How is satiety affected when consuming food while working on a computer?

by

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Abstract

More people working at offices are choosing to eat meals at their desks making "desktop dining" an increasingly common phenomenon. There has been substantial research undertaken on the role distraction and stress on people's eating behaviour. Previous studies have reported that environmental distractors such as television viewing can influence meal intake and subsequent snack intake. However, the impact of stressful mental tasks on eating behaviour have received relatively less attention, focusing only on subsequent meal intake or current snack intake. This study sets out to determine whether eating while working influenced current meal energy intake. This research also examined the roles played by individual eating trait profile by evaluating the relationship between dietary restraint status and energy intake. A crossover experimental design was used in this study recruiting 43 normal weight adults (14 males and 29 females). The participants were required to eat pizza: quietly alone (control) and while working on a computer (work). Measurements assessed in this study included BMI, energy intake, state anxiety using the State-Trait Anxiety Inventory (STAI), stress levels (pre- and post-eating), and appetite (before and after both work and control sessions). Besides these measurements, restrained eating behaviour was also determined before eating using The Dutch Eating Behavior Questionnaire (DEBQ). The findings showed that consuming food while working on a computer significantly increased stress but had no influence on energy intake compared to control. However, post-eating hunger level was significantly higher in the work group when comparing to the control group. In terms of hunger level, hunger levels decreased significantly from pre- to post-eating for both work and control conditions as expected. In addition, no significant relationship was observed between restrained eating behaviour and energy intake in both work and control conditions. These results suggest that eating while working can affect satiety of

normal weight participants as indicated by the significant difference in post-meal hunger levels between work and control conditions.

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Abbreviations

BMI	body mass index
DEBQ	The Dutch Eating Behavior Questionnaire
TFEQ	Three-Factor Eating Questionnaire
STAI	State-Trait Anxiety Inventory
VAS	visual analogue scale
ANOVA	analysis of variance
ANCOVA	analysis of covariance
SD	standard deviation
SEM	standard error of the mean

Attestation of Authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, 'How is satiety affected when consuming food while working on a computer?' contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

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Chapter 1 Introduction

Cases of overweight and obesity are increasing at a staggering rate worldwide. The World Health Organization reported that 39% of adults were overweight in 2016, and 13% were obese ("Obesity and overweight," 2018). Over the past few decades, researchers have been seeking reasons and solutions for this health problem, and it has been reported that satiety can be impacted by internal physiological factors such as appetite (Blass et al., 2006), as well as external factors such as environmental stimuli, such as television viewing (Hetherington, Anderson, Norton & Newson, 2006; Blass et al., 2006; Bellisle, Dalix & Slama, 2004; Bellisle et al.,2009; Higgs & Woodward, 2009; Ogden et al., 2013). As an extremely hungry state is rarely experienced, eating behavior depends heavily on the response of people to external factors rather than the basic homeostasis physiological function of the human body (Herman & Polivy, 2005).

Numerous studies have attempted to explain how eating behaviour can be influenced by environmental stimuli such as visual and auditory distractors. Hetherington, Anderson, Norton & Newson (2006) and Bellisle, Dalix & Slama (2004) concluded that consuming food while viewing television resulted in significantly higher energy intake than eating quietly alone. Blass et al. (2006) further stated that significantly higher energy intake was noted in the television viewing group when comparing to the music listening group. Bellisle & Dalix (2001) reported that eating while listening to a story resulted in significantly higher energy intake than eating alone.

In addition to energy intake, satiety can also be measured using self-reported appetite ratings (Benelam, 2009), which is influenced by physical, physiological and psychological factors before, during and after a meal (Campbell, Wagoner & Foegeding, 2017). The results of appetite rating after meals vary mainly due to the influence of different conditions. Playing computer games while having lunch resulted in significantly less post-lunch fullness than eating lunch with no distractor (Oldham-Cooper et al., 2010, Brunstrom & Mitchell, 2006). Bellisle et al. (2009) reported that eating with two other people resulted in significantly lower post-meal fullness than when eating alone, watching television without food cues, watching television with food advertisements, and when listening to a detective story. Born et al. (2010) found that participants doing unsolvable mathematical test had significantly less satiety scores in terms of fullness than people doing solvable mathematical test.

The biological demands of mental work are different from physical work. Thus, it is also necessary to figure out the impact of cognitive tasks on appetite sensation and energy intake. Mental work refers to a task needing cognitive efforts (Chaput & Tremblay, 2007), and food intake can be related to stress levels brought about by cognitive tasks. To investigate the relationship between psychological stress and energy intake, studies in laboratory settings have used different mental tasks to create acute stress. However, not all research that explored the correlation between food intake and stress induced by different mental tasks have yielded conclusive results. Rutters et al. (2009) reported that participants doing unsolvable math test had significantly higher energy intake than those who did solvable math test, while Born et al. (2010) showed that energy intake for participants doing unsolvable math tests did not differ from those who did solvable math tests. Chaput & Tremblay (2007) and Chaput et al. (2008) both reported that energy intake was significantly higher in participants doing reading-writing task compared to those who did nothing. However, Salama, Drapeau, Tremblay & Pérusse-Lachance (2016) found that male participants doing reading-writing task had significantly lower energy intake than those at rest.

Besides energy intake and appetite sensation, dietary restraint is increasingly important for human eating behaviour, which can be defined as a synonym for chronic dieting (Herman, 1978). Working on a task that distracts people may weaken their self-monitoring of food and influence food intake. This depends on the extent to which the consumers are dietary restrained (Bellisle & Dalix, 2001). Zellner et al. (2006) reported that restrained eaters in the stress group (working on unsolvable anagrams) consumed more than those in the no-stress group (working on solvable anagrams). Royal & Kurtz (2010) on the other hand found no significant interaction between restraint state and energy intake in both low-stress and high-stress conditions while working on solvable and unsolvable anagrams respectively.

Eating while working is increasingly becoming common in modern society. Working can be seen as both a visual distraction and a cognitive task. There is currently no study evaluating the impact of eating while working on current meal intake. Therefore, the current research sought to determine the impact of working on a computer on energy intake in a controlled experiment. The purpose of this research was to compare the ways in which the working stressor might influence eating behaviors. In both conditions with and without distraction, measures of hunger, fullness and food pleasantness were examined before and after lunch. In addition, it was also interesting to

determine whether the effects of working as distraction can be influenced by daily eating behaviour (dietary restraint).

Chapter 2 Literature Review

2.1 Satiety

2.1.1 Definition of Satiety

Satiety can be defined as the sense of fullness, which acts as the inhibition of hunger sensation experiencing after ingesting food (Karalus & Vickers, 2016) that can result in hunger decreased while fullness increased and further eating inhibited (Blundell et al., 2010).

2.1.2 Physiological indicators of satiety

Satiety is a common human experience, and changes in physiological indicators such as hormone levels are thought to be strongly correlated with satiety. Among them, the YY peptide, GLP-1, CCK and ghrelin are thought to be closely associated to satiety signals (Clamp et al., 2015; De Graaf et al., 2004). The YY peptide is believed to inhibit expression of neuropeptide Y by activation of the homeostatic center in the hypothalamus, thus inhibiting appetite (Abbott et al., 2005). YY peptide can also activate ileal brake (Maljaars, P. W. J., Peters, H. P. F., Mela, D. J., & Masclee, 2008) and postpone absorption of nutrients and gastric emptying, leading to increased satiety. In the gastrointestinal tract, GLP-1 supresses the secretion of the stomach and pancreas and the emptying of the stomach, thereby enhancing satiety (Van Can et al., 2014). Besides that, the sense of satiety can also be induced by CCK that is regulated by activation of the vagus nerve in stomach and duodenum (Overduin, Gibbs, Cummings & Reeve Jr, 2014). CCK can also slow down the emptying of the stomach and keep the stomach expanded, leading to a stronger sense of satiety in the body (Gamble, Kenny & Dockray, 2013). As a unique peripheral hormone, ghrelin is a powerful stimulant, which can influence appetite and energy intake. The level of ghrelin in the blood can be an indicator of satiety (Cummings & Overduin, 2007).

