-.025		

BMI: Body Mass Index (kg/m^2); BIS: Behavioural Inhibition System BAS: Behavioural Activation System
B: unstandardised coefficient; β: standardised coefficient. Gender coded as 0 = male.
*p < .05, **p <.01, ***p <.001

After removal of the BAS, only the BIS (β = .300, p < .001) and gender (β = .185, p = .022) significantly predicted explicit liking for high-fat sweet foods (Table 5.14). Subsequently, the BIS but not the BAS, independent of both age and BMI, significantly predicted, F (4, 163) = 5.00, p = .001, R^2 = .11, and explained 11% of the variance in explicit liking for high-fat sweet foods. The hierarchical multiple linear regression continued to determine whether the addition of effortful control and difficulties in emotion regulation significantly predicted EL_HFSW, beyond the addition of the BIS. The introduction of EC-T, at step 3, significantly explained 4.6% of the variance in explicit liking, R^2 change = .046; F (1, 162) = 8.73, p = .004. The Difficulty in Emotion Regulation Scale score (DERS-T) was added in a fourth step. Although the addition of DERS-T to the model explained an additional 0.5% to the variance in EL_HFSW, it did not add significantly to the prediction of EL_HFSW beyond the EC-T variable, *F* change (1, 161) = .940, *p* = .334. Subsequently, it was omitted from the final model.

Table 5.14

Hierarchical Regression Analysis Predicting Explicit Liking for High-Fat Sweet Foods with Temperament and Difficulty Regulating Emotion

Step and predictor variable	*B*	*SE B*	*β*	R^2	ΔR^2
Step 1:				.030	
Age	-0.200	0.149	-.103		
Gender	-3.990	3.770	.083		
BMI	0.452	0.271	.131		
Step 2:				.109	.079
BIS	1.911	0.502	.300***		
Step 3:				.155	.046
EC-Total	-0.391	0.132	-.230**		
Step 4:				.160	.005
DERS-Total	0.104	0.107	.094		

BMI: Body Mass Index (kg/m^2); BIS: Behavioural Inhibition System; EC-T: Effortful Control Total Scale; DERS-Total: Difficulties in Emotion Regulation Total Scale

B: unstandardised coefficient; β: standardised coefficient. Gender coded as 0 = male.

*p < .05, **p <.01, ***p <.001

In the final model, only the BIS (β = .219, *p* = .008), EC-T (β = -.230, *p* = .004) and gender (β = .164, *p* = .038) remained significant. The similar beta scores for the BIS and EC-T suggested that both a high level of the BIS and a low level of effortful control equally predict explicit liking for HF_SW foods and further that their relationship with explicit liking of high-fat sweet foods is independent of emotion-regulation difficulties, age and BMI. The final model was significant and explained 16% of the variance in explicit liking for high-fat sweet food items, *F* (5, 162) = 5.94, $p < .001$, $R^2 = .16$.

5.5.9 Temperament and its interaction with symptoms of anxiety, as a predictor of disinhibited-eating behaviour.

A hierarchical linear multiple regression was performed to determine whether the three-way interaction term of BIS x BAS x STAI-T significantly added to the variance in disinhibited-eating behaviour. The results of this analysis were not significant and are not reported in the main text. Please refer to Appendix D3, Table D.5 for a summary.

5.5.10 An exploration of the proportion of BIS_BAS phenotypes by gender, disinhibited-eating behaviour subtype and BMI

A series of Chi-square analyses were performed to investigate whether, within an overweight and obese community sample, there was a significant difference in: the proportion of BIS_BAS phenotypes by gender (HBIS_HBAS, HBIS_LBAS, LBIS_HBAS, LBIS_LBAS); the proportion of disinhibited-eating behaviour subtypes (HDHR, HDLR, LDHR, LDLR) by gender; the proportion of BIS_BAS phenotypes by level of disinhibited-eating behaviour (high or low) within gender; the proportion of BIS_BAS phenotypes by disinhibited-eating behaviour subtype in females; and the proportion of disinhibited-eating behaviour subtype by overweight or obese BMI classification in females. The Chi-square analyses, which reported the results by gender, may be found in Appendix D4. The results of the final three Chi-square analyses, which report upon the results within gender (in females), are presented below.

The first analysis explored whether there was a difference in the proportion of BIS_BAS phenotypes by level of disinhibited-eating behaviour within gender. The analysis indicated that there was no significant difference in the proportion of BIS_BAS phenotypes by Disinhibition level in males χ^2 (3, n = 64) = 1.28, p = .735, (Figure 5.3). However, a significant difference was found in the proportion of BIS_BAS phenotypes by Disinhibition level in females χ^2 (3, n = 105) = 12.98, p < .01.

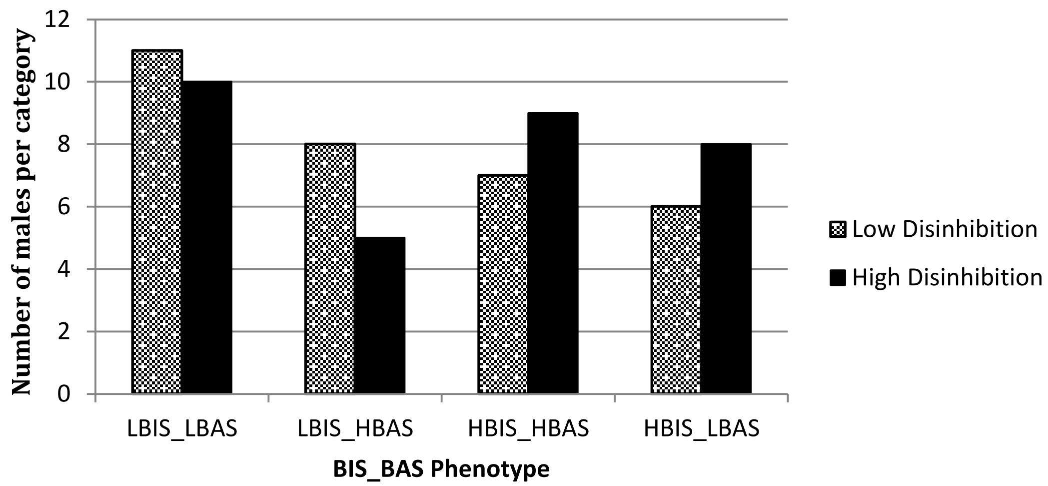


Figure 5.3. Proportion of the BIS_BAS phenotypes by high and low levels of Disinhibition, within a sample of overweight and obese males.

Post hoc analysis, with a Bonferroni adjustment (Figure 5.4 and Table 5.15), indicated that there was a significant (p < .05) difference in the proportion of LBIS_LBAS to HBIS_LBAS females with low levels of Disinhibition, such that a significantly greater proportion of LBIS_LBAS to HBIS_LBAS females had low levels of disinhibited-eating behaviour. Conversely, there was a significant difference (p < .05) in the proportion of HBIS_LBAS to LBIS_LBAS females with high levels of Disinhibition such that a significantly greater proportion of HBIS_LBAS to LBIS_LBAS females had high levels of disinhibited-eating behaviour. No other significant differences between other BIS_BAS phenotypes and level of Disinhibition were noted in females.

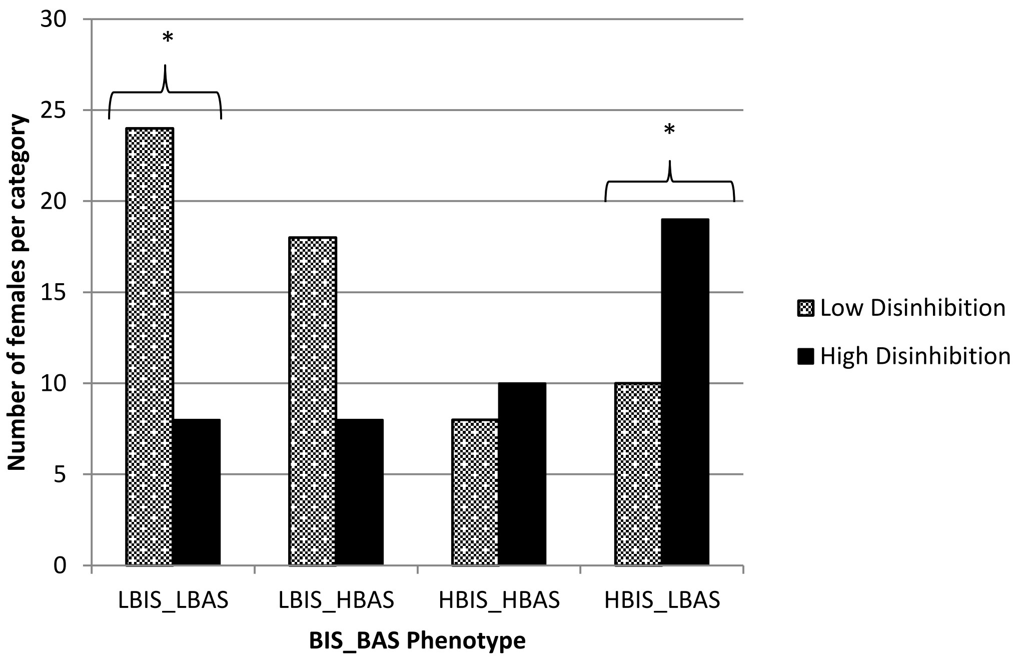


Figure 5.4. Proportion of BIS_BAS Phenotypes by level of Disinhibition, in females.

*p < .05

Table 5.15

Proportion of BIS_BAS Phenotypes by level of Disinhibited Eating Behaviour, in Females

	BIS_BAS Phenotype							
	LBIS_LBAS		LBIS _HBAS		HBIS_HBAS		HBIS_LBAS	
Disinhibited eating behaviour	*n*	%	*n*	%	*n*	%	*n*	%
Low	24a*	22.9	18a,b	17.1	8a,b	7.6	10b*	9.5
High	8b*	7.6	8a,b	7.6	10a,b	9.5	19b*	18.1

LBIS_LBAS: low BIS, low BAS; LBIS_HBAS: low BIS, low BAS; HBIS_HBAS: high BIS, high BAS; HBIS_LBAS: high BIS, low BAS

*Note. Counts in a row that share a common subscript are not significantly different at α = .05

The next analysis explored whether there was a difference in the proportion of BIS_BAS phenotypes by eating-behaviour subtype, in females. Six cells (37.5%) had an expected count less than 5. Therefore, the model was re-run with Monte Carlo estimation and the Fisher's exact test was used to accommodate small cell sizes. The fourth analysis indicated that there was a significant difference in the proportion of BIS_BAS phenotypes by eating-behaviour subtype Fisher's exact test (n = 105) = 20.07, $p < .013$.

From the HDHR, HDLR and LDHR eating-behaviour subtypes of interest, post hoc analysis, using Bonferroni adjustment (Figure 5.5 and Table 5.16), indicated that there was a significant ($p < .05$) difference in the proportion of LBIS_LBAS and HBIS_HBAS to HBIS_LBAS females with the LDHR eating-behaviour subtype, with a significantly greater proportion of LBIS_LBAS and HBIS_HBAS to HBIS_LBAS females with LDHR eating behaviour. Conversely, there was a significant difference ($p < .05$) in the proportion of HBIS_LBAS to LBIS_LBAS and LBIS_HBAS females with the HDLR eating-behaviour subtype, with a significantly greater proportion of HBIS_LBAS females with HDLR eating behaviour. No other significant differences between other phenotypes and eating behaviour subtypes were noted. These results suggest that the LBIS_LBAS phenotype is more likely to occur in the LDHR eating-behaviour subtype and not the HDLR eating behaviour subtype, whilst conversely the HBIS_LBAS phenotype is more likely to occur in the HDLR eating behaviour subtype and not the LDHR eating behaviour subtype.

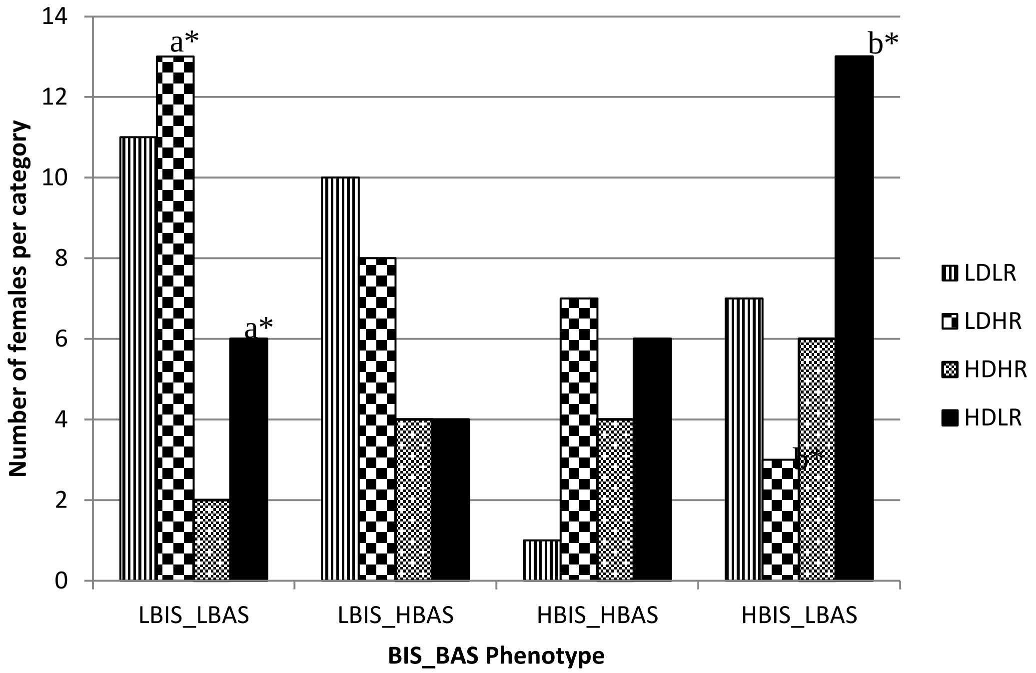


Figure 5.5. Proportion of BIS_BAS phenotypes by eating behaviour subtypes, in females.

*Note. The proportion of eating behaviour subtypes (of interest) within each BIS_BAS phenotype that differ by subscript are significantly different from one another at α = .05

Table 5.16

Proportion of BIS_BAS Phenotypes by Disinhibited and Restrained Eating Behaviour Subtypes, in Females

	BIS_BAS Phenotype							
	LBIS_LBAS		LBIS_HBAS		HBIS_HBAS		HBIS_LBAS	
Disinhibited eating behaviour subtype	*n*	%	*n*	%	*n*	%	*n*	%
LDLR	11a*	10.5	10a	9.5	1b*	1.0	7a,b	6.7
LDHR	13a*	12.4	8a,b	7.6	7a	6.7	3b*	2.9
HDHR	2a	1.9	4a	3.8	4a	3.8	6a	5.7
HDLR	6a*	5.7	4a	3.8	6a,b	5.7	13b*	12.4

HDHR: high Disinhibition, high restraint; HDLR: high Disinhibition, low restraint; LDHR, high restraint, low Disinhibition; LRLD: low restraint, low Disinhibition; LBIS_LBAS: low BIS, low BAS; LBIS_HBAS: low BIS, low BAS; HBIS_HBAS: high BIS, high BAS; HBIS_LBAS: high BIS, low BAS

*Note. Counts in a row that share a common subscript are not statistically different at α = .05

Having establised that the HDLR and the LDHR eating-behaviour subtype can be differentiated by their respective HBIS_LBAS and LBIS_LBAS phenotypes, a final analysis established the relevance of this result to their BMI classifications. Within this analysis, the HDLR and the LDHR eating-behaviour subtypes were examined to determine if one subtype was more likely to be obese than another. Females were divided into catogories of overweight and obesity, based on their BMI classifcation and a final Chi-square analysis was performed.

The final analysis indicated there was a significant difference in the proportion of eating-behaviour subtypes by BMI classification in females χ^2 (3, n = 105) = 12.84, p = .005. Post hoc analysis, with a Bonferroni adjustment indicated that there was a significant (p < .05) difference in the proportion of HDLR to LDHR females with an obese classification, such that a greater proportion of HDLR females were obese. Conversely, there was a significant (p < .05) difference in the proportion of LDHR to HDLR females in the overweight classification. It is also interesting that, when the HDLR eating-behaviour subtype is examined more closely, of the 29 individuals within this category, approximately 90% are classified as obese (Table 5.17, Figure 5.6).

Table 5.17

Proportion of Disinhibited and Restrained Eating Behaviour Subtypes by Overweight or Obese BMI Classification, in Females

	Eating behaviour subtype							
	LDLR		LDHR		HDHR		HDLR	
BMI	*n*	%	*n*	%	*n*	%	*n*	%
Overweight	15a	14.3	13a*	12.4	4a,b	3.8	3b*	2.9
Obese	14a	14.3	18a*	17.1	12a,b	11.4	26b*	24.8

HDHR: high Disinhibition, high restraint; HDLR: high Disinhibition, low restraint, LDHR, high restraint, low Disinhibition, LRLD: low restraint, low Disinhibition

*Note. Counts in a row that share a common subscript are not statistically different at α = .05

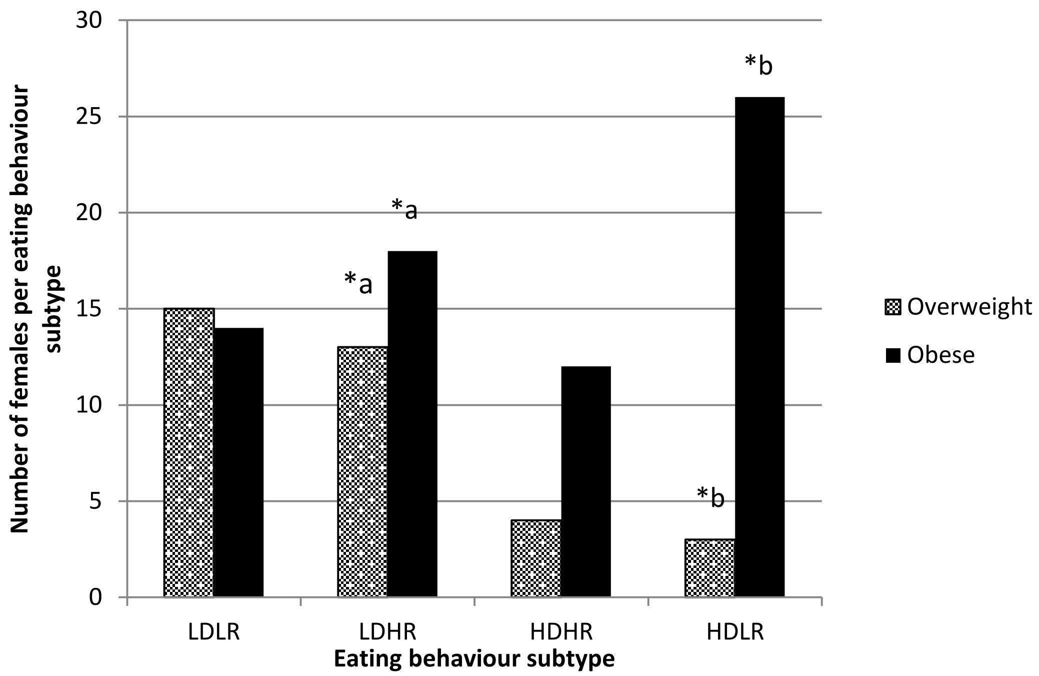


Figure 5.6. Proportion of eating behaviour subtypes by overweight and obese BMI classification, in females.

*Note: The proportion of individuals with an overweight or obese classification within each eating behaviour subtype that differ by subscript are significantly different from one another at $\alpha = .05$

5.6 DISCUSSION

The primary aim of this study was to determine whether the reactive temperament dimensions of BIS and BAS and the regulative temperament dimension of effortful control, in association with an inability to regulate emotion, predict disinhibited-eating behaviour and the psychological rewards of wanting and liking in an overweight and obese community sample. The secondary aims were to determine whether a particular BIS_BAS phenotype occurs in a significantly greater proportion in any of the disinhibited-eating-behaviour subtypes, relative to gender and BMI classification, and to determine if the experience of anxiety in response to stressful situations, i.e., trait anxiety, interacted with high levels of the BIS, and high and low levels of the BAS to significantly predict disinhibited-eating behaviour. The underlying intention of this second study was one of exploration, as none of these relationships have previously been reported in the literature.

5.6.1 Relationships between temperament (BIS, BAS and effortful control), BMI and disinhibited-eating behaviour.

The first aspect of the first hypothesis was fully supported. In the current study, the BIS, but not the BAS was positively associated and EC-T inversely associated with trait Disinhibition in both genders. To the best of my knowledge, this is the first time that an association between effortful control and the BIS and disinhibited-eating behaviour has been detected in a community sample of males and females. There was no evidence of a correlation between the BAS, Disinhibition and BMI or the BIS and BMI in either gender.

5.6.2 Temperament (BIS, BAS and effortful control) and its ability to predict disinhibited-eating behaviour.

The second aspect of the first hypothesis, that the BIS, but not the BAS, and a low level of effortful control would significantly add to the prediction of disinhibited eating behaviour, was fully supported. The second hypothesis that effortful control would mediate the effect of the BIS on disinhibited-eating behaviour was also fully supported. A novel finding was that the BIS and not the BAS predicted disinhibited-eating behaviour to a greater extent than BMI, independently of both age and gender. Moreover, a test of mediation indicated that a low level of effortful control partially mediated the effect of a reactive BIS to predict disinhibited-eating behaviour. Therefore, these results suggest that a high level of BIS reactivity may reduce the likelihood that an individual has learnt to effectively exert control over their emotions and their behaviour. Consequently, the possession of a reactive BIS may increase an individual’s risk of using food to regulate their emotions.

It was interesting that difficulties in emotion regulation did not predict disinhibited-eating behaviour, beyond the effects of a reactive temperament and a low level of effortful control. The results suggest that these temperament variables contributed to the prediction of disinhibited-eating behaviour through a loss of control over behaviour that was independent of emotion regulation difficulties. However, as an alternative way of explaining these results, it was noted that DERS-T was moderately correlated with both the BIS and EC-T. Therefore, the lack of contribution of DERS-T to disinhibited-eating behaviour is not interpreted as reflecting that a lack of emotion-regulatory skill does not contribute to disinhibited-eating behaviour. Instead, the lack of contribution of DERS-T is interpreted as reflecting the degree of overlap that DERS-T shares with a reactive BIS and a low level of effortful control.

5.6.3 Relationships between temperament (BIS, BAS and effortful control), and psychological reward (implicit wanting and explicit liking)

It was conceptualised in section 2.12 that a reactive BIS may contribute to the psychological rewards of wanting and liking. However, the manner in which self-reported temperament contributes towards these food reward systems, which have been linked to over-consumption (Dalton & Finlayson, 2013), is unknown. To the best of my knowledge, this is the first time that evidence of an association between the food-reward systems of implicit wanting and explicit liking, measured with the Leeds Food Preference Questionnaire (LFPQ), has been investigated with self-reported measures of temperament. The first aspect of the first exploratory hypothesis, that the BIS would be associated with implicit wanting and explicit liking of high-fat foods, was fully supported in males and females. However, the second aspect was not supported as only inverse associations were noted between the BAS and these measures of psychological reward in males and females. These correlational analyses provide the first evidence that the BIS is associated with the psychological rewards of implicit wanting and explicit liking in both genders. Furthermore, these results also appear to suggest that rather than being linked to a desire to obtain 'liked' high-fat foods, higher levels of BAS reactivity might protect against an individual's desire or drive to obtain them.

5.6.4 Temperament (BIS and effortful control) and its ability to predict psychological reward (explicit liking and implicit wanting).

Implicit wanting

The second aspect of the first exploratory hypothesis, that the BIS, but not the BAS, would predict implicit wanting of high-fat sweet foods, was supported. The second exploratory hypothesis, that DERS-T would mediate the BIS to predict implicit wanting, was not investigated, after finding it did not contribute to disinhibited-eating behaviour, beyond the addition of effortful control. Instead, a supplementary analysis investigated whether effortful control would mediate the BIS to predict implicit wanting. This model, which investigated whether temperament contributed to the variance of implicit wanting for high-fat sweet foods indicated that, whilst the BIS significantly contributed towards its prediction, the BAS did not.

Moreover, a lower level of effortful control was found to fully mediate the relationship between the BIS and implicit wanting.

This mediation effect suggests that a high level of BIS reactivity may reduce the likelihood that an individual has learnt to effectively exert control over their emotions, as shown by the inverse relationship between the BIS and effortful control. Furthermore, the failure to find an effect of the BAS on implicit wanting is an informative finding. It suggests that, at least in this sample of overweight and obese individuals, a reactive BIS, which is mediated by a low level of effortful control, may be a stronger predictor of implicit wanting than the BAS. The current temperament-based eating behaviour literature has conceptualised that an individual with a high level of BAS reactivity is highly motivated to approach highly palatable food items out of a desire to enhance an already highly rewarded state (Davis et al., 2009; Davis, Patte, et al., 2007). Therefore, this finding extends the conceptual basis of this current literature by introducing an alternative pathway to reward-based food seeking behaviour, which is facilitated by a reactive BIS.

Explicit liking

The second aspect of the first exploratory hypothesis, that the BIS would predict explicit liking of high-fat foods, was fully supported. The BAS failed to predict explicit liking for high-fat sweet foods and similarly to other models in this study, DERS-T did not add significantly to the prediction. As previously discussed, this result is interpreted as reflecting the degree of overlap that DERS-T shares with the BIS and a low level of effortful control. Therefore, this result is interpreted as suggesting that an individual with a reactive temperament, which is not well regulated, may have learnt to use high-fat sweet foods to regulate affect. Collectively, these results, which have linked the BIS and not the BAS to the implicit wanting and explicit liking of high-fat foods, implies there is an alternative pathway to reward-based food seeking behaviour. Importantly, these results imply that an individual may possess an enhanced level of reward sensitisation, which is the result of a reactive BIS and a low level of effortful control and not a reactive BAS.

5.6.5 The relationship between psychological reward and disinhibited-eating behaviour in an overweight and obese sample

In the temperament-based eating behaviour literature, an individual's level of sensitivity to reward has been attributed to Gray's BAS (Davis, Patte, et al., 2007;

Franken & Muris, 2005). Therefore, a high level of sensitivity to reward has been conceptualised as producing a strong appetitive drive and motivation to engage in hedonic-eating behaviour. For example, an individual with a high level of sensitivity to reward, measured either with the BIS/BAS Scales (Carver & White, 1994) or the SPSRQ (Torrubia et al., 2001), has been conceptualised as possessing an enhanced motivation to boost their level of reward through the over-consumption of highly palatable food (Davis, Patte, et al., 2007). Subsequently, research that investigated the effects of psychological reward in susceptible individuals has maintained a focus on an individual's level of BAS reactivity. It has not investigated an individual's level of BIS reactivity (Davis et al., 2009; Davis & Loxton, 2014). This strong appetitive drive and motivation to engage with highly palatable food is synonymous to the measure of implicit wanting, used in this research (Berridge, 1996; Corr & Mc Naughton, 2008; Finlayson & Dalton, 2012). However, the results of this study indicate that a reactive BIS and a low level of effortful control lead to both disinhibited-eating behaviour and the psychological rewards of liking and wanting. Furthermore, the psychological reward of liking was shown to be a stronger predictor of disinhibited-eating behaviour than wanting and the BAS did not predict psychological reward or disinhibited-eating behaviour. Therefore, the results of this study differ from the current temperament-based literature.

The results also differ from other investigations undertaken by Frankin and Muris (2005) and Davis et al (2007), who have both shown that the BAS was positively associated with craving in a sample of normal weight females with a mean BMI of 21.3kg/m^2 (*SD* = 2.6) and binge-eating behaviour in a mixed sample with a mean BMI of 27.6 kg/m^2 (*SD* = 5.9). Furthermore, Dietrich et al. (2014) recently investigated a relationship between disinhibited-eating behaviour and the BIS and BAS Scales, but their study did not report evidence of a significant association between the BIS or the BAS and disinhibited-eating behaviour. However, similar to the studies noted above, their participants had a mean BMI that classified them as overweight (*M* = 26.6 kg/m^2, *SD* = 6.1). The mean BMI in this study, by comparison, classified the sample as obese (*M* = 33.33 kg/m^2, *SD* = 6.82). Therefore, one critical difference between these studies and the results of this study is that the analyses have been undertaken in a sample with a higher mean BMI. As a result, it is possible that the higher mean BMI of this study permitted the emergence of these contrasting relationships.

Disinhibited-eating behaviour has been shown to have a robust association with BMI and weight gain (French et al., 2012). Moreover, it is established that there is an inverse-U relationship between the BAS and BMI in adults and children (Davis & Fox, 2008; Dietrich et al., 2014; Verbeken et al., 2012), and evidence of a linear relationship between the BIS and BMI is also present in the literature in adults and adolescents (Delgado-Rico et al., 2012; Dietrich et al., 2014). The relevance of these relationships to the results of this study is that the mean BMI of this sample was within the obese range. Subsequently, if a reactive BIS does contribute towards a higher BMI, a relationship between it and BMI may be more likely, as BMI increases from overweight to severe obesity. Perhaps the relationship between the BIS and BMI may be less confounded by the influence of the BAS as BMI increases. Therefore, the higher mean BMI of this sample may have contributed to the failure to find an association between the BAS, psychological reward and disinhibited-eating behaviour; it is possible that, as BMI increases, the influence of the BAS may diminish.

The psychological reward of liking reflects the degree to which an individual anticipates pleasure and experiences pleasure from highly palatable food, whilst wanting represents the motivation, desire or craving for food (Finlayson & Dalton, 2012; Mela, 2006). In the current literature, an individual with a high level of BAS reactivity is assumed to approach highly palatable food during a state of distress, because they possess an enhanced level of sensitivity to the hedonic properties of food (Aldao et al., 2010; Davis, 2009). However, in contrast to this assumption, the results of this study demonstrated that a reactive BIS, not a reactive BAS, a low level of effortful control and the psychological reward of liking, and not implicit wanting or 'craving' (Finlayson & Dalton, 2012) predicted disinhibited-eating behaviour. This is an informative finding because the psychological reward of liking can be learnt. Liking reflects the anticipation of pleasure that eating a particular food will provide and a liked food can be associated with the improvement of a negative mood state (Mela, 2000, 2006). Research from Hennegan, Loxton and Mattar (2013) linked reactivity within the BIS to external eating behaviour via the expectations that eating food is rewarding and pleasurable and helps to manage negative affect. Therefore, the relationships detected amongst Disinhibition, the BIS and the psychological reward of liking, could reflect the consumption of foods that are anticipated to improve mood in individuals with a reactive BIS.

5.6.6 Temperament and its interaction with symptoms of anxiety, as a predictor of disinhibited-eating behaviour.

The third exploratory hypothesis, that the three-way BIS x BAS x STAI-T interaction term would predict disinhibited-eating behaviour, was not supported. The aim of the final model in the regression series was to determine if a high level of trait anxiety moderated an interaction between the BIS x BAS to predict disinhibited-eating behaviour. The interaction did not significantly add to the prediction of Disinhibition. Instead, the final model suggested that higher levels of the BIS and lower levels of effortful control will significantly predict disinhibited-eating behaviour, irrespective of an interaction between the BIS, BAS and trait anxiety.

5.6.7 Stratification of the BIS_BAS phenotypes by gender, disinhibited-eating behaviour subtype and BMI

An interesting relationship became apparent when the BIS_BAS phenotypes and disinhibiting-eating behaviour subtypes were stratified in this community sample of overweight and obese individuals by gender. The results showed that the level of Disinhibition was not influenced by any particular combination of BIS_BAS phenotype in males. However, two particular BIS_BAS phenotype combinations in females influenced the level of Disinhibition. There was a greater proportion of HBIS_LBAS females with high-versus-low levels of Disinhibition when compared to LBIS_LBAS females. Conversely, there was a greater proportion of LBIS_LBAS females with low-versus-high levels of Disinhibition, when compared to HBIS_LBAS females. These results further highlight the importance of the high BIS phenotype in females. However, they also suggest that the possession of a specific BIS_BAS phenotype in males may not be a determining characteristic of highly disinhibited-eating behaviour. However it is also acknowledged that the smaller number of males, compared to females, may have precluded the opportunity for significant relationships to develop.

Upon establishing this significant difference in females, the next analysis investigated the influence of the BIS_BAS phenotypes on eating behaviour, in this gender. The first aspect of the final hypothesis was only partially supported. The results showed that the HBIS_LBAS phenotype was found more frequently in the HDLR subtype and less frequently in the LDHR subtype, whilst conversely, the LBIS_LBAS phenotype was found more frequently in the LDHR subtype and less frequently in the HDLR eating-behaviour subtype. However, the number of females with a HBIS_HBAS or HBIS_LBAS phenotype was similar regardless of whether they possessed HDHR or HDLR eating behaviours. Subsequently, the first aspect of the final exploratory hypothesis was only partially supported as only two BIS_BAS phenotypes were found to differ in relation to how frequently they occurred in two eating-behaviour subtypes of interest.

It is difficult to explain why the HBIS_HBAS and HBIS_LBAS temperament phenotypes were not able to differentiate between the HDHR or HDLR subtypes. It is possible that the median splits used to define the eating-behaviour groups were not sensitive enough to establish a true difference between the HDHR and the HDLR eating-behaviour subtypes, relative to temperament. However, the literature also supports that there is likely to be an extremely complex relationship between the BIS, BAS and BMI and between disinhibited and restrained eating behaviour and BMI (Davis & Fox, 2008; Delgado-Rico et al., 2012; Dietrich et al., 2014; Löffler et al., 2015; Verbeken et al., 2012). Therefore, whilst it has been conceptualised that, as BMI increases, there may be a greater proportion of individuals with a HBIS_LBAS temperament, the dynamics of these relationships have not yet been established. Further, it is not known at what level of BMI the BIS may exert its strongest influence or the BAS its weakest influence. It is currently not known at which level of disinhibited-eating behaviour and BMI an individual is likely to exhibit the highest amount of disinhibited or the lowest level of restrained-eating behaviour. Consequently, if a relationship between these temperament phenotypes and eating-behaviour subtypes does exist, it may not be found at the mean BMI of this sample.

By comparison, the emergence of significant differences between the two HBIS_LBAS/HDLR and LBIS_LBAS/LDHR temperament phenotype and eating behaviour subtype combinations does encourage further investigation at the temperament level. This is particularly so when these two eating-behaviour subtypes differ in their susceptibility towards over-consumption, propensity to binge-eat and capacity to successfully restrain intake. The HDLR eating-behaviour subtype has been reported to be susceptible to binge eating and to have the highest level of BMI when compared to the other eating-behaviour subtypes (Bryant et al., 2008; Lawson et al., 1995; Provencher et al., 2003; Williamson et al., 1995; Yeomans & Coughlan, 2009). On the other hand, the LDHR eating-behaviour subtype has been linked to successful dieting behaviour and is assumed to have a lower level of BMI (Yeomans & Coughlan, 2009; Yeomans, Tovey, et al., 2004). Therefore, it is possible that the higher sample mean BMI of this study led to the emergence of a significant difference between the HBIS_LBAS/HDLR and LBIS_LBAS/LDLR phenotype and eating-behaviour subtype combinations. This line of reasoning and the results from this study support the conceptualisation that the HBIS_LBAS temperament phenotype may be linked with trait-eating behaviours that lead to higher levels of BMI. Therefore, these results suggest that the HBIS_LBAS and LBIS_LBAS phenotypes may be capable of differentiating between trait behaviours, which determine opportunistic and binge-eating behaviour, capacity to control intake and, through the expression of these behaviours, BMI.

These results offer the first evidence to support the utility of a model that takes into consideration the effect of the BIS when differentiating between trait-eating behaviours that motivate some and not others to over-consume. This is particularly relevant when it is noted that, in this study, the main difference between the HDLR and LDHR eating-behaviour subtypes, when considered in relation to their temperament phenotypes, would appear to be their level of BIS and not their level of BAS reactivity. However, in order to determine the relevance of these findings, it was also important to identify if the LDHR eating-behaviour subtype was indeed more successful at managing their eating behaviour and, through this, it was assumed, their BMI. Most importantly, this eating-behaviour subtype, which has been described as a successful dieter, has a low level of BIS reactivity. Subsequently, a relevant question to ask is “Do they also have a lower level of BMI in comparison to the HDLR eating behaviour subtype, which has a higher level of BIS reactivity?”

The final analysis supported that a high BIS was linked to BMI and the last aspect of the final exploratory hypothesis: that the resultant eating-behaviour subtypes would be differentiated by their BMI classification. The HDLR eating-behaviour subtype was found to occur significantly more frequently in the obese category when compared to the LDHR eating-behaviour subtype and, conversely, the LDHR eating-behaviour subtype was found to occur significantly more frequently in the overweight category. Therefore, these results appear to support the utility of a psychobiological model of temperament, which includes the BIS, when differentiating between individuals who are successful and unsuccessful at managing disinhibited-eating behaviour and body weight. Of specific interest and relevance to this thesis, this segment of the research has identified that the difference between those individuals in an overweight and obese sample who are more successful at managing their eating behaviour when compared to those individuals who have been described as prone to opportunistic over-consumption and binge eating, is a reactive BIS.

The results of this study suggested that, as BMI increases, there is a greater likelihood of finding a higher proportion of individuals with a HBIS_LBAS phenotype. Therefore, it is possible that previous studies, which are often carried out with a mean BMI that ranges from normal to overweight, and which have not investigated the influence of the BIS, could inadvertently have sampled a greater proportion of individuals with higher (BIS and) BAS scores (i.e., HBIS_HBAS). Therefore, it is possible that, by not recognising the importance of including the BIS and stratifying the sample by psychobiological phenotype, the current research base may have characterised individuals with trait binge-eating behaviour as being sensitised to hedonic reward as a consequence of BAS reactivity. However, these results also suggest that there may be individuals present within the community who have been sensitised to the rewarding properties of food as a consequence of BIS reactivity.

5.6.8 Relationships between cognitive control (Stroop interference score), Disinhibition and implicit wanting

The final non-exploratory hypothesis of the study was only partially supported. There was no evidence of an association between Stroop interference scores, effortful control and Disinhibition between genders. However, there was evidence of a greater interference effect as BMI increased in women. Evidence of an association between the Stroop test and higher levels of BMI in females is in line with the findings of Gunstad et al. (2007). However, other researchers such as Volkow et al. (2009), J. Cohen et al. (2011) and Fagundo et al. (2012), did not report an association between Stroop interference and BMI. The literature is mixed in reporting upon the association between disinhibited-eating behaviour and Stroop interference scores. In regards to disinhibited-eating behaviour, the Stroop has been associated with disinhibited-eating behaviour in adolescent males (Maayan et al., 2011). However, Graham, Gluck, Votruba, Krakoff, and Thearle (2014) also failed to find evidence of an association between Disinhibition and Stroop interference scores in obese adult males and females.

The lack of a finding between the Stroop interference score and the self-report measure of effortful control is interesting, given the theoretical underpinnings of the Stroop task and the executive function of effortful control, which both measure an individual's capacity to control their attention (Rothbart et al., 2010; Rothbart & Rueda, 2005). Whilst this finding is consistent with the findings of two studies that have also failed to find evidence of an association between the Stroop and measures of effortful control in a bariatric (Müller et al., 2014) and eating disordered population (Claes et al., 2012), it is not clear why there may have been a failure to find evidence of an association between disinhibited-eating behaviour and Stroop interference scores in this study.

5.7 CONCLUSION

These results contribute to the current literature in three novel ways. Firstly, at the level of eating behaviour, a reactive BIS and a low level of effortful control has been shown to predict disinhibited-eating behaviour in males and females. Secondly, at the level of psychological reward, reactivity within the BIS, and a low level of effortful control predicts the psychological rewards of implicit wanting and explicit liking, which were additionally shown to contribute towards the prediction of disinhibited-eating behaviour. Thirdly, the consideration of a sample of overweight and obese individuals, with an average BMI that classifies them as obese, has highlighted the influence that a HBIS_LBAS temperament may have on dispositional trait eating behaviour and BMI. Collectively, the results suggest that, at this level of BMI, the female gender, a reactive BIS, a low level of effortful control, and enhanced liking for high-fat sweet foods predict disinhibited-eating behaviour. Furthermore, an inability to cognitively restrain intake and a propensity towards overconsumption, binge-eating and obesity may be influenced by the pre-dispositional traits that are inherent to a high BIS, low BAS temperament phenotype. Whilst on the other hand, the cognitive capacity to successfully restrain intake and subsequently reduce one's risk for obesity may be influenced by those predispositional traits that are inherent to a low BIS, low BAS temperament phenotype.

5.8 RATIONALE FOR THE FINAL STUDY

Enhanced activation within the food reward systems has been linked to a dysregulated appetite and a loss of control over eating behaviour (i.e., via an increase in hunger, an attenuated satiety response and over-consumption) (Dalton & Finlayson, 2013, 2014; Dalton et al., 2015; Finlayson et al., 2011; Finlayson et al., 2012). The results from study two have demonstrated that enhanced liking for high-fat sweet foods predicts disinhibited-eating behaviour to a greater extent than implicit wanting or craving for these same foods. They also demonstrated that a HBIS_LBAS phenotype occurred in a significantly greater proportion in the HDLR eating-behaviour subtype, whilst conversely a LBIS_LBAS phenotype was found in a significantly greater proportion in the LDHR eating-behaviour subtype. Therefore, these results introduced the likelihood that individual differences in dispositional trait-eating behaviours, which have been linked to successful dieting, a propensity for over-consumption and increased BMI may be influenced by psychobiological temperament.