2.1.3 Measures of satiety

Satiety influences the food consumption by a person and produces energy intake (Bank, nd). Although the detection of hormones related to satiety is objective and has a small error, it cannot be used to fully evaluate satiety. In researches, the widely used measurement of satiety combines energy intake with appetite sensations (Benelam, 2009), including fullness level, hunger

level, expected food consumption, and the extent to which people desire to eat after consuming a meal (Clark & Duncan, 2017). Self-reported appetite ratings can be measured using the Visual Analogue Scale (Forde, Almiron-Roig & Brunstrom, 2015; Bank, nd). The scale comprises a horizontal line with anchors, such as “not at all” and “extremely” (please see section 3.5.5), at the two extreme ends of the scale. The participants will mark on the scale to indicate appetite sensation at pre-set time intervals. The result is quantified by measurement of distance from the start of the scale to the mark indicated by the participants.

2.2 Factors influencing satiety

Satiety can be affected by varieties of factors, including physiological and psychological aspects before, during and after food consumption (Campbell, Wagoner & Foegeding, 2017).

In terms of the brain control over food intake, the hypothalamus and other brain regions jointly regulate individual’s food intake. The main information of ventromedial hypothalamus (VMH) and lateral hypothalamus (LH) comes from blood, while the major energy source of metabolism comes from blood glucose and fat. The two basic signals that trigger food intake are the receptors in blood, which monitor blood glucose and fat. When blood glucose levels are too low or not enough for metabolism, lateral hypothalamus will receive the signals from hepatocellular receptors. Then, some neurons in LH served as glucose detectors can adjust their activity according to changes. In addition, other neurons in the hypothalamus are responsible for the detection of free fatty acids and insulin changes in blood. Taken together, appetite system is activated by these neurons, thus triggering food intake (Rozin & Vollmecke, 1986).

Over the past few decades, multiple studies have explored the effect of psychological factors on energy intake. These studies introduced environmental and social interventions, including mental work (Zellner et al., 2006; Chaput & Tremblay, 2007; Chaput et al., 2008; Rutters et al., 2009; Born et al., 2010; Royal & Kurtz, 2010; Lemmens, Rutters, Born & Westerterp-Plantenga, 2011; Salama, Drapeau, Tremblay & Pérusse-Lachance, 2016; Klatzkin et al., 2016), eating with others (Bellisle & Dalix, 2001; Hetherington, Anderson, Norton & Newson., 2006; Bellisle et al.,2009; Ogden et al., 2013), and other distractions such as television viewing (Bellisle, Dalix & Slama, 2004; Higgs & Woodward, 2009; Hetherington, Anderson, Norton & Newson., 2006; Ogden et al., 2013; Blass et al., 2006; Bellisle et al., 2009). This review will discuss the

influence of various distractions on energy intake, appetite sensation, and the relationship between restrained eating behaviour and energy intake (see Table 2.1).

2.3 The influence of external stimuli on energy intake

Researches have shown that the external stimuli, such as eating with others (Hetherington, Anderson, Norton & Newson, 2006; Bellisle et al., 2009; Ogden et al., 2013), visual stimuli (Bellisle, Dalix & Slama, 2004; Blass et al., 2006; Hetherington, Anderson, Norton & Newson, 2006; Bellisle et al., 2009), auditory stimuli (Bellisle, Dalix & Slama, 2004; Blass et al., 2006; Bellisle et al., 2009; Long, Meyer, Leung & Wallis, 2011; Higgs & Donohoe, 2011), may influence energy intake.

Bellisle et al. (2009) invited participants to carry out experiments under five different environmental stimuli. The first condition required participants to eat alone quietly. The second condition required participants to eat in groups of three. The third and fourth conditions required subjects to eat alone while watching television with either no food-related cue or a series of advertisements presented varieties of foods. In the fifth condition, subjects were required to eat alone and listen to a recorded detective story at the same time. However, one problem here was that the authors did not define whether people in eating in groups of three were friends or not, as eating behaviour will be different in the presence of either friends or strangers. People tend to eat less in front of strangers in order to leave a good impression to others, while people tend to eat more when with families and friends because of longer meal time (Ogden et al., 2013). The results showed that total energy intakes were significantly different across the five conditions. Participants watching television had the highest total energy intake, while people eating in groups of three had the lowest total energy intake. However, they failed to make a specific analysis on the difference of total energy intake between these five conditions.

Hetherington, Anderson, Norton & Newson (2006) explored the influence of eating *ad libitum* lunch with two strangers and eating with two friends on energy intake. Moreover, they had solo eating and television conditions. The authors found out that subjects eating alone had significantly less energy intake than those who eating with two friends and eating in presence of television. However, energy intake for participants eating with two strangers did not differ from any other group, including eating with friends, eating alone and eating while watching television.

This outcome is contrary to that of Herman & Polivy (2005) who reported that if people were eat with strangers, they were more likely to eat minimally in order to impress on others satisfactory. In another study, Ogden et al. (2013) got participants to have a talk with the researcher during snack food consumption, which was seen as a social interaction condition. In addition, there was also a solo eating condition and television eating condition, similar to studies by Hetherington, Anderson, Norton & Newson (2006) and Bellisle et al. (2009). Moreover, a driving condition was introduced, where subjects were required to eat while driving. Interestingly, participants who watched television ate significantly more snacks compared to those who in the driving and social interaction groups. However, snack intake showed no significant difference between television-eating and solo-eating conditions. Hetherington, Anderson, Norton & Newson (2006), on the other hand reported that participants eating alone had significantly less food intake than those who watching television.

Studies have also been carried out to determine the impact of auditory stimuli such as recorded story and music, on energy intake. Bellisle & Dalix (2001) explored the effect of auditory and people distractions on food intake by designing four conditions, which involved eating either alone quietly, in a group, or while listening to a either a story or instructions that get participants to concentrate on sensory qualities of food. Participants were provided with French cottage pie (Hachis Parmentier) and fruit sherbet. The results showed that they ate significantly more when eating and listening to a recorded story at the same time compared to when eating quietly alone. However, energy intake did not differ when comparing the food instruction condition, auditory story condition and group condition with each other. The authors further reported that subsequent 24-hour food intake did not differ between these four conditions. Based on this study, Bellisle, Dalix & Slama (2004) further investigated the impact of visual and auditory distractions on food intake under four conditions. Two conditions were used as baseline and control, which both required participants to eat a French cottage pie (Hachis Parmentier) and fruit sherbet as lunch, while having a rest. In the two other conditions, participants were required to eat in the presence of television, and a recorded detective story respectively. Significantly higher energy intake was noted in the television and audio recording groups when comparing to subjects under the baseline and control conditions. However, energy intake did not differ between the television and audio recording groups, and between baseline and control groups. Blass et al. (2006) also compared the

impacts of visual and auditory stimuli on energy intake under two conditions. One required them to eat macaroni and cheese, or pizza when watching television. The other condition required them to eat the same food while listening to music. Significantly higher total caloric intake was noted in the television viewing group when comparing to the music listening group. This result indicated that visual stimuli was more effective in increasing food intake compared to auditory stimuli. However, Bellisle, Dalix & Slama (2004) found that participants who watched television consumed a similar amount of pie compared to those listening to a detective story.

Higgs & Donohoe (2011) also investigated how focusing on food, in contrast to eating with or without distraction during lunch influences later snack intake. The food focus group encouraged participants to concentrate on food they were eating. Eating with distraction involved participants reading a newspaper article on making healthier food choices. In the non-distraction condition, participants consumed lunch without any manipulation. Cookie intake was measured after lunch. The authors found significantly fewer cookies consumed by the group that focused on food compared to the group that consumed food under the distraction condition and the group without manipulation. Similarly, Long, Meyer, Leung & Wallis (2011) investigated how focused attention and distraction influenced food intake. The focused condition asked participants to eat pasta while listening to the recorded sensory characteristics of food. In the distraction condition, participants consumed food while listening to Jane Austin's Pride and Prejudice, and participants consumed food alone in the control condition. Long, Meyer, Leung & Wallis (2011) found that participants listening to a story had significantly more food intake when comparing to those who ate alone and listened to food characteristics. The result was different from Higgs & Donohoe (2011), who found no intake difference between participants eating alone and listening to food characteristics.

A few researchers also investigated the effect of sedentary activities like television viewing and computer games on subsequent food intake. Higgs & Woodward (2009) found that participants eating lunch in the presence of television ate significantly more afternoon snacks compared to those who ate lunch without television. Oldham-Cooper et al. (2010) further explored the effect of distractor when participants ate their lunch on their food intake. Participants in the intervention group were asked to play the card sorting game on a computer when they were consuming meals, and people in the non-distraction group did not receive any distractor while

eating lunch. They reported that participants playing the computer game had significantly more biscuits intake compared to those who consumed lunch without distraction.

2.4 Stress

Psychological stress refers to physical and mental tension, which is mainly caused by the inability to successfully deal with changes to meet the environmental requirements. The tension can be expressed by nonspecific psychological and physiological reactions. Stress is a kind of behavioral and cognitive experience composed of stressor and stress responses. Individuals' inner conflict and accompanying emotional experience contribute to psychological stress. Thus, psychologically, stress can be seen as an inner experience produced by external environment (Sherwood, 2015).

Studies investigating eating behaviour influenced by environment have used different measures to assess participant's psychological state. This included the use of the Positive and Negative Affect Schedule, PANAS (Royal & Kurtz, 2010, Long, Meyer, Leung & Wallis, 2011), visual analogue scale for anxious, relaxed, sociable and stress (Hetherington, Anderson, Norton & Newson, 2006; Higgs & Donohoe, 2011; Siervo et al., 2018), Profile of Mood States (POMS; Klatzkin et al., 2016), and the State Trait Anxiety Inventory (Chaput & Tremblay, 2007; Rutters et al., 2009).

2.4.1 The Positive and Negative Affect Schedule (PANAS)

PANAS is a widely used self-report questionnaire being made up of two 10-item scales to measure positive affect (PA) and negative affect (NA) (Seib-Pfeifer, Pugnaghi, Beauducel & Leue, 2017). Royal & Kurtz (2010) used PANAS to test momentary changes in mood, such as the stress change before and after consuming snacks. The authors reported negative affect was significantly higher in participants who ate meal while doing unsolvable anagrams compared to those who doing solvable anagrams. Long, Meyer, Leung & Wallis (2011) further used PANAS to measure the effect of eating alone, eating and listening to food characteristics instruction, and eating and listening to story, on participants' positive and negative affect. They found no significant influence of all conditions on mood. However, they reported that there were significant decreases for both positive and negative moods from pre-meal to post-meal, which revealed the effect of time on people's mood. On contrary, Higgs & Donohoe (2011) found no significant difference in

both pre-meal and post-meal mood ratings in three conditions: eating without manipulation, eating while reading a food article, and eating while listening to instructions about food sensory characteristics. Higgs & Donohoe (2011) used a line rating scale for stress and relaxed, while Long, Meyer, Leung & Wallis (2011) used PANAS. The determination of mood using different methods may be responsible for different results obtained.

2.4.2 The Profile of Mood States (POMS)

The POMS method is also used to evaluate subjects' mood, such as tension or anxiety, anger or hostility, fatigue or inertia, vigor or activity, confusion or bewilderment, depression or dejection (McNair, Droppleman & Lorr, 1992). Lemmens, Rutters, Born & Westerterp-Plantenga (2011) stated that scores for negative affect including confusion, anger depression and anxiety were significantly higher in groups who did the unsolvable math test than those who did solvable math test, which confirmed the psychological changes caused by different math problems administered. Recently, Klatzkin et al. (2016) also adopted POMS to assess participants' negative affect after completing cognitive tasks. They reported a significant increase in negative affect after completing speech and mental math tests. Moreover, they found that obese women with binge-eating disorder (BED) had more negative affect than normal weight women without BED. This indicated that BMI and binge-eating-disorder might influence affect to some extent. Klatzkin et al. (2015) explained that obese BED individuals were more susceptible to psychological dysfunctions, such as negative affect compared to obese non-BED individuals.

2.4.3 State-Trait Anxiety Inventory (STAI)

Apart from negative affect, anxiety level is also a good indicator of psychological change, which is widely measured using STAI. STAI has two different scales: anxiety-state scale and anxiety-trait scale, which both consist of 20 questions. The anxiety–state scale describes how they feel at a particular time, and the anxiety–trait scale describes how people feel generally (Chaput & Tremblay, 2007). The state anxiety dimension in STAI is widely employed to evaluate people's anxiety level. Rutters et al. (2009) used anxiety-state scale in STAI to measure participants' anxiety state under stress and control conditions by doing unsolvable and solvable mental arithmetic task respectively. They pointed out that significantly higher scores in the state anxiety were observed in the stress group when comparing to the control. Besides, after completing the stressful work,

there was a significantly increase in state anxiety scores, while no significant changes were observed in the control condition. Additionally, Chaput & Tremblay (2007) reported significantly higher anxiety–state scores in the STAI questionnaire between participants who completed reading and then writing a summary than those having a rest before they consumed a buffet meal. However, after eating, the anxiety-state scores in the two conditions did not differ greatly. In addition to POMS, Lemmens, Rutters, Born & Westerterp-Plantenga (2011) also used STAI to evaluate the pre-meal psychological stress between the two conditions, and found that participants doing unsolvable math test had significantly higher STAI scores when doing a solvable math test, which also confirmed different stress levels caused by different math tests.

2.4.4 Visual Analogue Scales (VAS)

Some studies take a more intuitive approach such as the use of VAS. Hetherington, Anderson, Norton & Newson (2006) used VAS to assess participants' mood including anxious, relaxed and sociable in four eating conditions: solo eating, eating while viewing television, eating with two friends and eating with two strangers. Participants were significantly less relaxed when they were with strangers than with friends before lunch meal. Besides, higher anxiety levels were noted in subjects eating with strangers in comparison to those eating by themselves, although not significant. Moreover, participants were all significantly less anxious and significantly more relaxed after consuming food. However, sociable rating for mood did not differ greatly between pre-meal and post-meal in three conditions except for eating with strangers. Siervo et al. (2018) also applied VAS to measure participants' stress levels. They found that violent and non-violent video game groups reported significantly higher in stress level than the television group, but the difference between the two video game groups did not reach significance.

2.5 The influence of mental task on energy intake

Eating behaviour may be influenced by acute stress. To explore the relationship between energy intake and stress, studies in laboratory settings have used different mental tasks to create acute stress. Chaput & Tremblay (2007) defined mental work as tasks demanding cognitive efforts. Mental work used in previous studies included solving anagrams (Royal & Kurtz, 2010; Zellner et al., 2006), reading and writing (Chaput & Tremblay, 2007; Chaput et al., 2008; Salama, Drapeau, Tremblay & Pérusse-Lachance, 2016), and doing a math problem (Rutters et al., 2009; Born et al.,

2010; Lemmens, Rutters, Born & Westerterp-Plantenga, 2011; Klatzkin et al., 2016).

Studies have explored the effect of working while eating on current energy intake. Royal & Kurtz (2010) provided 10 solvable and unsolvable anagrams to create low-stress and high-stress conditions. Subjects were required to eat M&M's, cheese crackers, peanuts and Reese's Pieces when they worked on the anagrams. They reported that the high-stress group consumed significant more total energy intake for these snack foods than the low-stress group. Another study (Zellner et al., 2006) also used 10 solvable and 10 unsolvable anagrams to create no-stress and stress conditions respectively. Under these conditions, participants consumed M&Ms, grapes, potato chips, and peanut. However, different from Royal & Kurtz (2010), who focused on the difference of total energy intake between the low-stress and high-stress groups, Zellner et al. (2006) analysed the differences in the food intake of individual snack between the two groups. They found that people in the stress group had significantly more M&Ms and significantly less grapes compared to those who in the no-stress group. The study suggested that people under stress conditions tended to choose unhealthy food. They explained that stress would cause disinhibition of self-imposed food choice rules avoiding foods that contribute to unhealthy and fattening, especially sweet foods.