The results of the second study subsequently informed the design of the final study in this thesis. In order to extend the results of the second study, the groups were designed to consist of the same level of temperament phenotype and eating-behaviour subtype combinations that were found to differ significantly from one another in study two. Therefore, study three was designed to produce two groups that differed significantly in their level of BIS reactivity and in their level of disinhibited and restrained eating behaviour. However, in determining the experimental design, it was identified that the HDLR eating-behaviour subtype appeared to show characteristics of the low-satiety phenotype (Drapeau & Gallant, 2013).

The low-satiety phenotype has been associated with a blunted satiety response, disinhibited-eating behaviour (Drapeau et al., 2013; Drapeau & Gallant, 2013), enhanced emotional susceptibility to opportunistic overconsumption (Therrien et al., 2008), and a behavioural profile that has been linked with the experience of stress and anxiety (Drapeau et al., 2013; Drapeau & Gallant, 2013). As described, the emotional characteristics of this phenotype appear to explain the emotional states and psychopathological characteristics that have been observed in individuals with high levels of BIS reactivity (Bijttebier et al., 2009; Hundt et al., 2007). Moreover, they also appear to describe the eating behaviour characteristics of an individual with a low level of effortful control and subsequent emotion regulation difficulties, who has learnt to use food to regulate affect. Therefore, a study design that included measures of subjective appetite was chosen to determine whether an attenuated-satiety response was capable of differentiating between the high BIS and low BIS phenotypes and eating-behaviour groups.

The design of the study took into consideration the possibility that the HDLR subtype may show evidence of an attenuated-satiety response as one reason for failing to successfully restrain intake. In relation to the link between the BIS, disinhibited-eating behaviour and explicit liking for high-fat sweet foods, it also considered the possibility that the HDLR subtype may show evidence of an enhanced liking response. Therefore, a simple study design which allowed for the measurement of psychological reward, appetite, and consumption between these groups was required. The goal was to expand upon the findings from study two by determining whether a reactive BIS phenotype was associated with psychological reward, appetite and energy intake.

Chapter 6: Temperament and its association with psychological food reward, satiety and the energy intake of high-fat snack foods

6.1 EXECUTIVE SUMMARY OF MAIN OUTCOMES

1. The BIS but not the BAS was associated with explicit liking of high-fat sweet and savoury foods and implicit wanting for high-fat sweet foods in the fed state and total ad libitum test-meal energy intake.
2. Low effortful control was associated with implicit wanting for high-fat savoury foods and energy intake of high-fat, non-sweet foods. High emotion-regulation difficulties were associated with explicit liking of high-fat sweet and savoury foods, total energy intake, and the energy intake of high-fat sweet snack foods at an ad libitum test meal.
3. A high BIS, HDLR eating-behaviour subtype had a higher level of explicit liking for high-fat sweet and savoury foods, in a fed state, when compared to a low BIS, LDHR eating-behaviour subtype.
4. A high BIS, HDLR eating-behaviour subtype had a higher total energy intake and higher energy intake of high-fat, non-sweet foods than a low BIS, LDHR eating-behaviour subtype.
5. A high BIS, HDLR eating-behaviour subtype had a higher level of hunger and a reduced feeling of fullness over time, after a 600kcal pre-load, when compared to a low BIS, LDHR eating behaviour subtype.
6. A high BIS, HDLR eating-behaviour subtype had a lower level of effortful control, activation control and attentional control, and a higher level of emotion-regulation difficulties, lower acceptance of their emotional state, less access to emotion-regulation strategies and greater impulse control difficulties, when experiencing negative emotions, than a low BIS, LDHR eating-behaviour subtype.

6.2 INTRODUCTION

It has been suggested that the maintenance of food intake under stress may be positively reinforced through the acquisition of a highly palatable stimulus that signals a state of 'safety' or feeling of reward (Robbins & Fray, 1980). Therefore, it is feasible that an individual who has learnt to associate feelings of 'safety', from the intake of highly liked, highly palatable, 'comfort foods', such as thse high in fat and suger will adopt a desire for these foods over time. The temperament-based, eating-behaviour literature has conceptualised that such hedonic desire for highly palatable food will arise from a reactive or hyper-reactive BAS (Aldao et al., 2010; Davis & Loxton, 2014; Davis, Patte, et al., 2007). However, it is important to consider that this association could initially be motivated from a reactive BIS (Corr & McNaughton, 2012). Furthermore, this level of BIS-facilitated motivation and the resultant consumption that ensues might also be associated with the psychobiological rewards of wanting and liking.

Research has shown that obese individuals with higher levels of trait binge-eating (Dalton et al., 2013a) have enhanced implicit wanting, notably for high-fat sweet foods, and explicit liking of high and low-fat, sweet and non-sweet foods, after the consumption of a pre-load, when compared to obese individuals with lower levels of trait binge-eating behaviour. This finding has been used to suggest that these individuals are highly sensitised to the rewarding properties of highly palatable foods and that such sensitisation places these individuals at risk of ongoing weight gain (Dalton et al., 2013a). Moreover, these findings have been mirrored in the non-obese. Normal-weight females with high levels of disinhibited and binge-eating behaviour have also been shown to have higher levels of implicit wanting, for high-fat sweet foods, and explicit liking for high and low-fat foods, both sweet and non-sweet, in the fed state, and an attenuated-satiety response (Finlayson et al., 2011; Finlayson et al., 2012).

These studies suggest that both normal weight and obese individuals with higher levels of trait binge and disinhibited-eating behaviour show evidence of enhanced levels of psychological reward and consumption in the fed state (Dalton & Finlayson, 2014). However, this field of research has not yet investigated the influence of eating behaviour on psychological reward and consumption in a sample with a higher-mean BMI, which is further stratified by their temperament phenotype

(Dalton et al., 2013a; Dalton & Finlayson, 2014; Finlayson et al., 2011). Therefore, it is currently unknown whether a reactive BIS temperament is associated with eating behaviours that have been linked to enhanced levels of psychological reward and the consumption, of high-fat foods, in the fed state. This lack of knowledge reflects a critical gap that warrants exploring within the temperament-based, eating-behaviour literature.

The current temperament-based, eating behaviour literature suggests that an individual with a high level of BAS reactivity or 'sensitivity to reward' possesses an enhanced motivation to attain reward and to improve their negative affective state via the over-consumption of highly palatable food (Aldao et al., 2010; Davis, Patte, et al., 2007). In other words, a reactive BAS has been suggested to increase risk for hedonic over-consumption (Davis, 2009; Davis et al., 2009; Davis, Patte, et al., 2007; Davis, Strachan, et al., 2004). Moreover, at higher levels of BMI, in response to reduced levels of BAS activity, it has been suggested that such individuals over-consume in response to addiction-related cues and triggers (Davis & Loxton, 2014). However, within this field, an investigation into the relationship between a reactive BIS, effortful control, and the pyschological rewards of wanting and liking at a higher BMI has not yet been undertaken (Dietrich et al., 2014). Associations amongst BIS, effortful control, and total energy intake of highly palatable snack foods at an ad libitum test meal are also unexplored. It is currently unknown whether the BIS could also be linked to an increased risk for hedonic consumption. Therefore, study three investigated whether an association exists between the BIS, psychological reward and consumption in an overweight and obese sample.

An individual's level of Disinhibition can be concurrently measured with their level of Restraint to define eating behaviour subtypes, which are successful and unsuccessful at restraining intake (Bryant et al., 2010; Yeomans & Coughlan, 2009). The results of study two highlighted two eating-behaviour subtypes of interest: the high in Disinhibition and low in Restraint (HDLR) and the low in Disinhibition and high in Restraint (LDHR) subtypes, which were simultaneously high and low in BIS reactivity, respectively. Highly disinhibited-eating behaviour that is inadequately restrained has been found in individuals diagnosed with BED (C. B. Peterson et al., 1998; Wadden et al., 1993; Yanovski & Sebring, 1994). Moreover, individuals with this eating behaviour subtype have been found to show enhanced sensitivity towards palatable food (Yeomans, Tovey, et al., 2004) and their subsequent failure to restrain intake is thought to place them at risk of weight gain and higher BMI (Bryant et al., 2008; Yeomans & Coughlan, 2009; Yeomans, Tovey, et al., 2004). By comparison, the LDHR subtype has been described as a successful dieter who is less sensitive to the rewarding properties of palatable food than their HDLR counterpart (Yeomans & Coughlan, 2009; Yeomans, Tovey, et al., 2004). As a result, these individuals are able to maintain control over their eating behaviour in a manner contrary to the HDLR eating-behaviour subtype (Yeomans, Tovey, et al., 2004).

It is unknown why the LDHR subtype is less responsive to highly palatable food and able to successfully restrain intake, whilst the HDLR subtype is not (Yeomans, Tovey, et al., 2004). Chapter 5 suggested that these eating-behaviour subtypes may be differentiated by their level of psychobiological phenotype: the HDLR and LDHR eating-behaviour subtypes were differentially associated by their respective HBIS_LBAS and LBIS_LBAS temperament phenotypes. The HDLR subtype has been shown to have the highest levels of BMI, when compared to the other subtypes (Lawson et al., 1995; Provencher et al., 2003; Williamson et al., 1995). Moreover, the inability of the HDLR subtype to restrain their eating behaviour clearly increases their risk for obesity when coupled with an enhanced sensitivity towards the rewarding value of food. Therefore, it is important to determine if differences between the HDLR and the LDHR subtypes can be found at the level of psychobiological temperament and whether these differences are linked to a loss of appetite control and consumption. This knowledge could lead to strategies for helping the HDLR subtype to successfully restrain their intake and thereby reduce their risk for weight gain and obesity.

Chapter 5 also demonstrated that disinhibited-eating behaviour was predicted by the psychological rewards of wanting and liking. It is clear that an observable difference between the HDLR and LDHR eating-behaviour subtypes and HBIS_LBAS and LBIS_LBAS temperament phenotypes is a reactive BIS. However, it is currently not known whether the motivated intake typical of the HDLR subtype is linked to a loss of appetite control that may be attributed to a reactive BIS. Therefore, study three explored whether individuals who possess a HBIS_LBAS temperament phenotype and a HDLR eating behaviour subtype lose control of their appetite in the fed state, when compared to individuals with a LBIS_LBAS temperament phenotype and LDHR eating-behaviour subtype. Furthermore, it sought to determine if their loss of appetite control is associated with a low level of effortful control and associated emotion-regulation difficulties.

As part of the research undertaken in this final study, it was also important to highlight that a low-satiety phenotype, which has been linked to the experiene of chronic anxiety and stress, dysregulation in the HPA axis, disinhibited-eating behaviour, psychological reward, over-consumption and obesity, has been identified (Dalton et al., 2015; Drapeau et al., 2013; Drapeau & Gallant, 2013). The introduction of the low-satiety phenotype at this later stage in the research is highly relevant because it has been linked to high levels of disinhibited-eating behaviour (Barkeling et al., 2007; Dalton et al., 2015; Drapeau & Gallant, 2013) and BAS reactivity via enhanced levels of sensitivity to reward (Drapeau, Hetherington, & Tremblay, 2011). The Disinhibition Scale of the Three Factor eating Questionnaire (Stunkard & Messick, 1985) encompasses emotional and external eating behaviours, which have both been linked to an attenuated-satiety response and eating in response to negative emotionality (Section 2.6.2) (Bruch, 1964; Robbins & Fray, 1980; Schachter, 1968; Slochower, 1983; van Strien & Schippers, 1995). Therefore, such a collection of factors supports an appealing hypothesis that ‘comfort foods’, i.e., those which an individual has learnt to ‘like’ for their affect-regulation properties, could disinhibit intake on a background of an attenuated-satiety response in susceptible individuals (Ouwens, van Strien, van Leeuwe, & van der Staak, 2009).

An individual can be classified with a high or low satiety phenotype by determining their satiety quotient. The satiety quotient measures the satiating efficiency of food by measuring the change in subjective appetite sensations as a function of caloric intake over time (Green, Delargy, Joanes, & Blundell, 1997). Used in this manner, the satiety quotient can be used to classify an individual with a high or low satiety phenotype in response to the change over time in subjective appetitive sensations, such as hunger and fullness, after a pre-load. The satiety quotient was recently used in a study by Dalton et al. (2015) to classify individuals with either a high or low satiety phenotype after measuring their change in subjective hunger levels after a test meal. Upon classification, Dalton et al. (2015) reported that the low satiety phenotype exhibited greater levels of disinhibited-eating behaviour, displayed enhanced psychological reward towards high-fat foods, and consumed more energy at an ad libitum test meal when compared to the high-satiety phenotype. From these results, it was concluded that the possession of a low-satiety phenotype may place an individual at risk of over-consumption.

Reactivity within the BAS via enhanced sensitivity to reward has been hypothesised to play a role in the enhanced hedonic behaviours of an individual with an impaired satiety response (Davis, Patte, et al., 2007; Drapeau et al., 2011). However, it is interesting that, similar to the low satiety phenotype, a reactive BIS, which has been conceptualised as the causal basis of anxiety (Gray, 1970), has also been associated with the experience of stress, anxiety and depression (Bijttebier et al., 2009; Dinovo & Vasey, 2011; Heponiemii et al., 2003; Mc Naughton & Corr, 2008). Moreover, the BIS was linked to external eating behaviour in females in Chapter 4, and to disinhibited-eating behaviour and psychological reward in Chapter 5. Therefore, it is feasible that reactivity within the BIS might be associated with an attenuated-satiety response. More specifically, a reactive temperament that is poorly regulated may contribute towards trait behaviours which have been hypothesised to underlie the “stress-related biopsychobehavioural profile” of the low-satiety phenotype (Drapeau et al., 2013, p. 70). However, to my knowledge, a relationship between psychobiological temperament and satiety has not been previously determined or explored. In order to determine whether a reactive BIS is linked to an attenuated-satiety response, study three investigated whether the BIS is associated with the satiety quotient. It also determined whether measures of subjective appetite, i.e. hunger and fullness over time, differ between the high and low BIS groups and whether these groups can be further differentiated by their satiety quotients of hunger and fullness.

As conceptualised by the psychobiological model of a failure to manage eating behaviour (section 2.4), it is conceivable that an individual with a reactive BIS and a low level of effortful control will be more likely to default to habitual rather than goal-directed actions (Schwabe & Wolf, 2011; Tyron, Carter, DeCant, & Laugero, 2013). Indeed, this effect has been hypothesised to occur in overweight and obese adolescents (Delgado-Rico et al., 2012). However, an attempt to link reactive, temperament-based subcortical behaviours with a reduced capacity to exert cognitive control and flexibility over behaviour has not yet been reported in an adult, non-clinical, non-bariatric, community-based sample. Furthermore, Chapter 4 attempted to investigate whether a relationship could be determined between a behaviourally-based measure of executive attention, The Stroop Colour Word Interference Test (SCWIT) and a self-report measure of executive attention, the Adult Temperament Questionnaire Effortful Control Scale. Due to a methodological limitation, a relationship between the computer-based SCWIT and the self-report measure of effortful control was not able to be determined. Subsequently, study three investigated whether the aforementioned BIS groups differed in behavioural-based measures of cognitive control and flexibility and overall level of self-reported effortful control and whether the Effortful Control Scale is associated with a behaviourally-based measure of executive function, the DKEFS-Stroop CWIT.

6.3 STUDY AIMS

The primary aim of this study was to explore whether the psychological rewards of wanting and liking and an attenuated-satiety response, after a pre-load, were associated with and were differentiated by reactivity within the BIS, a low level of effortful control and greater difficulties regulating emotion. Secondary aims were to determine whether psychobiological temperament was linked to consumption and whether individuals with a reactive BIS, who are concurrently high in disinhibited-eating behaviour and low in restrained-eating behaviour, showed evidence of a deficit in executive functioning when compared to individuals with lower levels of disinhibited-eating behaviour and BIS reactivity.

6.3.1 Hypotheses

- After adjusting for BMI, the BIS, but not the BAS, would be positively associated with implicit wanting of high-fat and not low-fat foods, in the fed state
- After adjusting for BMI, effortful control would be inversely associated with implicit wanting of high-fat and not low-fat foods, in the fed state.
- After adjusting for BMI, the BIS, but not the BAS, would be positively associated with explicit liking of high-fat and not low-fat foods, in the fed state.

- After adjusting for BMI, the BIS, but not the BAS, would be positively associated with the energy intake of high-fat snack foods at an ad libitum test meal
- After adjusting for BMI, effortful control would be inversely associated with the energy intake of high-fat snack foods at an ad libitum test meal.
- After adjusting for BMI, difficulties in emotion regulation would be positively associated with explicit liking of high-fat foods in the fed state and the energy intake of high-fat snack foods, at an ad libitum test meal.
- The BIS would be inversely associated with the satiety quotient.
- The HBIS_LBAS phenotype, HDLR subtype combination would have a higher level of implicit wanting and explicit liking for high-fat and not low-fat foods in the fed state when compared with the LBIS_LBAS, LDHR subtype combination.
- The HBIS_LBAS phenotype, HDLR subtype combination would have a significantly lower level of satiety, greater hunger and lower fullness, than the LBIS_LBAS, LDHR subtype combination.
- The HBIS_LBAS phenotype, HDLR subtype combination would have significantly higher levels of total energy intake, from high-fat snack foods than the LBIS_LBAS, LDHR subtype combination.
- The HBIS_LBAS phenotype, HDLR subtype combination would have a significantly higher level of emotion regulation difficulties and a lower level of effortful control than the LBIS_LBAS phenotype, LDHR subtype combination.
- The HBIS_LBAS phenotype, HDLR subtype combination would have a significantly lower level of inhibitory control and cognitive flexibility than the LBIS_LBAS phenotype, LDHR subtype combination.

6.4 METHODS

6.4.1 Participants

Participants from study two who had consented to take part in an additional study and met the inclusion and exclusion criteria were invited to take part in this final study. It was anticipated that not all of the participants who had previously expressed an interest were able to participate, thus new recruits were also sought. New recruits were sought within Brisbane and regional Queensland. Staff and students of QUT were recruited, as well as select government employees (i.e. Brisbane City Council, Department of Main Roads), non-government employees (i.e. Rio Tinto), community groups (i.e. Rotary). Select organisations/groups that assisted individuals to manage weight (i.e. Wesley LifeShape Clinic) were also invited to participate. Presentations through the media by the PhD candidate were used to facilitate recruitment. The screening questionnaires were administered via email and by hyperlinks on a media webpage and on a Facebook site that had been set up expressly for the study. The hyperlink took the participant to the secure KeySurvey online platform where potential recruits were able to view a Participant Information and Consent Form, which outlined the selection criteria and the study protocol, prior to accessing the questionnaires. Participants who completed the surveys also provided their contact details, either an email address or a telephone number, for scheduling their assessment.

6.4.2 Online screening component

The screening component consisted of two self-report questionnaires: The Three Factor Eating Behaviour Questionnaire (Stunkard & Messick, 1985) and The Behavioural Inhibition and Behaviour Activation Scales (BIS/BAS Scales) (Carver & White, 1994). In order to progress to the study, candidates were required to be either high in Disinhibition (12 to16), high in BIS (24 to 28) and low in BAS (24 to 40), or low in Disinhibition (2 to11), low in BIS (12 to 23) and low in BAS (24 to 40), based on the median splits that were conducted in study two (Chapter 5).

6.4.3 Successful recruitment: New recruits

Participants with a BMI $\geq$ 25 kg/m^2 and who met the screening criteria were invited to continue to laboratory testing. Participants were informed that there were an additional three online questionnaires to complete within two weeks of their assessment. The online self-report questionnaires consisted of the following: demographic, lifestyle and health questions, the Effortful Control Scale (Evans & Rothbart, 2007), the Diffiulties in Emotion Regulation Scale (DERS) (Gratz & Roemer, 2004) and the Binge Eating Scale (BES) (Gormally et al., 1982).

6.4.4 Successful recruitment: Previous recruits

Previous participants who met the screening criteria and who were identified from Study two (Chapter 5) as either high in Disinhibition (12 to 16), high in BIS (24 to 28) and low in BAS (24 to 40), or low in Disinhibition (2 to 11), low in BIS (12 to 23) and low in BAS (24 to 40), were invited to continue to laboratory testing. These participants were informed that there were an additional five online questionnaires to complete two weeks prior to their assessment. The online self-report questionnaires contained the following and were required to be completed in one sitting: demographic and lifestyle questions, the Three Factor Eating Behaviour Questionnaire (Stunkard & Messick, 1985), and the Behavioural Inhibition and Behaviour Activation Scales (BIS/BAS Scales) (Carver & White, 1994), the Effortful Control Scale (EC) (Evans & Rothbart, 2007), the Diffiulties in Emotion Regulation Scale (DERS) (Gratz & Roemer, 2004) and the Binge Eating Scale (BES) (Gormally et al., 1982).

Participants were asked to come in at a date that coincided with the follicular phase of their menstrual cycle, to reduce the impact of the premenstrual phase on food craving and over-consumption (I. Cohen, Sherwin, & Fleming, 1987; Dye & Blundell, 1997). Appointments were scheduled to coincide with the mid-meal time period (start time between 11:00am and 1:00pm, with lunch provided 30 minutes after starting). Participants were asked to arrive at their assessment 3.5 hours fasted, except for water; after finishing breakfast or a light morning tea snack.

Seventeen participants from the second study were contacted and ten were accepted. Seven did not take part in the assessment due to a change in their BIS/BAS scores that excluded their further participation. On the online survey platform, there was a total ‘click through’, indicating the number of individuals who accessed the hyperlink and survey, of 40,173 interested persons. One hundred and sixty one took part in the survey. Of that number, 57 met the inclusion criteria. In total, 26 of those individuals agreed to take part in the assessment. A total of 10 participants from the second study also agreed to take part, resulting in a total sample to 36 participants.

6.5 MEASURES

Upon arrival at the HARC, participants were familiarised with the timetable for the day of the intervention and were re-screened to ensure they met the inclusion criteria.

6.5.1 Anthropometry

Anthropometrical measurements were taken as outlined in the general methodology section.

6.5.2 Behavioural tasks of executive function

The Delis-Kaplan Executive Function System color-word interference test (D-KEFS CWIT) (Delis, Kaplan, & Kramer, 2001) was used as a test of executive function. It was used to assess both cognitive flexibility and the ability to suppress a dominant behavioural response. The D-KEFS CWIT (Delis et al., 2001) is based upon the Stroop procedure (Stroop, 1935). The D-KEFS CWIT has been correlated with snacking behaviour (Allan et al., 2011), and unintentional chocolate consumption in dieters (Allan et al., 2010). It has been reported as a valid and reliable test (Delis, Kramer, Kaplan, & Holdnack, 2004), with moderate to high split-half reliability (.62 to .86) and moderate test-retest reliability (.62 to .76) (Homack, Lee, & Riccio, 2007) that is sensitive to small differences in executive functioning (Allan et al., 2010; Delis et al., 2001; Swanson, 2005). It has normative values for the 18 to 65 age group in this study and provides scaled scores that have a mean of 10 and a SD of 3 for this age range (Delis et al., 2001).

The test measures both cognitive flexibility and the ability to inhibit a pre-potent response (i.e., reading the printed words) as sub-components of executive functioning. It consists of three traditional trials: the first is colour naming (where participants name the colour of the patch on the page); the second is colour name reading (where participants read the colour names printed in black ink); the third is the interference effect (where participants name the colour of the ink instead of reading the word, with words printed in an incongruent colour to their name; i.e., the word blue is printed in green ink). The D-KEFS additionally offers a fourth trial of cognitive flexibility, whereby the participant must switch back and forth between naming dissonant ink colours and reading their conflicting colour names (Delis et al., 2001). The D-KEFS CWIT was included in study three, to measure executive attention, after some participants disclosed that they used strategies to respond more quickly to the incongruent component of the computer-based Stroop test of cognitive interference in study two (Chapter 5).

6.5.3 Subjective appetite sensations

Subjective appetite was measured with 100mm visual-analogue scales (VAS). Measures of hunger ("how hungry do you feel now?") and fullness ("How full do you feel right now?") were anchored at 0mm with "not at all" and at 100mm with "extremely", following the methodology of Dalton et al. (2013a). For ease of reporting, the terms of implicit wanting and explicit liking are subsequently reduced to wanting and liking respectively. Visual analogue scales (VAS) are sensitive to experimental manipulations and have been shown to have good reliability and validity (R. J. Stubbs et al., 2000).

6.5.4 Satiety quotient

The satiety quotient (SQ) is a validated measure of the satiating capacity of foods in relation to their energy content, over time (Drapeau et al., 2007; Green et al., 1997). The SQ of each individual in the revised BIS groups (as described in section 6.6) was measured following the methodology of Dalton et al. (2013a) in which hunger and fullness VAS were used to calculate the average SQ for the 90-minute post pre-load period (VAS taken at 0 min, 30 min, 60 min and 90 min post pre-load). A higher SQ represents stronger satiety responses to the pre-load, a lower SQ an attenuated-satiety response.

The following formula was used to calculate SQ:

$$\underset{(\text{mm/kcal})}{\text{SQ}} = \left(\frac{\text{Rating before pre-load minus mean of the 90 minute post pre-load ratings}}{\text{600 kcal}} \right) \times 100$$

6.5.5 The Leeds Food Preference Questionnaire

The Leeds Food Preference Questionnaire has been outlined in detail in the general methodology – see Chapter 3.

6.5.6 Pre-load

The final study aimed to determine whether high BIS individuals possessed an attenuated satiety response and enhanced responsiveness to the rewarding properties of high-fat foods. Therefore, the pre-load meal design was selected based on the study of Nasser, Evans, Geliebter, Pi-Sunyer, and Foltin (2008), which reported that after consumption of a 600 kcal liquid preload, individuals with binge eating disorder, compared to those without, showed evidence of enhanced food reinforcement, when satiated. The pre-load consisted of a 600 kcal, nutritionally-balanced liquid commercial supplement (Sustagen 'Optimum') that supplied 1 kcal/ml. This supplement meets the recommended Nutrient Reference Values daily macronutrient distribution (National Health and Medical Research Council, 2015), supplying 16% protein, 34% fat and 46% carbohydrate. Participants were allowed 10 to15 minutes to consume the pre-load. Participants consumed the preload alone, in a quiet room with no distractions.

6.5.7 Ad libitum test meal

The ad libitum test meal was similar to the protocol used by Dalton et al. (2013a). The meal was delivered via simultaneous choice format. Six different snack items that were high in fat (> 40%) and varied in taste; i.e., either sweet (using milk chocolate, shortbread creams and milk chocolate biscuits) or non-sweet (using 70% dark chocolate, salted cashews and salted crisps) were presented in 60g to 70g portions in bite-sized pieces. Participants ate alone, in a quiet room with no distractions. They were provided with the instruction that they could eat as much or as little as they would like. Participants were also told that the food would be weighed, in order to maintain a level of objectivity, after they had finished. Participants were provided with 10 minutes to complete this part of the procedure.

6.5.8 Energy intake

Energy intake (kcal) was calculated by weighing each food choice on its plate before and after consumption. Food was weighed to the nearest 0.1gram and energy intake was calculated from the nutrition information provided by the manufacturer.

6.6 PROCEDURE

For a schematic of the study procedure please refer to Figure 6.1. In order to measure satiety as objectively as possible, individuals were asked to come in at lunch time because personal observation and research shows that overweight and obese individuals skip breakfast (Ma et al., 2003). The 90 minute interval post lunch time-frame, which was chosen to capture the satiating effect of the preload was based upon the work of Drapeau and colleagues (Drapeau et al., 2005; Drapeau et al., 2007) and Green et al (Green et al., 1997). On arrival, participants were re-screened to ensure compliance with study requirements and selection criteria. This was followed by anthropometrical measures and the D-KEFS, paper and pencil-based colour word interference test (CWIT). On completion of the CWIT, participants were presented with the subjective appetitive sensation VAS; which represented their 'baseline' appetitive state. Following this, they completed the LFPQ for the first time. This represented the 'fasting' state. On completion, participants were provided with the pre-load. They were provided with 10 to 15 minutes to consume the pre-load. After its consumption, they were asked to fill out the appetitive VAS for a second time, which marked the '0' time period. A ten-minute interlude was provided to allow for an increase in feelings of satiety before completing the LFPQ for a final time, representing the 'fed' condition. After completion of the LFPQ, and at thirty minutes post-pre-load, participants were asked to complete the subjective appetite sensation VAS for a third time (+30 minutes post-pre-load). Participants were then invited to sit quietly and to read for 30 minutes. After 30 minutes, participants completed the subjective appetite sensation VAS for a fourth time (+60 minute post pre-load). Participants again sat quietly for an additional 30 minutes and then completed the subjective appetite sensation VAS for a fifth time (+ 90 minute post pre-load). They were then invited to take part in afternoon tea; their ad libitum-test meal snack. Participants were provided with ten minutes to complete this part of the experiment. They were requested to taste each food item, as they would be required to rate how much they liked each of the foods after they had completed afternoon tea using VAS. Foods were removed after ten minutes and each bowl was weighed so that energy intake (kcal) could be calculated. Upon completion of the ad libitum-intake task, participants were asked to complete the subjective appetite sensation VAS for the sixth and final time and a subjective palatability VAS for each food that was tasted and consumed. Participants were then provided with a $25.00 gift voucher.

	STUDY DESCRIPTION AND TIMING (+mins)									
	0	+10	+20	+30	+60	+90	+120	+120	+130	
Arrival, study familiarisation, rescreening & anthropometry	Baseline VAS*1 LFPQ fasted	600ml Preload	VAS*2 0 min	LFPQ fed	VAS*3 +30min	VAS*4 +60 min	VAS*5 +90 min	Taste Task	End of Taste Task	Debrief $25.00 gift voucher Departure

Figure 6.1. Schematic of the study procedure.

6.7 DATA ANALYSIS

The sample was grouped according to their screened BIS and disinhibited-eating behaviour classification. Participants with a BIS score of 12 to 23 and a Disinhibition score of 2 to 11 were classified into a low BIS and low Disinhibition group (low BIS group, *n* = 18) and individuals with a BIS score of 24 to 28 and a Disinhibition score of 12 to16 were classified into a high BIS and high Disinhibition eating behaviour group (high BIS group, *n* = 18)

Descriptive statistics were used to describe the sample and to summarise the independent and dependent variables. Categorical variables were summarized and presented as counts and percentages for the total sample and by high and low BIS group. Continuous variables were presented as means and standard deviations or medians with interquartile ranges, depending upon the distribution of the independent and dependent variables, for both the total sample and between the high and low BIS groups.

Pearson’s Product Moment Correlation Coefficients, with and without adjustment for BMI, were computed to examine the relationships between the following: the BIS, explicit liking, implicit wanting, and energy intake at the ad libitum-intake task; total effortful control and difficulties in emotion regulation and their associated subscales and explicit liking, implicit wanting, and energy intake at the ad libitum-intake task; explicit liking, implicit wanting and the total energy intake at the ad libitum-intake task. For ease of reporting, all significant associations are in the positive direction, unless otherwise stipulated.

The second study highlighted significant differences between the HDLR and LDHR eating-behaviour subtypes, relative to their level of BMI. Therefore, prior to analysing the current sample's level of psychological reward, satiety and energy intake, the sample was adjusted to contain only those individuals who, based upon a median split of scores, were determined to be high in Disinhibition and low in Restraint (HDLR) and low in Disinhibition and high in Restraint (LDHR). Participants with a Disinhibition score of 2 to 11 and a Restraint score of 13 to 18 were classified as a LDHR, low BIS, eating-behaviour group (n = 15). Conversely, participants with a Disinhibition score of 12 to 16 and a Restraint score of 1 to 12 were classified as a HDLR, high BIS eating-behaviour group (n = 12). These individuals were retained in the sample and analysed within their respective groups, whilst the other eating behaviour subtypes, specifically those classified as low in Restraint and low in Disinhibition (LDLR) and high in Disinhibition and high in Restraint (HDHR) were excluded from further analyses (n = 9).

Pearson's Product Moment Correlation Coefficients were computed to examine the relationship between the BIS and SQ for hunger and fullness. The SQ for fullness was noted to have a negative value; subsequently, all values were multiplied by –1 to change the values to positive for ease of interpreting the results for the t-tests and the correlation. Independent samples t-tests were used to assess the differences between the revised groups and between their satiety quotients for hunger and fullness, levels of effortful control, executive function, difficulties in regulating emotion, and total energy intake when data were normally distributed. When data were not normally distributed, the non-parametric alternative, the Mann-Whitney U test was used to assess whether groups differed significantly from each other. Significant differences in scores between the high BIS and the low BIS group in terms of BMI ($p < .05$) were noted. Subsequently, all analyses were conducted controlling for BMI, where possible.

A marginal model was used to account for correlation of the data within a person. Group differences were examined for BIS (high and low), state (fasting and fed) and implicit wanting (appeal bias) and explicit liking across food categories. Group differences were examined for levels of hunger and fullness over time and for energy intake. The marginal model was chosen, as it offers a flexible approach to dealing with data that has unequal correlations between repeated measures. To examine the correlation within the data, three covariance structures were compared; compound symmetry, autoregressive and unstructured. The best model was determined, based upon it having the lowest Akaike's Information Criterion (AIC) (Akaike, 1981). Violation of the assumptions of normality was checked via visual inspection of the normal probability plot and the scatter plot of the residuals.

Differences between the high and low BIS groups in their levels of psychological reward were examined. The independent variable for each fed or fasted condition was included in the analyses to examine whether explicit liking or implicit wanting differed from the fasting to the fed condition, both between and within the groups. Explicit liking was examined according to four fat and taste categories: (high (HFSA) or low-fat savoury (LFSA), high (HFSW) or low-fat sweet (LFSW)). Implicit-wanting was examined according to an individual's level of bias for low or high-fat foods. To calculate the implicit wanting appeal bias for high-fat foods, mean low-fat implicit wanting scores were subtracted from mean high-fat implicit wanting scores (Dalton & Finlayson, 2014; Dalton et al., 2015; French et al., 2014). Calculated in this manner, an appeal bias for high-fat foods is represented by a positive score and an appeal bias for low-fat foods is represented by a negative score. Therefore, in this analysis, a preference for high-fat versus low-fat foods is indicated by a positive value, whilst a negative value indicates a preference for low-fat foods. To determine the effect of the BIS on measures of satiety, the groups were examined according to levels of hunger and fullness at five time points (relative to the consumption of the pre-load): baseline, 0, 30, 60 and 90 minutes. The effect of the BIS group on subsequent energy intake (kcal) at an ad libitum-intake task was also examined. Two energy-intake categories were analysed: energy intake of high-fat sweet (HFSW) and energy intake of high-fat, non-sweet (HFNSW) foods. BMI was included as a covariate in each analysis. Dieting status was included as a covariate in the final model of the series, which explored the effect of group status on the energy intake of high-fat sweet or high-fat non-sweet snacks intake during the ad libitum-test meal. When significant interactions occurred, post hoc analyses with Sidak correction were undertaken. An α-level of 0.05 was used to determine statistical significance

6.8 RESULTS

6.8.1 Participant characteristics

Total sample

Thirty six participants aged between 18 and 65 years (*M* = 48.64, *SD* = 10 years) were recruited (Table 6.1). Over two-thirds were married (69%) and the majority were highly educated. Almost two thirds of participants were tertiary qualified (61%, *n* = 22), almost one-quarter had post-secondary school qualifications (22%, *n* = 8), and 14 percent had between 10 to 12 years of education (*n* = 5). Over three-quarters owned their own home, either with a mortgage or outright (78%, *n* = 28) and less than one-quarter of participants (22%, *n* = 8) were renting. One-third of the sample had, at some stage, been diagnosed with anxiety, depression, or anxiety and depression (33%, *n* = 12), including a majority (25%, *n* = 9) with depression.

Less than one-half of participants were currently dieting (42%, *n* = 15). However, the sample contained a high number of frequent dieters. Almost one-half of the sample (42%, *n* = 15) had made over 11 attempts at weight loss. In relation to the samples' weight loss success, only 8% (*n* = 3) considered themselves to be very successful at losing weight; one-half categorised themselves as only 'somewhat' successful at losing weight (50%, *n* = 18), and the remainder (42%, *n* = 15) considered themselves to be 'not very' or to have 'failed' in their weight loss attempts.

Table 6.1

Demographic, Mood and Weight Management Characteristics of Participants

Characteristics (N = 36)	*n*	%	*M* (*SD*)
Age (years)			48.64 (10.00)
BMI			33.46 (6.59)
Region			
Oceania	31	86	
Europe	1	3	
Americas	1	3	
Africa	1	3	
Asia	2	6	
Marital Status			
Never married	5	14	
Widowed	1	3	
Divorced	4	11	
Separated	1	3	
Married	25	69	
Educational Attainment			
Post - school degree or higher	22	61	
Post-school diploma	6	17	
Post-school certificate	2	6	
Year 12	2	6	
Year 11	2	6	
Year 10	1	3	
Other	1	3	
Home Ownership			
Own outright	8	22	
Mortgage	20	56	
Renting	8	22	
Mood disorder			
Nil	24	67	
Anxiety	1	3	
Depression	9	25	
Anxiety and Depression	2	6	
Currently dieting			
Yes	15	42	
No	21	58	
Weight loss attempts			
1-5	13	36	
6-10	8	22	
11+	15	42	
Weight loss success			
Very	3	8	
Somewhat	18	50	
Not very	12	33	
Failed	3	8	

Note: Percentages have been rounded

High and low BIS group

The weight management characteristics of the high and low BIS groups are presented in Table 6.2. The low BIS group was more actively engaged with managing their weight. Half of the low BIS sample (50%, *n* = 18) and one-third of the high BIS sample were currently dieting (33%, *n* = 6). Interestingly, these dieting characteristics are in contrast to the group's weight management attempts: two thirds (67%, *n* = 12) of the high BIS sample reports having made more than 11 attempts at weight loss, in comparison to less than one-fifth of the low BIS sample (17%, *n* = 3).

Two thirds of the low BIS sample rated themselves as very or somewhat successful in their weight management attempts (67%, *n* = 12). This characterisation highlights another difference between the groups, as one-half of the high BIS sample (50%, *n* = 9) rated themselves as being 'not very' or to have 'failed' in their weight-management attempts.

Table 6.2

Weight Management Characteristics of Participants, Separated into BIS and Disinhibited Eating Behaviour Groups

Characteristic	High BIS_High_D (*n* = 18)		Low BIS_Low D (*n* =18)	
Age (years) *M (SD)*	51.11 (10)		46.17 (10.05)	
BMI *M (SD)*	36.00 (8)		30.94 (3.70)	
	n	%	*n*	%
Mood disorder				
Nil	10	56	14	78
Anxiety	1	6	-	-
Depression	5	28	4	22
Anxiety and Depression	2	11	-	
Currently dieting				
Yes	6	33	9	50
No	12	67	9	50
Weight loss attempts				
1-5	1	6	12	67
6-10	5	28	3	17
11+	12	67	3	17
Previous weight loss success				
Very	1	6	2	11
Somewhat	8	44	10	56
Not very	7	39	5	28
Failed	2	11	1	6

Note: Percentages have been rounded

6.8.2 Descriptive statistics of the main study variables for the total sample

Total sample, means and standard deviations or medians and interquartile range, depending upon normality of key variables, are presented in Table 6.3.