More studies have investigated the subsequent food intake after mental work. Chaput & Tremblay (2007) allocated subjects into two sessions where they were: i) asked to sit for 45 minutes, and ii) read and write for 45 minutes (cognitive task). After completing different tasks, subjects ate a buffet-style meal. The authors reported that people consumed significantly more energy after completing the cognitive task compared to people sitting. Later, Chaput et al. (2008) added a third condition, which involved another cognitive task: a comprehensive battery of computerized tests, in addition to the sitting, and reading and writing conditions. Similarly, Chaput et al. (2008) concluded that energy intake was significantly higher in participants who had completed the reading-writing task and computerized test when comparing to those who had a rest. However, no significant difference was detected in terms of after-task food intake between the two cognitive task conditions: reading and writing, and computerized tests. Recently, Salama, Drapeau, Tremblay & Pérusse-Lachance (2016) also employed reading and writing as a mental work condition and resting as a control condition, again similar to Chaput & Tremblay (2007) in terms of method. Salama, Drapeau, Tremblay & Pérusse-Lachance (2016) however further explored the differences between male and female participants. The results showed that after reading and

writing, men had significantly less energy intake than those having a rest. As for women, differently, energy intake was significantly higher for those who completed mental work compared to those resting. A possible explanation for this might be that women tend to eat food, while men tend to choose alcohol and tobacco when people want to get rid of stress (Torres & Nowson, 2007).

Math tests have also been widely employed to create stress conditions. Born et al. (2010) provided a solvable mathematical test (rest condition) and unsolvable mathematical test (stress condition). In this study, participants were served a standard breakfast, and then ate second meal after completing mathematical tests. The results demonstrated that people under the stress condition ate significantly more food in the second meal than people under the rest condition. Similarly, Rutters et al. (2009) used solvable and unsolvable mental arithmetic tasks for rest and stress conditions respectively. After completing the different tasks, participants were served sweet and salty snack foods. They reported that participants in the rest condition had significantly less total energy intake and sweet food intake when comparing to those who in the stress condition. Interestingly, salty food intake for participants in the stress group did not differ from those who in the rest group. This study indicated that after a mental task, stressed individuals tended to choose sweet foods instead of salty foods.

Lemmens, Rutters, Born & Westerterp-Plantenga (2011) further explored the differences in energy intake between normal weight and visceral overweight subjects under stressed (performing an unsolvable math test with background noises and annoying music) and unstressed (performing a solvable math test in the absence of background noises and music) conditions. They found that in visceral overweight participants, energy intake and 'wanting' for snacks and dessert were higher in the absence of hunger, under the stress compared to rest condition, in comparison to normal weight participants. In addition, under stress condition, daily energy requirements percentage for visceral overweight participants increased over two meals, in comparison to normal weight participants. Details of meals consumed in this study were not provided by the authors.

2.6 Appetite ratings

2.6.1 Pre-eating

Previous studies assessing the participants' pre-meal hunger and fullness levels all

reported no difference between conditions (Bellisle, Dalix & Slama, 2004; Mitchell & Brunstrom, 2005; Hetherington, Anderson, Norton & Newson, 2006; Brunstrom & Mitchell, 2006; Chaput & Tremblay, 2007; Rutters et al., 2009; Bellisle et al., 2009; Born et al., 2010; Higgs & Donohoe, 2011; Long, Meyer, Leung & Wallis, 2011; Ogden et al., 2013). This suggests that appetite remained the same before the meal, ensuring the subsequent measurements for energy intake and satiety.

2.6.2 Post-eating

Different from the measured results of satiety before meals, the results of satiety after meals vary mainly due to the influence of different conditions. Studies (Brunstrom & Mitchell, 2006; Oldham-Cooper et al., 2010) have investigated the effects of playing computer games on the post-meal satiety. Brunstrom & Mitchell (2006) found that participants eating cakes in silence had a significantly increase in fullness than people playing computer games during a meal. Participants eating cakes in silence also reported a greater decrease in hunger, but the difference was not significant. Similarly, Oldham-Cooper et al. (2010) reported that people playing computer games while having lunch had significantly less post-lunch fullness than eating lunch with no distractor. However, post-lunch hunger failed to reach significance. As Oldham-Cooper et al. (2010) did not measure hunger and fullness levels before participants consumed lunch, this may influence post-eating satiety assessment, although a standard breakfast was provided.

Bellisle et al. (2009) also reported that eating with two other people resulted in significantly lower post-meal fullness than when eating alone, watching television without food cues, watching television with food advertisements, and when listening to a detective story. Higgs & Donohoe (2011) further reported that participants eating sandwiches while reading food articles had higher levels of post lunch hunger than those who eating without manipulation and eating while listening to food characteristics instructions. However, results did not reach significance. Similarly, Long, Meyer, Leung & Wallis (2011) found hunger ratings did not differ significantly among participants in different conditions: solo-eating, eating when listening to a recorded story and eating when listening to food characteristics instruction. However, fullness was rated significantly higher in participants who consumed pasta while listening to a story when comparing to those eating alone.

Ogden et al. (2013) found that change in hunger was significantly higher in participants eating while watching television than those in the driving group, social group and solo-eating group. Besides, participants eating alone reported significantly higher post-meal fullness level than those in the driving group, television group and social group. Similarly, the effect of watching TV and eating alone on appetite was compared in the study conducted by Bellisle, Dalix & Slama (2004). They pointed out that no significant differences in post-lunch hunger ratings were detected under four conditions: eating quietly alone, eating and viewing television, eating in presence of a detective story and eating quietly alone. The result was different from Ogden et al. (2013), who concluded that participants who watched television had significantly lower hunger levels than those eating alone. The study carried out by Blass et al. (2006) further reported that the change in hunger ratings from pre-meal to post-meal were significantly higher in participants who had macaroni, pizza and cheese in presence of television when comparing to those in presence of music. The results also showed television group had significantly less post-meal hunger rating than the music group.

Some other studies required participants to consume food after performing tasks. Chaput & Tremblay (2007) concluded no significant difference in hunger and fullness levels after eating with participants who had completed reading-writing task compared to those who had a rest. However, the participants had significantly more food intake in the buffet-type meal after the mental work. The result suggests that people after mental work might eat more food to experience the same satiety as those who had a rest. Siervo et al. (2018) also reached a similar conclusion that there was no difference in post-meal hunger but significant difference in fore-noon snacks intake. They reported that the rated hunger did not differ significantly across the violent video game group, non-violent video game group and television group, although participants ate significantly more after playing violent video game when comparing to after viewing television. Although the conditions in the Chaput & Tremblay (2007) and Siervo et al. (2018) were different, both studies found that people who were more stressed ate more and ended up with a similar satiety to those who were less stressed. Born et al. (2010) however found that participants doing unsolvable mathematical test had significantly less satiety scores than people doing solvable mathematical test, although no significant differences in hunger status were detected between these two groups.

2.6.3 Satiety overtime

Previous studies have investigated the difference in hunger and fullness rating from pre meal to post meal. These studies reported that rated hunger decreased significantly while rated fullness increased significantly after eating food (Blass at el., 2006; Hetherington, Anderson, Norton & Newson, 2006; Rutters et al., 2009; Higgs & Woodward, 2009; Higgs & Woodward, 2009; Born et al., 2010; Long, Meyer, Leung & Wallis, 2011; Lemmens, Rutters, Born & Westerterp-Plantenga, 2011; Ogden et al., 2013).