Table 6.3

Mean, Standard Deviations, Medians and Interquartile Ranges of Study Variables

Measure	*M*	*SD*	*Mdn (IQR)*
BMI	33.46	6.59	-
Age	48.64	9.96	-
Disinhibition	10.83	3.66	-
Hunger	7.26	4.34	-
Restraint	10.33	4.52	-
BES	15.89	8.70	-
BIS	22.78	3.70	-
BAS	35.53	4.05	36.00 (34-39)
BAS_FS	10.11	2.03	-
BAS_DR	9.04	2.02	-
BAS_RR	12.70	1.49	-
EC_Total	85.39	10.88	-
EC_Inhibition	30.56	6.12	-
EC_Activation	33.19	5.62	-
EC_Attention	21.69	4.61	-
DERS_Total	84.44	21.16	76.50 (70-100.50)
DERS_Awareness	17.56	5.40	-
DERS_Clarity	10.86	3.45	-
DERS_Strategies	17.31	6.56	16.00 (12.25-21.25)
DERS_Impulse	11.78	4.53	10.50 (8.00-14.00)
DERS_Non-acceptance	13.75	6.04	12.50 (9.25-16.75)
DERS_Goals	13.19	4.37	13.00 (10-14.75)
FAST_IW_HFSA	4.82	40.58	-
FAST_IWL_LFSA	-10.54	30.22	-
FAST_IW_HFSW	1.21	29.42	-
FAST_IW_LFSW	4.51	31.86	-
FAST_EL_HFSA	46.53	25.90	-
FAST_EL_LFSA	43.26	21.23	-
FAST_EL_HFSW	48.26	26.47	-
FAST_EL_LFSW	53.58	18.97	-
FED_IW_HFSA	-10.20	35.52	-
FED_IWL_LFSA	-7.90	32.87	-
FED_IW_HFSW	-3.58	28.43	-
FED_IW_LFSW	21.68	29.44	-
FED_EL_HFSA	25.48	25.77	-
FED_EL_LFSA	20.72	17.61	-
FED_EL_HFSW	29.83	27.95	-
FED_EL_LFSW	32.86	22.34	-
Energy-T (kcal)	332.44	157.62	-
Energy_SW (kcal)	141.90	72.33	-
Energy_NSW (kcal)	190.54	112.91	-
CWIT_Inhibition (sec)	10.61	1.89	-
CWIT_Flexibility (sec)	54.32	11.71	-

BMI: Body Mass Index (kg/m^2); Disinhibition: Disinhibition Scale Score; Restraint: Restraint Scale Score; Hunger: Hunger Scale Score; BES: Binge Eating Scale; BIS: Behavioural Inhibition Scale; BAS: Behavioural

Activation Scale; BAS-FS: BAS Fun seeking Scale; BAS-DR: BAS Drive Scale; BAS-RR: BAS Reward Responsiveness Scale; EC-T: Effortful Control-total score; EC Inhibition: Inhibition subscale; EC Activation; EC Activation subscale; EC Attention subscale; DERS-Total: Difficulties in Emotion Regulation Total Scale; DERS_Awareness: Difficulties in Emotion Regulation Awareness subscale; DERS_Clarity: Difficulties in Emotion Regulation Clarity subscale; DERS_Strategies: Difficulties in Emotion Regulation Strategies subscale; DERS_Impulse: Difficulties in Emotion Regulation Impulsiveness Scale; DERS_Non Acceptance: Difficulties in Emotion Regulation Non Acceptance of Emotion subscale; DERS_Goals: Difficulties in Emotion Regulation Difficulty in Following Goal Directed Behaviour subscale; FAST_IWHFSA: Fasted Condition Implicit Wanting High-Fat Savoury; FAST_IWLFSA: Fasted Condition Implicit Wanting Low-Fat Savoury; FED_IW_HFSW: Fed Condition Implicit Wanting High-Fat Sweet; FAST_IW_LFSW: Fasted Condition Implicit Wanting Low-Fat Sweet; FAST_EL_HFSA: Fasted Condition Explicit Liking High-Fat Savoury; FAST_EL_LFSA: Fasted Condition Explicit Liking Low-Fat Savoury; FAST_EL_HFSW: Fasted Condition Explicit Liking High-Fat Sweet; FAST_EL_LFSW: Fasted Condition Low-Fat Sweet; FED_IWHFSA: Fed Condition Implicit Wanting High-Fat Savoury; FED_IWLFSA; Fed Condition Implicit Wanting Low-Fat Savoury; FED_IW_HFSW: Fed Condition Implicit Wanting High-Fat Sweet; FED_IW_LFSW: Fed Condition Implicit Wanting Low-Fat Sweet; FED_EL_HFSA: Fed Condition Explicit Liking High-Fat Savoury; FED_EL_LFSA: Fed Condition Explicit Liking Low-Fat Savoury; FED_EL_HFSW: Fed Condition Explicit Liking High-Fat Sweet; FED_EL_LFSW: Fed Condition Low-Fat Sweet; Energy-T: Total Energy Intake; Energy_SW: Energy Intake Sweet; Energy_NSW: Energy Intake Non-Sweet; CWIT_Inhibition: D-KEFS Colour Word Interference Test Inhibition Component; CWIT_Flexibility: D-KEFS Colour Word Interference Test, Flexibility Component.

6.8.1 Associations between the BIS, psychological reward and energy intake, in the fed state

Associations between the BIS, the psychological rewards of wanting and liking in the fed state, and energy intake at an ad libitum-test meal, are presented in Table 6.4. Associations between the BAS temperament are also presented in order to make a comparison between the BAS's association with food-reward behaviours and food intake. The results are presented after adjusting for BMI.

In the fed state, the BIS was significantly associated with explicit liking for all food categories ($p < .01$ for HFSW, HFSA, and LFSA; $p < .05$ for LFSW; see Table 6.4 for r values). This suggests that higher levels of the BIS are associated with greater explicit liking for all food categories, after the consumption of a 600 kcal pre-load. The BAS was significantly inversely associated with the explicit liking of the low-fat savoury category ($p < .05$). It was not associated with any other food categories. This suggests that higher levels of the BAS are associated with less explicit liking for low-fat savoury food items. In terms of implicit wanting, the BIS was significantly associated with implicit wanting for HFSW food items after a 600 kcal pre-load ($p < .05$). It was not associated with implicit wanting for any other food categories. This suggests that higher levels of the BIS are associated with higher levels of implicit wanting for high-fat sweet foods only, in the fed state. The BAS was not associated with implicit wanting for any of the four food categories.

BIS was significantly associated with total energy intake ($p < .05$), which indicates that higher levels of the BIS are associated with a higher total energy intake after a 600kcal pre-load. There was evidence of a trend for an association between the BIS and the intake of energy from both high-fat sweet ($p = .05$) and high-fat non-sweet foods ($p = .072$). The BAS was not significantly associated with total energy intake or the energy intake of high-fat sweet or non-sweet foods.

Table 6.4

Correlations Between Temperament, Psychological Reward, in the Fed State, and Energy Intake, adjusting for BMI

Variables	No adjustment for BMI		After adjusting for BMI	
	BIS	BAS	BIS	BAS
FED_EL_HFSW	.615**	-.300	.606**	-.029
FED_EL_LFSW	.599**	-.399*	.392*	-.095
FED_EL_HFSA	.676**	-.185	.534**	-.180
FED_EL_LFSA	.481**	-.206	.557**	-.342*
FED_IW_HFSW	.249	-.189	.354*	.117
FED_IW_HFSA	.449**	-.022	-.226	.009
FED_IW_LFSW	-.409*	.068	.089	-.050
FED_IW_LFSA	-.355*	.126	-.273	-.112
Energy _T	.426**	-.197	.375*	-.133
Energy _SW	.337*	.064	.334	-.042
Energy _NSW	.379*	-.235	.307	-.160

FED_EL_HFSA: Fed Condition Explicit Liking High-Fat Savoury; FED_EL_LFSA: Fed Condition Explicit Liking Low-Fat Savoury; FED_EL_HFSW: Fed Condition Explicit Liking High-Fat Sweet; FED_EL_LFSW: Fed Condition Low-Fat Sweet; Energy-T: Total Energy Intake; Energy_SW: Energy Intake Sweet; Energy_NSW: Energy Intake Non-Sweet; FED_IWHFSA: Fed Condition Implicit Wanting High-Fat Savoury; FED_IWLFSA, Fed Condition Implicit Wanting Low-Fat Savoury; FED_IW_HFSW: Fed Condition Implicit Wanting High-Fat Sweet; FED_IW_LFSW: Fed Condition Implicit Wanting Low-Fat Sweet
$*p < .05$, $**p < .01$

6.8.2 Relationships amongst effortful control, emotion regulation difficulties, psychological reward in the fed state, and energy intake

Both variables of effortful control and difficulties in regulating emotion have been noted throughout this thesis to be strongly associated with the BIS. For the first time, the association of the subscales of both measures are examined relative to implicit wanting, explicit liking, and total energy intake. The correlations between effortful control and implicit wanting, and energy intake are examined in Table 6.5.

Table 6.5

Correlations between Effortful Control, Psychological Reward, in the Fed State, and Energy Intake, adjusting for BMI

Variables	No adjustment for BMI				Adjustment for BMI			
	EC-T	EC-ACT	EC-INH	EC-ATT	EC-T	EC-ACT	EC-IN	EC-ATT
IW_HFW	-.242	-.173	-.220	-.070	-.129	-.145	-.092	.013
IW_HFSA	-.547**	-.549**	-.256	-.286	-.454*	-.619**	.007	-.235
IW_LFW	.375*	.414*	.084	.272	.309	.552**	-.229	.288
IW_LFSA	.465*	.372*	.392*	.126	.331	.310	.274	-.010
Energy _T	-.489**	-.325	-.338*	-.314	-.455**	-.309	-.297	-.291
Energy_SW	-.271	-.214	-.221	-.086	-.261	-.082	-.209	-.203
Energy_NS	-.509**	-.317	-.330	-.383*	-.469**	-.382*	-.280	-.276

IWHFSA: Fed Condition Implicit Wanting High Fat Savoury; IWLFSA, Fed Condition Implicit Wanting Low Fat Savoury; IW_HFSW: Fed Condition Implicit Wanting High Fat Sweet; IW_LFSW: Fed Condition Implicit Wanting Low Fat Sweet; Energy-T: Total Energy Intake; Energy_SW: Energy Intake Sweet; Energy_NS: Energy Intake Non Sweet; EC-T: Effortful Control total sale; EC-ACT: Effortful Control Activation subscale; EC-IN: Effortful Control Inhibition subscale; EC-ATT: Effortful Control Attention subscale
$*p < .05$, $**p < .01$

The correlations between difficulties in emotion regulation, implicit wanting and explicit liking in the fed state and energy intake are presented, without and with adjusting for BMI, in Tables 6.6 and 6.7 respectively. The results are presented after adjusting for BMI.

The Effortful Control Scale was significantly inversely associated with the implicit wanting of high-fat savoury foods ($p < .05$), total energy intake ($p < .01$) and the intake of high-fat non-sweet foods ($p < .01$). It was not significantly associated with the implicit wanting of high-fat sweet, low-fat savoury, or sweet foods or the energy intake from high-fat sweet foods. This suggests that individuals with low levels of effortful control implicitly want high fat-savoury foods at an ad libitum-test meal, they also consume more energy from high-fat non-sweet foods and have a greater total energy intake from the amount of foods consumed during this task.

Of the three Effortful Control subscales, only the Activation-Control subscale showed evidence of a further association with food-reward behaviours and total energy intake after adjusting for BMI. Activation control was significantly inversely ($p < .01$), associated with implicit wanting for high-fat savoury foods. However, it was also significantly positively ($p < .01$), associated with implicit wanting for low-fat sweet foods. These results suggest that individuals with lower levels of activation control implicitly want high-fat savoury foods, whilst individuals with higher levels of activation control implicitly want low-fat sweet foods, in the fed state.

Activation control was significantly inversely ($p < .05$), associated with the energy intake of high-fat non-sweet foods and with lower levels of activation control associated with a higher energy intake from these foods. None of the other Effortful Control subscales were significantly associated with implicit wanting or energy intake, after controlling for BMI. This evidence suggests that the use of avoidance behaviours (i.e., a low level of activation control) results in a greater implicit wanting for and a greater intake of high-fat savoury foods, whilst the ability to perform behaviours that one would prefer to avoid (i.e., a higher level of activation control), results in the implicit wanting for low-fat sweet foods and a lower energy intake of high-fat non-sweet foods.

Table 6.6

Correlations between Emotion Regulation Difficulties Psychological Reward, in the Fed State, and Energy Intake, not adjusting for BMI

Variables	No adjustment for BMI						
	DERS-T	DERS-A	DERS-C	DERS-S	DERS- I	DERS-N	DERS-G
FED_EL_HFSA	.482**	-.009	.268	.609**	.358*	.359*	.348*
FED_EL_LFSA	.352**	.009	.153	.395*	.289	.374*	.163
FED_EL_HFSW	.501**	.039	.217	.630**	.241	.547**	.256
FED_EL_LFSW	.454**	.225	.364*	.391*	.325	.432**	.111
Energy_T	.429**	.070	.093	.572**	.387*	.314	.224
Energy_SW	.389*	.069	.079	.611**	.317	.205	.210
Energy_NSW	.350*	.054	.080	.407*	.338*	.308	.178

FED_EL_HFSA: Fed Condition Explicit Liking High-Fat Savoury; FED_EL_LFSA: Fed Condition Explicit Liking Low-Fat Savoury; FED_EL_HFSW: Fed Condition Explicit Liking High-Fat Sweet; FED_EL_LFSW: Fed Condition Low-Fat Sweet; Energy-T: Total Energy Intake; Energy_SW: Energy Intake Sweet; Energy_NSW: Energy Intake Non-Sweet, DERS: Difficulties in Emotion Regulation Total Scale, DERS-A; Difficulties in Emotion Regulation Awareness subscale, DERS-C: Difficulties in Emotion Regulation Clarity subscale; DERS-S: Difficulties in Emotion Regulation Strategies subscale; DERS-I: Difficulties in Emotion Regulation Impulsiveness subscale; DERS-N: Difficulties in Emotion Regulation Non Acceptance of Emotion subscale; DERS-G: Difficulties in Emotion Regulation Difficulty in Following Goal Directed Behaviour subscale
*$p < .05$, **$p < .01$

Table 6.7

Correlations between Emotion Regulation Difficulties Psychological Reward, in the Fed State, and Energy Intake, adjusting for BMI

Variables	Adjustment for BMI						
	DERS-T	DERS-A	DERS-C	DERS-S	DERS- I	DERS-N	DERS-G
FED_EL_HFSA	.149	-.131	-.091	.431*	.120	-.072	.232
FED_EL_LFSA	.112	-.131	-.038	.190	.101	.226	.062
FED_EL_HFSW	.224	-.136	-.089	.520**	-.053	.369	.108
FED_EL_LFSW	.323	-.132	.293	.269	.087	.409*	-.035
Energy_T	.737*	.182	-.009	.553**	.345*	.220	.174
Energy_SW	.432**	.030	.051	.702**	.309	.208	.198
Energy_NSW	.239	.056	-.047	.314	.281	.172	.114

FED_EL_HFSA: Fed Condition Explicit Liking High-Fat Savoury; FED_EL_LFSA: Fed Condition Explicit Liking Low-Fat Savoury; FED_EL_HFSW: Fed Condition Explicit Liking High-Fat Sweet; FED_EL_LFSW: Fed Condition Low-Fat Sweet; Energy-T: Total Energy Intake; Energy_SW: Energy Intake Sweet; Energy_NSW: Energy Intake Non-Sweet, DERS: Difficulties in Emotion Regulation Total Scale; DERS-A; Difficulties in Emotion Regulation Awareness Scale, DERS-C: Difficulties in Emotion Regulation Clarity Scale; DERS-S: Difficulties in Emotion Regulation Strategies Scale; DERS-I: Difficulties in Emotion Regulation Impulsiveness Scale; DERS-N: Difficulties in Emotion Regulation Non Acceptance of Emotion Scale; DERS-G: Difficulties in Emotion Regulation Difficulty in Following
*$p < .05$, **$p < .01$

After adjusting for BMI, the total score for difficulty in emotion regulation (DERS) was not significantly associated with liking for any of the food categories. However, it was significantly associated with the total energy intake at the ad libitum-test meal ($p < .05$) and significantly associated with energy intake from high-fat sweet foods ($p < .01$). These results suggest that greater emotion-regulation difficulties are associated with greater total energy intake and a greater intake of high-fat sweet foods specifically.

Of the six DERS subscales, the lack of strategies to regulate emotions subscale only, showed evidence of a collective association with an explicit liking of high-fat foods, the energy intake of high-fat sweet foods and total energy intake after adjusting for BMI. The DERS lack of strategies to regulate emotions subscale was significantly associated with explicit liking for high-fat savoury foods ($p < .05$), significantly associated with explicit liking for high-fat sweet foods ($p < .01$), total energy intake ($p < .01$), and energy intake of high-fat sweet foods ($p < .01$). These results suggest that an individual who lacks strategies to deal with negative emotions has a greater liking for high-fat sweet and savoury foods, a greater total energy intake and a greater intake from high-fat sweet foods specifically.

Only one other DERS subscale was associated with liking and it was the DERS subscale of non-acceptance of emotions. It was significantly associated with liking for low-fat sweet foods ($p < .05$), such that a greater non-acceptance of emotion was associated with a greater liking for low-fat sweet foods. Finally, only one other DERS subscale was associated with total energy intake and this was the DERS subscale that was represented by impulse regulation difficulties when faced with negative emotions. It was significantly associated with total energy intake ($p < .05$), with higher levels of impulse regulation difficulties associated with higher total energy intake. No other DERS subscales were associated with total energy intake or intake from high-fat sweet or high-fat non-sweet foods.

6.8.3 The relationships between psychological reward and total energy intake at an ad libitum-test meal

The correlational analyses between the psychological rewards of implicit wanting and explicit liking, in the fed state, and total energy intake at an ad libitum-test meal were examined to determine if the psychological rewards of wanting and liking were associated with total energy intake (Table 6.8). All analyses reported have been adjusted for BMI.

Total energy intake was significantly associated with implicit wanting of HFSA ($p < .05$) and HFSW ($p < .05$). However, it was significantly inversely associated with implicit wanting for LFSW ($p < .05$) and LFSA ($p < .05$) food items. These results suggest that, in the fed state, higher levels of implicit wanting for high-fat foods and not low-fat foods were associated with greater energy intake.

There were significant associations between total energy intake and the explicit liking for LFSA ($p < .05$), high-fat sweet ($p < .01$) and savoury foods ($p < .01$). There was also a trend towards an inverse association between explicit liking for LFSW and total energy intake ($p = .051$). These results suggest that greater explicit liking for high and low-fat savoury and high-fat sweet food items results in a greater total energy intake than does explicit liking for low-fat sweet food items.

Table 6.8
Correlations between Total Energy Intake and Psychological Reward, in the Fed State, adjusting for BMI

Variables	No adjustment for BMI	Adjustment for BMI
	Energy-T	Energy-T
1.FED_IW_HFSA	.471*	.345*
2.FED_IWL_LFSA	-.362	-.335*
3.FED_IW_HFSW	.460*	.345*
4.FED_IW_LFSW	-.596**	-.383*
5.FED_EL_HFSA	.487*	.448**
8.FED_EL_LFSA	.415*	.339*
7.FED_EL_HFSW	.522**	.471**
8.FED_EL_LFSW	.315	.332

FED_IWHFSA: Fed Condition Implicit Wanting High-Fat Savoury; FED_IWLFSA: Fed Condition Implicit Wanting Low-Fat Savoury; FED_IW_HFSW: Fed Condition Implicit Wanting High-Fat Sweet; FED_IW_LFSW: Fed Condition Implicit Wanting Low-Fat Sweet; FED_EL_HFSA: Fed Condition Explicit Liking High-Fat Savoury; FED_EL_LFSA: Fed Condition Explicit Liking Low-Fat Savoury; FED_EL_HFSW: Fed Condition Explicit Liking High-Fat Sweet, FED_EL_LFSW: Fed Condition Low-Fat Sweet; Energy-T: Total Energy Intake
$^{*}p < .05$, $^{**}p < .01$

6.8.1 A comparison of the high and low BIS groups, differentiated into high in Disinhibition and low in Restraint (HDLR) and low in Disinhibition and high in Restraint eating behaviour subtypes (LDHR).

Before comparing differences between the revised BIS groups, an association between the BIS and the satiety quotients (SQ) for hunger and fullness was investigated. After adjusting for BMI, the BIS was significantly inversely associated with the SQs of hunger ($r = -.491$, $p < .05$) and fullness ($r = -.491$, $p < .05$), with higher levels of the BIS associated with lower SQs for both hunger and fullness. Independent samples t-tests confirmed that there were significant differences in Disinhibition, Restraint, binge-eating behaviour, SQs for hunger and fullness, and the BIS between the two groups. The HDLR (high BIS) group had significantly higher Disinhibition ($p < .001$), significantly lower Restraint ($p < .001$), significantly higher binge-eating scores ($p < .01$), significantly lower SQs for hunger ($p < .01$) and fullness ($p < .01$) and significantly higher BIS scores ($p < .001$), than the LDHR (low BIS) group, and all effect sizes were large (Table 6.9).

Further independent samples t-tests were conducted to determine if there were any significant differences between the BIS groups in terms of age and BMI. There was no significant difference in age between the high BIS group and the low BIS group. However, there was a significant difference in BMI between the high BIS and the low BIS groups. The high BIS group had a significantly higher level of BMI ($p < .05$) than the low BIS group. The Mann–Whitney U Test was used to test for differences between the BIS group's total BAS score. No significant differences were found between the groups in their total BAS scores: high BIS (*Mdn* = 35.00, $n = 15$) and low BIS (*Mdn* = 36.50, $n = 11$), $U = 69.50$, $z = -1.01$, $p = 0.314$, $r = -.19$ and Independent samples t-tests did not show evidence of significant differences between the subscales scores of the BAS measure: BAS-FS, BAS-RR, BAS-DR (Table 6. 9).

Table 6.9

Characteristics of High and Low BIS Groups

	High BIS (n = 15)		Low BIS (n = 12)					
Variable	*M*	*SD*	*M*	*SD*	*df*	*t*	*p*	*Cohen's d*
Age	50.53	10.17	46.58	9.86	25	1.02	.319	0.41
BMI	37.47	7.81	31.30	1.48	25	2.74	.013	1.10
Disinhibition	14.00	1.13	7.33	2.19	25	10.24	.000	4.20
Restraint	6.27	3.20	15.00	1.65	25	-8.57	.000	-3.41
BES	21.67	7.38	10.67	6.75	25	3.99	.001	1.61
SQ-H	3.09	4.62	8.52	4.01	24	-3.13	.005	-1.26
SQ-F	4.12	4.06	9.57	3.63	24	-3.53	.002	-1.42
BIS	25.80	1.47	19.83	2.95	25	6.40	.000	2.81
BAS-FS	9.80	2.24	10.50	1.57	25	-.92	.369	-0.37
BAS-DR	8.67	2.06	9.50	1.98	25	-1.06	.298	-0.43
BAS-RR	12.47	1.60	13.00	1.35	25	-.922	.365	-0.37

Disinhibition: Disinhibition Scale; Restraint: Restraint Scale, BES: Binge Eating Behaviour Scale, SQ-H: Satiety quotient hunger; SQ-F: Satiety quotient fullness; BIS: Behaviour Inhibition System; BAS-FS: Behaviour Activation System Fun Seeking subscale; BAS: Behaviour Activation System Drive subscale; BAS-RR: Behaviour Activation System Reward Responsiveness subscale

**p* < .05, ***p* < .01

6.8.2 The effect of BIS group on explicit liking, implicit wanting (appeal bias), appetite and energy Intake

In all the marginal models that follow, BMI was added as covariate (BMI = 34.73 kg/m^2). The first analysis investigated whether there were significant main effects of group (i.e. high and low BIS) and state (i.e., fasted and fed) on mean explicit liking scores, overall, and whether the effect of BIS group interacted with state to influence mean explicit liking. There were significant main effects of BMI, *F*

(1, 24) = 12.16, *p* < .001, group *F* (1, 24) = 7.86, *p* < .05, and state, *F* (1, 25) = 60.87, *p* < .001, on mean explicit liking. The high BIS group had significantly higher mean explicit liking scores than the low BIS group and mean explicit liking scores were significantly reduced in the fed state (Table 6.10). However, there was no significant interaction according to group by state, *F* (1, 25) = 0.98, *p* = .331. These results suggest that the high BIS group liked food more than the low BIS group and that explicit liking for food was lower in the fed than the fasted state for both groups.

Table 6.10

Main Effects of the High and Low BIS Groups on the Fasted and the Fed States on Mean Explicit Liking Scores

Factor	Variables	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Group					
	High BIS	40.79*	2.65	35.31	46.27
	Low BIS	28.96*	3.00	22.76	35.15
State					
	Fasted	46.56***	2.63	41.14	51.99
	Fed	23.18***	2.18	18.70	27.67

**p* <.05, ****p* <.001

The following analyses investigated whether there were significant main effects of group (i.e., high BIS, low BIS) and liking for the four food categories (HFSW, HFSA, LFSW, LFSA), separately in the fasted and the fed states. It also investigated whether the effect of BIS group interacted with the four food categories to influence liking for one fat and taste category over another.

In the fasted state, there was a significant main effect of liking on food category, *F* (3, 25) = 3.79, *p* < .05, such that LFSW foods were liked to a greater extent than LFSA foods. There were no other main effects of liking for any other food categories. There were no significant main effects of group, *F* (1, 24) = 2.53, *p* = .125 (Figure 6.2), and no significant interaction of group by liking, *F* (1,24) = 0.19, *p* = .902 (Table 6.11). These results suggest that, in the fasted state, whilst high-fat sweet and savoury food items are liked to a similar extent, there is a greater liking for sweet over savoury items when the foods are low in fat.

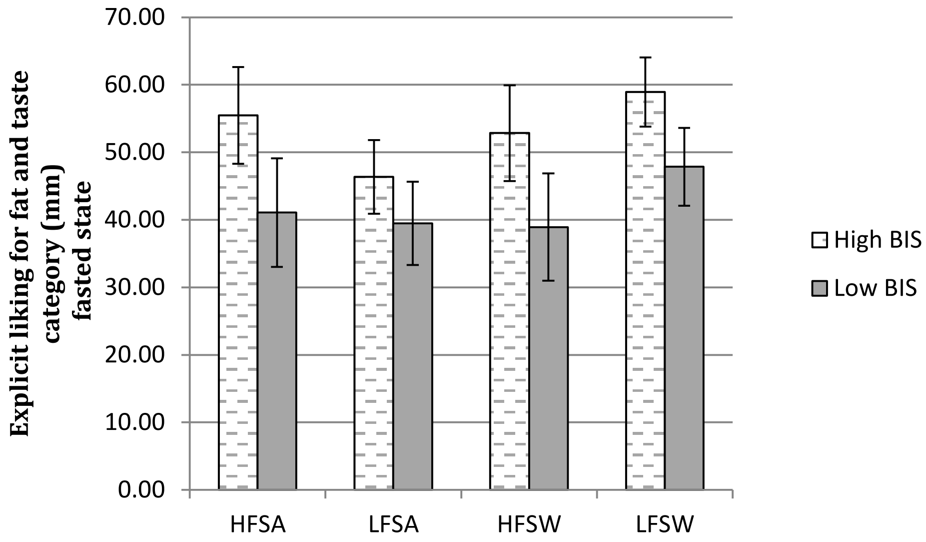


Figure 6.2. Explicit liking for the four fat and taste categories according to high and low BIS group, in the fasted state.

HFSA: High-fat Savoury, LFSA: Low-fat savoury, HFSW: high-fat sweet, LFSW: Low-fat sweet

Table 6.11

Main Effects of Explicit Liking for the Four Fat and taste Categories, in the Fasted State

State	Liking	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Fasted					
	HFSA	48.28	5.27	37.41	59.15
	LFSA	42.91*	3.96	34.73	51.08
	HFSW	45.88	5.20	35.08	56.67
	LFSW	53.39*	3.71	45.75	61.02

HFSA: High-fat Savoury, LFSA: Low-fat savoury, HFSW: high-fat sweet, LFSW: Low-fat sweet
*p <.05

In the fed state, there were significant main effects of BMI, F (1, 24) = 9.59, p < .01, group F (1, 25) = 8.86, p < .01, and liking for all food types, F (3, 25) = 5.68, p < .01. There was also a significant liking by group interaction, F (3, 25) = 3.43, p < .05. Post hoc examination of the group by liking interaction revealed that in the fed state the high BIS group had significantly higher explicit liking for high-fat savoury, F (1, 27) = 12.64, p = .001, and high-fat sweet foods, F (1, 26) = 6.88, p < .05, than the low BIS group (Figure 6.3. and Table 6.12). Explicit liking for low-fat sweet and savoury foods did not differ significantly by group. This suggests that, in the fed state, the high BIS group likes high-fat sweet and savoury foods to a significantly greater extent than the low BIS group and that both groups like low fat foods similarly.

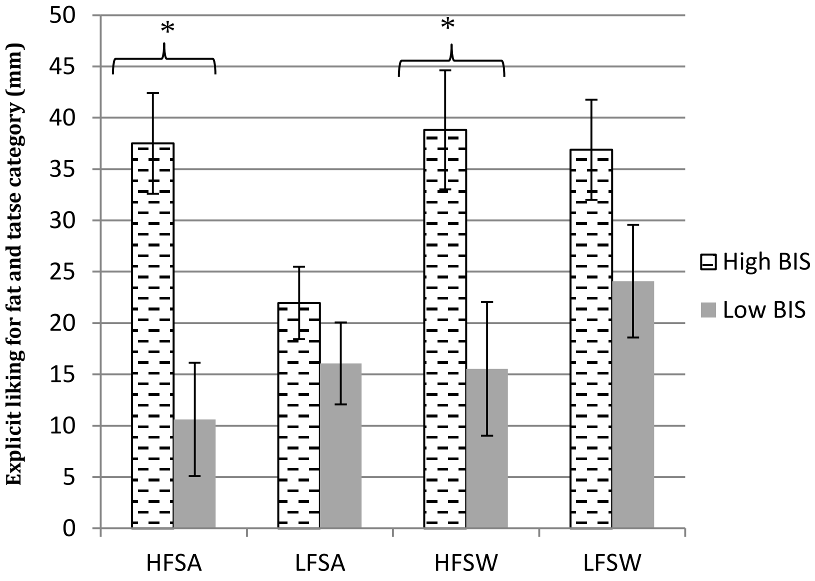


Figure 6.3. Explicit liking for the four fat and taste categories according to high and low BIS group, in the fed state.

HFSA: High-fat Savoury, LFSA: Low-fat savoury, HFSW: high-fat sweet, LFSW: Low-fat sweet
*p** < .05

Table 6.12

Simple Effects of the High and Low BIS Groups and Explicit Liking, for the Four Fat and Taste Categories, in the Fed State

Liking	Group	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
HFSA	High BIS	37.50**	4.91	27.41	47.59
	Low BIS	10.61**	5.52	-0.73	21.94
LFSA	High BIS	21.95	3.53	14.68	29.22
	Low BIS	16.08	3.99	7.87	24.30
HFSW	High BIS	38.82*	5.80	26.88	50.75
	Low BIS	15.54*	6.51	2.15	28.93
LFSW	High BIS	36.88	4.87	26.87	46.90
	Low BIS	24.08	5.48	12.83	35.34

HFSA: High-fat Savoury, LFSA: Low-fat savoury, HFSW: high-fat sweet, LFSW: Low-fat sweet
*p < .05, **p <.01

Implicit wanting (appeal bias)

These analyses investigated whether there were significant main effects of group (i.e., high and low BIS) and state (i.e. fasted and fed) on implicit wanting (appeal bias) for high or low-fat foods and whether the effect of BIS group interacted with state to influence the implicit wanting for high or low-fat foods. In these analyses, a positive value indicates implicit wanting for high-fat foods and a negative value indicates implicit wanting for low fat-foods. There were significant main effects of BMI, F (1, 24) = 10.80, $p < .01$, and state, F (1, 25) = 13.19, $p < .01$, but not group on implicit wanting, F (1, 24) = 0.79, $p = .384$, for high or low-fat foods. There was also a significant group by state interaction on implicit wanting for high and low-fat foods, F (1, 25) = 7.25, $p < .05$.

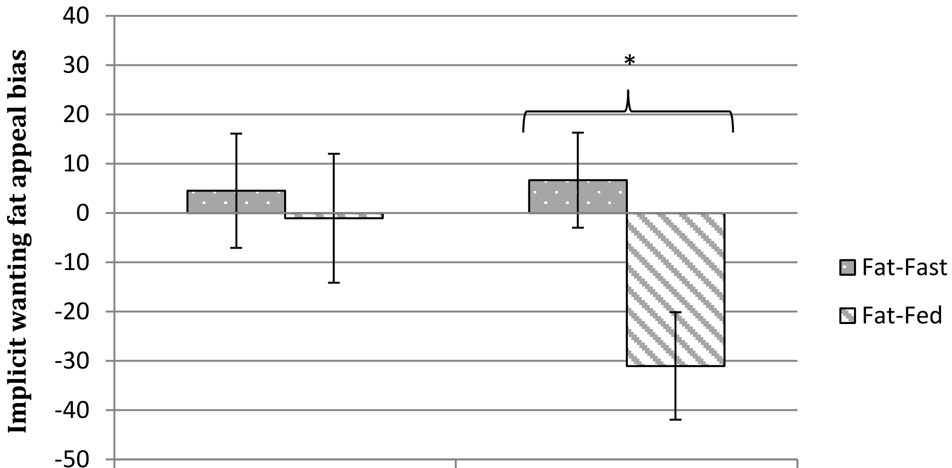
Post hoc examination of the group by state interaction on implicit wanting revealed that, whilst the groups did not differ significantly from one another in their bias for high or low-fat foods, across the fasted, F (1, 25) = 0.01, $p = .908$, or fed states, F (1, 24) = 3.81, $p = .063$, there was a significant difference according to the effect of state within the groups (Table 6.13 and Figure 6.4). In the low BIS group, the implicit wanting for high-fat foods in the fasted state changed to an implicit wanting of low fat foods in the fed state and this change was significant, F (1, 25) = 17.99, $p < .001$. Whilst the high BIS group also changed their implicit wanting for high-fat foods in the fasted state to an implicit wanting for low-fat foods in the fed state, this change was not significant, F (1, 25) = 0.50, $p = .488$. These results suggest that the low BIS group changed their implicit appeal bias away from high-fat towards low-fat foods, from the fasted to the fed state.

Table 6.13

Simple Effects of the High and Low BIS Groups, on Implicit Wanting (Appeal Bias), for High and Low-Fat Foods, in the Fasted and Fed State

Group	State	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
High BIS	Fasted	4.51	11.60	-19.40	28.42
	Fed	1.09	9.64	-20.98	18.81
Low BIS	Fasted	6.64***	13.08	-20.31	33.58
	Fed	-31.05***	10.92	-53.57	-8.52

Note: A positive value indicates a bias towards high-fat foods; a negative value indicated a bias towards low-fat foods
****p* <.001



	High BIS	Low BIS
Fat-Fast	4.51	6.64
Fat-Fed	-1.09	-31.05

Figure 6.4. Implicit wanting (appeal bias) for high and low-fat foods in the fed and fasted state, within the high and low BIS groups.

Note: A positive value indicates implicit wanting of high-fat foods; a negative value indicated a bias towards low-fat foods
**p* < .05

6.8.3 Effect of BIS group on profiles of subjective appetite sensations

There were marked differences in post-prandial responses in subjective sensations of hunger and fullness between the two groups – see Figures 6.5 and 6.6.

Hunger

The effect of the BIS group on measures of satiety, specifically hunger and fullness, after the intake of a 600 kcal pre-load was analysed over five time points. The first analysis investigated whether there were significant main effects for group (i.e., high and low BIS) and time (i.e., baseline, 0, 30, 60 and 90 minutes) on hunger. The analysis also investigated whether the effect of BIS group interacted with the effects of time to influence hunger levels. It showed significant main effects for BMI, F (1, 24) = 9.73, $p < .01$, group, F (1, 27) = 10.56, $p < .01$, and time F (4, 25) = 16.29, $p < .001$. There was also a significant group by time interaction, F (4, 25) = 7.25, $p < .01$.

Post hoc examination of the group by time interaction revealed that, at baseline, there was no significant difference in the level of hunger experienced between the groups prior to the pre-load, F (1, 25) = .413, $p = .526$. However, immediately after consumption of the pre-load, there was a trend towards a significant difference at time zero, F (1, 27) = 3.58, $p = .069$, and statistically significant differences at the 30, F (1, 27) = 16.34, $p < .001$; 60 F (1, 26) = 24.65, $p <$ .001, and 90 minute time points, F (1, 27) = 9.96, $p < .01$ (Table 6.14, Figure 6.5.), such that the high BIS group experienced a weaker suppression of hunger 30 and up to 90 minutes post pre-load, when compared to the low BIS group.

Table 6.14

Simple Effects of the High and Low BIS Groups, on Subjective Feelings of Hunger (mm), Over Time

Time	Group	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Baseline	High BIS	53.97	6.94	39.66	68.28
	Low BIS	60.73	7.78	44.70	76.76
0 minutes	High BIS	20.27	3.56	12.95	27.60
	Low BIS	9.77	4.02	1.51	18.04
30 minutes	High BIS	32.77***	3.82	24.91	40.64
	Low BIS	8.82***	4.31	-0.05	17.68
60 minutes	High BIS	43.47***	4.07	35.07	51.88
	Low BIS	12.23***	4.59	2.77	21.69
90 minutes	High BIS	45.14**	5.41	34.01	56.26
	Low BIS	18.89**	6.16	6.24	31.54

*$p < .05$, **$p < .01$, ***$p < .001$

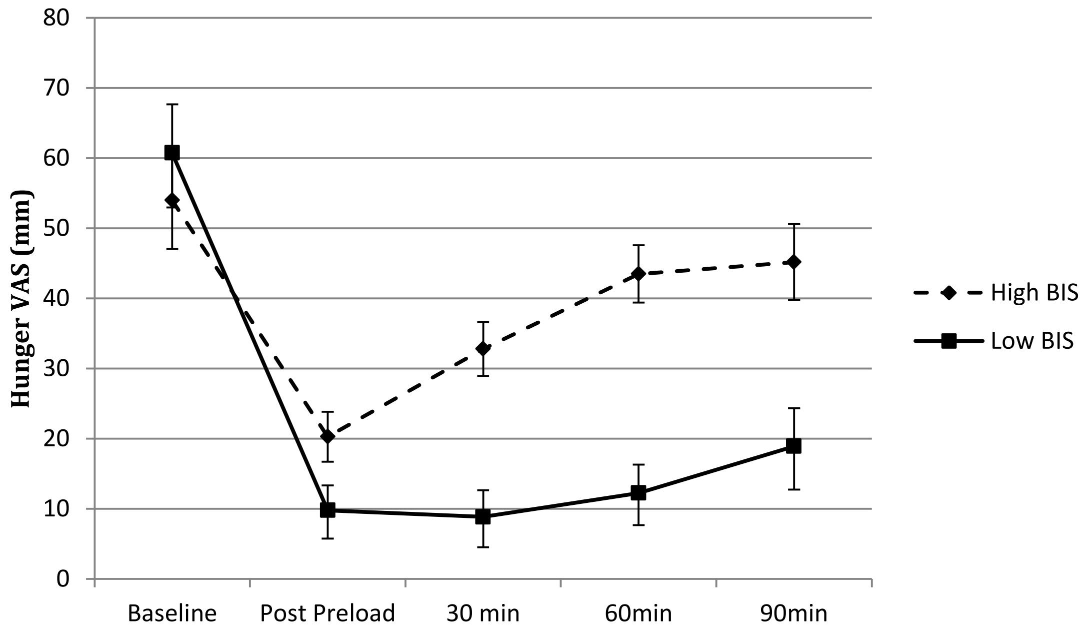


Figure 6.5. Profiles of subjective hunger for the high and low BIS groups

Fullness

The next analysis investigated whether there were significant main effects for group (i.e. high and low BIS) and time (i.e., baseline, 0, 30, 60 and 90 minutes) on fullness. The analysis also investigated whether the effect of belonging to either a high or low BIS group interacted with the effects of time to influence fullness levels. It showed significant main effects for BMI, $F\ (1, 24) = 5.86$, $p < .05$; group, $F\ (1, 24) = 7.02$, $p < .05$, and time, $F\ (4, 25) = 19.35$, $p < .001$. There was also a significant group-by-time interaction, $F\ (4, 25) = 3.05$, $p < .05$.

Post hoc examination of the group by time interaction revealed (Table 6.15) that, at baseline, there was no significant difference in the level of fullness experienced between the groups prior to the pre-load, $F\ (1, 27) = .55$, $p = .467$. There was a trend towards a significant difference at time zero, $F\ (1, 27) = 3.91$, $p = .058$ and statistically significant differences at the 30, $F\ (1, 27) = 10.77$, $p = < .01$; 60 $F\ (1, 27) = 9.15$, $p < .01$, and 90 minute time points, post pre-load, $F\ (1, 27) = 8.63$, $p < .01$ (Figure 6.6.), such that the high BIS group experienced lower levels of fullness at 30 and up to 90 minutes post pre-load, compared to the low BIS group (Figure 6.6).

Table 6.15

Simple Effects of the High and Low BIS Groups, on Subjective Feelings of Fullness (mm), Over Time

Time	Group	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Baseline	High BIS	35.82	5.78	23.93	47.71
	Low BIS	29.22	6.51	15.84	42.61
0 minutes	High BIS	70.99	5.60	59.46	82.51
	Low BIS	88.14	6.32	75.15	101.12
30 minutes	High BIS	60.85**	5.17	50.22	71.49
	Low BIS	87.26**	5.83	75.27	99.26
60 minutes	High BIS	58.72**	4.95	48.54	68.90
	Low BIS	82.10**	5.59	70.60	93.59
90 minutes	High BIS	51.59**	5.54	40.18	63.00
	Low BIS	77.03**	6.34	64.00	90.05

**$p < .01$

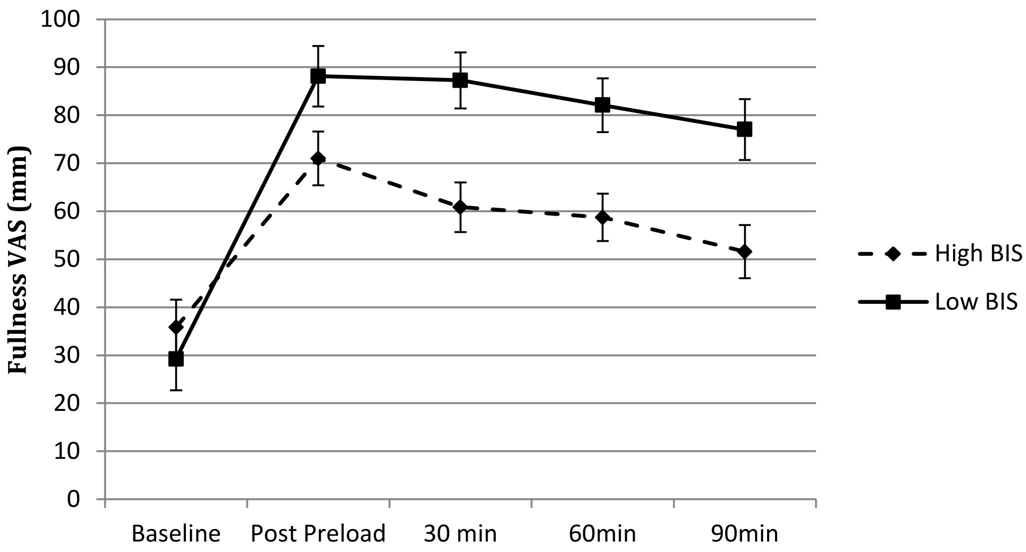


Figure 6.6. Profiles of subjective fullness for the high and low BIS groups

6.8.4 Effect of BIS group on ad libitum energy intake at a test meal

An independent samples t-test was conducted to compare the total energy intake scores for the high BIS and low BIS groups. The results of the independent samples t-test indicated that there was a significant difference in total energy intake between the high BIS (*M* = 413.40, *SD* = 124.27) and the low BIS group (*M* = 230.73, *SD* = 133.87l; *t* (25) = 3.67, *p* = .001), such that the high BIS group consumed significantly more energy during the ad libitum test meal than the low BIS group. The effect size was large, calculated using Cohen's *d* = 1.48.