2.7 Restrained eating behaviour

2.7.1 Concept of restrained eating behaviour

Herman & Mack (1975) first proposed the restrained eating concept, which referred to the long-term restrictions on eating for weight control that was found to be more common in young women (Ricciardelli & Mccabe, 2001). The author explained that restrained eaters could control their food intake even when they are hungry, whereas dietary unrestrained people depend on hunger signals in vivo to determine how much and what time to eat. Besides, restricted consumers habitually count calories and make plans for future meals to avoid foods they think “bad” or “forbidden,” ensuring them effective cognitive control on their food selections (Ward & Mann, 2000). Many researchers have found that restrained eating behaviour could predict the extent of eating disorders (Stice, 2001; Johnson & Wardle, 2005; Neumark-sztainer et al., 2006), and was found to be an important predictor of overeating symptoms (Stice, 1998; Stice, Ozer, & Kees, 1997). In addition, restrained eating behaviour played a significant role in the profile of eating disorders (Herman & Polivy, 1990; Polivy & Herman, 1985; Papies, Stroebe & Aarts, 2008).

Herman & Polivy (1984) came up with the Boundary Model, which stated that there exist two different physiological boundaries, namely the hunger boundary and the satiety boundary, that controlled human responses to food. When an individual felt hungry, the hunger boundary would take effect and influence eating behavior. When feeling full, the satiety boundary kicks in and eating stops. However, restrained eaters often ignore their body's internal hunger and satiety signals, setting an artificial cognitive boundary (diet boundary) to regulate eating behavior to control weight. Under the long-term regulation of the diet boundary, restricted eaters gradually

became insensitive to hunger and satiety signals. Once this regulation mechanism is broken, the diet boundary cannot regulate food intake, and they might overeat in pursuit of physiological satiety (to inhibit eating).

2.7.2 Measurements of restrained eating behaviour

Restrained eating behaviour can be measured using the Restrained Scale (RS; Polivy, Herman & Warsh, 1978), Dutch Eating behavior Questionnaire (DEBQ; Van Strien, Frijters, Bergers & Defares, 1986) and Three Factor Eating Questionnaire (TFEQ; Stunkard & Messick, 1985). The Restrained Scale has 10 items that is further divided into two subscales: diet concern (6 items) to measure long-term dieting motivation, and weight fluctuation (4 items) used to record the process of weight change of subjects. The Dutch Eating behavior Questionnaire contains three subscales: restrained, emotional and external eating. Among them, emotional eating and external eating are often combined to serve as an indicator of disinhibited eating. In addition, the original Three Factor Eating Questionnaire has 51 items and is separated into three traits: cognitive restraint, disinhibition, and hunger. Karlsson et al. (2000) further developed the TFEQ-18 to make it easier to use, and assessed emotional eating, and cognitive restrained and uncontrolled eating.

2.7.3 The relationship between restrained eating behaviour and energy intake

Zellner et al., (2006) reported that restricted consumers are more likely to overeat in stressful situations. The authors found that restrained eaters working on an unsolvable anagram were stressed and consumed more snacks than those working on a solvable anagram task. This might be due to the fact that the demanding cognitive task prevented people from monitoring their food intake carefully. Similarly, Bellisle & Dalix (2001) reported that compared to the rest condition, participants with higher restrained scores in the different distraction conditions, including eating while listening to a story or food characteristics instructions or eating with others, had significantly higher energy intake. On the other hand, Chaput & Tremblay (2007) confirmed the effect of cognitive dietary restraint on consumption restriction. The authors demonstrated that in the rest and reading-writing sessions, subjects with higher cognitive dietary restraint consumed significantly less food compared to subjects with lower cognitive dietary restraint scores when eating a buffet meal.

Interestingly, Ogden, Oikonomou & Alemany (2017) specially investigated the influence

of dietary restraint on food intake under different conditions. After walking, participants higher in restrained scores ate significantly more snacks compared to those with lower restrained scores. At the same time, they reported that participants higher in restrained eating consumed significantly less snacks after watching TV than those lower in restrained eating. However, total energy intake did not differ between higher and lower restrained participants under the social condition.

More researches have concluded that energy intake was not related to dietary restricted eating behaviour. Royal & Kurtz (2010) reported that dietary restraint status did not interact with snack intake, among participants doing solvable and unsolvable anagrams. Salama, Drapeau, Tremblay & Pérusse-Lachance (2016) also found no significant interaction between restrained eating behaviour and buffet intake in both reading-writing and rest conditions. Moreover, Bellisle, Dalix & Slama (2004) claimed that dietary restricted status was not correlated with energy intake when participants consumed Hachis Parmentier while having a rest, watching television and listening to a detective story. Bellisle et al. (2009) further showed that energy intake for low dietary restricted participants did not differ from those who were high restricted in all five eating conditions: solo eating, eating in presence of television without food cues, eating in presence of television with food advertisements, eating in presence of story listening, and eating in groups of three.

Table 2.1 A summary of studies showing the influence of external factors on satiety.

Reference	Purpose	Participants	Treatments	Measures	Significant results
Bellisle & Dalix. (2001)	- to evaluate the relationship between energy intake and dietary restrained eating behaviour	n=41 normal weight female	- eating lunch while doing different tasks - four conditions: 1) eat quietly alone 2) eating while listening to instruction about food sensory qualities, for example, focusing on color, texture, temperature, etc) 3) eating while listening to a recorded detective story 4) eating in groups of four - food: 1 kg shepherd's pie (Hachis Parmentier) and 150 g fruit sherbet.	- TFEQ - DEBQ - EI - 9-point category scale for hunger and palatability	- energy intake: meal size was significantly higher for participants listening to a detective story than those eating alone - restrained eating behaviour: compared to the rest condition, participants with higher restrained scores in the different distraction conditions, eating while listening to a story or food characteristics instructions or eating with others, had significantly higher energy intake
Bellisle, Dalix & Slama. (2004)	- to evaluate the effect of two non-food related external distractors	n=48 normal weight woman	- eating lunch while doing different tasks - three conditions:	- TFEQ - nine-point category scales for appetite	- energy intake: meal size in the television and auditory groups were both

	such as television and auditory stimuli on food intake		1) eating without distraction 2) eating while watching television 3) eating while listening to a recorded story. -food: 1 kg shepherd's pie (Hachis Parmentier) and 150 g fruit sherbet.	- EI	significantly more than the control group; Energy intake in the television group did not differ from the auditory group - appetite sensation: no differences in hunger and thirst ratings were noted in four conditions, either before or after lunch; No difference in palatability scores was observed across the meal conditions; - restrained eating behaviour: no significant relationship was detected between restrained eating and energy intake in all the three conditions
Blass et al. (2006)	- to investigate whether food intake would increase or not during the meal with visual auditory distractors	n= 20 male (n=5) and female (n=15) all normal weight	- eating lunch while doing different tasks - two conditions: 1) eating while watching television 2) eating while listening to Rachmaninoff's	- body weight and height - TFEQ - VAS for hunger, satiety, and food palatability - EI	- energy intake: participants in the television viewing condition had significant more energy intake than those who in the music condition - food intake was significantly associated

			Second Symphony - food: pizza and macaroni and cheese (M&C)		with hunger levels at the beginning of each session - energy intake was not certainly correlated to either eating restraint behaviour or BMI.
Zellner et al. (2006)	- to explore the impact of stress on food selection (healthy snacks or unhealthy snacks)	n=34 female	- eating snacks while doing mental work - two conditions: 1) no-stress group: do 10 solvable anagrams; 2) stress group: do 10 unsolvable anagrams - snacks: M&M, peanuts, potato chips and grapes	- 11-point rating scale for stress - Restraint Scale - EI	- energy intake: no significant difference in terms of the consumption of either peanuts or potato chips was reported between the stress and no-stress groups; Stress group ate significantly more M&Ms and significantly less grapes compared to the no-stress group. - stress: stress group reported to be significantly more stressful than the no-stress group. - restrained eating behaviour: restrained eaters in the stress group consumed more snacks than those in the no-stress group
Hetherington, Anderson,	- to examine the hypothesis that	n=37 male (n=21)	- eating while doing different tasks	- VAS for appetite and mood (anxious,	- energy intake: males had significantly more energy