The final marginal model in the series investigated whether there were significant main effects of group (i.e. high and low BIS) and energy intake according to taste (i.e., high-fat sweet and high-fat non-sweet) after an ad libitum test meal. The analysis also investigated whether the effect of BIS group interacted with the effects of taste to influence the amount of energy consumed.

The results of the marginal model indicated there was a significant main effect for group, *F* (1, 24) = 8.89, *p* = .006, and energy intake according to taste, *F* (1,25) = 8.03, *p* = .009, and a significant interaction between group and energy intake according to taste, *F* (1, 25) = 9.35, *p* = .005. Post hoc examination revealed (Table 6.16 and Figure 6.7) that the high BIS group had a significantly higher energy intake from HFNSW foods, *F* (1, 25) = 12.78, *p* = .001, when compared with the low BIS group. However, there was no significant difference in energy intake between the groups for HFSW foods, F (1, 25) = 0.81, p = .378. This suggests that the high BIS group consumed more energy from high-fat non-sweet foods than the low BIS group and that both groups consume similar amounts of energy from high-fat sweet foods.

Table 6.16

Simple Effects of the High and Low BIS groups, and Intake according to Taste, on Total Energy Intake (kcal), during an ad libitum Test Meal

Energy	Group	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
HFSW	High BIS	154.55	19.60	114.06	195.03
	Low BIS	126.35	22.22	80.48	172.22
HFNSW	High BIS	244.00***	21.36	199.92	288.08
	Low BIS	122.95***	24.16	73.13	172.77

HFSW: high-fat sweet; HFNS: high-fat non-sweet
****p* <.001

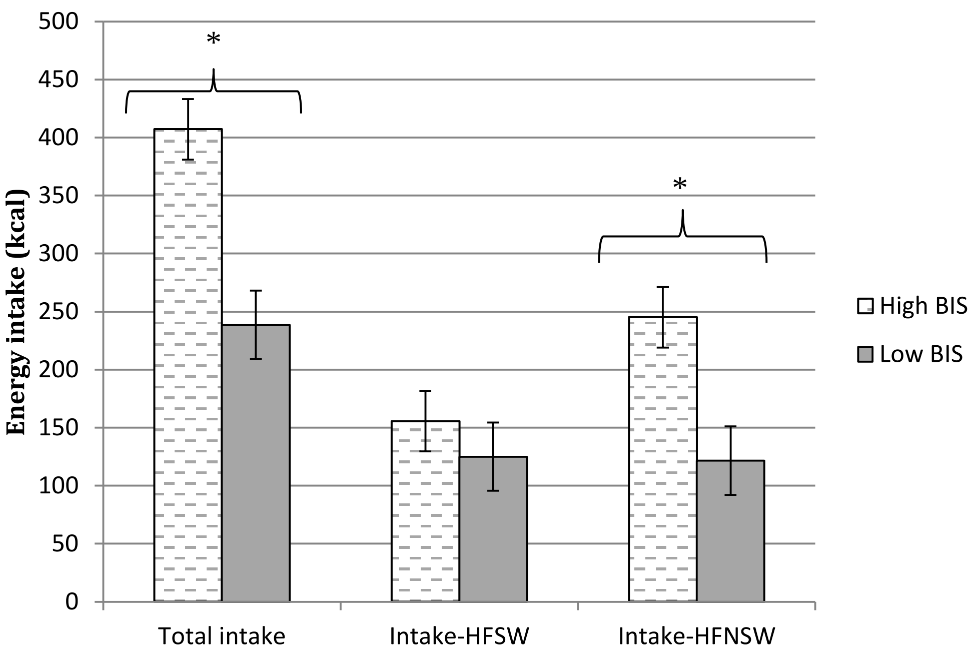


Figure 6.7. Total energy intake and energy intake from high-fat sweet and high-fat non-sweet snack foods during an ad libitum test meal according to high and low BIS group
Energy intake: HFSW: high-fat sweet; HFNSW: high-fat non-sweet
**p* < .05

6.8.5 Differentiating the high BIS and the low BIS phenotype relative to level of effortful control, executive function and difficulties in emotion regulation.

Independent t-tests for normal data and Mann-Whitney's U test, for non-normal data were conducted to determine if there were any significant differences between the groups in their levels of effortful control, executive function and difficulty in regulating emotion. Results are in table 6.17 for the independent t-tests and Table 6.18 for Mann-Whitney's U test.

Effortful control and executive function

The high BIS group had a significantly lower level of effortful control than the low BIS group (p < .001) and the effect size, using Cohen's d, was large. When individual subscales were examined, the high BIS group had a significantly lower level of activation (p < .05) and attentional control (p < .05) and a trend towards a lower level of inhibitory control (p = .052) than the low BIS group. These results suggest that, overall, the high BIS group had a lower level of effortful control, compared with the low BIS group. There were no significant differences by group for the D-KEFS color word interference test scaled scores for cognitive inhibition or cognitive flexibility.

Difficulties in emotion regulation

Similar results were apparent when differences between the groups were examined relative to their ability to regulate emotion. The high BIS group had a significantly higher level (p < .001) of total emotion regulation difficulties than the low BIS group and the effect size, using Cohen's d, was large. When the individual subscales from the DERS were examined, it was revealed that the high BIS group had significantly greater difficulty regulating their emotion in terms of a lack of strategies (p < .01), impulse regulation difficulties (p < .05), non-acceptance of their emotional state (p < .05) and there was evidence of a trend towards a greater difficulty in following goal-directed behaviour when distressed (p = .050). There were no group differences for the DERS subscales measuring a lack of emotional awareness and understanding and a lack of clarity of emotional state. These results suggest that, overall, the high BIS group has a greater difficulty in regulating their emotional state compared with the low BIS group.

Table 6.17

Mean Differences in Effortful, Cognitive Control and Emotion regulation Characteristics between the High and Low BIS Groups

	High BIS n =15		Low BIS n = 12					
Variable	*M*	*SD*	*M*	*SD*	*df*	*t*	*p*	*d*
EC - Total	79.53	8.83	93.17	8.07	25	-4.14	.000	-1.67
EC_Activation	30.93	6.09	36.33	4.01	25	-2.64	.014	-1.01
EC_Inhibition	28.40	6.52	33.00	4.82	25	-2.04	.052	-0.82
EC_Attention	20.20	4.80	23.33	3.96	25	-2.12	.045	-0.73
CWIT_Inhibition	12.20	1.32	12.25	1.71	25	-0.09	.932	-0.04
CWIT_Flexibility	12.40	2.16	12.00	1.54	25	0.54	.594	0.22
DERS_Total	97.53	21.59	75.58	17.29	25	2.86	.008	1.15
DERS_Awareness	17.80	6.92	18.19	4.39	25	-0.17	.868	-0.07
DERS_Clarity	12.00	4.24	10.08	2.61	25	1.37	.183	0.55

EC-Total: Effortful Control-total score; EC Inhibition: Inhibition subscale; EC Activation; EC Activation subscale; EC Attention subscale; CWIT: D-KEFS Colour Word Interference test scaled scores for both tasks of cognitive inhibition and flexibility; DERS-Total: Difficulties in Emotion Regulation Total Scale; DERS_Awareness: Difficulties in Emotion Regulation Awareness subscale; DERS_Clarity: Difficulties in Emotion Regulation Clarity subscale

Table 6.18

Differences in Emotion Regulation Characteristics Between the High and Low BIS Groups (Median, IQR)

	High BIS n = 15	Low BIS n = 12				
Variable	*Mdn (IQR)*	*Mdn (IQR)*	*U*	*Z*	*p*	*r*
DERS_Strategies	22.00 (17.00 – 24.00)	12.00 (12.00 – 14.75)	20.50	-3.411	.001	-.66
DERS_Impulse	14.00 (10.00 – 16.00)	9.50 (7.00 – 11.50)	42.00	-2.352	.019	-.45
DERS_NA	17.00 (12.00 – 17.00)	10.50 (8.25 – 13.75)	45.00	-2.199	.028	-.42
DERS_Goals	14.00 (12.00 – 18.00)	10.50 (8.25 – 13.75)	50.00	-1.961	.050	-.38

DERS_Strategies: Difficulties in Emotion Regulation Strategies Scale; DERS_Impulse: Difficulties in Emotion Regulation Impulsiveness subscale; DERS_NA: Difficulties in Emotion Regulation Non Acceptance of Emotion subscale; DERS_Goals: Difficulties in Emotion Regulation Difficulty in Following Goal Directed Behaviour subscale;

6.8.6 Summary of results

Figure one provides a summary of the main findings between the high and low BIS groups according to eating behaviour subtype (HDLR/LDHR).

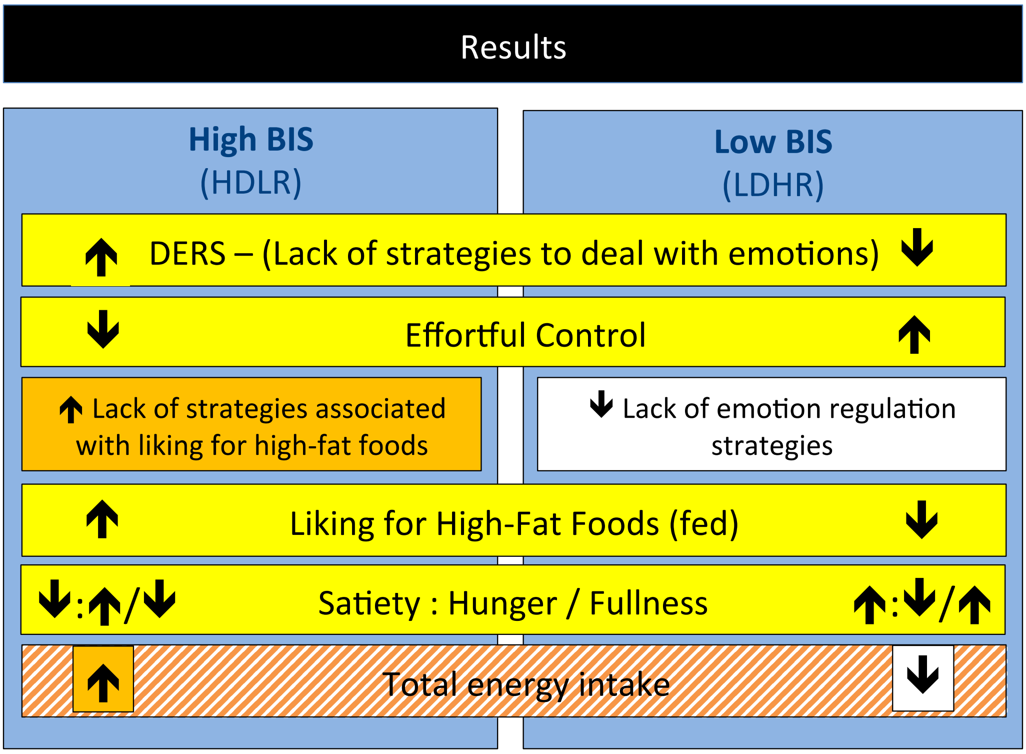


Figure 6.8. Summary of results

When compared to the low BIS group, the high BIS group had a higher level of emotion regulation difficulties (DERS) and a lower level of effortful control. They also liked high-fat foods to a greater extent than the low BIS group, when fed, and showed an attenuated capacity to detect satiety signals, notably feelings of hunger and fullness after the consumption of a 600 kcal preload. Following the consumption of the preload, the high BIS group showed a greater total energy intake of high-fat non-sweet foods when compared to their low BIS counterparts. Upon comparing the data within the sample, a positive association between a lack of emotion regulation strategies, liking of high-fat foods and total energy intake was observed.

6.9 DISCUSSION

6.9.1 Associations between the BIS, effortful control, the psychological rewards of wanting and liking, and energy intake

The overarching theme of study three was to determine whether a 'phenotypic trait' of enhanced physiological and psychological arousal, which is assumed to stem from a reactive BIS, a low level of effortful control and associated emotion regulation difficulties, might differentiate two eating-behaviour subtypes by their level of psychological reward, satiety and consumption.

The first six hypotheses will be discussed here. After adjusting for BMI, in the fed state, the BIS, but not the BAS, was positively associated with implicit wanting for high-fat sweet food and total energy intake of high-fat foods at an ad libitum test meal. Interestingly, the BIS was positively associated with explicit liking for both high and low-fat sweet and savoury foods in the fed state. In addition, the Effortful Control Scale was inversely associated with implicit wanting for high-fat savoury foods, energy intake of high-fat non-sweet snack foods and the total energy intake of high-fat snack foods. Whilst finally, the DERS Scale was positively associated with explicit liking of high-fat foods, energy intake of high-fat sweet and total energy intake at an ad libitum test meal. Closer inspection of the effortful control subscales revealed that the activation subscale was both positively and inversely associated with the implicit wanting of low and high-fat savoury tastes respectively and inversely associated with the energy intake from high-fat non-sweet foods. Before proceeding, it is important to recall that the Activation subscale from the Effortful Control Scale refers to an individual's capacity to overcome a desire to avoid performing a disliked action and to subsequently motivate themselves to undertake an activity which they would prefer to avoid (Evans & Rothbart, 2007). In the context of practicing healthy eating behaviours, this subscale could represent an individual's capacity to consume low-fat foods that are not desired, such as eating an apple, when a high-fat food such as a chocolate bar or bag of potato crisps is more strongly desired. These associations between the intake of high-fat foods and a reactive BIS that is accompanied by a low level of effortful control are noteworthy, as these types of foods typically describe 'comfort' type foods, which are commonly eaten during the experience of stress and negative affect. Therefore, these results suggest that a reactive BIS may be linked to the intake of high-fat comfort foods and maintained by a lack of motivation to change behaviour.

The DERS Scale was associated with energy intake from high-fat sweet foods and total energy intake. Closer inspection of the DERS subscales revealed that the lack of strategies to regulate affect subscale was associated with the explicit liking of high-fat sweet and savoury foods, the energy intake of high-fat sweet foods, and total energy intake at an ad libitum test meal. Only one other DERS subscale was associated with total energy intake and this was the difficulty controlling impulses when distressed subscale. The only association noted for the BAS Scale was an inverse association between the BAS and the explicit liking for low-fat savoury foods. These associations between the intake of high-fat foods and difficulty regulating emotions are interesting, as a reactive BIS and a low level of effortful control have been conceptualised as leading to emotion regulation difficulties and maladaptive, affect-regulated eating behaviour (section 2.4). These results suggest that an individual who lacks strategies to regulate emotion may have learnt to like and impulsively use high-fat foods as an affect-regulation strategy.

Collectively, the correlational results highlight an enhanced risk of reward-driven over-consumption. They suggest that individuals with a reactive BIS and a low level of effortful control may have learnt to use foods, which they like and desire, to regulate affect. Moreover, they indicate that these individuals may not be motivated to restrain their intake of high-fat foods, even in the fed state, possibly because they lack the strategies to regulate their emotions via other means. In order to understand the implications of these correlational results, the study subsequently investigated whether two groups who differed by their level of BIS reactivity, disinhibited and restrained eating-behaviour traits, significantly differed in their level of psychological reward, satiety, energy intake, level of effortful control, and difficulty in regulating emotion.

6.9.2 The effect of BIS group on explicit liking, implicit wanting, energy intake and satiety

Explicit liking, implicit wanting and ad libitum test meal energy intake

The hypotheses that the high BIS group would have higher levels of explicit liking and energy intake and lower levels of satiety when compared to the low BIS group were supported. However, unexpectedly, the hypothesis that the high BIS group would have higher levels of implicit wanting when compared to the low BIS group was not supported. The high BIS group had a higher level of explicit liking for high-fat sweet and savoury foods than the low BIS group, in the fed state. Subsequently, these results suggest that the high BIS group liked high-fat sweet and savoury foods to a greater extent than the low BIS group, in the fed state. These results are interesting in light of the finding that the high BIS group consumed more energy from high-fat non-sweet foods and more total energy at the ad libitum test meal than the low BIS group. They suggest that the greater liking for high-fat non-sweet foods by the high BIS group may lead to a greater total energy intake. Unexpectedly, there was no evidence of a significant difference between the groups in their level of implicit wanting (appeal bias), in the fed state. However, the low BIS group was shown to have a significantly higher implicit wanting for low-fat and not high-fat foods in the fed state, when compared to the fasted state.

These results suggested that enhanced liking for high-fat non-sweet foods, rather than a greater implicit wanting for these foods, in the fed state, was linked to higher total energy intake in the high BIS group. The finding that the low BIS group had a higher implicit wanting for low-fat and not high-fat foods in the fed and not the fasted state suggested that the low BIS group was unconsciously attracted to low-fat foods, in the fed state. Furthermore, there was evidence of a trend that the low BIS group wanted these foods to a greater extent, in the fed state, in comparison to the high BIS group. These findings are interesting, given that the eating behaviour traits which, characterise this phenotype, embody the traits of a successful dieter.

The LDHR eating-behaviour subtype has been characterised in the literature as a successful dieter who is less attracted to the rewarding properties of palatable food (Yeomans & Coughlan, 2009; Yeomans, Tovey, et al., 2004). Therefore, the implications of these findings are that an unconscious orientation towards low-fat foods that are a ‘healthier choice in the fed state might facilitate successful weight management activities in the LDHR eating-behaviour subtype. Taken together, these are important findings because the measure of implicit wanting that was used in this study measures an individual’s subconsciously motivated reaction towards a particular food category (Finlayson & Dalton, 2012). Therefore, they suggest that the low BIS, LDHR eating-behaviour subtype may find it easier to control their eating behaviour, in comparison to the high BIS, HDLR eating behaviour subtype, which appears to maintain an unconscious desire for high-fat foods, even in the fed state.

The HDLR eating-behaviour subtype has been previously identified in individuals with binge eating disorder (BED) (C. B. Peterson et al., 1998; Wadden et al., 1993; Yanovski & Sebring, 1994). The Binge Eating Scale (Gormally et al., 1982) has the capacity to determine the level of severity of binge-eating behaviour in obese individuals (Greeno et al., 1995) and the measure has been used in related research to identify an obese phenotype that is susceptible to over-consumption (Dalton et al., 2013a, 2013b). Although the groups in this study were preselected based upon their levels of Disinhibition and Restraint and not binge-eating behaviour, the high BIS group was shown to have a mean binge-eating score of 21.67 (*SD* = 7.38), which classified them with a moderate level of binge-eating behaviour. By comparison, the low BIS group was shown to have a binge-eating score of 10.67 (SD = 6.75), which classified them with a mild level of binge-eating behaviour (Marcus et al., 1988).

These binge-eating scores are similar to the levels of binge-eating behaviour found in obese individuals who have been described as susceptible to hedonic over-consumption as a result of a dysregulated appetite (Dalton et al., 2013a, 2013b; Dalton & Finlayson, 2014). However, it is interesting that, whilst the level of binge-eating behaviour may be similar between these groups, the results between this study and those of Dalton and colleagues were mixed. The results were similar in that the high BIS group in this study and the higher trait binge-eaters in the studies of Dalton and colleagues showed evidence of enhanced levels of explicit liking for high-fat foods, in the fed state. They also showed evidence of greater total energy intake during an ad libitum intake task, when compared to the lower BIS and lower trait binge-eaters. However, there was a notable difference between this study and the studies of Dalton and colleagues when the groups were compared in relation to their levels of implicit wanting after a pre-load.

The research from Dalton and colleagues showed evidence of enhanced implicit wanting for high-fat sweet foods, in the fed state, in individuals with higher levels of trait binge-eating behaviour, when compared to individuals low in trait binge eating. Moreover, greater implicit wanting for high-fat sweet foods, in the fed state, was found in the trait binge-eating group when compared to the fasted state, which suggests that the motivation for these foods is capable of overriding a state of satiety. As a result of these findings in obese adults and similar findings in normal weight females, the collective studies from Dalton and colleagues have attributed the major risk for over-consumption and obesity as arising from higher trait binge-eating behaviours, which are linked to greater implicit wanting for high-fat sweet foods (Dalton & Finlayson, 2014).

The results of Dalton and colleagues have also been indirectly supported by another study, which has linked the psychological rewards of wanting and liking to reactivity in the BAS, in obese adults with binge-eating disorder (Davis et al., 2009). In this study, obese binge-eaters were identified as possessing genetic markers for the systems underlying the psychological rewards of wanting and liking, thus supporting an effect of these systems on binge-eating behaviour. Collectively, the study by Davis et al. (2009) and the results of Dalton and colleagues have contributed towards a psychobiological model of susceptibility to overeating and a behavioural phenotype of obesity that implicates a desire to approach food-based rewards as a result of an enhanced level of the psychological reward of implicit wanting (Dalton et al., 2013a; Dalton & Finlayson, 2014). Theoretically, these results also indirectly implicate the BAS (Davis et al., 2009; Davis, Patte, et al., 2007). However, the results of this study have indicated that a high level of BAS reactivity and greater implicit wanting may not be relevant for all obese individuals who display a tendency to binge eat. In particular, they may not be relevant for an individual with a high BIS and low BAS phenotype in possession of HDLR eating behaviour traits.

It is feasible that the psychological traits underlying a reactive BIS are linked to affect regulated eating behaviour, via enhanced liking response, in the HDLR eating behaviour subtype. The results, which suggested that a reactive BIS may be linked to the HDLR subtype via enhanced liking response to high-fat foods in the fed state, are supported theoretically by the literature. For example, Mela (2000) has indicated that foods, which are used to improve mood, may learnt to be ‘liked’ via process of associative conditioning. Therefore, an individual who eats to regulate affect could associate an improvement in mood with the positive psychological reward inherent to the liking response (Berridge, 2003). Subsequently, they could learn to ‘like’ foods for their affect regulation properties (Macht, 2008). The psychopathological states of anxiety and depression have been linked to individuals with HDLR and BED (American Psychiatric Association, 2013; Wadden et al., 1993) and a reactive BIS (Bijttebier et al., 2009). Moreover, emotional and binge-eating behaviours have been linked to eating as an affect-regulation strategy (Macht, 2008). Therefore, it is possible that a process of affect regulated eating behaviour, which is initiated by a reactive BIS phenotype, underlies the enhanced liking response to palatable food in the HDLR eating behaviour subtype. However, the temperament-based and the appetite regulation and eating behaviour literature have not investigated a relationship between a reactive BIS and explicit liking as an initiator of disinhibited-eating behaviour and obesity. Instead, there has been a strong focus on the BAS and implicit wanting (Dalton & Finlayson, 2014; Davis & Loxton, 2014).

One reason for maintaining a focus on the BAS and the psychological reward of implicit wanting may be based upon the findings in normal weight or mildly obese individuals. To provide an illustration: the highest levels of BAS reactivity are typically associated with BMI values of approximately 30 kg/m^2. However, as BMI increases beyond 30 kg/m^2, reactivity within the BAS is reduced (Davis & Fox, 2008; Dietrich et al., 2014). The mean BMI of the high BIS group in this study was 37.47 (SD = 7.81), whilst the mean BMI of the obese binge types in the studies from Dalton and colleagues ranged from 31.5 to 32 kg/m^2. Subsequently, if the BAS is more reactive at lower levels of BMI, there could be a stronger effect of implicit wanting or the desire to approach a reward, which theoretically would involve the BAS (Corr, 2008), at a lower BMI. This is one reason that the results of the current study may have differed from Dalton and colleagues. This sample had a higher mean BMI and, furthermore, was preselected in accordance to varying levels of BIS reactivity that were paired with lower levels of BAS reactivity. Therefore, a reactive BIS, which was found to be associated with explicit liking, may have impacted eating behaviour to a greater extent than a reactive BAS.

Satiety

An attenuated capacity to be sensitive to satiety signals has been linked to disinhibited-eating behaviour, weight gain over time, and obesity. Obese individuals have been characterised with an impaired capacity to be sensitive to satiety signals when compared with normal weight controls (Drapeau et al., 2011). Higher levels of trait disinhibited-eating behaviour have been linked to an attenuated-satiety response in normal weight individuals and difficulty with accurately identifying appetite sensations of hunger and fullness in obese individuals (Barkeling et al., 2007; Finlayson et al., 2012). Moreover, an impaired sensitivity to satiety signals has been linked to a total higher energy intake and subsequently hypothesised to lead to weight gain over time (Drapeau et al., 2011; Drapeau et al., 2007). The satiety quotient (SQ), which measures an individual’s capacity to be sensitive to satiety signals in response to a fixed caloric intake, provides a marker for characterising an individual’s ability to detect a state of satiety (Drapeau et al., 2011; Green et al., 1997). A high SQ is indicative of a normal or high capacity to be sensitive to satiety signals, whilst a low SQ is a marker for an impaired capacity to be sensitive to satiety signals (Drapeau et al., 2011). Research has shown that a lower SQ for fullness predicts higher overall intake (Drapeau et al., 2007), whilst a lower SQ for hunger has been linked to greater energy intake at an ad libitum test meal (Dalton et al., 2015). In this study, the SQ was used as a marker of satiety efficiency by measuring the extent to which a 600 kcal pre-load suppressed subjective hunger and increased subjective fullness between the high and low BIS groups.

The BIS was shown to be inversely associated with the satiety quotients for both appetite sensations of hunger and fullness, after controlling for BMI. There were no differences between the groups in their subjective appetite measures of hunger or fullness before or directly after consumption of the pre-load, which suggests that both groups began the task at an equal state of hunger and fullness and reached a comparable state of satiety. However, the high BIS group was found to have a weaker suppression of hunger, reduced feelings of fullness, and lower mean satiety quotients for both appetite sensations of hunger and fullness when compared to the low BIS group. Specifically, the high BIS group was shown to experience higher levels of hunger and reduced levels of fullness at 30 minutes after the consumption of a pre-load, which persisted until 90 minutes after the pre-load was consumed, when compared to the low BIS group. These results provide, to the best of this author’s knowledge, the first evidence to indicate that a reactive BIS may be linked to an attenuated-satiety response.

The results of this final study suggested that the pre-dispositional temperament traits underlying the HDLR subtype influenced their capacity to be sensitive to feelings of hunger and fullness, which might place them at risk of increased energy intake and weight gain over time (Barkeling et al., 2007; Drapeau et al., 2007). These results are novel and cannot be explained within the temperament-based or psychological reward-based eating-behaviour literature. However, as outlined earlier in section 2.4, a phenotypic trait of enhanced physiological and psychological arousal is assumed to stem from a reactive BIS and a low level of effortful control. Consequently, an individual with a reactive BIS and a lower level of effortful control may be more susceptible to the acquisition of a conditioned liking response (Mela, 2000), as the pleasurable effects of the ingested foods are associated with a subjective improvement in mood (Gibson, 2006; Macht, 2008) and a reduction in the physiological stress response (Adam & Epel, 2007; Dallman, 2010). Therefore, these results could be explained within the stress-based eating-behaviour literature, which supports the expected action of a reactive BIS (Corr & Mc Naughton, 2008), and a low level of effortful control (Derryberry & Rothbart, 1997; Rothbart et al., 2013), on the physiological stress response, and disinhibited-eating behaviour (Adam & Epel, 2007; Dallman, 2010). Therefore, it was informative to observe that the appetite regulation and eating-behaviour literature had made a link between individuals who possess a low-satiety phenotype and the experience of chronic stress.

In the appetite regulation and eating-behaviour literature, an individual can be classified with either a low or a high satiety phenotype according to cut-off values that have been observed clinically to relate to atypical appetitive responses to a meal (Drapeau et al., 2013). The current study was not designed to classify individuals according to a high or a low satiety phenotype. However, the mean SQs for hunger and fullness of the high BIS group were found to be similar to a group who were classified with a low satiety phenotype in a study by Drapeau et al. (2013). In that study, the mean SQ for fullness was inversely related to state anxiety and participants who were classified with a low satiety phenotype showed evidence of dysregulation within the hypo-thalamic pituitary adrenal (HPA) axis. Dysregulation within the HPA axis has been observed in individuals suffering from chronic stress and depression (Edwards, Heyman, & Swidan, 2011; Gold & Chrousos, 2002). It has also been linked to emotional eating behaviour and the intake of highly palatable 'comfort'-type foods (Adam & Epel, 2007; Dallman, 2010; Pecoraro et al., 2004; Tomiyama et al., 2011; Tyron, DeCant, & Laugero, 2013). The relationship between the low-satiety phenotype and dysregulation within the HPA axis is highlighted here because an inability to perceive a state of satiety appears to be linked to the experience of enhanced negative emotionality. Consequently, an individual with high levels of disinhibited-eating behaviour and a phenotype that is predisposed to experience higher levels of negative emotionality (Gray, 1970) and negative affect (Carver & White, 1994) should be at the greatest risk of weight gain as a result of affect-regulated eating behaviour that is combined with an attenuated-satiety response.

6.9.3 The effect of belonging to either a high or a low BIS group on emotion regulation difficulties and effortful control

The ninth hypothesis that the HBIS_LBAS phenotype, HDLR subtype combination would have a significantly lower level of effortful control and a significantly higher level of emotion regulation difficulties than the LBIS_LBAS phenotype, LDHR subtype combination was fully supported. Overall, the high BIS group had a lower level of effortful control and activation control when compared with the low BIS group. Measures of negative emotionality have been inversely associated with effortful control in adults (Rothbart & Rueda, 2005), low levels of effortful control have been linked to emotion regulation difficulties (Derryberry & Rothbart, 1997; Eisenberg et al., 2013; Rothbart et al., 2013) and the Carver and White BIS Scale (Carver & White, 1994) has been associated with the Difficulties in Emotion Regulation Scale (Tull et al., 2010). Therefore, it should not be surprising that the high BIS group were also shown to have a significantly greater level of emotion regulation difficulties compared to the low BIS group. However, they were also shown to possess a greater lack of access to strategies to regulate their emotions, a greater difficulty remaining in control of behaviour when experiencing negative emotions, and to possess a lower level of activation control, which is associated with an individual’s capacity to motivate themselves to engage in less-desired behaviours, when compared with the low BIS group.

The literature discussed above indicates that a reactive BIS phenotype, which is poorly regulated, can be linked to difficulties in emotion regulation. However, difficulties in emotion regulation have also been linked to binge eating behaviour (Aldao et al., 2010; Munsch et al., 2012; Svaldi, Caffier, & Tuschen-Caffier, 2010) and the lack of access to emotion regulation strategies subscale, from the Difficulties in Emotion Regulation Scale (Gratz & Roemer, 2004), has been shown to predict binge-eating episodes (U. Whiteside et al., 2007) and emotional eating behaviour (Gianini et al., 2013). Furthermore, the HDLR eating-behaviour subtype has been linked to binge-eating behaviour (C. B. Peterson et al., 1998; Wadden et al., 1993; Yanovski & Sebring, 1994) and the predispositional traits of a HBIS_LBAS phenotype underlay HDLR eating behaviours in this study. Therefore, the literature supports that the traits of a reactive BIS may negatively affect the HDLR eating behaviour subtype's capacity to regulate their emotions, which may subsequently influence their consumption of highly palatable foods, as an affect-regulation strategy (Macht, 2008).

The predispositional traits of the HBIS_LBAS phenotype may also influence the expression of unrestrained eating behaviour by negatively influencing an individual's capacity to actively restrain their intake of 'liked' foods, which have been linked to an improvement in a negative mood state (Gibson, 2006; Macht, 2008; Macht & Mueller, 2007). The HBIS_LBAS phenotype was found to possess lower levels of activation control when compared to the LBIS_LBAS phenotype. Lower levels of effortful control, and its subscale of activation control, have been associated with higher levels of state anxiety and self-rated depression (Moriya & Tanno, 2008). Moreover, both the HBIS_LBAS phenotype and the HDLR eating behaviour subtype have been independently linked to the experience of depressive symptoms (Vasey et al., 2014; Vasey et al., 2013; Wadden et al., 1993) and there is evidence to suggest that a low level of activation control may be linked to an inability to actively engage in motivated behaviour when feeling depressed (Carver, Johnson, & Joorman, 2008; Carver et al., 2009). Therefore, this evidence suggests that collectively, the predispositional traits of the HBIS_LBAS phenotype may underlay the expression of highly disinhibited, unrestrained, binge-eating behaviour. They also suggest that the HBIS_LBAS/HDLR eating-behaviour subtype combination, when contrasted with the LBIS_LBAS/LDHR subtype combination, might lack the motivation *not* to impulsively indulge in high-fat food choices when feeling depressed. Subsequently, these results suggest that the HBIS_LBAS phenotype might be susceptible to a greater total energy intake when feeling depressed. Therefore, a high level of BIS reactivity, a low level of effortful control, and associated emotion regulation difficulties may influence the liking of, desire for, and unrestrained consumption of high-fat dietary choices, when individuals simultaneously possess a lower level of BAS activation.

On the other hand, these results also suggest that the LBIS_LBAS phenotype, with their lower level of emotion regulation difficulties and higher levels of attentional and activation control, appear to be motivated to choose a lower-fat and therefore lower-calorie option, in the fed state. It is clear that the successful engagement with a lower-calorie choice would lead to a lower overall-caloric intake and greater weight-management success, under such circumstances. Subsequently, a low level of BIS reactivity, a higher level of effortful control, especially activation control, and a lower level of emotion-regulation difficulties might enable the desire for low-fat food choices. Therefore, it is possible that the predispositional traits inherent to a low level of BIS reactivity and a higher level of effortful control might be linked to the successful dietary restraint practises of the LDHR eating behaviour subtype.

6.9.4 The effect of BIS group on measures of cognitive control

The hypothesis that the HBIS_LBAS phenotype, HDLR subtype combination would have significantly lower levels of cognitive inhibition and flexibility when compared with the LBIS_LBAS phenotype, LDHR subtype combination was not supported. When the high and low BIS groups were examined relative to their level of executive function, there was no evidence of a difference in cognitive inhibitory control or flexibility between a successful dietary subtype, the LDHR, and those individuals who have been described as prone to overeating and low in Restraint the HDLR subtype. However, a similar result has previously been reported by Galioto et al. (2012), whereby there was a lack of difference to find an effect of executive function between two obese groups, one diagnosed or previously diagnosed with BED and one without BED. The authors suggested that this effect may have been due to the higher levels of obesity of both groups, which itself has been associated with reduced executive functioning, and which could have masked the ability to detect group differences. It is possible that such masking also occurred in the current study, as both groups were almost one standard deviation above the mean value for normative scores on the Delis-Kaplan Executive Function System (D-KEFS) Color Word Interference Test (CWIT) (Delis et al., 2001).

6.10 CONCLUSION

When examined at the group level, the high BIS group showed enhanced liking for high-fat foods after a pre-load and a greater total energy intake at an ad libitum test meal, when compared with the low BIS group. They also had a lower level of perceived satiety, and effortful control (i.e., activation control), and a higher level of emotion-regulation difficulties (i.e., a greater lack of strategies to deal with emotions) than the low BIS group. A lack of strategies to regulate emotions was associated with the explicit liking of high-fat foods and the total energy intake from high-fat foods, and a lower level of activation control was associated with a higher total energy intake from high-fat foods. Moreover, a high level of BIS reactivity was associated with an attenuated capacity to be sensitive to satiety signals. Therefore, these results suggest that the predispositional traits of a reactive BIS phenotype are linked to affect-regulated eating behaviour, via association with a greater liking of high-fat foods, a low level of activation control, and an attenuated capacity to be sensitive to satiety signals in overweight and obese females. When taken together this collection of factors indicates that the possession of a reactive BIS phenotype might increase an individual's risk for expressing highly disinhibited eating behaviours that are unrestrained.

Chapter 7: General Discussion

7.1 EATING BEHAVIOUR

The correlational results from studies one (Chapter 4) and two (Chapter 5) suggested that an individual's tendency towards a heightened level of emotional and disinhibited-eating behaviour placed both genders at risk of over-consumption and weight gain. In both studies, higher levels of emotional and disinhibited-eating behaviours were associated with higher levels of BMI, in both genders. A reactive BIS and a low level of effortful control were significant predictors of such eating behaviour in both studies. However, females showed evidence of higher levels of emotional and disinhibited-eating behaviour, BIS reactivity and trait anxiety, when compared to males. This finding is interesting because reactivity within the BIS has been hypothesised to lead to an enhanced vulnerability to anxiety in females (Catuzzi & Beck, 2014).

Catuzzi and Beck (2014) proposed a 'two-hit' model of vulnerability to anxiety in females. Firstly, females are hypothesised to possess a greater attentional bias towards threat that is independent of BIS reactivity. Secondly, a high level of BIS reactivity is hypothesised to facilitate the acquisition of rapidly conditioned and difficult to extinguish active avoidance behaviours. Therefore, being female and having a higher level of reactivity within the BIS are hypothesised to contribute towards strongly reinforced active avoidance behaviours and an enhanced vulnerability to anxiety. The higher level of BIS reactivity, trait anxiety and eating behaviours in females in the current samples might indicate that BIS reactivity and an associated increase in state anxiety in response to stressful situations (Gray, 1970; McEwan & Stellar, 1993) is linked to higher levels of disinhibited-eating behaviour. Higher levels of disinhibited-eating behaviour have been linked to eating more than usual during specific and general stress in females but not in males (Weinstein, Shide, & Trolls, 1997). Given the higher level of disinhibited-eating behaviour in females, it is possible that this eating behaviour might reflect the habitual reaction to a reactive BIS, which is to use a strongly reinforced active-avoidance behaviour, such as eating, to regulate affect during the experience of a stressful event.

7.1.1 Eating behaviour and effortful control

Studies one (Chapter 4) and two (Chapter 5) supported Rothbart and Bates' psychobiological model of temperament (2006), which describes a hierarchical relationship between the executive function of effortful control and reactivity within the BIS and BAS on emotional and disinhibited-eating behaviour and a conceptual psychobiological model of a failure to manage eating behaviour (see section 2.2 and 2.4). Study one demonstrated that a low level of effortful control and emotion regulation difficulties predicted emotional-eating behaviour and study two demonstrated that the BIS and a low level of effortful control predicted disinhibited-eating behaviour. Collectively, these results suggested that reactivity within the BIS, a low level of effortful control and emotion-regulation difficulties, might increase susceptibility to emotional and disinhibited-eating behaviour. However, in study one (Chapter 4), the relationship between the BIS and emotional eating appeared to be partially mediated by a low level of effortful control. Furthermore, study two (Chapter 5) also showed that the relationship between the BIS and disinhibited eating was significantly partially mediated by effortful control and the relationship between the BIS and implicit wanting of high-fat sweet foods was significantly fully mediated by effortful control.

These results, which suggest that the relationship between the BIS, disinhibited eating, and implicit wanting was partially and fully mediated by a low level of effortful control, are important. High levels of negative emotionality and a related measure of neuroticism, which have all been linked to reactivity within the BIS (Gray, 1970; Heym et al., 2008), have also been linked to low levels of effortful control (Rothbart & Rueda, 2005) and a related personality measure of conscientiousness (Evans & Rothbart, 2007). Therefore, these results suggest that, as reactivity within the BIS increases, an individual's capacity to exert effortful control over their emotions and behaviours decreases. Subsequently, these results raise an interesting question. Specifically, if an individual has a reactive BIS and, furthermore, it contributes towards a low level of effortful control, how efficacious will they be to resist consumption of a highly liked and desired food, especially if it has been used to habitually manage a state of negative affect? These results suggest that an individual with a reactive BIS may be less likely to exert effortful control over their behaviour and more likely to give in to their desire for high-fat sweet, 'comfort-style' foods, when the BIS is activated.

7.2 THE EFFECTS OF TEMPERAMENT AND TRAIT ANXIETY ON EMOTIONAL AND DISINHIBITED-EATING BEHAVIOUR

According to the new Reinforcement Sensitivity Theory (RST), simultaneous activation of the FFFS and the BAS will lead to activation of the BIS (Gray & McNaughton, 2000). Therefore, high BIS and BAS scores, from the Carver and White BIS/BAS Scales (1994), should lead to the experience of anxiety and an increase in autonomic arousal (Corr, 2008; Gray, 1970). The psychosomatic theory of emotional eating posits that an increase in negative emotionality and autonomic arousal will lead to emotional eating (van Strien, 2002). Therefore, in order to understand the effect that trait anxiety may have on emotional and disinhibited-eating behaviour in an individual with a temperament phenotype that is predisposed to experience state anxiety in response to stressful situations (Gray, 1970), the BIS and BAS were interacted against trait anxiety in study one (Chapter 4) and study two (Chapter 5).

The aim was to determine if an individual’s temperament phenotype could predispose them to increased emotional and disinhibited eating at high levels of trait anxiety. The results indicated that the HBIS_HBAS phenotype, which has been experimentally linked to the experience of anxiety, general distress, and increased feelings of autonomic arousal when effortful control is low (Bijttebier et al., 2009; Dinovo & Vasey, 2011; Vasey et al., 2014), was the only phenotype to be significantly associated with greater emotional eating when experiencing high levels of trait anxiety. Furthermore, closer scrutiny of the relationship between effortful control and a BIS x BAS interaction indicated that a low level of effortful control was associated with higher levels of emotional-eating behaviour when an individual has a HBIS_HBAS temperament phenotype.

The data also suggested that a reactive BIS and a low level of effortful control were significant predictors of disinhibited-eating behaviour in individuals who lack awareness of or who fail to accept their emotional state. The results of study one (Chapter 4), in which an interaction between the BIS x BAS x STAI-T did predict emotional eating, highlighted an interesting difference between the HBIS_HBAS and HBIS_LBAS temperament phenotypes. The HBIS_LBAS phenotype had a higher level of emotional eating at a low level of trait anxiety, when compared to the HBIS_HBAS phenotype. Further, the HBIS_LBAS phenotype lacked awareness of their emotional state to a significantly greater degree than the HBIS_HBAS phenotype. They also showed a significantly greater non-acceptance of their emotions when compared to the LBIS_LBAS phenotype in study three (Chapter 6).

An inability to easily identify and express feelings has been associated with emotional-eating behaviour and linked to obesity (Elfhag & Lundh, 2007; Ouwens, van Strien, & van Leeuwe, 2009; Wickramasekera & Price, 1997). Although an interaction between BIS x BAS x STAI-T did not predict disinhibited-eating behaviour in study two, a high BIS and a low level of effortful control, which has been linked to the experience of general distress (Dinovo & Vasey, 2011), did contribute to the prediction of disinhibited-eating behaviour. Subsequently, it is possible that the lack of an interaction between the BIS x BAS and trait anxiety is because some individuals, as suggested by the results of study one (Chapter 4) and study three (Chapter 6), may have difficulty accurately identifying or accepting their emotions.

It is acknowledged that it is not possible to prove the existence of such a relationship from the results of this study. However the nature of the Carver and White BIS Scale (1994) is not to ask the individual to identify their current emotional state but rather to identify their expected emotional reaction during an imagined future event. Therefore, when an individual lacks sufficient awareness or acceptance of their current emotional state, it is possible that the BIS Scale offers a more sensitive indicator of their inclination to react to such events emotionally. This could explain why the BIS and a low level of effortful control predicted disinhibited-eating behaviour and not the three-way BIS x BAS x STAI-T interaction term, as initially hypothesised in study two (Chapter 5).

In summary, these results imply that an individual with a HBIS_HBAS temperament phenotype, when combined with a low level of effortful control, might overeat in an attempt to assuage non-specific physiological arousal or in an attempt to reduce the psychological load of their symptoms. The data also provided a basis from which to consider why some individuals may not be able to control their eating behaviour, despite their best intentions. From the evidence presented here, it might be because they do not have an adequate level of effortful control in combination with a reactive BIS (Vasey et al., 2014; Vasey et al., 2013). Furthermore, these results also suggest that the high BIS and low BAS phenotype may lack a true awareness and understanding of their emotional state and subsequently may be at risk of eating in response to a lack of interoceptive awareness and an attenuated-satiety response, as suggested by the psychosomatic theory of emotional eating, which might increase their risk for obesity (Bruch, 1961; van Strien, 2002).

7.3 IS A PARTICULAR BIS_BAS PHENOTYPE MORE LIKELY TO BE OVERWEIGHT OR OBESE?

7.3.1 BMI and association with temperament

Neither the BIS nor the BAS were associated with BMI in studies one and two, and there was no evidence of a curvilinear relationship between the BMI And BAS. These results differ from the results of both Davis and Fox (2008) and Dietrich et al. (2014), which have shown a curvilinear relationship between the BAS and BMI across both genders and from Dietrich et al., who reported evidence of a linear relationship between the BIS and BMI in adult females. As previously discussed, high levels of the BIS and high and low levels of the BAS have been linked to the states of anxiety and depression (Bijttebier et al., 2009; Zinbarg & Yoon, 2008). Furthermore, these states have been further linked to eating behaviour and BMI (Alexander & Siegel, 2013; Haghighi et al., 2016; Keranen et al., 2010; Ostrovsky et al., 2013; Ouwens, van Strien, & van Leeuwe, 2009; R. Peterson et al., 2012; Schneider et al., 2010; Stunkard et al., 2003). Therefore, to determine whether higher levels of eating behaviour and BMI could be explained by an interaction between the temperament dimensions, which have been linked to the experience of anxiety and depression, the sample was stratified by their BIS_BAS phenotype.

Although no significant differences were found in study one (Chapter 4), the results indicated that a greater proportion of females who were overweight or obese possessed a phenotype that was higher in BIS and concurrently high or low in BAS, whilst males who were overweight or obese possessed a phenotype that was higher in BAS and concurrently low in BIS. Furthermore, the finding in study two (Chapter 5) that a significantly greater proportion of overweight and obese females possessed a HBIS_HBAS temperament phenotype and higher levels of disinhibited-eating behaviour, when compared to the proportion of overweight and obese males with a LBIS_LBAS phenotype and lower levels of disinhibited-eating behaviour supported the two-hit vulnerability model of Catuzzi and Beck (2014) introduced earlier. Therefore, these results suggest that high levels of BIS reactivity in females may increase the risk of higher levels of disinhibited-eating behaviour.

To determine if a particular disinhibited-eating behaviour subtype was linked to the temperament traits of a particular BIS_BAS phenotype in females, the sample was further stratified by the four disinhibited-eating behaviour subtypes. A significantly greater proportion of females with HDLR eating behaviour were characterised by HBIS_LBAS temperament traits, whilst a significantly greater proportion of females with LDHR eating behaviour were characterised by LBIS_LBAS temperament traits. Furthermore, additional analyses demonstrated that the HDLR subtype was found in significantly higher proportions in the obese category in comparison to the LDHR subtype, who was found in significantly greater numbers in the overweight category. Collectively, these results suggested that the eating-behaviour traits of the HDLR and the LDHR eating-behaviour subtypes and their associated risk for increased BMI might be linked to pre-dispositional trait behaviours in females.

Within the disinhibited-eating behaviour literature, the evidence suggests that the HDLR eating-behaviour subtype has the greatest risk for the greatest amount of weight gain, whilst the LDHR subtype possesses as yet unknown processes that enable this subtype to more effectively manage their eating behaviour (Bryant et al., 2008; Lawson et al., 1995; Provencher et al., 2003; Williamson et al., 1995; Yeomans & Coughlan, 2009; Yeomans, Tovey, et al., 2004). The results of study two suggested that there was a relationship between the possession of specific temperament traits and an individual’s capacity to successfully manage eating behaviour and BMI. The only difference between the eating behaviour subtypes, one who is successful at dietary restraint (LDHR) and another who is not (HDLR), was their level of BIS reactivity. Consequently these results suggested that the traits associated with a high level of BIS reactivity might explain the high levels of disinhibited-eating behaviour, low levels of restrained-eating behaviour and higher BMI of the HDLR eating behaviour subtype, when compared to the low levels of disinhibited-eating behaviour and high levels of restrained-eating behaviour of the LDHR subtype.

7.4 EXPLICIT LIKING AND IMPLICIT WANTING

Liking is a learnt response that may be built up via associative conditioning (Mela, 2006). Therefore, it was conceptualised in section 2.12 that individuals with a reactive BIS may be motivated to obtain food that they 'like' because it has been associated with an improvement in mood and feelings of pleasure and positive affect. Such an association could subsequently increase their desire to obtain highly palatable food and simultaneously reduce their perception of satiety via increased feelings of hunger (Bruch, 1964; Dalton & Finlayson, 2013; van Strien, 2002). The results from study two (Chapter 5) demonstrated that a reactive BIS, not a reactive BAS, and a low level of effortful control predicted explicit liking. Moreover, these variables collectively predicted disinhibited-eating behaviour. Furthermore, explicit liking for high-fat sweet foods was found to be a stronger predictor of disinhibited-eating behaviour than implicit wanting of high-fat sweet foods. Therefore, these results suggested that disinhibited-eating behaviour may be initiated by a reactive BIS and an explicit liking for high-fat sweet foods and not a reactive BAS or the implicit wanting for high-fat sweet foods. The results from the third study (Chapter 6) supported these findings. They demonstrated that, whilst there was no difference between the groups in implicit wanting for high-fat sweet foods in the fed state, by comparison, the high BIS group was shown to explicitly like high-fat foods to a greater extent than the low BIS group in the fed state.

These results suggested that the high BIS group, when compared with the low BIS group, may experience a dysregulated appetitive response to consumption. Furthermore, a dysregulated appetitive response was linked to an enhanced response within the hedonic reward system of explicit liking, in the fed state but not with implicit wanting. Therefore, these results provide preliminary support to the hypothesis that a greater explicit liking of high-fat foods but not the implicit wanting of high-fat foods, in the fed state, at least in the HBIS_LBAS/HDLR temperament and eating-behaviour subtype combination, might increase susceptibility to over-consumption. Specifically, the HDLR eating-behaviour subtype with trait HBIS_LBAS behaviours may have an attenuated suppression of explicit liking of high-fat foods in the fed state, which may place them at increased risk of over-consumption.

7.5 EMOTION REGULATION, EXPLICIT LIKING AND CONSUMPTION

The results of study three (Chapter 6) extended the results from studies one (Chapter 4) and two (Chapter 5) by highlighting that two eating-behaviour subtypes, who differed in their level of BIS reactivity, also differed in their level of effortful control and their capacity to regulate their emotions. As a consequence of these differences, the results suggested that HBIS_LBAS/HDLR participants, who had lower levels of effortful control and greater difficulty regulating emotion, experienced an enhanced explicit liking for high-fat foods, when in the fed state, and consumed more high-fat, energy dense food compared to LBIS_LBAS/LDHR participants, who had higher levels of effortful control and less difficulty regulating emotion. This was an important finding because HBIS_LBAS/HDLR participants showed evidence of moderate levels of binge-eating behaviour and HDLR eating behaviours have been linked to individuals with binge-eating disorder in the literature (C. B. Peterson et al., 1998; Wadden et al., 1993; Yanovski & Sebring, 1994). Moreover, unregulated affect has been associated with self-regulatory failure (Heatherton & Wagner, 2011; Wagner & Heatherton, 2013a), binge eating (Aldao et al., 2010) and emotional and binge-eating behaviour (Evers et al., 2010; Gianini et al., 2013; Ouwens, van Strien, & van Leeuwe, 2009; U. Whiteside et al., 2007). Consequently, these results and related literature supported the suggestion that a reactive and unregulated BIS phenotype could be at risk of failing to restrain their intake when distressed, by impulsively regulating their emotions with 'liked' high-fat foods.

7.6 APPEAL BIAS FOR LOW-FAT FOODS

Study three (Chapter 6) also examined the effect of temperament on the LDHR eating-behaviour subtype. The results demonstrated that the low BIS group, which represented a LDHR successful-dieting subtype, showed enhanced implicit wanting for low-fat foods, in the fed state, compared with the high BIS group. This suggests that one of the successful dietary strategies that may be employed by the low BIS group is linked to their habitual behaviour of making a low-fat choice, when satiated. In the fasted state, the low BIS group were shown to implicitly want high-fat foods. However, after the ingestion of a 600 kcal pre-load, they were shown to implicitly want low-fat foods to a significantly greater extent.

This result could be explained by group differences in the ability to regulate emotion and the ensuing capacity to exert activation control over behaviour. For example, in the correlational analyses, activation control was inversely associated with the implicit wanting for high-fat foods and with the total level of energy intake at the ad libitum meal. These results suggest that, as conceptualised earlier in the psychobiological model of a failure to manage eating behaviour (see section 2.4), the possession of a less-reactive temperament phenotype may assist an individual to make the most advantageous choice and enable them to successfully restrain their eating behaviour. Specifically, a lower level of BIS reactivity and a higher level of effortful control may enable such behaviour. The implicit wanting reaction-time task covertly measures an unconscious response. Subsequently, such unconscious behaviour may reflect the 'hard-wiring' of the habitual (Dayan & Balleine, 2002) healthier eating behaviours that assist this phenotype to more effectively manage their intake and hence their weight. Therefore, an *implicit motivation* to do that which they do not wish to do, i.e., to make a low-fat choice over a more desired high-fat choice, may have enabled the low BIS group to successfully restrain their eating behaviour, when compared to the high BIS group.

7.7 SATIETY

By reducing the desire to eat in between meals, the satiety process represents one way in which the human body regulates homeostatic intake (Chapelot, 2013). Therefore, the finding of an attenuated-satiety response in the HBIS_LBAS compared to the LBIS_LBAS temperament phenotype may subsequently place them at risk of over-consumption. A reduced sensitivity to hunger and satiety signals have been reported in obese and normal weight individuals exhibiting higher levels of disinhibited-eating behaviour (Barkeling et al., 2007; Drapeau et al., 2011; Finlayson et al., 2012), and a lower satiety quotient (SQ), for fullness has been shown to predict energy intake in females (Drapeau et al., 2007). Therefore, it was informative that, when compared to the LBIS_HBAS/LDHR eating-behaviour group, the HBIS_LBAS/HDLR eating-behaviour group showed evidence of a lower SQ for both subjective appetite sensations of hunger and fullness after a 600 kcal pre-load.

A low satiety phenotype, which showed evidence of a low SQ for the appetitive sensations of hunger and fullness, has been identified in the literature and linked to the experience of chronic stress, anxiety, and dysregulation within the HPA axis (Drapeau et al., 2013; Drapeau & Gallant, 2013). This relationship is highlighted here because the perception of satiety is a learned response (Chapelot, 2013) and is one which Bruch, who is a proponent of the psychosomatic theory of emotional eating, believes has not been effectively learnt in obese individuals (Bruch, 1964). Bruch asserts that people eat emotionally when they experience certain emotionally aroused states such as anger, fear, or anxiety (Bruch, 1973; van Strien, 2002). Specifically, those who eat emotionally are thought to have confused their perception of an internally aroused state with a feeling of hunger and a subsequent lack of satiety (van Strien & Schippers, 1995). Therefore, the finding of higher levels of hunger and lower levels of fullness in the HBIS_LBAS group, which are coupled with enhanced liking and higher levels of disinhibited-eating behaviour, could be a reflection of this process at the subconscious level. To the best of my knowledge, a relationship between the BIS and satiety has not been previously reported. Subsequently, the finding of an attenuated-satiety response to a pre-load and an inverse relationship between the BIS and the SQs for hunger and fullness in the HBIS_LBAS phenotype provides the first evidence that an impaired capacity to be sensitive to satiety signals and the 'low-satiety phenotype' may be linked to reactivity within the BIS.

It is also possible that a dysregulated HPA axis and an attenuated-satiety response might be linked to the psychological reward of explicit liking. An unfettered stress response is deleterious to health (McEwan & Stellar, 1993). Therefore, in order to reduce the effect of stress on the organism, endogenous opioids are released alongside activation of the HPA axis (Adam & Epel, 2007). It has been suggested that the release of opioids reduces activity within the HPA axis via the process of negative feedback, thus reducing the impact of the physiological stress response on the body (Adam & Epel, 2007; Drolet et al., 2001). However, an increase in the release of endogenous opioids can also be linked to an enhanced liking response (Berridge, 2009a), greater food intake (Adam & Epel, 2007) and an attenuated-satiety response (Berridge et al., 2010; Olszewski et al., 2011). Subsequently, this process suggests a possible mechanism of facilitated negative reinforcement, whereby the habitual use of comfort foods, in response to chronic stress, could also lead to an enhanced liking response and an attenuated-satiety response in susceptible individuals.

7.8 EXECUTIVE FUNCTIONING BETWEEN THE GROUPS

Contrary to expectations based upon Attentional Control Theory (ACT) (Eysenck et al., 2007), study three (Chapter 6) found no evidence of a difference in cognitive inhibitory control or flexibility between the LDHR or the HDLR eating-behaviour subtypes. Whilst the failure to detect a significant difference between the groups may have been due to their higher BMI, there was also no evidence of an association between the Effortful Control Scale, or any of its subscales and the D-KEFS CWIT, which measures the executive function of cognitive inhibition (Delis et al., 2001). These results are aligned with study 2 (Chapter 5) and Müller et al. (2014), who also failed to find an association between self-reported effortful control and the Stroop task (Stroop, 1935). A possible reason for this failure to find an association between self-reported effortful control and the D-KEFS CWIT (Delis et al., 2001) might be found in the results of a study by Bridgett, Oddi, Laake, Murdock and Bachmann (2013).

Bridgett et al. (2013) determined across a series of studies that the Adult Temperament Questionnaire (ATQ) Effortful Control subscales (Evans & Rothbart, 2007) were associated with an ability to update and monitor information in working memory but not with the executive function of inhibition, which was measured via the D-KEFS CWIT. Critically, this aspect of working memory was associated with a lower predisposition to experience negative affect, whilst, in contrast, the executive function of inhibition was associated with the tendency to express negative affect. Subsequently, they concluded that effortful control might contribute to the regulation of negative affect via the use of effective emotion-regulation strategies (e.g, cognitive reappraisal), which are associated with working memory capacity. In contrast, however, the executive function of inhibition measured via the D-KEFS CWIT, which is a Stroop-like task measuring cognitive inhibition, appeared to be associated with the tendency to express, rather than to experience negative affect. Subsequently, the hypothesis examined in study one (Chapter 4) that there would be an association between the ATQ Effortful Control Scale and the Stroop task measuring an individual's capacity to inhibit a dominant response (Stroop, 1935) and the assumption that there will be an association between the D-KEFS Color Word Interference Test, and the ATQ Effortful Control Scale in (Chapter 6) may not have been appropriate. The reason for this is that the self-report measure of effortful control from the ATQ and the D-KEFS CWIT (Delis et al., 2001) appears to be measuring two different executive functions: updating/monitoring information in working memory and inhibition, respectively, as demonstrated by Bridgett et al.

7.9 IMPLICATIONS FOR THE CURRENT CONCEPTUALISATION OF THE BAS AS A PRIMARY DRIVER OF HEDONIC INTAKE

Trait binge-eating behaviour has been linked to a behavioural phenotype of obesity and implicit wanting for high-fat sweet foods has been described as a psychobiological feature of over-consumption in susceptible individuals (Dalton & Finlayson, 2014). Similarly, at the level of psychobiological temperament, a high level of BAS reactivity, which has been conceptualised as a marker of an individual's risk for hedonic over-consumption, has been linked to binge-eating behaviour (Davis et al., 2009; Davis, Patte, et al., 2007). Therefore, the evidence from two independent research fields suggests that a high level of BAS reactivity and an associated increase in the psychological reward of implicit wanting increase risk for over-consumption and obesity.

In the final study (Chapter 6), the mean binge eating and disinhibited-eating behaviour scores, of HBIS_LBAS/HDLR participants were similar to obese participants (Dalton et al., 2013a, 2013b) and higher-than-normal weight participants (Finlayson et al., 2011; Finlayson et al., 2012), who have shown enhanced levels of implicit wanting and explicit liking for high-fat sweet food, in the fed state. Moreover, similar to the findings of previous research (Dalton et al., 2013a, 2013b), HBIS_LBAS/HDLR participants did show an enhanced explicit-liking response for high-fat sweet and savoury foods, in the fed state. However, contrary to previous findings (Dalton et al., 2013a, 2013b), they did not show an enhanced implicit-wanting response towards high-fat sweet foods, in the fed state. It is proposed that the failure to find a similar result is a reflection of the temperament-based characteristics, and the higher level of BMI, for which the sample was pre-selected.

Based upon the findings of study two (Chapter 5), study three (Chapter 6) was specifically designed to create a LBIS_LBAS group and a HBIS_LBAS group with a BMI that was in the overweight and the obese ranges. Based upon the median splits obtained from study two, the LBIS_LBAS group was selected for low BIS and low BAS scores and low levels of disinhibited-eating behaviour and the HBIS_LBAS group was selected for high BIS and low BAS scores and high levels of disinhibited-eating behaviour (Chapter 6, sections 6.3.3 and 6.3.5). Therefore, the study was optimally positioned to capture an effect of a reactive BIS on psychological reward, satiety and energy intake, should such a relationship between the BIS and these variables exist.

There was, however, an unexpected finding from the recruitment process. The HBIS_LBAS group had a mean BAS score that was substantially lower than the mean for Australian females, matched for age. These findings suggested that above-average levels of the BIS may coincide with lower-than-average BAS scores, at least in those individuals with a concurrently high level of disinhibited-eating behaviour. As a result, such a phenotype could be linked to a low level of BAS functioning and depression (Bijttebier et al., 2009; Kasch et al., 2002) or to a predisposition to anxiety and depression (Fowles, 1994; Henriques & Davidson, 1990, 2000). Negative affective states, such as anxiety and depression, are in turn associated with binge and disinhibited-eating behaviour (Bryant et al., 2008; Wadden et al., 1993), BMI (de Wit et al., 2010; Petry et al., 2008; Scott et al., 2008; Simon et al., 2008; Strine et al., 2008; Stunkard et al., 2003), weight gain (Brumpton et al., 2013; Gaysina et al., 2011; Lasserre et al., 2014) and weight regain (Elfhag & Rössner, 2005). Subsequently, the HBIS_LBAS phenotype could be at risk of disinhibited and binge-eating behaviour, obesity and weight management difficulties because of their underlying temperament predisposition to experience these negative affective states.

Therefore, the results from studies two and three suggested that both a reactive BIS and the explicit liking for high-fat foods, rather than implicit wanting or a reactive BAS, predicted disinhibited-eating behaviour and subsequent consumption. They also suggested that the relationship between a reactive BIS and disinhibited-eating behaviour might only become evident at a higher BMI. Finally, they also indicated that disinhibited-eating behaviour might occur in response to the experience of the negative affective states of anxiety and depression. Therefore, it is possible that, by not considering an individual's level of BIS reactivity when investigating an individual's level of risk for hedonic over-consumption, vital information might be missed.

7.10 THE BIS ACTS AS A PRIMARY DRIVER OF HEDONIC INTAKE

Reactivity within Gray's BAS is currently conceptualised within the literature as contributing towards an enhanced motivation for highly palatable foods or craving and risk for over-consumption (Davis, 2009; Davis et al., 2009; Davis & Loxton, 2014; Davis, Patte, et al., 2007; Davis, Strachan, et al., 2004; Dawe & Loxton, 2004; Franken & Muris, 2005). Subsequently, studies one and two investigated whether the BAS contributed towards the prediction of eating behaviour and the psychological rewards of implicit wanting and explicit liking. Activation within the BAS may be measured by an individual's reaction time towards an appetitive cue (Corr & Mc Naughton, 2008). The measure of implicit wanting employed by the Leeds Food Preference Questionnaire (LFPQ) measures an individual's reaction time to pictures of four categories of food, according to fat and taste (Finlayson et al., 2007). Although the psychobiological construct of implicit wanting, which is measured by the LFPQ, is assumed to be capable of capturing reactivity within the BAS (Corr & Mc Naughton, 2008), the finding that the BAS did not significantly add to the variance in eating behaviour, implicit wanting, or explicit liking was unexpected. This result suggested that either the assumed BAS motivation-, behind eating behaviour and the psychological rewards of wanting and liking was mediated by another variable or that it may not be strongly related to the Carver and White BAS Scale (Carver & White, 1994).

It was hypothesised that this other variable could be the BIS, as it promotes the active avoidance of a threat by facilitating approach behaviours towards stimuli that have been associated with the obtainment of reward and a state of 'safety' (Corr, 2008; Corr & McNaughton, 2012; Derryberry & Reed, 2002; Derryberry & Rothbart, 1997; Gray, 1987a; Robbins & Fray, 1980). At a superficial level, the feelings of reward and safety could theoretically arise from the learnt association between the psychological reward of liking, which has been linked to endogenous opioid release and the experience of pleasure and positive affect (Berridge, 1996; Macht, 2008; Mela, 2000). Moreover, these feelings could be further reinforced by the subsequent reduction in the physiological stress response from the ingestion of highly palatable foods, as has been demonstrated in the stress-related eating-behaviour literature (Adam & Epel, 2007; Dallman, 2010; Laugero, 2001; Macht, 2008; Pecoraro et al., 2004). Consequently, an individual with a reactive BIS and a low level of effortful control might have learnt to respond habitually to liked highly palatable foods when induced into a state of anxiety or in response to enhanced levels of non-specific arousal via a process of facilitated negative reinforcement (Corr & Mc Naughton, 2008; Derryberry & Reed, 2002; Mela, 2000).

The suggestion that affect-regulated eating behaviour might be linked initially to a reactive BIS and not a reactive BAS is strengthened by the findings of study two. The results showed that the BIS and/or a low level of effortful control predicted both implicit wanting and explicit liking food-reward behaviours and not the BAS. Moreover, the explicit liking of high-fat sweet foods was a stronger predictor of disinhibited-eating behaviour than the implicit wanting for high-fat sweet foods and the HBIS_LBAS group was found to have an enhanced liking response for high-fat foods, in the fed state. Subsequently, as supported by the analyses within this thesis, trait-eating behaviours may be initiated by an enhanced explicit liking response for high-fat foods, not an enhanced implicit wanting response. Moreover, the psychobiological temperament traits underlying these trait eating behaviours might be linked to a reactive BIS and not only with a high or a low level of BAS in isolation, as suggested by the current temperament and eating-behaviour literature base (Aldao et al., 2010; Blum et al., 2000; Davis, 2009; Davis & Carter, 2009; Davis, Levitan, Muglia, Bewell, & Kennedy, 2004; Davis & Loxton, 2014; Wang et al., 2001).

Over time, the motivated approach to a reward, even when it is initially motivated by reactivity within the BIS, should lead to BAS mediated approach behaviours (Corr, 2003; Corr & McNaughton, 2012). Subsequently, the failure to find a relationship between the BAS, implicit wanting, and eating behaviour was puzzling. However, one explanation for the lack of a relationship between the Carver and White BAS Scale (Carver & White, 1994) and the implicit-wanting measure of the LFPQ (Finlayson et al., 2007) could come from a review by Ikemoto and Panksepp (1999). They implied that the activation of dopamine-mediated approach behaviours in response to an orientation towards safety signals may not be associated with feelings of positive affect. Therefore, the Carver and White BAS Scale (Carver & White, 1994), which measures feelings that are associated with the experience of positive affect, may not capture this response in individuals with a high level of BIS reactivity or predisposition towards trait anxiety. However, if the individual was initially motivated to orient towards and engage the BAS to approach stimuli that signal a state of 'safety', as a result of the perception of a conditioned threat or frustration via activation within the BIS (Corr & McNaughton, 2012; Derryberry & Reed, 2002; Derryberry & Rothbart, 1997; Gray & McNaughton, 2003), it is assumed that the BIS Scale from Carver and White (1994) will capture this effect. Therefore, as suggested by the recently revised action of the BIS in the new Reinforcement Sensitivity Theory (RST) (Corr, 2008; Gray & McNaughton, 2003), which implies an action of facilitated negative reinforcement, it is plausible that such motivated behaviour will be measured by the Carver and White BIS Scale and not the BAS Scale (1994).

7.10.1 Perspectives from the stress-based, eating-behaviour literature

The findings from the research undertaken throughout this thesis are novel and cannot be explained within the temperament-based or appetite-regulation and eating-behaviour literature. However, due to the expected action of a reactive and unregulated BIS on the physiological stress response, as described by Corr and McNaughton (2008), they can theoretically be explained by related findings within the stress-based, eating-behaviour literature.

It was highlighted earlier that Drapeau et al. (2013) had linked an attenuated sensitivity to satiety signals to the experience of state anxiety and dysregulation within the HPA axis. An extensive body of research has linked dysregulation within the HPA axis to the experience of chronic stress and depression, highly palatable food intake, emotional-eating behaviour, and obesity (Adam & Epel, 2007; Dallman, 2010; Edwards et al., 2011; Gold & Chrousos, 2002; Pecoraro et al., 2004; Tomiyama et al., 2011; Tyron, DeCant, et al., 2013). The consensus from this field is that the intake of comfort foods by individuals under stress appears to serve the dual purpose of reducing the physiological stress response and improving mood (Adam & Epel, 2007; Dallman, 2010). However, besides effectively reducing the stress response, it is assumed that the consumption of highly palatable foods during stress will be linked via enhanced explicit liking towards these comfort foods. Moreover, it is possible that these eating behaviours will be laid down as a neurologically ‘hard-wired’ and habitual response at the subconscious level and that these individuals will become sensitised to the rewarding properties of highly-palatable foods (Adam & Epel, 2007; Dallman, 2010; Tryon, Carter, DeCant, & Laugero, 2013). Therefore, a link between a reactive BIS and the intake of highly palatable foods to regulate affect may explain the enhanced liking response to high-fat foods observed in the final study.

It may seem counterintuitive that an individual with a high level of BIS reactivity and a low level of BAS reactivity could exhibit disinhibited behaviour. Within Reinforcement Sensitivity Theory, the action of the BIS is to restrain the behavioural approach system during times of conflict (Corr, 2008). From this perspective, its role is to constrain what could potentially be inappropriate or dangerous behaviour. Subsequently, when considered from this perspective, it is not feasible to consider that it could motivate eating behaviour in individuals who wish to manage their body weight. However, one way to conceptualise this paradox is to consider the following: Individuals with high levels of BIS and low levels of BAS reactivity may be predisposed to experience anxiety and depression (Bijttebier et al., 2009; Zinbarg & Yoon, 2008). The experience of depression is associated with feelings of hopelessness and helplessness (Schroder & Ollis, 2013) and it has been suggested that, in a situation where an individual feels helpless, impulsive behaviours which reflect a reduced level of motivation are likely to be triggered (Carver et al., 2009). Specifically, these behaviours have been suggested to reflect outcomes that are influenced by negative affect and a tendency towards a state of *inaction* (Carver et al., 2008). Therefore, it is possible that this state of inaction is represented by outcome behaviours linked to a low level of activation control.

It was interesting that the results of study three indicated that HBIS_HBAS/HDLR participants, who had moderate levels of binge-eating behaviour, also had lower levels of activation control than LBIS_LBAS/LDHR participants and, further, that a low level of activation control was associated with a higher total energy intake. This finding is interesting because it could reflect the habitual use of high-fat ‘comfort-type’ foods over low-fat, healthier options to regulate affect in HBIS_LBAS/HDLR participants. For example, the exertion of activation control describes an individual’s capacity to enact behaviours that they would prefer to avoid (Evans & Rothbart, 2007). Binge-type eating disorders occur co-morbidly with anxiety and depressive disorders (American Psychiatric Association, 2013) and binge-eating behaviour has have been linked to a model of negative reinforcement by Svaldi, Brand and Tuschen-Caffier (2010), whereby the binge-eating behaviour reinforces its re-occurrence as a way to avoid the experience of a negative mood state. Subsequently, if binge-eating serves to regulate feelings of negative affect, as suggested by Svaldi et al. (Svaldi, Brand, et al., 2010), and the individual is either suffering from or experiencing symptoms of anxiety and depression, it is possible that they will possess a lower level of activation control and a subsequent implicit lack of motivation to change their eating behaviour. Moreover, such a conceptualisation is likely to be strengthened if the individual also lacked access to emotion-regulation strategies to regulate their state of physiological arousal or level of psychological affect (Svaldi, Caffier, et al., 2010; U. Whiteside et al., 2007) and additionally, felt depressed (Carver et al., 2009). This effect is also likely to be compounded if an individual has a reduced sensitivity to satiety signals.

The high BIS group had significantly higher scores on the Disinhibition and Binge Eating Scales than the low BIS group. They also had a lower level of effortful control and activation control and they also lacked access to emotion-regulation strategies and had difficulty controlling their impulses during the experience of negative emotional states. Therefore, it is possible that these individuals could intrinsically lack the required motivation to manage their eating behaviour, as suggested by their lower level of activation control. Indeed, a low level of activation control has been associated with state and trait anxiety (Clements & Bailey, 2010) and depressive symptoms (Moriya & Tanno, 2008). Correspondingly, a low level of activation control that may arise as a result of a temperament predisposition to experience trait anxiety and depression might help to explain the link between a low level of activation control and a higher energy intake in the HBIS_LBAS group, in the final study (Carver et al., 2009).

Although measures of stress, anxiety, and depression were not administered in the final study, it is feasible that a HBIS_LBAS phenotype would be exposed to the experience of everyday minor discomforts and some levels of emotional distress, given their above-average level of BIS reactivity (Gable, Reis, & Elliot, 2000; Heponiemii et al., 2003; Jorm et al., 1999). Therefore, the enhanced-liking response in the fed state and the attenuated-satiety response observed in HBIS_LBAS/HDLR females could reflect their habitual consumption of highly palatable, ‘comfort-type’ foods as a result of their temperament-based vulnerability to heightened states of negative affect that are ineffectively regulated.

7.11 LIMITATIONS AND FUTURE RECOMMENDATIONS

This thesis provides novel insights into the utility of Rothbart and Bates' (2006) psychobiological model of temperament to investigate an individual's degree of risk for obesity. Moreover, the results are consistent with a psychobiological temperament model of vulnerability to use food as an affect-regulation strategy. However, several limitations must be noted.

The use of self-report measures, the cross-sectional nature of the assessments, and the use of general measures of effortful control and eating behaviour impose limitations on the validity of these results. As most of the variables across the studies were measured at the one time-point, the direction of associations amongst the variables is unclear and causal links between psychobiological temperament, eating behaviour, psychobiological reward, and energy intake cannot be established. Therefore, further research is required to establish causal links, preferably using longitudinal studies. However, the findings of this study are consistent with previous research and theory, which supports the findings.

Regarding the correlational results in studies one (Chapter 4) and two (Chapter 5), it is noted that, whilst the descriptive statistics did reflect the expected gender differences in emotional-eating behaviour and reactivity within the BIS, the unequal distribution of gender was a limitation that may have impacted the significance of some of the associations in males. A strength of study one (Chapter 4) and two (Chapter 5) was that they had a sufficient sample size and adequate power to investigate the regression analyses that did not investigate an interaction term. However, it was noted that, even though the findings were significant, in the regression analysis that investigated the interaction term in study one (Chapter 4), the act of classifying individuals into their respective BIS_BAS phenotypes resulted in small cell sizes for this aspect of the study. Subsequently, these novel findings require replication in a larger sample.

There is a limitation inherent to the use of the LFPQ implicit-wanting and explicit-liking tasks as a measure of BIS and BAS reactivity. Although it was assumed that reactivity within both the BIS and the BAS could be measured against the LFPQ explicit-liking and implicit-wanting tasks (Finlayson et al., 2007), these measures of psychological reward have not been previously validated against the Carver and White BIS/BAS Scales (Carver & White, 1994). Therefore, until the

LFPQ explicit liking and implicit-wanting measures are validated against this or other measures of BIS or BAS reactivity, it cannot be inferred that the association found between the BIS Scale and explicit liking or the failure to find an association between the BAS Scale and implicit wanting are valid findings. However, the observed relationships between the BIS, BAS and the psychological rewards of wanting and liking are consistent with the theory underpinning this research, which does provide some support for the results found within these studies.

There were also limitations inherent to the design of the 600 kcal pre-load chosen for the final study and the assessment of energy intake at the ad libitum test meal. A 600 kcal pre-load was chosen, which followed the methodology of Nasser, Evans, Geliebter, Pi-sunyer and Foltin (2008). This test meal was chosen because it was reported that this energy intake had consistently induced a state of extreme fullness in obese women, varying in binge-eating disorder status. The potential limitation inherent to the 600 kcal pre-load was that it was not individually calibrated to each individual's basal energy needs and the HBIS_LBAS group was found to have a significantly higher BMI (M = 37.47 kg/m^2, SD = 7.81) than the LBIS_LBAS group (M = 31.30 kg/m^2, SD = 1.48). Although all analyses were subsequently adjusted for BMI, it is possible that the attenuated suppression of hunger and the reduced feelings of fullness in HBIS_LBAS group could be partially explained by these differences in BMI.

It is also acknowledged that the small sample size within each group of the final study, which was driven by the selection criteria, is a limitation that may affect the robustness of the reported results. Although the findings of this study are consistent with theory, which does provide some support for the results, they will need to be replicated by other researchers before any inferences can be made for females within the general community. Finally, the results in the final study are specific to a combined temperament phenotype and eating-behaviour subtype. Subsequently, these results cannot be generalised to individuals who do not possess these particular characteristics.

Another limitation of all the studies is that they did not exclude individuals with a diagnosis of anxiety and depression and only excluded individuals taking antidepressants and anxiolytics in the final study. It is acknowledged this represents a limitation, given the links between these medications and weight gain (Blumenthal, Castro, Clements, & et al., 2014) and between symptoms of anxiety, depression, eating behaviour and BMI (reviewed in sections 2.7.1 and 2.7.2). Whilst an effort was made to exclude individuals taking these medications at the start of recruitment, the candidate found she was unable to recruit an adequate number of participants, despite increasing the number of sites that were targeted for recruitment. Therefore, this exclusion criteria was relaxed, which increased subsequent recruitment within a very short time-frame. Subsequently, it could also be argued that, by not excluding these individuals, the participant gained a more realistic sample of the general overweight and obese community.

Forty-five percent or 7.3 million Australians aged 16 to 85 years have experienced a mental disorder at some time in their life (Australian Bureau of Statistics, 2008) and anxiety and depression disorders are currently considered to be one of the most commonly occurring illnesses within the community and general practice (Tiller, 2012). Alongside the prevalence of mental illness, the prevalence of overweight and obesity is also increasing in the Australian population (Australian Bureau of Statistics, 2012). Therefore, the very act of sampling overweight and obese individuals within the community will lead to the recruitment of individuals with a concurrent diagnosis of anxiety and or depression, who may or may not be taking antidepressants or anxiolytics. Furthermore, if an individual's underlying temperament is reactive and they are not able to regulate this reactivity, it is expected that they will present with a diagnosis of psychopathology or similarly experience symptoms of psychopathology (Bijttebier et al., 2009). Therefore it is reasonable to assume that a proportion of individuals seeking weight management advice will likewise present with a reactive temperament that is poorly regulated and a diagnosis of anxiety, depression, or both. Subsequently, it would be counterintuitive to exclude those individuals in the community whose temperament characteristics must be studied if doing so encourages the development of a more effective way to treat them.

7.12 HYPOTHESES ARISING FROM THIS RESEARCH

It is hypothesised that individuals possessing a HBIS_LBAS phenotype will experience a higher level of physiological and psychological arousal. By nature of their reactive BIS, they will have a lower level of effortful control, which encompasses a low level of activation control. Subsequently, whenever the BIS is activated and an individual lacks access to effective emotion regulation strategies, they will choose to manage their reactivity with a commodity that is easily obtainable, provides a suitable feeling of reward, and predictably alters their affective state, such as highly palatable food. Because of their low level of activation control, it could be misconstrued that such individuals are not first-and-foremost extrinsically motivated to change their behaviour. However, the research within this thesis suggests that their inability to change might be related primarily to a reactive BIS that is ineffectively regulated and which, subsequently, undermines their level of intrinsic motivation.

7.13 SIGNIFICANCE OF THE RESULTS

The results within this thesis have demonstrated that a reactive BIS and a low level of effortful control, and not a reactive BAS in isolation, predict eating behaviour and the psychological food rewards of implicit wanting and explicit liking. A reactive BIS phenotype was also linked to a dysregulated appetite via an attenuated capacity to be sensitive to satiety signals and an enhanced liking response, in the fed state, and energy intake. A reactive BIS is an underexplored temperament dimension in the literature that presents a model of eating behaviour and increased risk for obesity that is attributed to either high or low levels of reward that are synonymous with high or low reactivity within the BAS (Aldao et al., 2010; Appelhans, Whited, Schneider, & Pagoto, 2011; Davis, 2009; Davis & Carter, 2009; Davis & Fox, 2008; Davis & Loxton, 2014; Davis, Patte, et al., 2007; Davis, Strachan, et al., 2004; Franken & Muris, 2005; Small, 2009).

The significance of these results is that an individual with a reactive BIS, in combination with a high or a low level of BAS reactivity, may overeat for very different reasons compared to an individual who is only motivated by a high level of BAS reactivity. Subsequently, these individuals require different strategies to manage their eating behaviours. Furthermore, the HDLR eating behaviour subtype has been shown to be at risk for the highest levels of BMI (Bryant et al., 2008). Obesity levels in Australia are continuing to increase and there has been a disturbing trend whereby individuals with severe obesity are increasing disproportionately to those with mild obesity (Peeters et al., 2015; Walls et al., 2012). Moreover, Australians are concurrently struggling to manage their eating behaviour, as evidenced by their reluctance to consume the recommended five serves of vegetables per day and an inability to implement behaviours that would lead to healthier choices (Australian Bureau of Statistics, 2012; Queensland Health, 2011). Mirroring these relationships, a high level of BIS reactivity was linked to a low level of activation control and a higher total energy intake in obese individuals. Collectively, the results of this research and the literature suggest a greater understanding and management of the temperament traits in individuals at risk of the highest levels of BMI might lead to more effective management of eating behaviour and body weight in Australians.