Norton & Newson. (2006)	environmental and social distractors impair people's capacity to monitor their food intake.	and female (n=16) all normal weight	- four conditions: 1) eating alone 2) watching TV 3) eating with two same sex friends 4) eating with two same sex strangers - a buffet-style lunch eating *ad libitum*	relaxed and sociable) - TFEQ - DEBQ - EI	intake in each condition than females; Eating in the presence of television and eating with two friends resulted in significantly more energy intake than eating alone; there was no significant difference in energy intake between the stranger eating group and the other conditions. - stress: participants reported higher rated anxiety when they ate with strangers compared to those who ate alone, although not significant; Participants reported to feel significantly less anxious and more relaxed after eating their meals, which was the same in all conditions; a significant increase in sociability rating was observed from before to after eating with strangers, and there was no change in sociability rating in other

					groups.
Chaput & Tremblay (2007)	- evaluate the impact of knowledge-based work (KBW) on feeding behavior and spontaneous energy intake.	n=15 normal weight female	- eating lunch after different tasks - two conditions: 1) rest 2) KBW (knowledge-based work) group: read a paper and write a 350-word summary on the computer - standardized breakfast - Buffet-type meal eating *ad libitum*	- anthropometric measurements: body weight, height, and waist and hip circumferences - TFEQ - STAI - VAS for appetite - EI	- energy intake: participants in the KBW had significant more total energy intake than those who in the rest group; Carbohydrate, protein and lipid intakes were significantly higher in the KBW group when comparing to the control group - stress: in terms of STAI, significantly higher scores on anxiety–state scale were detected in the KBW group, indicating that KBW could effectively make participants stressed - appetite sensation: appetite ratings did not differ between two groups at beginning and after the task, and after meal consumption. - restrained eating behaviour: participants with higher restrained eating scores consumed significantly less food in

					both sessions.
Chaput et al. (2008)	- to further document the impact of knowledge-based work (KBW) on spontaneous energy intake and glucose homeostasis.	n=14 normal weight female	- eating lunch after different tasks - three conditions: 1) control condition: have a rest; 2) reading-writing condition: read a paper and write a 350-word summary with a computer; 3) test-battery condition: comprehensive battery of computerized tests - standardized breakfast - buffet-type meal eating *ad libitum*	- anthropometric measurements: body weight, height, and waist and hip circumferences - TFEQ - STAI - The Cohen's Perceived Stress Scale - VAS for appetite - EI	- energy intake: participants in the reading-writing and the test-battery conditions had significantly higher energy intake than those who in the control condition; There was no specific food preference observed in three conditions, reflected by the relevant percentage of macronutrient intake; - stress: significant higher scores were detected in the reading-writing group and test-battery group when comparing to the rest group in terms of anxiety-state scale in STAI. - appetite sensation: no significant difference was observed for appetite ratings in three conditions.
Bellisle et al. (2009)	- to confirm and extend the effect of restraint eating behaviour and external stimuli on food intake	n=40 normal weight female	- eating while doing different tasks - five eating conditions: 1) eating alone	- eating inventory questionnaire - VAS for hunger, fullness and palatability	- energy intake: participants in the group meal condition had lower energy intake when comparing to the other four conditions, but it failed to

			2) eating in groups of three 3) eating while listening to a recorded detective story 4) eating while watching television (without food cues) 5) eating while watching television (with food advertisements) - lunch: Hachis parmentier (ground beef and mashed potatoes) and fruit sherbets	- FI	reach significance. - restrained eating behavior: there was no significant influence of dietary restraint status on energy intake, and there was no interaction with meal conditions. - appetite sensation: group meals were found to have significantly less post-meal fullness than other conditions. - restrained eating behaviour: energy intake did not differ between low restraint participants and high dietary restraint participants in all five eating conditions
Rutters et al. (2009)	- to explore the influence of stress on food intake	n=130 male (n=65) and female (n=65), Partially overweight and partially normal weight	- eating snacks after doing different tasks - two conditions: 1) control condition: doing solvable mental arithmetic task; 2) stress condition: doing unsolvable	- anthropometric measurements: body weight, height, and waist and hip circumferences - TFEQ - STAI	- energy intake: stress group had significant more energy intake and sweet food intake compared to the control group; There was no significant difference in salty food consumption between these two groups

			mental arithmetic task - a standard lunch - snacks: chocolate, fruit-chew candy, potato chips, pretzels and nuts	- VAS for hunger and satiety - POMS - EI	- stress: participants in the stress condition reported significantly higher state anxiety scores in STAI than those who in the control condition; Participants in the stress condition reported significantly higher POMS scores for depression, tension, confusion and anger were when comparing to those who in the control condition
Higgs & Woodward (2009)	- to assess whether eating lunch in the presence of television increased afternoon snack intake	n=16 normal weight female	- eating lunch in the presence or absence of television, and then afternoon snacks intake was measured. - two conditions: 1) television condition: watching television while eating lunch 2) control condition: eating in the absence of television - lunch: ham sandwiches and salted crisps	- BMI - DEBQ - line rating scales for appetite and mood - FI	- energy intake: participants who ate lunch while watching television consumed significantly more afternoon snacks compared to those who ate meal in the absence of television - appetite sensation: hunger rating decreased significantly after eating a meal, while rated fullness increased significantly; There was no effect of television for both hunger and fullness ratings.

			- snacks: milk chocolate fingers, chocolate chip cookes and McVities digestives		
Royal & Kurtz (2010)	- to explore the relationship between food intake, eating behavior traits and conscious of how much has been eaten when performing a stressful task.	n=56 normal weight female	- eating snacks while doing mental work - two conditions: 1) high-stress condition: doing 10 unsolvable anagrams such as juice and radio; 2) low-stress condition: doing 10 solvable anagrams such as meat and layer - snacks: M&M's, cheese crackers, peanuts and Reese's Pieces.	- PANAS - DEBQ - Demographics: age, race/ethnicity, year, height and weight - EI	- energy intake: the high-stress group consumed significantly more snacks compared to the low-stress group - stress: participants in the high-stress condition marked significantly higher negative affect than those who in the low-stress group - restrained eating behaviour: no significant interaction between dietary restraint status and snack intake was detected
Born et al. (2010)	- determine the effect of acute stress on food choice and food choice reward-related brain activity	n=9 normal weight female	- eating lunch after doing different tasks - two conditions: 1) rest condition: solvable mathematical test;	- TFEQ - VAS for hunger and satiety - EI	- energy intake: participants in the stress condition had relatively higher total energy intake, carbohydrate intake and protein intake when comparing to those who in the rest condition, but it did

			2) stress condition: unsolvable mathematical test - breakfast - the second meal		not reach significance. - appetite sensation: after breakfast, participants reported significantly lower rated satiety in the stress group compared to the rest group; Hunger scores were the same in both control and stress conditions.
Oldham-Cooper et al. (2010)	- to examine the hypothesis that distraction can inhibit meal memory encoding, resulting in the increase in subsequent food intake	n=44 male (n=22) and female (n=22) all normal weight	- eating lunch while doing different tasks, and then the afternoon snacks intake measured. - two conditions: 1) distraction condition: eating while playing a computer card sorting game (solitaire) 2) no-distraction condition: eating in the absence of any distractor - lunch: 9 savory items - biscuits: chocolate chip cookies, milk	- height and weight - DEBQ - PANAS - VAS for appetite - EI	- energy intake: distraction group had significantly more snacks intake than the no-distraction group; no significant difference in snacks intake was found between male and female - appetite sensation: after lunch, distraction group showed significantly less fullness than the non-distraction condition; After lunch, male showed significantly greater hunger than female

			chocolate digestive biscuits, and sweet oat-based biscuits		
Higgs & Donohoe. (2011)	- to investigate whether eating with various distractions would reduce subsequent snack intake, and if the effect is associated with meal memory	n=29 normal weight female	- eating lunch while doing different tasks, and then the afternoon snack intake was measured. - three conditions: 1) food focus group (instruction about food sensory characteristics, i.e. What does it taste like?) 2) food thoughts group (reading an article on food) 3) neutral control group (in the absence of distractors) - fixed lunch: ham sandwiches and salted crisps - snacks: Maryland chocolate chip cookies, McVities digestives and Cadbury's milk	- demographics - line rating scales for mood, appetite and memory - DEBQ - EI	- energy intake: subjects in the food focus condition consumed significantly fewer snacks after lunch when comparing to those who in the food thought group and control group - stress: no impact of different distractions on pre-snack marked mood were found. - appetite sensation: the food focus group had significantly lower marked pre-snack hunger than the food thought and control groups; No main effect of condition was noted on the rated enjoyment of snacks

			chocolate fingers		
Long, Meyer, Leung & Wallis (2011)	- determine the effects of distraction and focused attention on both food intake and accuracy of perceived intake in women with non-clinical levels of disordered eating.	n=27 normal weight female	- eating while doing different tasks - three conditions: 1) control: eating alone 2) distraction: eat alone whilst listening to Jane Austin's Pride and Prejudice 3) focused attention: eating while listening to the recorded food sensory characteristics instructions, for example, think about the texture/ taste / colour) - food: cooked white wheat pasta and pasta sauce	- Eating Disorders Inventory-2 - VAS for appetite - PANAS - EI	- energy intake: distraction group ate significantly more food compared to those who in the control and focused attention groups. - no significant relationship was observed between food intake and EDI-2 subscale scores (Bulimia, Drive for Thinness and Body Dissatisfaction) in all the three conditions - stress: no main effect of condition was noted on the positive and negative affect; there was a significant decrease in positive and negative affect from pre-meal to post-meal. - appetite ratings: control group had significant higher fullness level than the distraction group; no main effect of condition was noted on hunger and desire to eat

Lemmens, Rutters, Born & Westerterp-Plantenga. (2011).	- to evaluate the influence of stress on energy intake and food reward system	n=42 male (n=16) and female (n=26) n=27 normal weight n=15 visceral overweight	- eating meals after doing different tasks - two conditions: 1) control condition: doing solvable math test with background noises and annoying music; 2) stress condition: doing unsolvable math test without sounds - two meals	- TEFQ - VAS for appetite profile - POMS for mood state - STAI for state anxiety - liking and wanting computer test - EI	- energy intake: in visceral overweight participants, energy intake and 'wanting' for dessert and snacks were higher in the absence of hunger, under the stress compared to rest condition, in comparison to normal weight participants; Visceral overweight participants under stress condition reported an increase in daily energy requirement percentage over two meals, in comparison to normal weight participants. - stress: STAI scores and scores for negative affect in POMS including confusion, anger depression and anxiety were significantly higher in groups who did unsolvable math test than those who did solvable math test
Ogden et al. (2013)	- to compare the impact of various distractors on eating behaviour	n=81 normal weight female	- eating snacks while doing different tasks - four conditions: 1) driving group:	- anthropometry: age, employment, ethnicity, weight and height - 5- point Likert	- energy intake: television group ate significantly more snack food compared to the driving and social interaction groups;

			eating while driving 2) television group: eating while watching television 3) social interaction group: eating while talking to a researcher 4) control group: eating alone - snack food	scales for desire to eat - DEBQ - Body Shape Questionnaire - FI	However, there was no significant difference in snack intake between the solo-eating group and the television group - appetite sensation: in terms of hunger level, a significant difference was noted between the social interaction group and both the driving and television groups; In terms of fulness level, a significant difference was observed between the solo-eating group and both the driving and social groups; In terms of motivation to eat, a significant difference was detected between social group and both the television and solo-eating groups.
Salama, Drapeau, Tremblay & Pérusse-Lachance. (2016)	- evaluate the impact of knowledge-based work on food preferences, eating behavior traits and appetite sensations - to assess the	n=35 normal weight males (n=22) and females (n=13)	- eating lunch after different tasks - two conditions: 1) mental work: reading and writing; 2) control: having a	- anthropometric variables: height, weight, waist and hip circumferences, and body fat percentage - TFEQ	- energy intake: for women, food intake in the mental work group was significantly higher compared to the control group; For men, food intake in the mental work group was

	relationship between these effects and anthropometric variables		rest - Standardized breakfast - buffet-type meal eating *ad libitum*	- STAI - NASA Task Load Index - VAS for appetite - FI	lower when comparing to the control group, with the significant reduction in dessert consumption - restrained eating behaviour: dietary restraint eating was not correlated with energy intake in these two conditions - after mental work, energy intake was significantly positively correlated with waist circumference - waist circumference was negatively associated with satiety quotient for fullness in mental work group. - body fat percentage was significantly positively associated with satiety quotient for fullness

PANAS: Positive and Negative Affect Schedule
POMS: the profile of mood states
DEBQ: Dutch Eating Behavior Questionnaire
TFEQ: Three-Factor Eating Questionnaire
STAI: State-Trait Anxiety Inventory
VAS: visual analogue scale
EI: energy intake
FI: food intake

Chapter 3 Materials and Methods

3.1 Participants

The Auckland University of Technology Ethics Committee (AUTEC) provided ethical approval (EA 18/179) for this study on 22 May 2018. Forty subjects were recruited through the advertisements posted at the Auckland University of Technology and surrounding areas. The Participant Information Sheet was used to screen all participants. Inclusion criteria included: aging between 18 and 65 years old, being in good health (no medical condition or an injury), and consume food regularly while working. Participants having food allergies (such as gluten, milk, eggs, wheat, ham and food preservatives), who consume vegan, vegetarian or kosher diet, and who have medical conditions were excluded from this study. Participants were required to attend two sessions that included two different conditions that took no more than one hour per session in this study. A consent form was signed by each participant before starting the experiment.

All the participants were unaware the aim of this research that investigating how satiety was influenced when consuming food while working. Throughout the study, participants conducted the experiments alone in the sensory booth.

3.2 Overview of the project

A crossover design was applied in the current research, incorporating a mental work condition and a control condition. The experiment was conducted in the sensory laboratory at Auckland University of Technology, New Zealand. Participants were invited to the laboratory between11am - 12 pm on weekdays. Figure 3.1 summarizes how the research was carried out. In the first condition, participants were required to consume food alone quietly. In the second condition, participants were required to perform a task on the computer while consuming a meal. The task involved copying data from thirty data files into an excel spread sheet over 20 minutes while consuming pizza. Forty participants attended both sessions. For each participant, the control and working condition were carried out in 1-week intervals, at the same time and day of the week.

3.3 Meal

Ham and cheese pizza (Dominos, New Zealand) was provided as a lunch meal. One whole pizza provided 5848 KJ calories, and contained 52g protein, 28 fat, 223.2g carbohydrate, 9.6g sugars and 3.368g sodium (https://www.dominos.co.nz/media/3550/nz-value-range-2017.pdf). All participants were provided with the same lunch meal. They were given 20 minutes to consume the pizza until they were comfortably full. Besides, they were permitted to consume water during the experiment.

3.4 Experimental procedure

On the day of experiment, participants were required to consume breakfast, and then nothing besides water was allowed to be consumed following breakfast. Upon arrival at the sensory laboratory, the weight, height and waist circumference of participants were measured. Firstly, participants completed a Dutch Eating Behaviour Questionnaire (DEBQ; Van Strien, Frijters, Bergers & Defares, 1986) to examine if they were restrained eaters or not, emotional eaters or not, and external eaters or not. Then, the current state of anxiety of the participant was evaluated with the state anxiety dimension in the State-Trait Anxiety Inventory questionnaire (STAI; Spielberger, Gorsuch & Lushene, 1970). Besides this, the single-item stress scale (Karvounides et al., 2016) was used to evaluate subjects' current stress level. Moreover, the Visual Analogue Scales for hunger and fullness were employed to evaluate subjects' satiety level. Next, a whole pizza was presented, and subjects were required to assess its pleasantness and palatability before eating it. After that, they had 20 minutes to consume the pizza. After eating, their state of stress and satiety were measured again. Finally, a new pizza was presented to participants for them to assess pleasantness and palatability again, but they were not allowed to eat it. Energy intake was assessed by determining the weight of pizza consumed and changing these values to energy (kJ) based on the nutritional information published on the Dominos website (https://www.dominos.co.nz/media/2822/nz-value-range-2017.pdf). Each step in the two experimental conditions was the same except that participants were either given a task while eating or ate without any distraction.