7.14 IMPLICATIONS FOR FURTHER RESEARCH

The implications of these findings for future research are that, when an individual's level of risk for reward driven eating behaviour is considered, it must be considered holistically. As a result of individual differences in BIS or BAS reactivity and that individual's capacity to manage this reactivity, individuals may overeat for very different reasons. The results of this thesis have indicated that it might be important to concurrently consider an individual's level of BIS reactivity and their level of effortful control alongside their level of BAS reactivity. It might also be important for future researchers to consider the contribution that a reactive BIS and low effortful control makes to eating behaviours that are currently labelled as addictive. Without concurrently measuring reactivity within the BIS or an individual's level of effortful control, researchers cannot be clear why an individual might be displaying an addictive style of eating behaviour. The findings from this thesis have highlighted it cannot be assumed that, at the level of an individual's psychobiological temperament, a high level of BAS reactivity is a main driver of reward-based eating behaviour.

This thesis set out to determine whether trait eating behaviours overlap with levels of trait reactivity that are inherent to an individual's constitutional temperament. In doing so it endeavoured to make *explicit* the *implicit processes* associated with uncontrolled hedonic eating behaviours in individuals who possess a reactive temperament that is ineffectively regulated. This approach was used because it was conceptualised that individuals with a reactive temperament may not possesses the level of effortful control necessary to manage innate levels of emotional reactivity and subsequent states of arousal. Consequently, such individuals may choose to regulate these states via the consumption of high-fat foods. Therefore, it was hypothesised that such individuals would express uncontrolled hedonic eating behaviours, which have been previously linked to weight management failure and high levels of BMI.

The results of this thesis suggest that an individual’s constitutional level of emotional reactivity is synonymous with their susceptibility to express an uncontrolled and hedonic eating behaviour style. Therefore, these results offer novel insight for future research, which aims to understand why some individuals are more susceptible to uncontrolled hedonic eating behaviours, weight management difficulty and higher levels of BMI than others. An individual cannot avoid a genetic predisposition to experience frequent states of emotional reactivity. However, an individual’s capacity to regulate their reactivity can be improved with training. According to Rothbart, Sheese and Posner (2013), the construct of effortful control is synonymous with an individual’s capacity to regulate their emotional state as they override a habitual pattern of behaviour. Therefore, targeted training, aimed at strengthening effortful control could lead to an improved capacity to regulate the negative affect generated by a reactive BIS and reduce subsequent levels of eating behaviour. It remains for future research to determine whether strengthening the effortful control of overweight and obese individuals, who indulge in high-fat foods as an affect regulation strategy, leads to a reduced use of hedonic and uncontrolled eating behaviours and a reduction in weight gain.

7.15 IMPLICATIONS FOR HEALTH PROFESSIONALS

'Going on a diet' is a common short-term approach to weight management. However, for dieters with high levels of emotional and disinhibited-eating behaviour, a dieting approach may not lead to weight management success (A. Blair et al., 1990; Elfhag & Rössner, 2005; Mc Guire et al., 1999; Teixeira et al., 2010; Wing & Phelan, 2005). The studies within this thesis have demonstrated that a lower level of effortful control or a reactive BIS and a lower level of effortful control predict emotional and disinhibited-eating behaviour, respectively. Moreover, within these studies, a reactive BIS, lower levels of effortful control, and associated emotion-regulation difficulties were also linked to a dysregulated appetite, which appears to be linked to the habitual intake of highly palatable foods, as an affect-regulation strategy. Therefore, it would seem reasonable to suggest that dieters with high levels of emotional or disinhibited-eating behaviour, may struggle to achieve weight management success as a result of a reactive and unregulated BIS temperament.

Further interpretation of the results appears to indicate that, in order to achieve success at weight management, the dieter must be taught effective emotion-regulation strategies. Otherwise, as supported by the results from this research and the literature, any weight loss may lead to eventual regain (Tryon et al., 2013).

The results from this study suggest that a weight management program, which takes into consideration the dieter’s level of BIS reactivity and their concurrent level of effortful control, is likely to lead to more successful weight management outcomes in individuals with high levels of emotional and disinhibited-eating behaviour. However, the current temperament-based literature has not considered the action of the BIS on eating behaviour. Instead it has focussed on a model of eating behaviour that is driven by a high level of BAS reactivity. Therefore, health professionals who assist individuals to manage their weight need to be educated about these alternative psychobiological temperament constructs, which are proposed to lead to the hard-wiring of habitual behaviours that are extremely difficult to change. Furthermore, the development of educational programs could also be of benefit. For example, as highlighted by Deary and Johnson (2009), it would be more helpful for the participant of a weight-loss program to understand that they had lost control over their eating behaviour because their 'BIS”' had taken the upper hand, as opposed to their thinking they were hopeless or helpless to control their eating behaviour. For example, an unsuccessful dieter who believes they are 'addicted' as a result of these seemingly recalcitrant, habitual behaviours may believe they are helpless to change their eating behaviour or their body weight. However, an unsuccessful dieter who is educated to understand that they have a reactive BIS, which can be regulated, might be more likely to remain an active participant in their weight management program.

In order for the high BIS dieter to gain control over their eating behaviours, they require strategies that improve their ability to regulate their underlying level of BIS reactivity. Therefore, they will need to learn how to effectively regulate their emotions, including strategies that assist them to strengthen their level of effortful control. The executive function of effortful control can be trained through attention network training and mindfulness meditation practices, which train the executive attention network (Posner, Rothbart, & Tang, 2015; Tang & Posner, 2014). Mindfulness training has been described as “a form of meditation that keeps attention focussed on the current moment” (Posner et al., 2015, p. 1). It is a form of executive function training that is gaining support as an effective emotion regulatory practice in individuals with anxiety and depressive disorders (Hofmann, Sawyer, Witt, & Oh, 2010). It is also gaining empirical support as an effective method for the short-term treatment of emotional, external and binge-eating behaviours in adults (Mantzios & Wilson, 2015; O'Reilly, Cook, Spruijt-Metz, & Black, 2014). Therefore, the delivery of a weight management program that considers a dieter's temperament phenotype and, additionally, incorporates a mindfulness-based meditation intervention may improve weight management outcomes in dieters with high levels of emotional and disinhibited-eating behaviour.

7.16 ORIGINAL CONTRIBUTION OF THE THESIS TO THE BODY OF KNOWLEDGE

The results of this thesis extend the current literature by showing that high levels of BIS reactivity and low levels of effortful control are linked to disinhibited and binge eating behaviour, the psychological rewards of wanting and liking, an attenuated satiety response and the consumption of high-fat snack foods. Enhanced levels of wanting and liking are capable of overriding satiety signals and within the literature it has been construed that an individual's level of BAS reactivity is linked to their motivation to over-consume high-fat sweet foods**.** However, an inability to feel satiated and the consumption of high-fat sweet foods have also been linked to the experience of negative emotional states that have been associated with BIS reactivity. As shown in Figure 7.1, individuals with a reactive and poorly regulated BIS could also be sensitised to the rewarding properties of high-fat foods, and further, they might experience difficulty restraining their intake due to an attenuated satiety response. Thus, it is feasible that an overweight or obese individual may be at risk of uncontrolled eating behaviour if they possess a reactive BIS and a low level of effortful control.

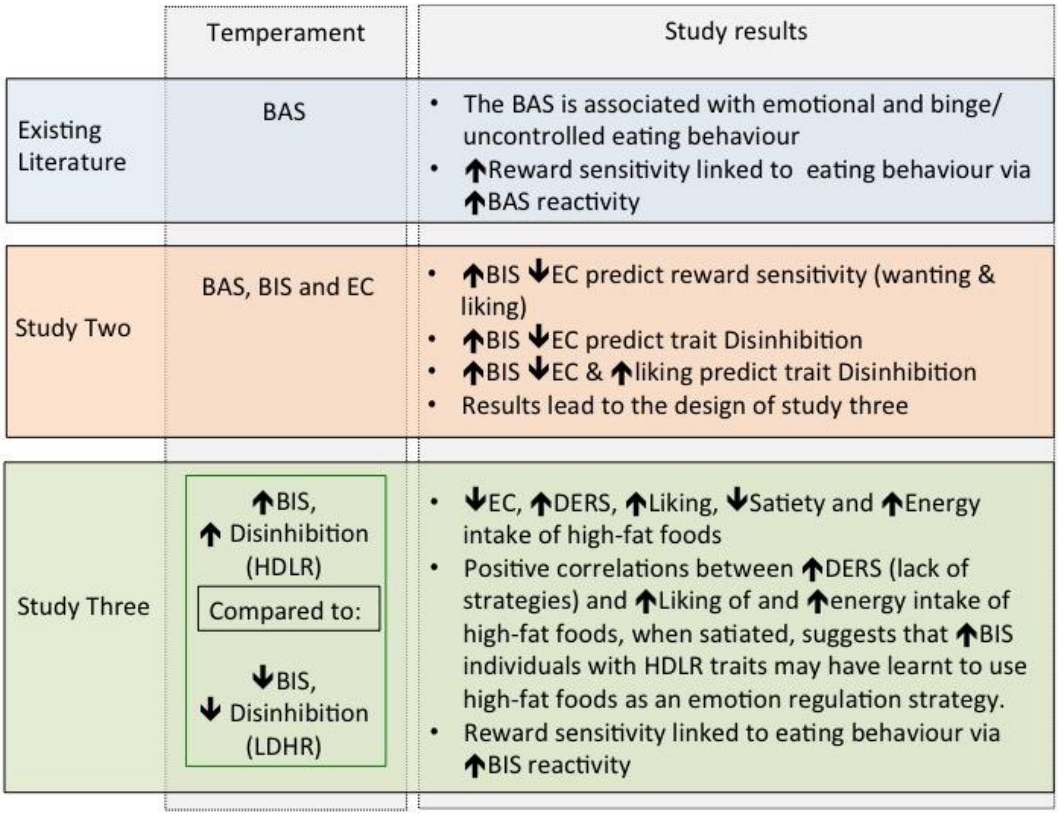


Figure 7.1. The results of this thesis extend the current literature

When compared to the existing literature, the results of studies two and three show that individuals with high levels of BIS reactivity and low levels of effortful control may also be sensitised to the rewarding properties of food and exhibit a disinhibited eating behaviour style. Informatively, the results of study three show that high BIS individuals with an uncontrolled eating behavioural style (HDLR) have a lower level of effortful control and subsequently greater difficulty regulating emotion, when compared to low BIS individuals with a more restrained eating behavioural style (LDHR). High BIS individuals also showed enhanced liking for high-fat foods, an attenuated capacity to detect satiety signals and greater intake of high-fat snack foods, when satiated, which appears to be linked to a lack of strategies to regulate emotion. Therefore, individuals with a reactive BIS and a low level of effortful control may be at risk of uncontrolled eating behaviour and subsequent obesity as a result of their inability to regulate their emotions and their associated sensitivity to the rewarding properties of high-fat foods.

This thesis has contributed to the body of knowledge in a number of novel and informative ways. Firstly, it has introduced the importance of considering a reactive and unregulated BIS alongside an individual's level of BAS reactivity, when characterising individuals as being at risk of reward-driven eating behaviour. Secondly, it has contributed to the characterisation of the low-satiety phenotype by demonstrating that an attenuated capacity to be sensitive to satiety signals is linked to reactivity within the BIS. In doing so, it has also highlighted an important link between reactivity within the BIS and an attenuated satiety response in disinhibited-eating behaviour and a lack of interoceptive awareness in individuals who display emotional and external-eating behaviours. Thirdly, it has also added to the appetite regulation, temperament and eating-behaviour literature in a number of novel ways by linking a reactive temperament phenotype and associated emotion regulation difficulties to the psychological rewards of wanting and liking. Specifically, this research linked reactivity within the BIS to implicit wanting and explicit liking, a low level of effortful control to implicit wanting, and emotion regulation difficulties to explicit liking. In doing so, it has highlighted previously obscure relationships between trait-eating behavior and eating to regulate affect, and between trait-eating behaviour and an individual's underlying psychobiological temperament.

Appendix A: Experimental Measures

A1. Demographic Questionnaire (Chapters 4 – 6)

Please answer the following questions by marking the box that applies.

1. Date of Birth____________________________

2. Gender

☐ Male ☐ Female

3. Marital Status:

What is your present marital status?

☐ Never married

☐ Widowed

☐ Divorced

☐ Separated but not divorced

☐ Married (married or living together)

4. Indigenous Status:

Are you of Aboriginal, Torres Strait Islander, or South Sea Islander origin (choose 1 or more options)?

☐ No

☐ Yes, Aboriginal

☐ Yes, Torres Strait Islander

☐ Yes, South Sea Islander ☐ Not stated

5. Educational Attainment:

What is the highest level of education you have completed?

☐ Post-school degree or higher

☐ Post-school diploma or advanced diploma

☐ Post-school certificate

☐ Year 12 or equivalent ☐ Year 11 or equivalent ☐ Year 10 or equivalent

☐ Year 9 or equivalent

☐ Year 8 or equivalent

☐ Year 7 or below

☐ Did not go to school

☐ Other (please specify)____

6. Employment status:

What is your current employment status?

☐ Not employed - Full time student **(Go to Question 8, home ownership)**

☐ Not employed - unable to work due to sickness or disability **(Go to question 8, home ownership)**

☐ Not employed - looking after family **(Go to Question 8, home ownership)**

☐ Retired **(Go to Question 8, home ownership)**

☐ Looking for work **(Go to Question 8, home ownership)**

☐ Employed - full time (35 hours or more per week)

☐ Employed - part time (less than 35 hours per week)

☐ Other (please state)____

7. Occupation:

In your most recent main job what is your occupation?

Please state the full title

____

What are the main tasks that you usually perform in this occupation?

Please describe____

8. Home ownership:

Do you own the place where you usually live (including caravan, houseboat, manufactured home)?

☐ Yes, own outright

☐ Yes, own with a mortgage

☐ No, rent

☐ Other – please specify, for example, purchasing under a rent/buy scheme, occupied rent free, occupied under a life tenure scheme

____

9. Physical activity:

Do you engage in physical activity?

☐ Yes ☐ No

At what level of intensity do you exercise?

☐ Low ☐ Moderate ☐ Hard

How long do you exercise for?

☐ < 30mins ☐ 30 – 45 mins ☐ 46 - 60mins
☐ > 60 mins

How many times per week do you exercise?

☐ 1 x week ☐ 2 x week ☐ 3 x week ☐ 4 x week

☐ 5 x week ☐ > 5 x week

10. How many alcoholic beverages do you consume per week?

☐ 0 ☐ 1-5 ☐ 6-10 ☐ 11- 20 ☐ 21 – 30 ☐ > 30

11. Do you smoke

☐ Yes ☐ No

What size packet do you buy?

☐ 20 pack ☐ 25 pack ☐ 30 pack ☐ 40 pack ☐ 50 pack

How many packets do you smoke per week?

☐ < 7 ☐ 7-14 ☐ 15 - 21 ☐ > 21

12.Could you please list your health conditions below:

A 2. Diet History Questionnaire (Chapters 4 – 6)

Please answer by placing an X or writing on the lines below:

Are you currently dieting?

YES____ NO____

If yes, how much weight have you lost so far?

0 – 5Kgs____ 6 – 10Kgs_____ 11 – 15Kgs_____ 16 – 20Kgs____

20+Kgs_____

What diet are you currently following?

____

Approximately how times have you attempted to lose weight ?

0-5_____ 6-10_____ 11+_____

Please list the weight-loss programs that you have attended in the past.

____

____

____

How successful do you feel that you have been with your weight loss in general

1. Very______2. Somewhat_____ 3. Not very______ 4. Failed_______

5. I have not tried to lose weight_______

A3. BIS/BAS Scales (Carver & White, 1994) (Chapters 4 – 6)

Response options: Very true for me, Somewhat true for me, Somewhat false for me, Very false for me

1. A person's family is the most important thing in life.

2. Even if something bad is about to happen to me, I rarely experience fear or nervousness.

3. I go out of my way to get things I want.

4. When I'm doing well at something I love to keep at it.

5. I'm always willing to try something new if I think it will be fun.

6. How I dress is important to me.

7. When I get something I want, I feel excited and energized.

8. Criticism or scolding hurts me quite a bit.

9. When I want something I usually go all-out to get it.

10. I will often do things for no other reason than that they might be fun.

11. It's hard for me to find the time to do things such as get a haircut.

12. If I see a chance to get something I want I move on it right away.

13. I feel pretty worried or upset when I think or know somebody is angry at me.

14. When I see an opportunity for something I like I get excited right away.

15. I often act on the spur of the moment.

16. If I think something unpleasant is going to happen I usually get pretty "worked up."

17. I often wonder why people act the way they do.

18. When good things happen to me, it affects me strongly.

19. I feel worried when I think I have done poorly at something important.

20. I crave excitement and new sensations.

21. When I go after something I use a "no holds barred" approach.
22. I have very few fears compared to my friends.
23. It would excite me to win a contest.
24. I worry about making mistakes.

A4. Effortful Control Scale – short form (Evans & Rothbart 1994) (Chapters 4 – 6)

Response options: Extremely untrue of you, quite untrue of you, slightly untrue of you, neither true nor false of you, slightly true of you, quite true of you, extremely true of you, X.

1. I am often late for appointments.
2. It's often hard for me to alternate between two different tasks.
3. I often make plans that I do not follow through with.
4. Even when I feel energized, I can usually sit still without much trouble if it's necessary.
5. I can keep performing a task even when I would rather not do it.
6. It is easy for me to hold back my laughter in a situation when laughter wouldn't be appropriate.
7. I can make myself work on a difficult task even when I don't feel like trying.
8. When I am trying to focus my attention, I am easily distracted.
9. When interrupted or distracted, I usually can easily shift my attention back to whatever I was doing before.
10. It is very hard for me to focus my attention when I am distressed.
11. I can easily resist talking out of turn, even when I'm excited and want to express an idea.
12. If I think of something that needs to be done, I usually get right to work on it.
13. When I am happy and excited about an upcoming event, I have a hard time focusing my attention on tasks that require concentration.
14. I often have trouble resisting my cravings for food drink, etc.
15. I usually finish doing things before they are actually due (for example, paying bills, finishing homework, etc.).
16. When I'm excited about something, it's usually hard for me to resist jumping right into it before I've considered the possible consequences.
17. When I see an attractive item in a store, it's usually very hard for me to resist buying it.

18. When I am afraid of how a situation might turn out, I usually avoid dealing with it.
19. It is easy for me to inhibit fun behaviour that would be inappropriate.

A5. Difficulties in Emotion Regulation Scale (Gratz & Roemer, 2004)

(Chapters 4 – 6)

Response options: Almost never, Sometimes, About half the time, Most of the time, Almost always

1. I am clear about my feelings.
2. I pay attention to how I feel.
3. I experience my emotions as overwhelming and out of control.
4. I have no idea how I am feeling.
5. I have difficulty making sense out of my feelings.
6. I am attentive to my feelings.
7. I know exactly how I am feeling.
8. I care about what I am feeling.
9. I am confused about how I feel.
10. When I'm upset, I acknowledge my emotions.
11. When I'm upset, I become angry with myself for feeling that way.
12. When I'm upset, I become embarrassed for feeling that way.
13. When I'm upset, I have difficulty getting work done.
14. When I'm upset, I become out of control.
15. When I'm upset, I believe that I will remain that way for a long time.
16. When I'm upset, I believe that I will end up feeling very depressed.
17. When I'm upset, I believe that my feelings are valid and important.
18. When I'm upset, I have difficulty focusing on other things.
19. When I'm upset, I feel out of control.
20. When I'm upset, I can still get things done.
21. When I'm upset, I feel ashamed at myself for feeling that way.

22. When I’m upset, I know that I can find a way to eventually feel better.

23. When I’m upset, I feel like I am weak.

24. When I’m upset, I feel like I can remain in control of my behaviours.

25. When I’m upset, I feel guilty for feeling that way.

26. When I’m upset, I have difficulty concentrating.

27. When I’m upset, I have difficulty controlling my behaviours.

28. When I’m upset, I believe there is nothing I can do to make myself feel better.

29. When I’m upset, I become irritated at myself for feeling that way.

30. When I’m upset, I start to feel very bad about myself.

31. When I’m upset, I believe that wallowing in it is all I can do.

32. When I’m upset, I lose control over my behaviour.

33. When I’m upset, I have difficulty thinking about anything else.

34. When I’m upset I take time to figure out what I’m really feeling.

35. When I’m upset, it takes me a long time to feel better.

36. When I’m upset, my emotions feel overwhelming.

A6. STAI-Trait Scale (Spielberger, Gorsuch, Jacobs, Luschene & Vagg, 1977) (Chapters 4 – 5)

Response options: Almost never, Sometimes, Often, Almost always

1. I feel pleasant
2. I feel nervous and restless
3. I feel satisfied with myself
4. I wish I could be as happy as others seem to be
5. I feel like a failure

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Instrument: ***State-Trait Anxiety Inventory for Adults***

Authors: ***Charles D. Spielberger, in collaboration with R.L. Gorsuch, G.A. Jacobs, R. Lushene, and P.R. Vagg***

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for his/her thesis research.

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The entire instrument may not be included or reproduced at any time in any other published material.

Sincerely,

Robert Most
Mind Garden, Inc.
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A7. Binge Eating Scale (Gormally, Black, Daston & Rardin, 1982) (Chapters 4 & 6)

Instructions. Below are groups of numbered statements. Read all of the statements in each group and mark on this sheet the one that best describes the way you feel about the problems you have controlling your eating behaviour.

(1)

1. I don't feel self-conscious about my weight or body size when I'm with others.
2. I feel concerned about how I look to others, but it normally does not make me feel disappointed with myself.
3. I do get self-conscious about my appearance and weight, which makes me feel disappointed in myself.
4. I feel very self-conscious about my weight and frequently; I feel intense shame and disgust for myself. I try to avoid social contacts because of my self-consciousness.

(2)

1. I don't have any difficulty eating slowly in the proper manner.
2. Although I seem to 'gobble down' foods, I don't end up feeling stuffed because of eating too much.
3. At times, I tend to eat quickly and then, I feel uncomfortably full afterwards.
4. I have the habit of bolting down my food, without really chewing it. When this happens I usually feel uncomfortably stuffed because I've eaten too much

(3)

1. I feel capable to control my eating urges when I want to.
2. I feel like I have failed to control my eating more than the average person.

3. I feel utterly helpless when it comes to feeling in control of my eating urges.
4. Because I feel so helpless about controlling my eating I have become very desperate about trying to get in control.

(4)

1. I don’t have the habit of eating when I’m bored.
2. I sometimes eat when I’m bored, but often I’m able to “get busy” and get my mind off food.
3. I have a regular habit of eating when I’m bored, but occasionally, I can use some other activity to get my mind off eating.
4. I have a strong habit of eating when I’m bored. Nothing seems to hlp me break the habit.

(5)

1. I’m usually physically hungry when I eat something.
2. Occasionally, I eat something on impulse even though I really am not hungry
3. I have the regular habit of eating foods that I might not really enjoy, to satisfy a hungry feeling even though physically, I don’t need the food.
4. Even though I’m not physically hungry, I get a hungry feeling in my mouth that only seems to be satisfied when I eat a food, like a sandwich, that fills my mouth. Sometimes, when I eat the food to satisfy my hunger, I then spit the food out so I won’t gain weight.

(6)

1. I don’t feel any guilt or self-hate after I overeat.
2. After I overeat, occasionally I feel guilt or self-hate.
3. Almost all the time I experience strong guilt or self-hate after I overeat.

(7)

1. I don’t lose total control of my eating when dieting even after periods when I overeat.

2. Sometimes when I eat a ‘forbidden food’ on a diet, I feel like I ‘blew it’ and eat even more.
3. Frequently, I have the habit of saying to myself “I’ve blown it not, why not go all the way” when I overeat on a diet. When that happens I eat even more.
4. I have a regular habit of starting strict diets for myself, but I break the diets by going on an eating binge. My life seems to be either a ‘feast or ‘famine.’

(8)

1. I rarely eat so much food that I feel uncomfortably stuffed afterwards.
2. Usually about once a month, I eat such a quantity of food; I end up feeling very stuffed.
3. I have regular periods during the month when I eat large amounts of food, either at mealtime of at snacks.
4. I eat so much food that I regularly feel quite uncomfortable after eating and sometimes a bit nauseous.

(9)

1. My level of calorie intake does not go up very high or go down very low on a regular basis.
2. Sometimes after I overeat, I will try to reduce my calorie intake to almost nothing to compensate for the excess calories I’ve eaten.
3. I have a regular habit of overeating during the night. It seems that my routine is not to be hungry in the morning but overeat in the evening.
4. In my adult years, I have had weeklong periods where I practically starve myself. This follows periods when I overeat. It seems I live a life of either ‘feast or famine.’

(10)

1. I usually am able to stop eating when I want to. I know when ‘enough is enough.’

2. Every so often, I experience a compulsion to eat which I can't seem to control.
3. Frequently, I experience strong urges to eat which I seem unable to control, but at other times I can control my eating urges.
4. I feel incapable of controlling urges to eat. I have a fear of not being able to stop eating voluntarily.

(11)

1. Don't have any problem stopping eating when I feel full.
2. I usually can stop eating when I feel full but occasionally overeat leaving me feeling uncomfortably stuffed.
3. I have a problem stopping once I start and usually I feel uncomfortably stuffed after a meal.
4. Because I have a problem not being able to stop eating when I want, I sometimes have to induce vomiting to relieve my stuffed feeling.

(12)

1. I seem to eat just as much when I'm with others (family, social gatherings) as when I'm by myself.
2. Sometimes, when I'm with other persons, I don't eat as much as I want to eat because I'm self-conscious about my eating.
3. Frequently, I eat only a small amount of food when others are present, because I'm very embarrassed about my eating.
4. I feel so ashamed about overeating that I pick times to overeat when I know no one will see me. I feel like a 'closet eater.'

(13)

1. I eat three meals a day with only an occasional between-meal snack.
2. I eat three meals a day, but I normally snack between meals.
3. When I am snacking heavily, I get in the habit of skipping regular meals.

4. There are regular periods when I seem to be continually eating, with no planned meals.

(14)

1. I don't think much about trying to control unwanted eating urges
2. At least some of the time, I fell my thoughts are pre-occupied with trying to control my eating urges.
3. I feel that frequently I spend much time thinking about how much I ate or about trying not to eat anymore.
4. It seems to me that most of my waking hours are pre-occupied by thoughts about eating *or* not eating. I fell like I'm constantly struggling not to eat.

(15)

1. I don't think about food a great deal
2. I have strong cravings for food but they last only for brief periods of time.
3. I have days when I can't seem to think about anything else but food.
4. Most of my days seem to be pre-occupied with thoughts about food. I feel like I live to eat.

(16)

1. I usually know whether or not I'm physically hungry. I take the right portion of food to satisfy me.
2. Occasionally, I feel uncertain about knowing whether or not I'm physically hungry. At these times it's hard to know how much food I should take to satisfy me.
3. Even though I might know how many calories I should ear, I don't have any idea what is a 'normal' amount of food for me.

A8. Three Factor Eating Questionnaire: Disinhibition Scale (Stunkard & Messick, 1985) (Chapters 5 & 6)

Response options: True, False

1. When I smell a sizzling steak or see a juicy piece of meat, I find it very difficult to keep from eating, even if I have just finished a meal.
2. I usually eat too much at social occasions, like parties and picnics.
3. Sometimes things just taste so good that I keep on eating even when I am no longer hungry.
4. When I feel anxious, I find myself eating.
5. Since my weight goes up and down, I have gone on reducing diets more than
6. Once.
7. When I am with someone who is overeating, I usually overeat too.
8. Sometimes when I start eating, I just can't seem to stop.
9. It is not difficult for me to leave something on my plate.
10. When I feel blue, I often overeat.
11. My weight has hardly changed at all in the last ten years.
12. When I feel lonely, I console myself by eating.
13. Without even thinking about it, I take a long time to eat.
14. While on a diet, if I eat a food that is not allowed, I often then splurge and eat other high calorie foods.
15. Do you eat sensibly in front of others and splurge alone? (Response options: Never, Rarely, Often, Always)
16. Do you go on eating binges though you are not hungry? (Response options: Never, Rarely, Sometimes, At least once a week)

17. To what extent does this statement describe your eating behaviour? ‘I start dieting in the morning, but because of any number of things that happen during the day, by evening I have given up and eat what I want, promising myself to start dieting again tomorrow.’ (Response options: Not like me, Little like me, Pretty good description of me, Describes me perfectly)

A9. Three Factor Eating Questionnaire: Restraint Scale (Stunkard & Messick, 1985) (Chapters 5 & 6)

Response options: True, False

1. When I have eaten my quota of calories, I am usually good about not eating any more.
2. I deliberately take small helpings as a means of controlling my weight.
3. Life is too short to worry about dieting.
4. I have a pretty good idea of the number of calories in common food.
5. While on a diet, if I eat food that is not allowed, I consciously eat less for a period of time to make up for it.
6. I enjoy eating too much to spoil it by counting calories or watching my weight.
7. I often stop eating when I am not really full as a conscious means of limiting the amount that I eat.
8. I consciously hold back at meals in order not to gain weight.
9. I eat anything I want, any time I want.
10. I count calories as a conscious means of controlling my weight.
11. I do not eat some foods because they make me fat.
12. I pay a great deal of attention to changes in my figure.
13. How often are you dieting in a conscious effort to control your weight? (Response options: Rarely, Sometimes, Usually, Always)
14. Would a weight fluctuation of 5 lbs (2 kg) affect the way you live your life? (Response options: Not al all, Slightly, Moderately, Very much)
15. Do your feelings of guilt about overeating help you to control your food intake? (Response options: Never, Rarely, Often, Always)
16. How conscious are you of what you are eating? (Response options: Not at all, Slightly, Moderately, Extremely)

17. How frequently do you avoid ‘stocking up’ on tempting foods? (Response options: Almost never, Seldom, Usually, Almost never)
18. How likely are you to shop for low calorie foods? (Response options: Unlikely, Slightly unlikely, Moderately likely, Very likely)
19. How likely are you to consciously eat slowly in order to cut down on how much you eat? (Response options: Unlikely, Slightly unlikely, Moderately likely, Very likely)
20. How likely are you to consciously eat less than you want? (Response options: Unlikely, Slightly likely, Moderately likely, Very unlikely)
21. On a scale of 0 to 5, where 0 means no restraint in eating (eating whatever you want, whenever you want it) and 5 means total restraint (constantly limiting food intake and never ‘giving in’), what number would you give yourself?

(0) Eat whatever you want, whenever you want it

(1) Usually eat whatever you want, whenever you want it

(2) Often eat whatever you want, whenever you want it

(3) Often limit food intake, but often “give in”

(4) Usually limit food intake, rarely “give in”

(5) Constantly limiting food intake, never “giving in”

A10. Dutch Eating Behaviour Questionnaire: Emotional Eating Scale (van Strien et al., 1986) (Chapter 1)

Response options: Never, Rarely, Sometimes, Often, Very Often

1. Do you have the desire to eat when you are irritated?
2. Do you have the desire to eat when you have nothing to do?
3. Do you have the desire to eat when you are depressed or discouraged?
4. Do you have the desire to eat when you are feeling lonely?
5. Do you have a desire to eat when somebody lets you down?
6. Do you have a desire to eat when you are cross?
7. Do you have a desire to eat when you are approaching something unpleasant to happen?
8. Do you get the desire to eat when you are anxious, worried or tense?
9. Do you have a desire to eat when things are going against you or when things have gone wrong?
10. Do you have a desire to eat when you are frightened?
11. Do you have a desire to eat when you are disappointed?
12. Do you have a desire to eat when you are emotionally upset?
13. Do you have a desire to eat when you are bored or restless?

A11. Dutch Eating Behaviour Questionnaire: External Eating Scale (van Strien et al., 1986) (Chapter 1)

Response options: Never, Rarely, Sometimes, Often, Very Often

1. If food tastes good, do you eat more then usual?
2. If food smells and looks good, do you eat more than usual?
3. If you see or smell something delicious, do you have a desire to eat it?
4. If you have something delicious to eat, do you eat it straight away?
5. If you walk past the baker do you have the desire to buy something delicious?
6. If you walk past a snack bar or a café do you have the desire to buy something delicious?
7. If you see others eating do you also have the desire to eat?
8. Can you resist eating delicious foods?
9. Do you eat more than usual, when you see others eating?
10. When preparing a meal are you inclined to eat something?

A12. Perceived Stress Scale (S. Cohen, Karmack & Mermelstein, 1983) (Chapter 1)

Response options: Never, Almost never, Sometimes, Fairly often, Very Often

1. In the last month, how often have you been upset because of something that happened unexpectedly?
2. In the last month, how often have you felt that you were unable to control the important things in your life?
3. In the last month, how often have you felt nervous and “stressed”?
4. In the last month, how often have you felt confident about your ability to handle your personal problems?
5. In the last month, how often have you felt that things were going your way?
6. In the last month, how often have you found that you could not cope with all the things that you had to do?
7. In the last month, how often have you been able to control irritations in your life?
8. In the last month, how often have you felt that you were on top of things?
9. In the last month, how often have you been angered because of things that were outside of your control?
10. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?

A13. The brief Positive and Negative Affect Schedule (Watson & Clark, 1998) (Chapter 1)

Response Options: (Very slightly or not at all, A little, Moderately, Quite a bit, Extremely)

1. Interested
2. Distressed
3. Excited
4. Upset
5. Strong
6. Guilty
7. Scared
8. Hostile
9. Enthusiastic
10. Proud
11. Irritable
12. Alert
13. Ashamed
14. Inspired
15. Nervous
16. Determined
17. Attentive
18. Jittery
19. Active
20. Afraid

A14. The UPPS Impulsive Behaviour Scale: Urgency subscale (S. Whiteside & Lynam, 2001) (Chapter 1)

Response Options: (Agree strongly, Agree some, Disagree some, Disagree strongly)

1. I have trouble controlling my impulses.
2. I have trouble resisting my cravings (for food, cigarettes, etc.).
3. I often get involved in things I later wish I could get out of.
4. When I feel bad, I will often do things I later regret in order to make myself feel better now.
5. Sometimes when I feel bad, I can’t seem to stop what I am doing even though it is making me feel worse.
6. When I am upset I often act without thinking.
7. When I feel rejected, I will often say things that I later regret.
8. It is hard for me to resist acting on my feelings.
9. I often make matters worse because I act without thinking when I am upset.
10. In the heat of an argument, I will often say things that I later regret.
11. I always keep my feelings under control.
12. Sometimes I do impulsive things that I later regret.

A15. Visual Analogue Scales (VAS) Appetite: Instructions for participants

Please answer the following questions by placing a vertical mark through the line on the scale

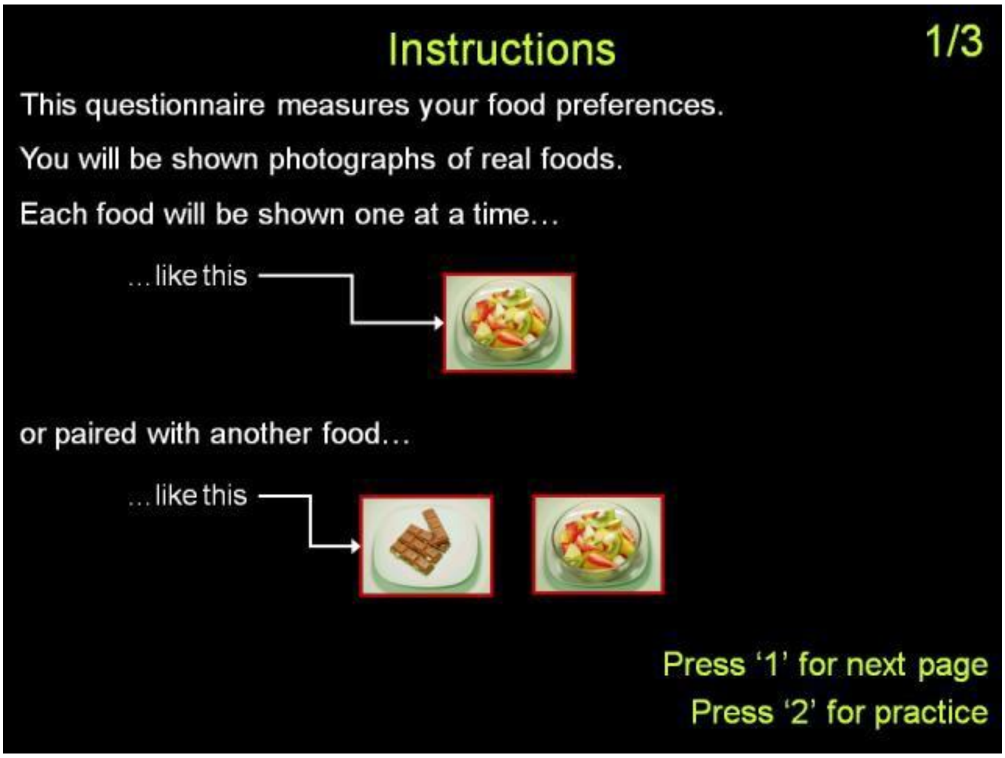
How hungry do you feel right now?

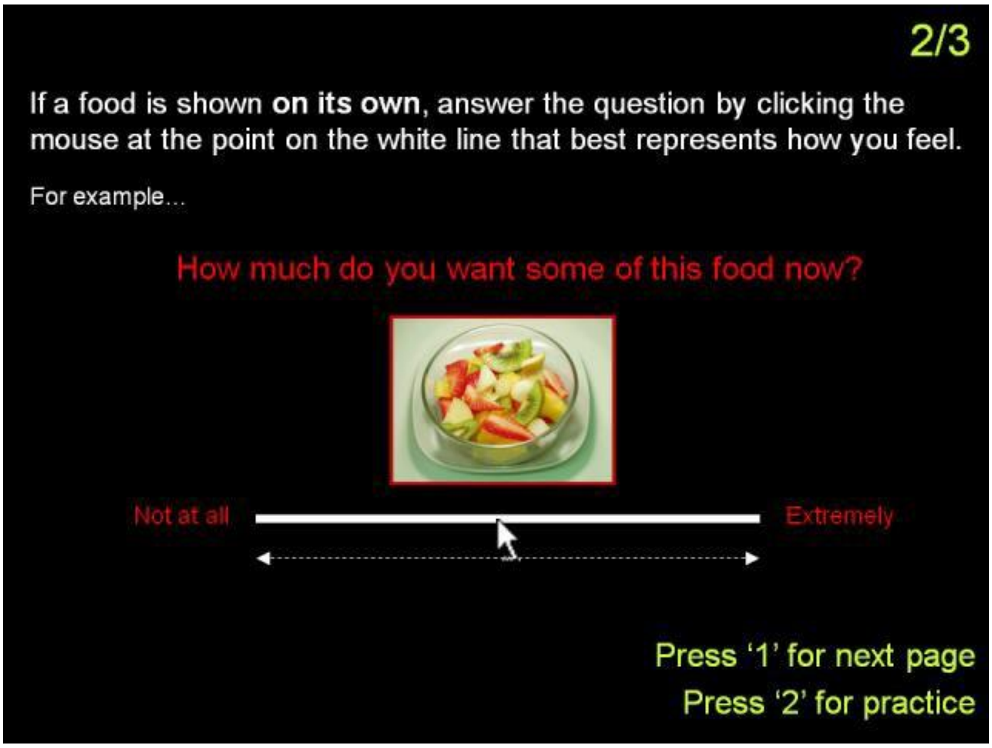
Not at all ____ Extremely

How full do you feel right now?

Not at all ____ Extremely

A16. Leeds Food Preference Questionnaire (Finlayson, King & Blundell, 2007): Instructions for participants





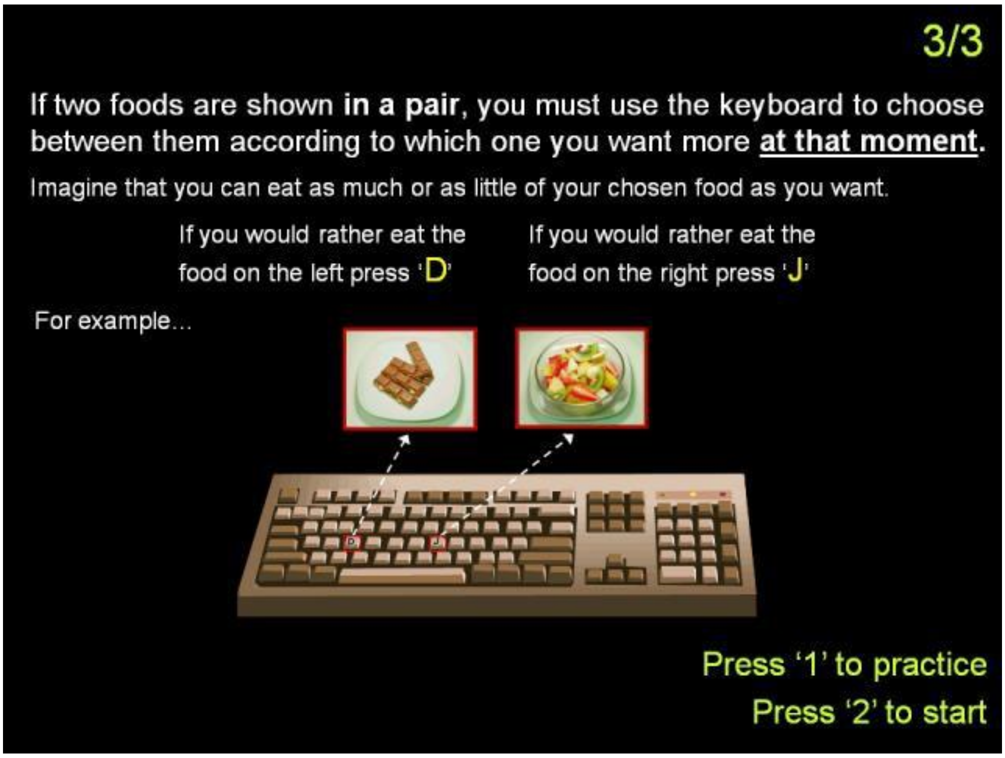
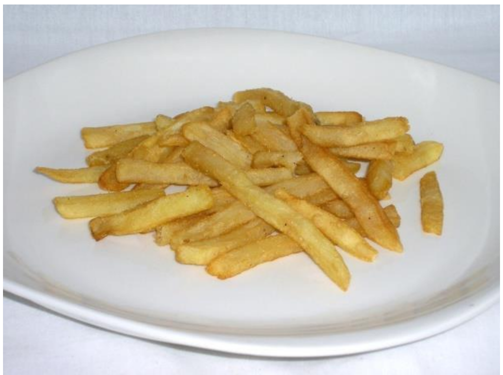


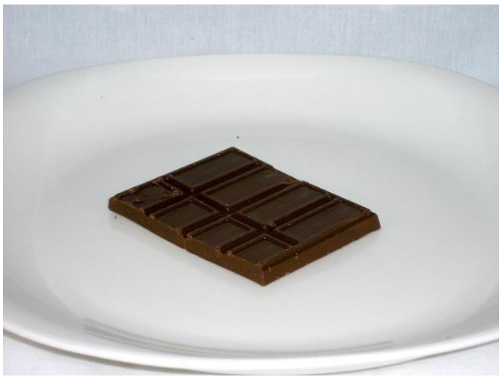
Figure A.1. Leeds Food Preference Questionnaire (LFPQ) screenshot of participant instructions.

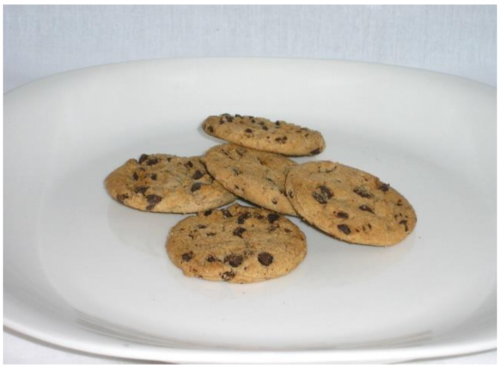
Appendix B: Leeds Food Preference Questionnaire Photographic Stimuli

B1. Category: High-fat savoury (HFSA)

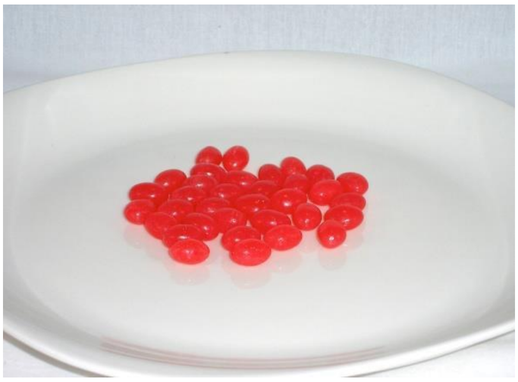



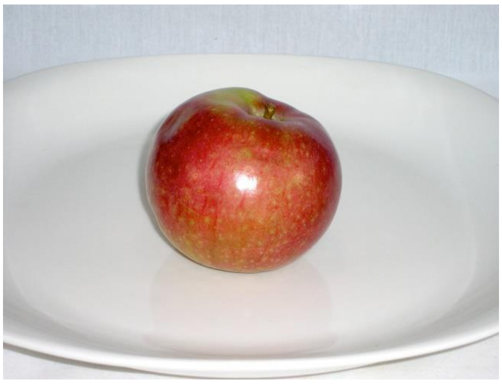
B2. Category: High-fat sweet (HFSW)

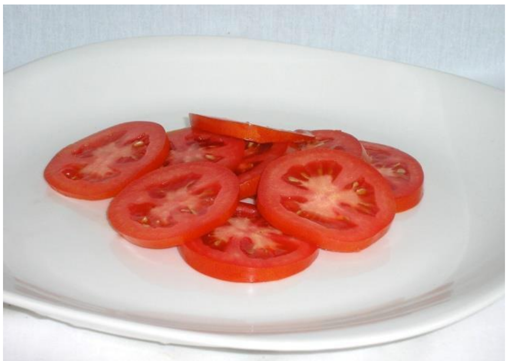


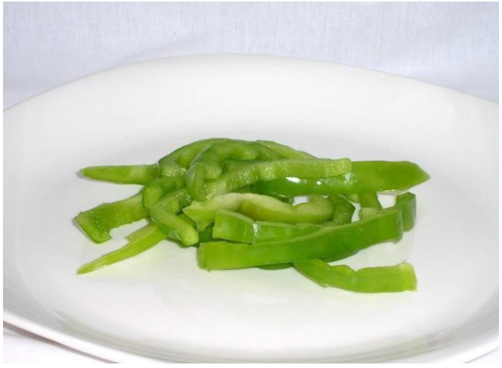
B3. Category: Low-fat sweet (LFSW)





B4. Category: Low-fat savoury (LFSA)



Appendix C: Data and Supplementary Analyses from Chapter 1

Table C.1

Mean Gender Differences in External Eating, Effortful Control, Behavioural Activation System and Urgency Subscale Scores

	Females *n* = 81		Males *n* = 57				
Variable	*M*	*SD*	*M*	*SD*	*df*	*t*	*p*
DEBQ-Ext	2.89	0.60	2.85	0.58	136	-0.47	.640
EC-T	88.25	13.21	88.44	14.53	136	.081	.936
BAS	38.35	5.40	39.88	5.61	136	1.62	.109
UPPS-U	2.33	0.53	2.33	0.61	136	0.06	.956

DEBQ-Ext: Dutch Eating Behaviour Questionnaire External Eating Scale; EC-T: Effortful Control Total Scale; Behavioural Activation Scale; UPPS-U: UPPS Urgency subscale

Table C.2

Gender Differences in Level of BMI and Difficulty in Regulating Emotion, a Comparison of Median Scores

	Female *n* = 81	Male *n* = 57			
Variable	*Mdn (IQR)*	*Mdn (IQR)*	*U*	*Z*	*p*
BMI	27.27 (23.37-35.87)	27.74 (25.60 – 32.37)	2264.00	-0.19	.847
DERS-T	74.00 (62.50-94.00)	70 .00 (61.00 – 87.50)	2023.00	-1.23	.217

DERS-Total: Difficulties in Emotion Regulation Total Scale

Table C.3

One-Way Analysis of Variance for the Effects of the Independent Variables on BMI Category

Variable & Source	*SS*	*MS*	*F* (2, 135)	*p*	η^2
DEBQ-Em			8.19	.000	
Between	15.10	7.55			.11
Within	124.36	0.92			
DEBQ-Ext			3.67	.027	
Between	2.50	1.25			.05
Within	45.59	0.34			
STAI-T			1.62	.201	
Between	386.75	193.38			.02
Within	16076.41	119.09			
DERS-Total			.79	.458	
Between	764.18	382.09			.01
Within	65710.23	486.74			
DERS-Goals			.975	.380	
Between	33.34	16.67			.01
Within	2308.26	17.10			
EC-Total			2.53	.084	
Between	930.31	465.15			.04
Within	24858.02	184.13			
BIS			.75	.476	
Between	17.58	8.79			.01
Within	1591.07	11.79			
BAS			0.33	.718	
Between	20.37	10.18			.00
Within	4148.57	30.73			
UPPS-Urg			4.19	.017	
Between	2.56	1.28			.06
Within	41.2	0.31			

DEBQ-Em: Dutch Eating Behaviour Questionnaire Emotional Eating Scale, DEBQ-Ext: Dutch Eating Behaviour Questionnaire External Eating Scale, STAI-T: State Trait Anxiety Inventory Trait Anxiety Scale, DERS-Total: Difficulties in Emotion Regulation Total Scale, EC-T: Effortful Control Total Scale BIS: Behavioural Inhibition System, BAS: Behavioural Activation System, UPPS-U: UPPS Urgency subscale

C1. BIS_BAS phenotype stratified by gender and BMI cateogry

Methodology

In order to ascertain whether a difference existed in the proportion of BIS-BAS phenotypes across the BMI categories and between genders, the sample was divided into four BIS-BAS groups and then again into gender based on a median split of BIS, BAS scores. Median splits for the total sample were based upon the following levels of each BIS and BAS dimension, across the sample: low BIS: 12 to 21, high BIS: 22 to 27, low BAS: 24 to 39 and high BAS: 40 to 52.

Four BIS_BAS groups (phenotypes) were subsequently created: High BIS and High BAS (H_BIS_H_BAS), High BIS and Low BAS (H_BIS_L_BAS), Low BIS and High BAS (L_BIS_H_BAS) and Low BIS and Low BAS (L_BIS_L_BAS). A Chi-square test for independence was used to explore the relationship between the proportion of BIS_BAS phenotypes that occur between the genders and across the lean, overweight and obese BMI categories according to gender. When the expected frequency in any cell was less than 5, the data was re-run with the Monte Carlo estimation and Fisher's exact probability statistic for contingency tables, was used to determine significance.

Results

The proportion of the BIS_BAS phenotypes was explored, relative to BMI category in males and females, using a Chi-square test for independence. Seven cells (58.3%) had an expected count less than five, therefore the model was interpreted using the Monte Carlo estimation and the Fisher's exact test was used to accommodate small cell sizes. Fisher's exact test statistic indicated that there were no significant differences between the proportions of the four BIS _BAS groups according to BMI for females, $\chi^2 = 5.79$, 6; p = .484, or for males, $\chi^2 = 4.75$,6; p = .601. However, visual inspection of the histograms indicated a trend towards increasing levels of BIS and decreasing levels of BAS as weight increased from the lean to the obese category in women (Figure C.1.) and the opposite pattern of high levels of BAS and low levels of BIS as weight increased from lean to obese in men (Figure C.2.).

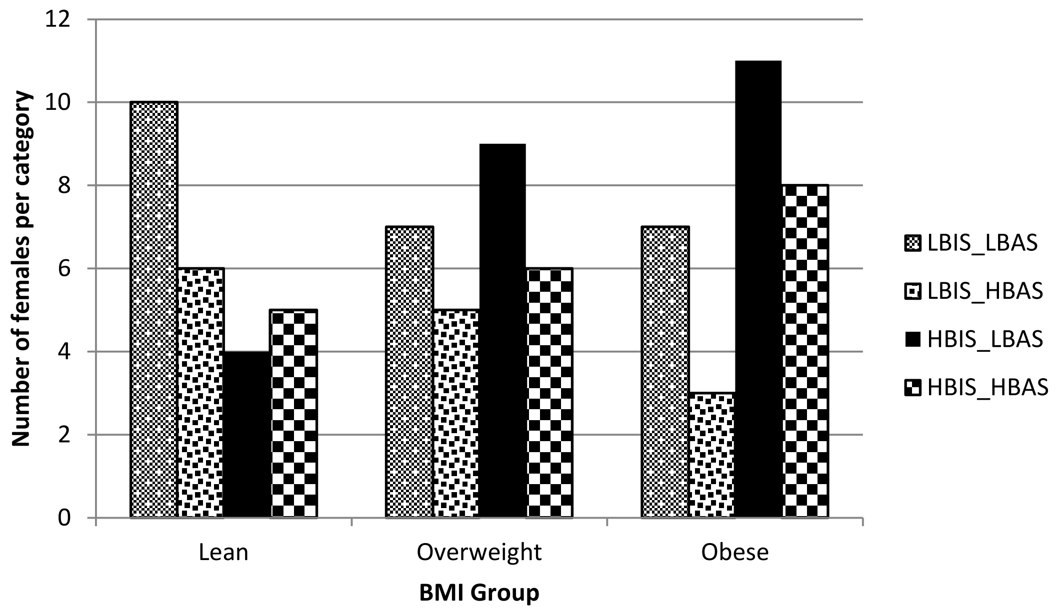


Figure C.1. Frequencies of the BIS _BAS phenotypes by BMI category for females.

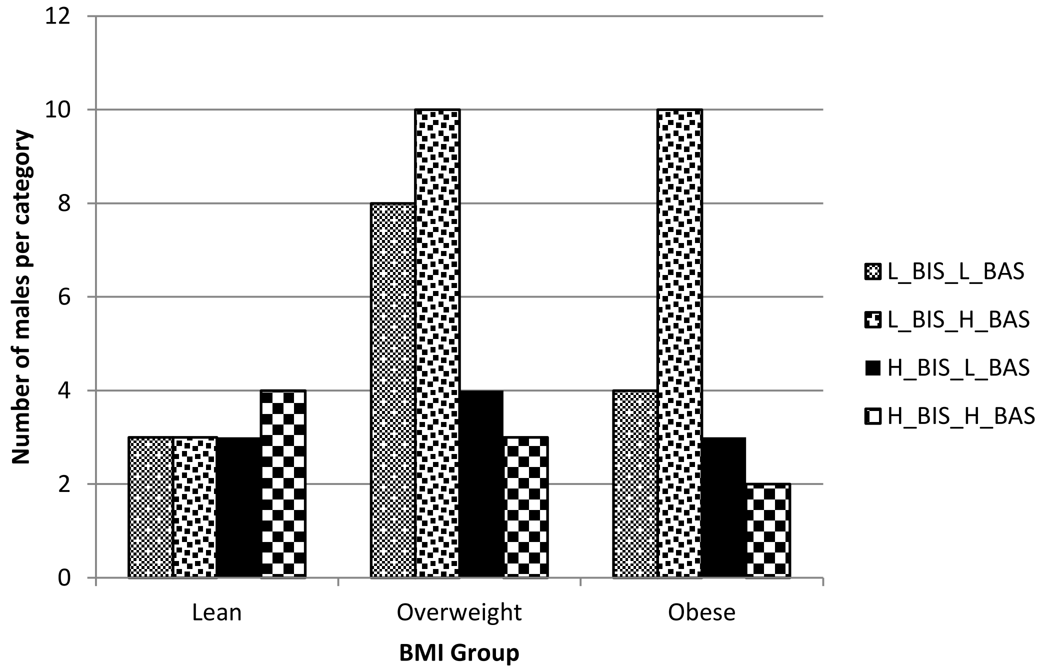


Figure C.2. Frequencies of the BIS _BAS phenotypes by BMI category for males.

Appendix D: Data from Chapter 2

Table D.1

Non-Significant Mean Differences in the Main Study Variables, by Gender

	Males *n* = 64		Females *n* = 105			
Variable	*M*	*SD*	*M*	*SD*	*t* (167)	*p*
Age	45.8	11.96	46.31	12.28	0.64	.520
Restraint	8.77	4.10	9.82	4.47	1.53	.130
BAS	37.98	5.69	39.39	5.75	1.55	.124
DERS-T	71.95	18.38	77.50	22.48	1.75	.083
4.DERS-C	9.97	3.91	77.50	22.48	0.17	.866
5.DERS-G	12.56	4.79	10.07	3.50	0.19	.852
6.DERS-A	16.69	4.86	12.70	4.26	-0.86	.394
EC	89.98	13.04	85.58	14.40	-1.08	.280
IW_HFSW	-3.21	29.84	2.32	33.21	1.09	.279
IW_HFSA	-12.55	43.37	-22.04	30.73	-1.66	.099
EL_HFSW	44.25	22.44	41.10	24.17	-.842	.401

BAS: Behavioural Activation System; DERS-T: Difficulties in Emotion Regulation Total Scale; DERS-C: Difficulties in Emotion Regulation Clarity subscale; Difficulties in Emotion Regulation Goals subscale; Difficulties in Emotion Regulation Awareness subscale; EC-T: Effortful Control Total Scale; IW_HFSW: Implicit wanting high-fat sweet; IW_HFSA: Implicit wanting high-fat savoury; EL_HFSW: Explicit liking high-fat sweet

D1. Investigating the mediation of effortful control on the association between the BIS and disinhibited-eating behaviour

To investigate whether EC-T mediated the association between the BIS and Disinhibition, a relationship between EC-T and the BIS was determined. Preliminary analysis revealed a negative correlation between the two variables, (r = -.345, n = 169, p <. 001), with high levels of BIS associated with low levels of EC-T. The variables that were entered into the mediation model are presented in Table 5.9 on page 174.

To test for mediation, hierarchical multiple linear regression assessed the ability of EC-T to mediate the effect of the BIS on disinhibited-eating behaviour after controlling for gender and BMI (Table D.2). In the first step, gender, BMI and BIS explained 25% of the variance in Disinhibition, F (3,165) = 18.50, p < .001. The introduction of EC-T in the second step explained an additional 6% variance in Disinhibition, after controlling for BMI, gender and the BIS, R^2 change = .060; F (1,

164) = 14.30, p < .001, and the model was significant, F (4,164) = 418.57, p < .001. As proof of partial mediation, the impact of the BIS on Disinhibition decreased from the first (β = .326, p = <0.001) to the second step and the BIS remained significant (β = .231, p = .002).

Table D.2

Mediation Model of EC-T on the association between the BIS and Disinhibition

Step and Predictor Variable	R	R^2	ΔR^2	B	SE	β
Step 1	.502	0.252	.252			
Gender				1.137	.571	.145*
BMI				0.145	.038	.260***
BIS				0.337	.074	.326***
Step 2	.558	.312	.060			
BIS				.239	.076	.231**
EC-T				-.073	.019	-.265***

BIS: Behavioural Inhibition System; EC-T: Effortful Control Total Scale. Gender coded as 0 = male.

**p* < .05, ***p* < .01, ****p* < .001

D2. Investigating the mediation of effortful control on the association between the BIS and implicit wanting of high-fat sweet foods

To investigate whether EC-T mediated the association between the BIS and implicit wanting of high-fat sweet foods, a relationship between EC-T and the BIS was determined. Preliminary analysis revealed a negative correlation between the two variables, (r = -.345, n = 169, p <. 001), with high levels of BIS associated with low levels of EC-T. The variables that were entered into the mediation model are presented in Table 5.9 on page 174.

To test for mediation, hierarchical multiple linear regression assessed the ability of EC-T to mediate the BIS, after controlling for gender and BMI (Table D.3). In the first step, gender, BMI and BIS explained 6.9% of the variance in implicit wanting, F (3,164) = 4.04, p < .01. The introduction of EC-T in the second step explained an additional 3.8% variance in implicit wanting, after controlling for BMI, gender and the BIS, R^2 change = .037; F (1, 163) = 7.0, p < .05, and the model was significant, F (4,163) = 4.85, p < .01. In the final model, EC-T and BMI were significant with EC-T recording a higher beta value (β = -.209, $p < .01$) than BMI (β = .160, $p < .05$). As proof of mediation, the impact of the BIS on IW-HFSW decreased from the first (β = .171, p = < 0.05) to the second step and the BIS became non-significant (β = .097, $p = .247$) and the decrease was reliable, Sobel's $z = 2.28$, p = < .05. This result suggests that a low level of EC-T mediates the BIS to increase an individual's level of implicit wanting (Figure D.1).

Table D.3

Mediation Model of EC-T on the BIS to Predict Implicit Wanting of High-Fat Sweet Foods

Step and Predictor Variable	*R*	R^2	ΔR^2	*B*	*SE*	*β*	*t*
Step 1	.262	.069	.263				
Gender				- 0.648	5.360	-.010	0.121
BMI				0.905	0.359	.193	2.520
BIS				1.481	0.695	.171*	2.130
Step 2	.326	.106	.037				
BIS				0.830	0.727	.096	1.142
EC-T				- 0.481	0.184	-.209*	-2.614

BIS: Behavioural Inhibition System; EC-T: Effortful Control Total scale. Gender coded as 0 = male.

*$p < .05$

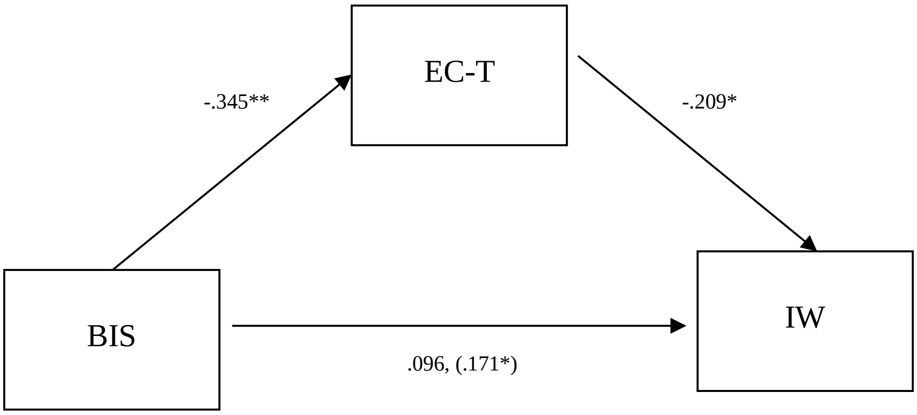


Figure D.1. Mediation of EC-T on the association between the BIS and implicit wanting (n=169).

**p* <. 05, * **p* <.01, * * **p* <.001

D3. Temperament and its interaction with symptoms of anxiety, as a predictor of disinhibited eating behaviour.

A hierarchical, linear, multiple regression was performed to determine whether the three-way interaction term of BIS x BAS x STAI-T significantly added to the variance in disinhibited eating behaviour. The means, standard deviations and correlations are presented in Table D.4 and the regression model in Table D.5.

Table D.4

Means, Standard Deviations, and Intercorrelations Between Disinhibited Eating Behaviour, Temperament and Trait Anxiety

Variables	*M*	*SD*	1	2	3	4	5	6
1. D	9.17	3.82	---					
2. BMI	33.33	6.82	.306**	---				
3. BIS	21.41	3.69	.392**	.061	---			
4. BAS	38.86	5.75	-.014	-.136	-.009	---		
5. EC-T	86.49	13.91	-.395**	-.169*	-.345**	-.107	---	
6. STAI-T	38.49	11.41	.415**	.260**	.632**	-.181*	-.481**	---

D: Disinhibited eating behaviour scale, BMI: Body Mass Index (kg/m^2), BIS: Behavioural Inhibition System, BAS: Behavioural Activation System, EC-T: Effortful Control Total Scale STAI-T: State Trait Anxiety Inventory-Trait Scale
*p < .05, ** p < .01,

To assess the ability of the BIS x BAS x STAI interaction term to predict disinhibited eating behaviour, age, gender, BMI, BIS, BAS, STAI and EC-T were entered as control variables in step 1. This step significantly increased the model's ability to predict disinhibited eating behaviour and explained 31.5% of the variance in disinhibited eating behaviour, R^2 change = .315; *F* change (7, 162) = 10.59, p <

.001. The addition of the interaction terms in step 2 explained an additional 2.3% of the variance in disinhibited eating behaviour. However, they did not significantly increase the model's ability to predict disinhibited eating behaviour, R^2 change = .023; *F* change (3, 158) = 1.82, p = .146, although the model was significant, *F* (10, 158) = 8.07, p < .001. Entry of the three way BIS x BAS x STAI, interaction term at step 3 explained an additional 0.1% of the variance in disinhibited eating behaviour. However, the addition of the BIS x BAS x STAI interaction, did not significantly increase the model's ability to predict disinhibited eating behaviour, R^2 change = .001; *F* change (1, 157) = .157, p = .692, although the model was significant: *F*, (11, 157) = 7.31, p < .001, R^2 = .339. Furthermore, it was noted in the second step that the two-way interaction term of BAS x STAI was significant (*p* = .021). Therefore the model was re-run and the BIS x STAI term was added on its own, in a second step. However by removing the interaction terms of BIS x STAI-T and BIS x BAS, the interaction term of BAS x STAI-T did not retain significance, R^2 change = .013; *F* change (1, 160) = 3.02, *p* = .084. Therefore, in this regression model, the three-way BIS x BAS x STAI-T interaction term did not significantly add to the variance of disinhibited eating behaviour, nor did a two-way interaction between the BAS and STAI-T, beyond the first step.

After the first step, EC (β = -.246, *p* = .002), BMI (β = .201, *p* = .005), the BIS (β = .189, *p* = .036) and gender (β = .161. *p* = .028) all contributed significantly to disinhibited eating behaviour. These results suggest that a low level of effortful control is predictive of disinhibited eating behaviour to a greater extent than BMI and the BIS. Furthermore, these results are independent of age and STAI-T.

Table D.5

Hierarchical Linear Multiple Regression Analysis Predicting Disinhibited Eating Behaviour with a Three-Way BIS x BAS x STAI-T Interaction

Step and predictor variable	*B*	*SE B*	*β*	R^2	ΔR^2
Step 1:				.315***	
Age	0.006	.021	.020		
BMI	0.112	.039	.201**		
Gender	1.260	.569	.161*		
BIS	0.195	.092	.189*		
BAS	-0.010	.047	-.015		
EC - total	-0.067	.021	-.246**		
STAI-T	0.026	.034	.078		
Step 2:				.338	.023
BIS x BAS	0.022	.015	.145		
BIS x STAI-T	-0.002	.006	-.020		
BAS x STAI-T	-0.011	.005	-.214*	.339	.001
Step 3:					
BIS x BAS x STAI-T	0.000	.001	-.043		

BMI: Body Mass Index (kg/m^2), BIS: Behavioural Inhibition System, BAS: Behavioural Activation System, EC-T: Effortful Control Total Scale, STAI-T: State Trait Anxiety Inventory-Trait Scale. Gender coded as 0 = male.
B: unstandardised coefficient; □□□standardised coefficient
*p < .05, * *p < .01, * * *p < .001

D4. An exploration of the proportion of BIS _BAS phenotypes by gender, disinhibited-eating behaviour subtype and BMI

The first analysis, indicated that there was a significant difference in the proportion of BIS_BAS phenotypes by gender χ^2 (3, *n* =169) = 23.67, *p* < .001. Post hoc analysis (Table D 6) indicated that there was a significant (*p* < .05) difference in the proportion of LBIS_LBAS males to females, with a greater proportion of males with this phenotype. Conversely, there was a significant difference (*p* < .05) in the proportion of HBIS_HBAS females to males with a greater proportion of females with this phenotype. Although, not statistically significant, there did appear to be a trend towards a greater proportion of females to males with the HBIS_LBAS phenotype (Figure D.2).

Table D.6

Frequencies of the BIS_BAS Phenotype by Gender

	BIS _BAS Phenotype							
Gender	LBIS _L_BAS		LBIS_HBAS		HBIS_HBAS		HBIS_LBAS	
	n	%	*n*	%	*n*	%	*n*	%
Males	28a*	22.9	16a	25	7a*	10.9	13a	20.3
Females	14b*	7.6	24a	22.9	31b*	29.5	36a	34.3
Post hoc	a > b		a = a		a < b		a = a	

LBIS_LBAS: low BIS, low BAS, LBIS_HBAS: low BIS, low BAS; HBIS_HBAS: high BIS, h BAS; HBIS_LBAS: high BIS, low BAS. *p <.05

*Note. Counts in a column that share a common subscript are not statistically different at α = .05

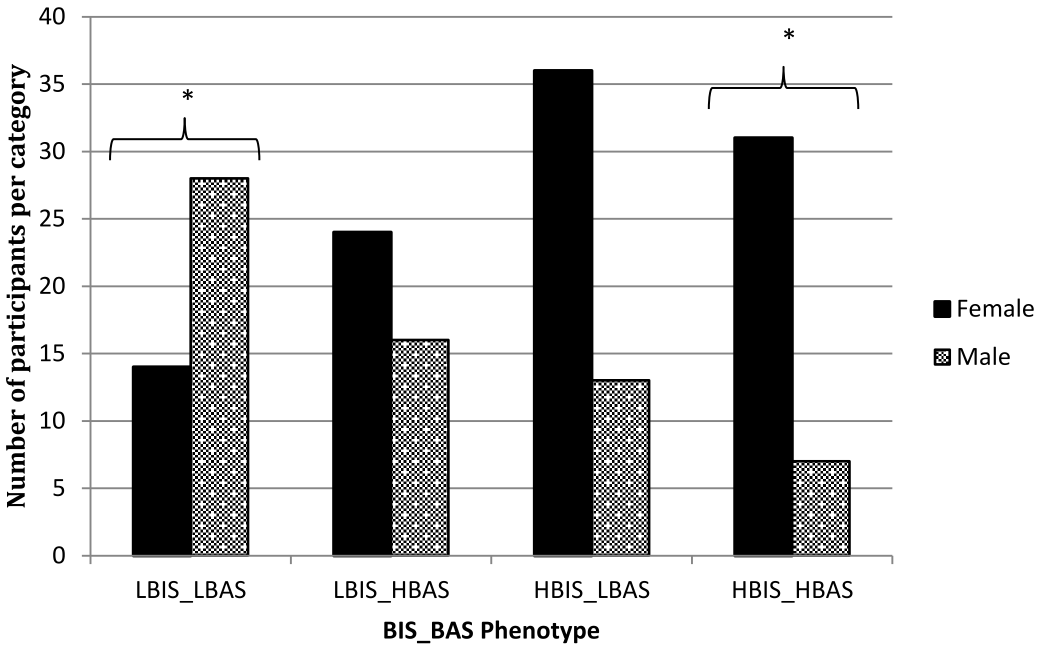


Figure D.2. Frequencies of the BIS_BAS phenotype by gender in an overweight and obese sample.

*Note. The proportion of males and females within each BIS_BAS phenotype that are significantly different from one another at α = .05

The second analysis indicated that there was a significant difference in the proportion of disinhibited eating behaviour subtypes by gender χ^2 (3, *n* = 169) =

11.43, $p < .05$. Post hoc analysis (Table D.7), indicated that there was a significant ($p < .05$) difference in the proportion of HDHR females to males, with a greater proportion of females with this eating behaviour subtype. Conversely, there was a significant difference ($p < .05$) in the proportion of LDLR males to females, with a greater proportion of males with this eating behaviour subtype. No other statistically significant differences between the other subtypes were noted, although there appeared to be a trend towards a higher proportion of females to males with the HDLR eating behaviour subtype (Figure D.3).

Table D.7

Frequencies of Disinhibited Eating Behaviour Subtypes, in an Overweight and Obese Sample, by Gender

	Eating Behaviour Subtype							
	HDHR		HDLR		LDHR		LRLD	
Gender	*n*	%	*n*	%	*n*	%	*n*	%
Males	15a*	25.0	17a	34.7	18a	48.6	14a*	60.9
Females	45b*	75.0	32a	65.3	19a	51.4	9b*	39.1
Post hoc	a < b		a = a		a = a		a > b	

HDHR: high Disinhibition, high restraint; HDLR: high Disinhibition, low restraint, LDHR, high restraint, low Disinhibition, LRLD: low restraint, low Disinhibition. *p <.05
*Note. Counts in a column that share a common subscript are not statistically different at α = .05

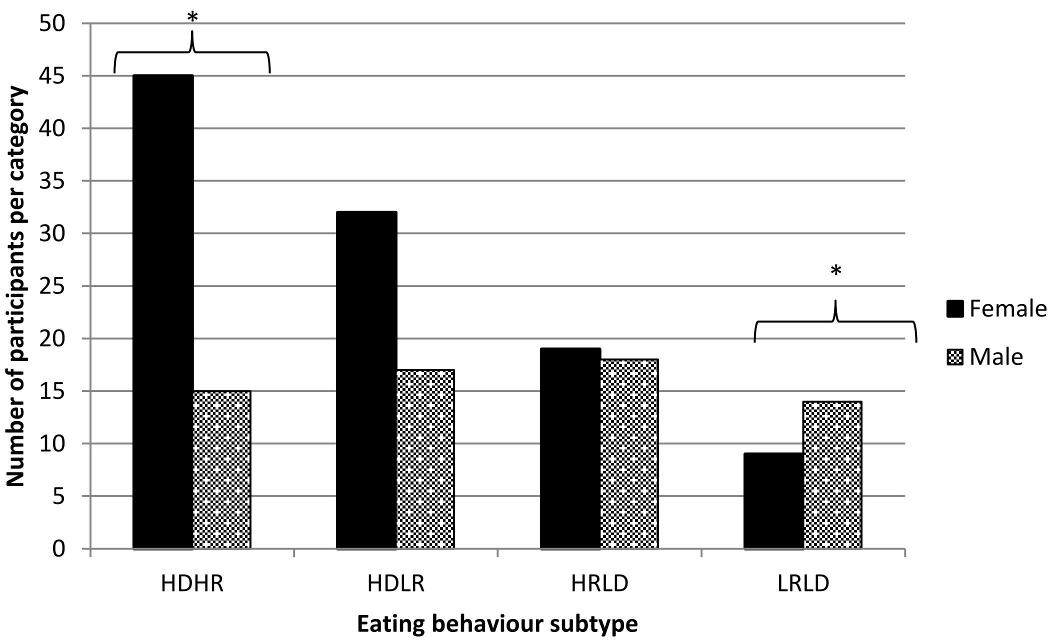


Figure D.3. Frequencies of the disinhibited eating behaviour subtype by gender in an overweight and obese sample.

*Note. The proportion of eating behaviour subtypes by gender that are significantly different from one another at α = .05

Appendix E: Ethics Committee Approval Documents

E1. Experimental Sample: Chapter 4

Queensland University of Technology
Brisbane Australia

PARTICIPANT INFORMATION AND CONSENT FORM (PICF)

Queensland Government

Full Project Title:

"Psychological markers of susceptibility to weight gain: what is the role of Temperament in the aetiology of obesity?

UHREC Ethics Approval Number 12/CQ/6

Principal Researchers:

Lynette Mackey de Paiva	Dr Zephanie Tyack
Community Dietitian	Principal Research Fellow
Allied Health, Gladstone Hospital	Allied Health, Rockhampton Hospital

1. What is the purpose of this research project?

- Lynette is currently undertaking her PhD study at the Queensland University of Technology (QUT) and this research will count towards the successful completion of her PhD program. The aim of the project is to show whether certain personality characteristics are related to being overweight or obese. It also seeks to determine whether an individual's personality characteristics are related to eating behaviour, experience of symptoms of stress, anxiety and depression and whether this is related to their level of overweight/obesity.
- There is currently limited evidence to inform dietitians about whether or not an individuals' personality could influence them to become overweight or obese. Thus, there is a need to research the factors that impact upon ones' level of overweight, so as to guide the development of future weight management services both locally and in other communities.

2. What does participation in this research project involve?

- This research consists of two components - a baseline component and a follow up component that will be carried out 12 months from this day.
- Both components will follow the process below:
- Participants who agree to take part in the research will be seen by a qualified Health Professional (Dietitian) who will ask you to complete:
  - Two questionnaires that measures your eating behaviour;
  - Two questionnaires that measure your temperament characteristics;
  - One questionnaire that measures how prone you are to experience anxiety
  - One questionnaire that measures the extent to which you experience depressive symptoms
  - One questionnaire that measures your level of perceived stress;
  - One questionnaire that measures your difficulty to manage your emotions
  - One questionnaire that measures how impulsive you are
  - One questionnaire that measures how much you experience positive or negative states
  - One questionnaire that will ask you about details such as your age, gender, socioeconomic status ,lifestyle choices, current health conditions, current weight height and waist/hip measurement and two single questions that ask you about your current state of health.

This process may take up to 1 hour to complete.

Participant Information & Consent Form, Baseline, Version 3, Date: 15/11/12 Page 1 of 4 than 5 minutes and will be conducted in a closed room to ensure complete privacy.

- After today:
- You will be contacted again 1 month before the 12-month follow up stage.
- At this time, all efforts will be made to coordinate this appointment with another appointment that you may have scheduled with your health professional team.
- If you do not have a scheduled appointment you will be invited to attend your follow up appointment at an outpatient clinic that will be nominated closer to this date.
- If you are unable to attend the follow-up appointment in person, the questionnaires will be sent to you and you will be requested to fill out the self-report questionnaires and self-report weight and waist/hip circumference and return by post.
- To compensate you for your time, you will be provided with a $20 gift card at the follow-up appointment to be used at your discretion.

3. What are the possible benefits?

The benefit of this research is to assist in the development and design of highly targeted and effective weight management programs that can be run by Dietitians or other Allied Health Professionals. By consenting to this research you will assist Health Professionals ensure that their recommendations are in line with current research to provide you with the best possible care.

4. What are the possible risks?

It is not expected that participation in this research project should cause any discomfort, foreseeable risk of harm or side effects. The information gathered will be coded which means that none of the details that identify you such as your name or date or birth will be kept with the information you provide. However the researchers can link your information with your name.

6. Do I have to take part in this research project?

Participation in any research project is voluntary. If you do not wish to take part, you do not have to.

7. How will I be informed of the final results of this research project?

If you would like to be provided with a summary of the results when the research project is completed please indicate at the end of this form. The results from this research project are expected to be published in national and international literature. It is expected that final results will be available from June 2013.

8. What will happen to information about me?

Any information obtained for the purpose of this research project that can identify you, such as your consent form, will be treated as confidential and securely stored. It will be disclosed only with your permission, or as permitted by law.

Once the information has been collected the information will be coded and securely kept by the research team. Paper copies will be kept in a locked filing cabinet and will not be made available to persons outside the research team. Once the project is completed your information will be stored as non-identifiable and the codes linking your name etc to the data will be destroyed. All collected data will be destroyed after 5 years after the final publication of results.

In any publication and/or presentation, information will be presented in such a way that you cannot be identified, except with your permission.

9. Is this research project approved?

The ethical aspects of this research project have been approved by the Human Research Ethics Committee of Central Queensland Health Service District.

This project will be carried out according to the *National Statement on Ethical Conduct in Human Research (2007)* produced by the National Health and Medical Research Council of Australia. This statement has been developed to protect the interests of people who agree to participate in human research studies.

PARTICIPANT INFORMATION AND CONSENT FORM (PICF)

11. Consent

I have read, or have had this document read to me in a language that I understand, and I understand the purposes, procedures and risks of this research project as described within it.

I have had an opportunity to ask questions and I am satisfied with the answers I have received.

I freely agree to participate in this research project, as described. I have not been coerced in any way to participate.

I understand that if I do not consent to take part in this study that it will not affect the services that I expect to receive at the centre that I am attending.

I agree to be contacted for a follow-up appointment approximately 12-months from today

I understand that I will be given a signed copy of this document to keep.

Participant's name (printed) ....

Signature Date

Declaration by researcher: I have given a verbal explanation of the research project, its procedures and risks and I believe that the participant has understood that explanation.

Researcher's name (printed) ....

Signature Date

Note: All parties signing the consent section must date their own signature.

If you would like a copy of the results once the study is completed, please provide your details below so that they may be sent out to you:

....

....

Who can I contact?
For further information or appointments:
If you want any further information concerning this project or if you have any problems which may be related to your involvement in the project (for example, feelings of distress), you can contact any of the following people:

Name:	Lynette Mackey de Paiva	Dr Zephanie Tyack
Role:	Principal Investigator	Co-Investigator
Telephone:	(07) 4976 3601	(07) 4922 7396

For complaints:
If you have any complaints about any aspect of the project, the way it is being conducted or any questions about being a research participant in general, then you may contact:
Name: Rod Boddice
Position: Director of Central Queensland Hospital and Health Service Human Research Ethics Committee
Telephone: (07) 4920 5774

E2. Experimental Sample: Chapter 5

QUT Queensland University of Technology
Brisbane Australia

PARTICIPANT INFORMATION FOR QUT RESEARCH PROJECT

TEMPERAMENT AND ITS IMPACT ON FOOD REWARD AND EATING BEHAVIOURS

QUT Ethics Approval Number 1400000275

RESEARCH TEAM

Principal Researcher:	Lynette Mackey	PhD Student
Associate Researchers:	Professor Neil King	School of Exercise & Nutrition Sciences, Faculty of Health and Institute of Health and Biomedical Innovation (IHBI), Queensland University of Technology (QUT)
	Dr Melanie White	School of Psychology and Counselling, Faculty of Health, IHBI, QUT
	Dr Zephanie Tyack	School of Allied and Public Health, Faculty of Health Sciences, Australian Catholic University (ACU)

DESCRIPTION

Lynette Mackey, who is an accredited practicing dietitian (APD), is undertaking this project as part of a PhD program.

The purpose of this project is to determine whether certain personality characteristics are related to being overweight or obese.

You are invited to participate in this project if you are non-smoking, aged between 18 – 65 years, with a body mass index of greater then 25, not pregnant or breastfeeding, do not suffer from an eating disorder and are not currently using antidepressants or medication that reduces anxiety symptoms. To work out your body mass index, divide your current weight by your height (in metres squared). For example if you weigh 80kg and your height in metres is 1.75 metres: 80/ (1.75 x 1.75) = 80/ 3.06 = 26.

PARTICIPATION

Your participation will require your attendance at the QUT Appetite Test Laboratory, Kelvin Grove campus:
The visit at QUT is expected to take up to 1 hour and 15 minutes. You will be asked to come in a minimum of 2 hours and up to a maximum of 4 hours since you have last eaten anything. At this visit a qualified Health Professional (accredited practicing dietitian) will measure your weight, height and waist circumference. Then you will be asked to complete 6 questionnaires and two behavioural measures.

<u>The questionnaires measure the following</u>:

- One questionnaire measures the type of temperament that you have
  - Questions will include “I worry about making mistakes” and “I have very few fears compared to my friends”
- One questionnaire measures your eating behaviour
  - Questions will include “ I usually eat too much at social occasions, like parties and picnics” and “Life is too short to worry about dieting”
- Two questionnaires measure your mood
  - Questions will include rating your mood i.e. “ I feel pleasant” and “I feel happy” and choosing one statement out of four that applies to you i.e.:
    a. I get as much satisfaction out of things as I used to.
    b. I don't enjoy things the way I used to.
    c. I don't get real satisfaction out of anything anymore.

d. I am dissatisfied or bored with everything.

- Two questionnaires measure your ability to manage your emotions and your temperament/personality traits:
  - Questions will include “I am clear about my feelings” and “I can keep performing a task even when I would rather not do it”

<u>The behavioural tasks:</u>

  - These will consist of two computerized tasks that require you to respond as quickly and accurately as possible to word and food images.

Your participation in this project is voluntary. If you agree to participate you do not have to complete any question(s) you are uncomfortable answering. Your decision to participate or not participate will in no way impact upon your current or future relationship with QUT. If you do agree to participate you can withdraw from the project at any time without comment or penalty.

EXPECTED BENEFITS

It is expected that this project will not benefit you directly. However, it is increasingly recognised that managing weight and eating behaviour is not simply about applying greater amounts of will power. This research aims to extend current knowledge beyond the paradigm of “applying will power” and “going on another diet” to successfully manage weight. Therefore, this research has been developed to explore, inform and subsequently assist in the development and design of highly targeted and effective weight management programs that empower, rather then disempower the individual.

To compensate you for your contribution should you choose to participate the research team will provide you with out of pocket expenses to cover the cost of public transport or parking at QUT. Additionally, to recognise your contribution and thank you for your time (should you choose to participate), you will be entered into a random draw to receive one of two $50 gift vouchers.

RISKS

There are minimal risks associated with your participation in this project. These include the filling out of questionnaires that seek to determine if you possess any symptoms of anxiety or discomfort. They are not expected to cause you any distress or discomfort however, if required QUT provides for limited free psychology, family therapy or counseling services for research participants of QUT projects who may experience discomfort or distress as a result of their participation in the research. Should you wish to access this service please contact the Clinic Receptionist of the QUT Psychology and Counseling Clinic on 3138 0999. Please indicate to the receptionist that you are a research participant.

PRIVACY AND CONFIDENTIALITY

All comments and responses will be treated confidentially unless required by law. The names of individual persons are not required in any of the responses. However, we will ask for identifying details, such as your name, email address and a telephone number, if you express an interest to take part in a planned future study. Your contact details will be stored separately to your completed questionnaires in a secure electronic folder. You will be asked to create your own identity code so that data, obtained from the testing session, can be linked to your identity. This link will be destroyed once all of the data has been collected in the future study.

Any data collected as part of this project will be stored securely as per QUT’s Management of research data policy. Please note that non-identifiable data collected in this project may be used as comparative data in future projects or stored on an open access database for secondary analysis.

QUESTIONS / FURTHER INFORMATION ABOUT THE PROJECT

If have any questions or require further information please contact one of the research team members below.

Lynette Mackey	3138 6399	lynette.mackey@student.qut.edu.au
Professor Neil King	3138 3528	n.king@qut.edu.au

CONCERNS / COMPLAINTS REGARDING THE CONDUCT OF THE PROJECT

QUT is committed to research integrity and the ethical conduct of research projects. However, if you do have any concerns or complaints about the ethical conduct of the project you may contact the QUT Research Ethics Unit on 3138 5123 or email ethicscontact@qut.edu.au. The QUT Research

Ethics Unit is not connected with the research project and can facilitate a resolution to your concern in an impartial manner.

CONSENT TO PARTICIPATE

If you would like to take part in the study, you will be asked to check the box below and write your name and sign this form in the space below, to indicate your informed consent.

Please check the relevant boxes below If you would like to receive the results of this study, or would like to express an interest to be followed up in a further study (planned within the next 6 months). Your contact details will be stored securely with this form in a secure electronic folder.

☐ I hereby provide my consent to participate in the research project named above.

☐ I would like to receive details of the study results upon completion of the study and thus have provided my email address to receive these results.

☐ I hereby express an interest in being followed up for an additional research project, within the next 6 months, and have provided my contact details: email address and phone number, for this purpose, below.

Name: ………

Signature: ………

Date: ………

Email address: ………

Phone: ………

Thank you for helping with this research project. Please keep this sheet for your information.

E3. Experimental Sample (Rio Tinto Corporate Office): Chapter 5

QUT Queensland University of Technology Brisbane Australia

PARTICIPANT INFORMATION FOR QUT

RESEARCH PROJECT

TEMPERAMENT AND ITS IMPACT ON FOOD REWARD AND EATING BEHAVIOURS

QUT Ethics Approval Number 1400000275

RESEARCH TEAM

Principal Researcher:	Lynette Mackey	PhD Student
Associate Researchers:	Professor Neil King	School of Exercise & Nutrition Sciences, Faculty of Health and Institute of Health and Biomedical Innovation (IHBI), Queensland University of Technology (QUT)
	Dr Melanie White	School of Psychology and Counselling, Faculty of Health, IHBI, QUT
	Dr Zephanie Tyack	School of Allied and Public Health, Faculty of Health Sciences, Australian Catholic University (ACU)

DESCRIPTION

Lynette Mackey, who is an accredited practicing dietitian (APD), is undertaking this project as part of a PhD program.

The purpose of this project is to determine whether certain personality characteristics are related to being overweight or obese.

You are invited to participate in this project if you are non-smoking, aged between 18–65 years, with a body mass index of greater then 25, not pregnant or breastfeeding and do not suffer from an eating disorder. To work out your body mass index, divide your current weight by your height (in metres squared). For example if you weigh 80kg and your height in metres is 1.75 metres: 80/ (1.75 x 1.75) = 80/ 3.06 = 26. Alternatively you may access an online BMI calculator here:
http://www.health.gov.au/internet/healthyactive/publishing.nsf/Content/your-bmi

PARTICIPATION

Your participation will require your attendance at a regional Rio Tinto Wellness Centre or Metropolitan Office. You will be invited to complete the questionnaires below online before your visit. This process is expected to take approximately 30 minutes of your time. Your scheduled visit will then incorporate the behavioural tasks mentioned below and will take up to 20 minutes of your time.

a. To complete the surveys online, you must place an identifying code on the survey which will consist of the first 3 letters of your first and last name and your date of birth i.e. lynmac00/00/00
b. You may access the surveys here: https://survey.qut.edu.au/f/181228/a992/
   *** Your attendance requires that you must come in a minimum of 2 hours up to a maximum of 4 hours since you have last eaten anything. At this visit a qualified Health Professional (accredited practicing dietitian) will measure your weight, height and waist circumference.

The questionnaires measure the following:

- One questionnaire measures the type of temperament that you have
  - Questions will include "I worry about making mistakes" and "I have very few fears compared to my friends"
- One questionnaire measures your eating behavior
  - Questions will include " I usually eat too much at social occasions, like parties and picnics" and "Life is too short to worry about dieting"
- Two questionnaires measure your mood
  - Questions will include rating your mood i.e. " I feel pleasant" and "I feel happy" and choosing one statement out of four that applies to you i.e.:

e. I get as much satisfaction out of things as I used to.
f. I don't enjoy things the way I used to.
g. I don't get real satisfaction out of anything anymore.
h. I am dissatisfied or bored with everything.

- Two questionnaires measure your ability to manage your emotions and your temperament/personality traits:
  - Questions will include "I am clear about my feelings" & "I can keep performing a task even when I would rather not do it"

The behavioural tasks:

- These will consist of two computerized tasks that require you to respond as quickly and accurately as possible to word and food images.

Your participation in this project is voluntary. If you agree to participate you do not have to complete any question(s) you are uncomfortable answering. Your decision to participate or not participate will in no way impact upon your current or future relationship with QUT. If you do agree to participate you can withdraw from the project at any time without comment or penalty.

EXPECTED BENEFITS

It is anticipated that you will gain insight into an emerging area of investigation. This might then provide you with a platform of appreciation you may wish to further explore and utilise in your weight management efforts. It is increasingly recognised that managing weight and eating behaviour is not simply about applying greater amounts of will power. This research aims to extend current knowledge beyond the idea of "applying will power" and "going on another diet" to successfully manage weight. Therefore, this research has been developed to explore, inform and subsequently assist in the development and design of highly targeted and effective weight management programs that empower, rather than disempower the individual. Following this study, you will be provided with a synopsis of findings from which you may further explore your personal eating behaviour patterns. Additionally, you will have 10 minutes of a dietitian's expertise to answer any weight management questions they may have.

RISKS

There are minimal risks associated with your participation in this project. These include the filling out of questionnaires that seek to determine if you possess any symptoms of anxiety or discomfort. They are not expected to cause you any distress or discomfort.

PRIVACY AND CONFIDENTIALITY

All comments and responses will be treated confidentially unless required by law. The names of individual persons are not required in any of the responses. However, we will ask for identifying details, such as your name, email address and a telephone number, if you express an interest to take part in a planned future study. Your contact details will be stored separately to your completed questionnaires in a secure electronic folder. You will be asked to create your own identity code so that data obtained from the testing session can be linked to your identity. This link will be destroyed once all of the data has been collected in the future study.

Any data collected as part of this project will be stored securely as per QUT's Management of research data policy. Please note that non-identifiable data collected in this project may be used as comparative data in future projects or stored on an open access database for secondary analysis.

QUESTIONS / FURTHER INFORMATION ABOUT THE PROJECT

If have any questions or require further information please contact one of the research team members below.

Lynette Mackey	3138 6399	lynette.mackey@student.qut.edu.au
Professor Neil King	3138 3528	n.king@qut.edu.au

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CONSENT TO PARTICIPATE

If you would like to take part in the study, you will be asked to check the box below and write your name and sign this form in the space below, to indicate your informed consent.

Please check the relevant boxes below If you would like to receive the results of this study, or would like to express an interest to be followed up in a further study (planned within the next 6 months). Your contact details will be stored securely with this form in a secure electronic folder.

☐ I hereby provide my consent to participate in the research project named above.

☐ I would like to receive details of the study results upon completion of the study and thus have provided my email address to receive these results.

☐ I hereby express an interest in being followed up for an additional research project, within the next 6 months, and have provided my contact details: email address and phone number, for this purpose, below.

Name: ………

Signature: ………

Date: ………

Email address: ………

Phone: ………

Thank you for helping with this research project. Please keep this sheet for your information.

E4. Experimental Sample (Rio Tinto on site – Yarwun): Chapter 5

QUT Queensland University of Technology Brisbane Australia	**PARTICIPANT INFORMATION FOR QUT RESEARCH PROJECT**

TEMPERAMENT AND ITS IMPACT ON FOOD REWARD AND EATING BEHAVIOURS

QUT Ethics Approval Number 1400000275

RESEARCH TEAM

Principal Researcher:	Lynette Mackey	PhD Student
Associate Researchers:	Professor Neil King	School of Exercise & Nutrition Sciences, Faculty of Health and Institute of Health and Biomedical Innovation (IHBI), Queensland University of Technology (QUT)
	Dr Melanie White	School of Psychology and Counselling, Faculty of Health, IHBI, QUT
	Dr Zephanie Tyack	School of Allied and Public Health, Faculty of Health Sciences, Australian Catholic University (ACU)

DESCRIPTION

Lynette Mackey is an accredited practicing dietitian (APD), is undertaking this project as part of a PhD program.

The purpose of this project is to determine whether certain personality characteristics are related to being overweight or obese.

You are invited to participate in this project if you are non-smoking, aged between 18–65 years, with a body mass index of greater then 25, not pregnant or breastfeeding and do not suffer from an eating disorder. To work out your body mass index, divide your current weight by your height (in metres squared). For example if you weigh 80kg and your height in metres is 1.75 metres: 80/ (1.75 x 1.75) = 80/ 3.06 = 26. Alternatively you may access an online BMI calculator here:

http://www.health.gov.au/internet/healthyactive/publishing.nsf/Content/your-bmi

PARTICIPATION

Your participation will require your attendance to an appointment at Yarwun. You will need to complete a questionnaire (link below) online before your visit. This process is expected to take approximately 30 minutes of your time. On completion of the survey you will be required to attend a 20 minute follow up appointment with the dietician to complete some behavioural tasks.

a. To complete the surveys online, you must place an identifying code on the survey which will consist of the first 3 letters of your first and last name and your date of birth. For example, John Smith with birthday 1/1/1975 = johsmi01/01/75

b. You may access the surveys here: https://survey.qut.edu.au/f/181228/a992/

*** Your attendance requires that you must come in a minimum of 2 hours up to a maximum of 4 hours since you have last eaten anything. At this visit a qualified Health Professional (accredited practicing dietitian) will measure your weight, height and waist circumference.

<u>The questionnaires measure the following</u>:

- One questionnaire measures the type of temperament that you have
  - Questions will include “I worry about making mistakes” and “I have very few fears compared to my friends”
- One questionnaire measures your eating behavior
  - Questions will include “ I usually eat too much at social occasions, like parties and picnics” and “Life is too short to worry about dieting”
- Two questionnaires measure your mood
  - Questions will include rating your mood i.e. “ I feel pleasant” and “I feel happy” and choosing one statement out of four that applies to you i.e.:
    i. I get as much satisfaction out of things as I used to.
    j. I don't enjoy things the way I used to.
    k. I don't get real satisfaction out of anything anymore.
    l. I am dissatisfied or bored with everything.

- Two questionnaires measure your ability to manage your emotions and your temperament/personality traits:
  - Questions will include "I am clear about my feelings" & "I can keep performing a task even when I would rather not do it"

<u>The behavioural tasks:</u>

- These will consist of two computerized tasks that require you to respond as quickly and accurately as possible to word and food images.

Your participation in this project is voluntary. If you agree to participate you do not have to complete any question(s) you are uncomfortable answering. Your decision to participate or not participate will in no way impact upon your current or future relationship with QUT. If you do agree to participate you can withdraw from the project at any time without comment or penalty.

EXPECTED BENEFITS

It is anticipated that you will gain insight into an emerging area of investigation. This might then provide you with a platform of appreciation you may wish to further explore and utilise in your weight management efforts. It is increasingly recognised that managing weight and eating behaviour is not simply about applying greater amounts of will power. This research aims to extend current knowledge beyond the idea of "applying will power" and "going on another diet" to successfully manage weight. Therefore, this research has been developed to explore, inform and subsequently assist in the development and design of highly targeted and effective weight management programs that empower, rather than disempower the individual. Following this study, you will be provided with a synopsis of findings from which you may further explore your personal eating behaviour patterns. Additionally, you will have 10 minutes of a dietitian's expertise to answer any weight management questions they may have.

RISKS

There are minimal risks associated with your participation in this project. These include the filling out of questionnaires that seek to determine if you possess any symptoms of anxiety or discomfort. They are not expected to cause you any distress or discomfort.

PRIVACY AND CONFIDENTIALITY

All comments and responses will be treated confidentially unless required by law. The names of individual persons are not required in any of the responses. However, we will ask for identifying details, such as your name, email address and a telephone number, if you express an interest to take part in a planned future study. Your contact details will be stored separately to your completed questionnaires in a secure electronic folder. You will be asked to create your own identity code so that data obtained from the testing session can be linked to your identity. This link will be destroyed once all of the data has been collected in the future study.

Any data collected as part of this project will be stored securely as per QUT's Management of research data policy. Please note that non-identifiable data collected in this project may be used as comparative data in future projects or stored on an open access database for secondary analysis.

QUESTIONS / FURTHER INFORMATION ABOUT THE PROJECT

If have any questions or require further information please contact one of the research team members below.

Lynette Mackey	3138 6399	lynette.mackey@student.qut.edu.au
Professor Neil King	3138 3528	n.king@qut.edu.au

CONCERNS / COMPLAINTS REGARDING THE CONDUCT OF THE PROJECT

QUT is committed to research integrity and the ethical conduct of research projects. However, if you do have any concerns or complaints about the ethical conduct of the project you may contact the QUT Research Ethics Unit on 3138 5123 or email ethicscontact@qut.edu.au. The QUT Research Ethics Unit is not connected with the research project and can facilitate a resolution to your concern in an impartial manner.

CONSENT TO PARTICIPATE

If you would like to take part in the study, you will be asked to check the box below and write your name and sign this form in the space below, to indicate your informed consent. If you decide not to consent to this research this will not affect your access to the Refine Health program or future dietetic appointments.

Please check the relevant boxes below If you would like to receive the results of this study, or would like to express an interest to be followed up in a further study (planned within the next 6 months). Your contact details will be stored securely with this form in a secure electronic folder.

☐ I hereby provide my consent to participate in the research project named above.

☐ I would like to receive details of the study results upon completion of the study and thus have provided my email address to receive these results.

☐ I hereby express an interest in being followed up for an additional research project, within the next 6 months, and have provided my contact details: email address and phone number, for this purpose, below.

Name: ………

Signature: ………

Date: ………

Email address: ………

Phone: ………

Thank you for helping with this research project. Please keep this sheet for your information.

E6. Experimental Sample (Re-recruitment): Chapter 6

Queensland University of Technology Brisbane Australia	**PARTICIPANT INFORMATION FOR QUT RESEARCH PROJECT** **- Re-Recruit -**

PERSONALITY AND ITS ASSOCIATION WITH EATING BEHAVIOUR AND FOOD CRAVING.

QUT Ethics Approval Number 1500000100

RESEARCH TEAM

Principal Researcher:

Associate Researchers: Professor Neil King School of Exercise & Nutrition Sciences, Faculty of

	Health and Institute of Health and Biomedical Innovation (IHBI), QUT
Dr Melanie White	School of Psychology and Counselling, Faculty of Health, IHBI, QUT
Dr Zephanie Tyack	School of Allied and Public Health, Faculty of Health Sciences, Australian Catholic University (ACU)

DESCRIPTION

Lynette Mackey, who is an accredited practicing dietitian (APD), is undertaking this project as part of a PhD program.

The purpose of this project is to determine whether certain personality characteristics are related to being overweight or obese.

You are invited to participate in this project if you are female, non-smoking, aged between 18–65 years, with a body mass index of 25 or greater, not pregnant or breastfeeding, not suffering from an eating disorder and not taking any medication for anxiety or depression, have successfully passed the screening process or have been invited to participate secondary to your expression of interest from a previous study. To work out your body mass index, divide your current weight by your height (in metres squared). For example if you weigh 80kg and your height in metres is 1.75 metres: 80/ (1.75 x 1.75) = 80/ 3.06 = 26.

Alternatively please use the following calculator:
http://www.health.gov.au/internet/healthyactive/publishing.nsf/Content/your-bmi

PARTICIPATION

A. If you have been invited to participate in this study, in its entirety, you are required to complete a total of 6 x online questionnaires prior to your attendance at the QUT, Kelvin Grove campus.
   a. Please access the surveys here: https://survey.qut.edu.au/f/182955/4b7f/
   b. Surveys will need to be completed prior to your scheduled testing session at QUT.
   c. To complete the surveys online, please place an identifying code on the survey which will consist of the first 3 letters of your first name and your date of birth i.e. lyn00/00/00

B. The laboratory testing session will take part at the QUT, Kelvin Grove Campus.

C. As part of the testing procedure, you will be asked to consume a nutritionally balanced meal replacement as an alternative to lunch. After a short time interval you will be asked to consume *as much or as little as you would like* from some common snack items; such as milk/dark chocolate, assorted Arnotts biscuits, cashews, crisps and corn chips. Please inform Lynette if you foresee any problem consuming these common food items, i.e. you do not like them or are allergic to them.

*****Your attendance at QUT requires that you eat your usual breakfast (or a small snack) and then arrive fasted, 3.5 hours after your breakfast/snack (drinking water during this time is fine). You cannot be assessed if you have fasted for longer than 3.5 hours.**

D. Schedule of expected testing procedure:
   a. Measures of weight, height and waist circumference will be taken
   b. Complete a behavioural task of your ability to inhibit or switch habitual behaviours.
   c. Complete a computer-based measure of how much you would like and want to consume some common food items x 2
   d. Consume a nutritionally complete, meal replacement for lunch
   e. Complete 4 x appetite measures – i.e. to rate how hungry you are or to indicate whether you could eat more food at 7 different time-points.
   f. Consume common snack food items to provide ratings of how enjoyable you find them.

Total testing time is expected to take a maximum of 2 hours.

<u>The questionnaires measure the following</u>:

- One questionnaire measures the type of temperament that you have. Questions will include "I worry about making mistakes" and "I have very few fears compared to my friends"
- Two questionnaires measure eating behavior. Questions will include "I usually eat too much at social occasions, like parties and picnics", "Life is too short to worry about dieting" and "I feel capable to control my eating urges when I want to".
- Two questionnaires measure your ability to manage your emotions and your temperament/personality traits. Questions will include "I am clear about my feelings" & "I can keep performing a task even when I would rather not do it"
  - One questionnaire will measure symptoms of depression. Questions will include "I do not feel sad" & "I get as much satisfaction out of things as I used to."

<u>The behavioural tasks</u>:

- These will consist of a computerized tasks that requires you to respond as quickly and accurately as possible to word and food images.
- The other task consists of a paper and pencil task that measures how easily you can identify that a colour word i.e. "green" is written in a different coloured ink i.e. "yellow". It measures the time that you take to choose the colour "yellow" when promoted to name the *word* that you see and not the *colour* that you see.

Your participation in this project is voluntary. If you agree to participate you do not have to complete any question(s) you are uncomfortable answering. Your decision to participate or not participate will in no way impact upon your current or future relationship with QUT. If you do agree to participate you can withdraw from the project at any time without comment or penalty.

EXPECTED BENEFITS

It is not expected that this project will benefit you directly. However, it is increasingly recognised that managing weight and eating behaviour is not simply about applying greater amounts of will power. This research aims to extend current knowledge beyond the paradigm of "applying will power" and "going on another diet" to successfully manage weight. Therefore, this research has been developed to explore, inform and subsequently assist in the development and design of highly targeted and effective weight management programs that empower, rather then disempower the individual.

To compensate you for your contribution, you will be provided with a $25.00 gift voucher after completion of the laboratory experiment.

RISKS

The research team does not believe there are any risks beyond the inconvenience of completing the questionnaires and behavioural tasks, if you participate in this research.

At no time are any of the testing procedures expected to cause you any distress or discomfort however, if required QUT provides for limited free psychology, family therapy or counseling services for research participants of QUT projects who may experience discomfort or distress as a result of their participation in the research. Should you wish to access this service please contact the Clinic Receptionist of the QUT Psychology and Counseling Clinic on 3138 0999. Please indicate to the receptionist that you are a research participant.

PRIVACY AND CONFIDENTIALITY

All comments and responses will be treated confidentially unless required by law. The names of individual persons are not required in any of the responses. However, we will ask for identifying details, such as your name, email address and a telephone number, if you express an interest to take part in a planned future study. Your contact details will be stored separately to your completed questionnaires in a secure electronic folder. You will be asked to create your own identity code so that data, obtained from the testing session, can be linked to your identity. This link will be destroyed once all of the data has been collected in the future study.

Any data collected as part of this project will be stored securely as per QUT's Management of research data policy. Please note that non-identifiable data collected in this project may be used as comparative data in future projects or stored on an open access database for secondary analysis.

CONSENT TO PARTICIPATE

Submitting the completed online questionnaire is accepted as an indication of consent to participate in this component of the project.

If you would like to take part in the study, you will be asked to check the box below and write your name and sign this form in the space below, to indicate your informed consent.

Please check the relevant boxes below If you would like to receive the results of this study, or would like to express an interest to be followed up in a further study (planned within the next 6 months). Your contact details will be stored securely with this form in a secure electronic folder.

QUESTIONS / FURTHER INFORMATION ABOUT THE PROJECT

If have any questions or require further information please contact one of the research team members below.

Lynette Mackey	3138 6399	lynette.mackey@student.qut.edu.au
Professor Neil King	3138 3528	n.king@qut.edu.au

CONCERNS / COMPLAINTS REGARDING THE CONDUCT OF THE PROJECT

QUT is committed to research integrity and the ethical conduct of research projects. However, if you do have any concerns or complaints about the ethical conduct of the project you may contact the QUT Research Ethics Unit on 3138 5123 or email ethicscontact@qut.edu.au. The QUT Research Ethics Unit is not connected with the research project and can facilitate a resolution to your concern in an impartial manner.

Thank you for helping with this research project. Please keep this sheet for your information.

QUT Queensland University of Technology Brisbane Australia	CONSENT FORM FOR QUT RESEARCH PROJECT – Re-Recruit –

PERSONALITY AND ITS ASSOCIATION WITH EATING BEHAVIOUR AND FOOD CRAVING.

QUT Ethics Approval Number 1500000100

RESEARCH TEAM CONTACTS

Lynette Mackey	3138 6399	lynette.mackey@student.qut.edu.au
Professor Neil King	3138 3528	n.king@qut.edu.au

STATEMENT OF CONSENT

By signing below, you are indicating that you:

- Have read and understood the information document regarding this project.
- Have had any questions answered to your satisfaction.
- Understand that if you have any additional questions you can contact the research team.
- Understand that you are free to withdraw at any time without comment or penalty.
- Understand that you can contact the Research Ethics Unit on 3138 5123 or email ethicscontact@qut.edu.au if you have concerns about the ethical conduct of the project.
- Understand that non-identifiable data collected in this project may be used as comparative data in future projects.

☐ **I hereby provide my consent to participate in the research project named above.**

☐ **I would be happy to be contacted again for a follow up study.**

☐ **I would like to receive details of the study results upon completion of the study and have provided my email address to receive these results below.**

Name ....

Signature ....

Email address ....

Date

***Please return this sheet to the investigator*.**

E7. Experimental Sample (New recruitment: Pre-screening): Chapter 6

Queensland University of Technology Brisbane Australia	PARTICIPANT INFORMATION FOR QUT RESEARCH PROJECT

PERSONALITY AND ITS ASSOCIATION WITH EATING BEHAVIOUR AND FOOD CRAVING.

QUT Ethics Approval Number 1500000100

RESEARCH TEAM

Principal Researcher:	Lynette Mackey	PhD Student, Queensland University of Technology (QUT)
Associate Researchers:	Professor Neil King	School of Exercise & Nutrition Sciences, Faculty of Health and Institute of Health and Biomedical Innovation (IHBI), QUT
	Dr Melanie White	School of Psychology and Counselling, Faculty of Health, IHBI, QUT
	Dr Zephanie Tyack	School of Allied and Public Health, Faculty of Health Sciences, Australian Catholic University (ACU)

DESCRIPTION

Lynette Mackey, who is an accredited practicing dietitian (APD), is undertaking this project as part of a PhD program.

The purpose of this project is to determine whether certain personality characteristics are related to being overweight or obese.

You are invited to participate in this project if you are female, non-smoking, aged between 18–65 years, with a body mass index of 25 or greater, not pregnant or breastfeeding, not suffering from an eating disorder and not taking any medication for anxiety or depression, have successfully passed the screening process or have been invited to participate secondary to your expression of interest from a previous study. To work out your body mass index, divide your current weight by your height (in metres squared). For example if you weigh 80kg and your height in metres is 1.75 metres: 80/ (1.75 x 1.75) = 80/ 3.06 = 26.

Alternatively please use the following calculator:
http://www.health.gov.au/internet/healthyactive/publishing.nsf/Content/your-bmi

PARTICIPATION

E. You will need to pass a screening component to take part in this study. As part of the screening process, you are required to complete 2 online questionnaires (approximately 10 minutes).
F. If you are invited to take part in the study, you will be invited to undertake laboratory testing.
G. The laboratory testing session will take part at the QUT, Kelvin Grove Campus.
H. Prior to your laboratory session, you will be asked to complete 3 x additional online questionnaires (approximately 15 minutes).
I. As part of the testing procedure, you will be asked to consume a nutritionally balanced meal replacement as an alternative to lunch. After a short time interval you will be asked to consume *as much or as little as you would like* from some common snack items; such as milk/dark chocolate, assorted Arnotts biscuits, salted cashews, crisps and corn chips. Please inform Lynette if you foresee any problem consuming these common food items i.e. you do not like them or are allergic to them.

*****Your attendance at QUT requires that you eat your usual breakfast (or a small snack) and then arrive fasted, 3.5 hours after your breakfast/snack (drinking water during this time is fine). You cannot be assessed if you have fasted for longer than 3.5 hours.**

J. Schedule of expected testing procedure:
   a. Measures of weight, height and waist circumference will be taken.
   b. Complete a behavioural task of your ability to inhibit or switch habitual behaviours.

c. Complete a computer-based measure of how much you would like and want to consume some common food items x 2
d. Consume a nutritionally complete, meal replacement for lunch.
e. Complete 4 x appetite measures – i.e. to rate how hungry you are or to indicate whether you could eat more food at 7 different time-points.
f. Consume common snack food items to provide ratings of how enjoyable you find them.
g. End of testing procedure – total testing time is expected to take a maximum of 2 hours.

The questionnaires measure the following:
Screening component:

- One questionnaire measures the type of temperament that you have. Questions will include "I worry about making mistakes" and "I have very few fears compared to my friends".
- One questionnaire measures your eating behavior. Questions will include " I usually eat too much at social occasions, like parties and picnics", "Life is too short to worry about dieting".

Study component:

- One questionnaire measures your eating behavior. Questions will include "I feel capable to control my eating urges when I want to".
- Two questionnaires measure your ability to manage your emotions and your temperament/personality traits. Questions will include "I am clear about my feelings" & "I can keep performing a task even when I would rather not do it".

The behavioural tasks:

- These will consist of one computerized tasks that require you to respond as quickly and accurately as possible to word and food images.
- The other task consists of a paper and pencil task that measures how easily you can identify that a colour word i.e. "green" is written in a different coloured ink i.e. "yellow". It measures the time that you take to choose the colour "yellow" when promoted to name the *word* that you see and not the *colour* that you see.

Your participation in this project is voluntary. If you agree to participate you do not have to complete any question(s) you are uncomfortable answering. Your decision to participate or not participate will in no way impact upon your current or future relationship with QUT. If you do agree to participate you can withdraw from the project at any time without comment or penalty.

EXPECTED BENEFITS

It is not expected that this project will benefit you directly. However, it is increasingly recognised that managing weight and eating behaviour is not simply about applying greater amounts of will power. This research aims to extend current knowledge beyond the paradigm of "applying will power" and "going on another diet" to successfully manage weight. Therefore, this research has been developed to explore, inform and subsequently assist in the development and design of highly targeted and effective weight management programs that empower, rather than disempower the individual.

To compensate you for your contribution, you will be provided with a $25.00 gift voucher after completion of the laboratory experiment.

RISKS

The research team does not believe there are any risks beyond the inconvenience of completing the questionnaires and behavioural tasks, if you participate in this research.

At no time are any of the testing procedures expected to cause you any distress or discomfort however, if required QUT provides for limited free psychology, family therapy or counseling services for research participants of QUT projects who may experience discomfort or distress as a result of their participation in the research. Should you wish to access this service please contact the Clinic

Receptionist of the QUT Psychology and Counseling Clinic on 3138 0999. Please indicate to the receptionist that you are a research participant.

PRIVACY AND CONFIDENTIALITY

All comments and responses will be treated confidentially unless required by law. The names of individual persons are not required in any of the responses. However, we will ask for identifying details, such as your name, email address and a telephone number, if you express an interest to take part in a planned future study. Your contact details will be stored separately to your completed questionnaires in a secure electronic folder. You will be asked to create your own identity code so that data, obtained from the testing session, can be linked to your identity. This link will be destroyed once all of the data has been collected in the future study.

Any data collected as part of this project will be stored securely as per QUT's Management of research data policy. Please note that non-identifiable data collected in this project may be used as comparative data in future projects or stored on an open access database for secondary analysis.

CONSENT TO PARTICIPATE

Submitting the completed online questionnaire is accepted as an indication of your consent to participate in this component of the project.

QUESTIONS / FURTHER INFORMATION ABOUT THE PROJECT

If have any questions or require further information please contact one of the research team members below.

Lynette Mackey	3138 6399	lynette.mackey@student.qut.edu.au
Professor Neil King	3138 3528	n.king@qut.edu.au

CONCERNS / COMPLAINTS REGARDING THE CONDUCT OF THE PROJECT

QUT is committed to research integrity and the ethical conduct of research projects. However, if you do have any concerns or complaints about the ethical conduct of the project you may contact the QUT Research Ethics Unit on 3138 5123 or email ethicscontact@qut.edu.au. The QUT Research Ethics Unit is not connected with the research project and can facilitate a resolution to your concern in an impartial manner.

Thank you for helping with this research project. Please keep this sheet for your information.

E7. Experimental Sample (New recruitment: Post-screening): Chapter 6

Queensland University of Technology Brisbane Australia	**PARTICIPANT INFORMATION FOR QUT RESEARCH PROJECT**

PERSONALITY AND ITS ASSOCIATION WITH EATING BEHAVIOUR AND FOOD CRAVING.

QUT Ethics Approval Number 1500000100

RESEARCH TEAM

Principal Researcher:	Lynette Mackey	PhD Student, Queensland University of Technology (QUT)
Associate Researchers:	Professor Neil King	School of Exercise & Nutrition Sciences, Faculty of Health and Institute of Health and Biomedical Innovation (IHBI), QUT
	Dr Melanie White	School of Psychology and Counselling, Faculty of Health, IHBI, QUT
	Dr Zephanie Tyack	School of Allied and Public Health**,** Faculty of Health Sciences, Australian Catholic University (ACU)

DESCRIPTION

Lynette Mackey, who is an accredited practicing dietitian (APD), is undertaking this project as part of a PhD program.

The purpose of this project is to determine whether certain personality characteristics are related to being overweight or obese.

You are invited to participate in this project if you are female, non-smoking, aged between 18–65 years, with a body mass index of 25 or greater, not pregnant or breastfeeding, not suffering from an eating disorder and not taking any medication for anxiety or depression, have successfully passed the screening process or have been invited to participate secondary to your expression of interest from a previous study. To work out your body mass index, divide your current weight by your height (in metres squared). For example if you weigh 80kg and your height in metres is 1.75 metres: 80/ (1.75 x 1.75) = 80/ 3.06 = 26.

Alternatively please use the following calculator:
http://www.health.gov.au/internet/healthyactive/publishing.nsf/Content/your-bmi

PARTICIPATION

K. Now that you have passed the screening component, you are invited to undertake laboratory testing.
L. The laboratory testing session will take part at the QUT, Kelvin Grove Campus.
M. Prior to your laboratory session, you will be asked to complete 4 x additional online questionnaires (approximately 20 minutes).
   a. Please access the screening surveys here: http://survey.qut.edu.au/f/183400/17be/
   b. To complete the surveys online, please place the same identifying code on the survey, that you used for the screening survey that consisted of the first 3 letters of your first name and your date of birth i.e. lyn00/00/00
N. As part of the testing procedure, you will be asked to consume a nutritionally balanced meal replacement as an alternative to lunch. After a short time interval you will be asked to consume *as much or as little as you would like* from some common snack items; such as milk/dark chocolate, assorted Arnotts biscuits, salted cashews, crisps and corn chips. Please inform Lynette if you foresee any problem consuming these common food items, i.e. you do not like them or you are allergic to them.

*****Your attendance at QUT requires that you eat your usual breakfast (or a small snack) and then arrive fasted, 3.5 hours after your breakfast/snack (drinking water during this time is fine). You cannot be assessed if you have fasted for longer than 3.5 hours.**

O. Schedule of expected testing procedure:
   h. Measures of weight, height and waist circumference will be taken.
   i. Complete a behavioural task of your ability to inhibit or switch habitual behaviours.
   j. Complete a computer-based measure of how much you would like and want to consume some common food items x 2
   k. Consume a nutritionally complete, meal replacement for lunch.
   l. Complete 4 x appetite measures – i.e. to rate how hungry you are or to indicate whether you could eat more food at 7 different time-points.
   m. Consume common snack food items to provide ratings of how enjoyable you find them.
   n. End of testing procedure – total testing time is expected to take a maximum of 2 hours.

<u>The questionnaires measure the following</u>:
<u>Screening component:</u>

- One questionnaire measures the type of temperament that you have. Questions will include "I worry about making mistakes" and "I have very few fears compared to my friends".
- One questionnaire measures your eating behaviour. Questions will include " I usually eat too much at social occasions, like parties and picnics", "Life is too short to worry about dieting".

Study component:

- One questionnaire measures your eating behavior. Questions will include "I feel capable to control my eating urges when I want to".
- Two questionnaires measure your ability to manage your emotions and your temperament/personality traits. Questions will include "I am clear about my feelings" & "I can keep performing a task even when I would rather not do it".
- One questionnaire will measure symptoms of depression. Questions will include "I do not feel sad" & "I get as much satisfaction out of things as I used to."

<u>The behavioural tasks:</u>

- These will consist of one computerized tasks that require you to respond as quickly and accurately as possible to word and food images.
- The other task consists of a paper and pencil task that measures how easily you can identify that a colour word i.e. "green" is written in a different coloured ink i.e. "yellow". It measures the time that you take to choose the colour "yellow" when promoted to name the *word* that you see and not the *colour* that you see.

Your participation in this project is voluntary. If you agree to participate you do not have to complete any question(s) you are uncomfortable answering. Your decision to participate or not participate will in no way impact upon your current or future relationship with QUT. If you do agree to participate you can withdraw from the project at any time without comment or penalty.

EXPECTED BENEFITS

It is not expected that this project will benefit you directly. However, it is increasingly recognised that managing weight and eating behaviour is not simply about applying greater amounts of will power. This research aims to extend current knowledge beyond the paradigm of "applying will power" and "going on another diet" to successfully manage weight. Therefore, this research has been developed to explore, inform and subsequently assist in the development and design of highly targeted and effective weight management programs that empower, rather than disempower the individual.

To compensate you for your contribution, you will be provided with a $25.00 gift voucher <u>after completion of the laboratory experiment</u>.

RISKS

The research team does not believe there are any risks beyond the inconvenience of completing the questionnaires and behavioural tasks, if you participate in this research.

At no time are any of the testing procedures expected to cause you any distress or discomfort however, if required QUT provides for limited free psychology, family therapy or counseling services for research participants of QUT projects who may experience discomfort or distress as a result of their participation in the research. Should you wish to access this service please contact the Clinic Receptionist of the QUT Psychology and Counseling Clinic on 3138 0999. Please indicate to the receptionist that you are a research participant.

PRIVACY AND CONFIDENTIALITY

All comments and responses will be treated confidentially unless required by law. The names of individual persons are not required in any of the responses. However, we will ask for identifying details, such as your name, email address and a telephone number, if you express an interest to take part in a planned future study. Your contact details will be stored separately to your completed questionnaires in a secure electronic folder. You will be asked to create your own identity code so that data, obtained from the testing session, can be linked to your identity. This link will be destroyed once all of the data has been collected in the future study.

Any data collected as part of this project will be stored securely as per QUT's Management of research data policy. Please note that non-identifiable data collected in this project may be used as comparative data in future projects or stored on an open access database for secondary analysis.

CONSENT TO PARTICIPATE

Submitting the completed online questionnaires is accepted as an indication of your consent to participate in the online component of this project. If you would like to take part in the study, you will be asked to check the box below and write your name and sign the attached form to indicate your informed consent. Please also indicate if you would like to receive the results of this study. Your contact details will be stored securely with this form in a secure electronic folder.

QUESTIONS / FURTHER INFORMATION ABOUT THE PROJECT

If have any questions or require further information please contact one of the research team members below.

Lynette Mackey	3138 6399	lynette.mackey@student.qut.edu.au
Professor Neil King	3138 3528	n.king@qut.edu.au

CONCERNS / COMPLAINTS REGARDING THE CONDUCT OF THE PROJECT

QUT is committed to research integrity and the ethical conduct of research projects. However, if you do have any concerns or complaints about the ethical conduct of the project you may contact the QUT Research Ethics Unit on 3138 5123 or email ethicscontact@qut.edu.au. The QUT Research Ethics Unit is not connected with the research project and can facilitate a resolution to your concern in an impartial manner.

Thank you for helping with this research project. Please keep this sheet for your information.

QUT Queensland University of Technology Brisbane Australia	**CONSENT FORM FOR QUT RESEARCH PROJECT**

PERSONALITY AND ITS ASSOCIATION WITH EATING BEHAVIOUR AND FOOD CRAVING.

QUT Ethics Approval Number 1500000100

RESEARCH TEAM CONTACTS

Lynette Mackey	3138 6399	lynette.mackey@student.qut.edu.au
Professor Neil King	3138 3528	n.king@qut.edu.au

STATEMENT OF CONSENT

By signing below, you are indicating that you:

- Have read and understood the information document regarding this project.
- Have had any questions answered to your satisfaction.
- Understand that if you have any additional questions you can contact the research team.
- Understand that you are free to withdraw at any time without comment or penalty.
- Understand that you can contact the Research Ethics Unit on 3138 5123 or email ethicscontact@qut.edu.au if you have concerns about the ethical conduct of the project.
- Understand that non-identifiable data collected in this project may be used as comparative data in future projects.

☐ **I hereby provide my consent to participate in the research project named above.**

☐ **I would like to receive details of the study results upon completion of the study and have provided my email address to receive these results below.**

Name ....

Signature ....

Email address ....

Date

Please return this sheet to the investigator.

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