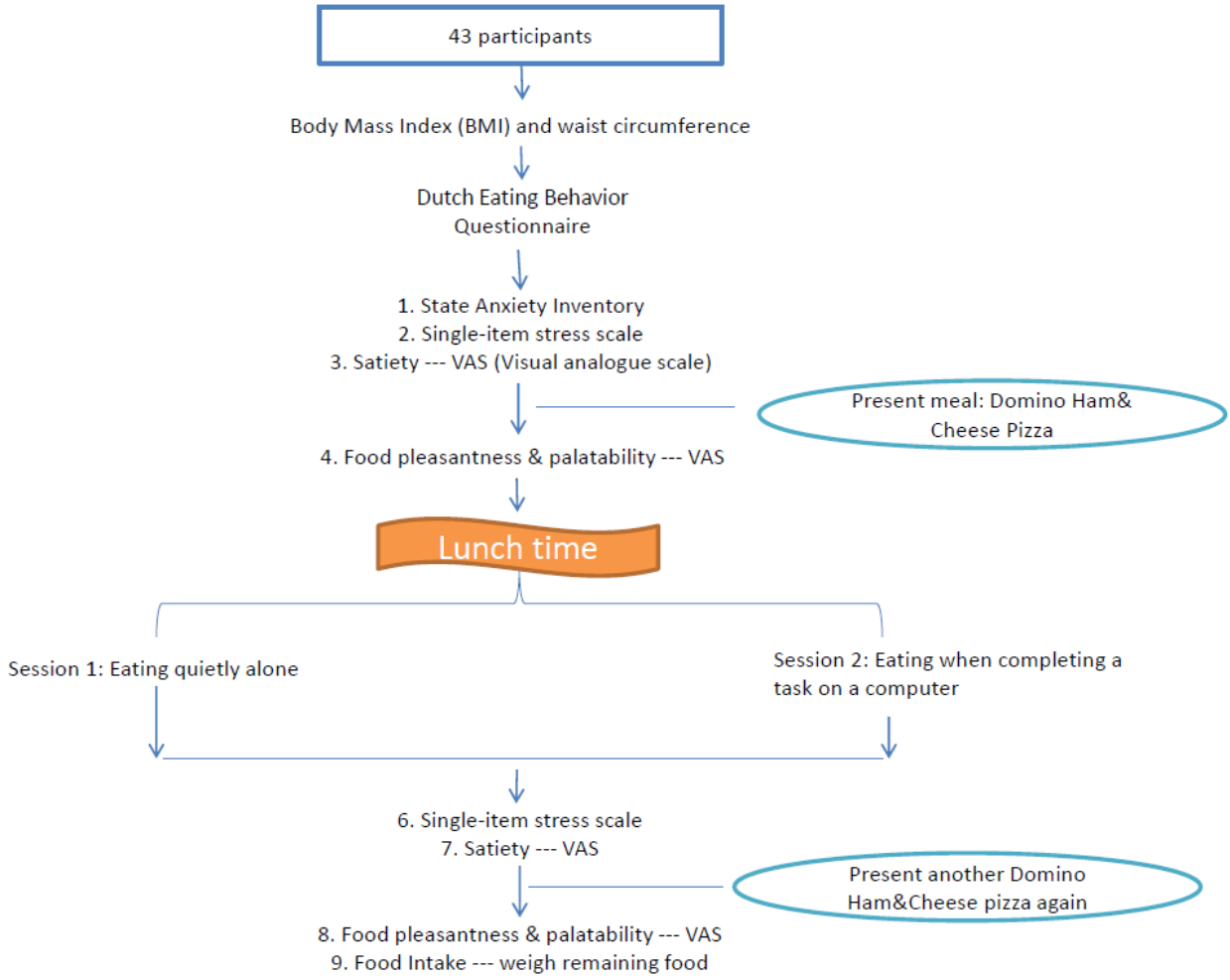


Fig 3.1 Overview of experimental procedure

3.5 Measures

3.5.1 Demographic (BMI and waist circumference)

Each participant's body mass index (BMI, kg/m^2) and waist circumference were calculated. BMI is determined by a person's weight and height. It is essential to determine BMI and waist circumference of subjects because the physiological and behavioral responses to satiety, appetite and hunger between lean, over-weight and obese subjects are likely to be different (Dalton, Finlayson, Esdaile & King, 2013).

3.5.2 Dutch Eating Behaviour Questionnaire

The Dutch Eating Behavior Questionnaire (DEBQ; Van Strien et al., 1986) was employed to evaluate whether participants were restrained eaters or not, whether they are emotional eaters or not, and whether they are external eaters or not. This self-reported evaluation tool was composed of three different subscales containing 33-items altogether (see Table 3.1). The Emotional Eating scale had 13 items, and the External Eating scale and Restraint Eating scale contained 10 items each. Each question item in the DEBQ was rated with a 5-point Likert scale that anchored with "never" to "very often" at each end. The Dutch Eating Behavior Questionnaire provided total scores of three different dimensions: restrained, emotional and external eating. Van Strien et al. (2007) noted that the mean score of the DEBQ-restrained eaters was referred to as the restrained score. Subjects with restrained scores greater than or equal to three were restrained eaters, while those with restrained scores less than three were non-restricted eaters. The results obtained by administering this questionnaire might explain the difference in food intake (van Strien & Oosterveld, 2008; Patel et al., 2011).

Table 3.1: Dutch Eating Behaviour Questionnaire (DEBQ; Van Strien, Frijters, Bergers & Defares, 1986)

Restraint eating questions:

1. If you put on weight, would you eat less than you usually do?
   □ Never □ Seldom □ Sometimes □ Often □ Very often
2. Do you try to eat less at mealtimes than you would like to eat?
   □ Never □ Seldom □ Sometimes □ Often □ Very often
3. How often do you refuse food or drink because you are concerned about your weight?
   □ Never □ Seldom □ Sometimes □ Often □ Very often
4. Do you monitor exactly what you eat?
   □ Never □ Seldom □ Sometimes □ Often □ Very often
5. Do you deliberately eat foods that are slimming?
   □ Never □ Seldom □ Sometimes □ Often □ Very often
6. When you have eaten too much, do you eat less than usual on the following days?
   □ Never □ Seldom □ Sometimes □ Often □ Very often
7. Do you deliberately eat less in order not to become heavier?
   □ Never □ Seldom □ Sometimes □ Often □ Very often

8. How often do you try not to eat between meals because you are watching your weight?

□ Never □ Seldom □ Sometimes □ Often □ Very often

9. How often in the evening do you try not to eat because you are watching your weight?

□ Never □ Seldom □ Sometimes □ Often □ Very often

10. Do you take into account your weight with what you eat?

□ Never □ Seldom □ Sometimes □ Often □ Very often

Emotional eating questions:

11. Do you have the desire to eat when you are irritated?

□ Never □ Seldom □ Sometimes □ Often □ Very often

12. Do you have a desire to eat when you have nothing to do?

□ Never □ Seldom □ Sometimes □ Often □ Very often

13. Do you have a desire to eat when you are depressed or discouraged?

□ Never □ Seldom □ Sometimes □ Often □ Very often

14. Do you have a desire to eat when you are feeling lonely?

□ Never □ Seldom □ Sometimes □ Often □ Very often

15. Do you have a desire to eat when somebody lets you down?

□ Never □ Seldom □ Sometimes □ Often □ Very often

16. Do you have a desire to eat when you are angry?

□ Never □ Seldom □ Sometimes □ Often □ Very often

17. Do you have a desire to eat when you are expecting something unpleasant to happen?

□ Never □ Seldom □ Sometimes □ Often □ Very often

18. Do you get the desire to eat when you are anxious, worried or tense?

□ Never □ Seldom □ Sometimes □ Often □ Very often

19. Do you have a desire to eat when things are going against you or when things have gone wrong?

□ Never □ Seldom □ Sometimes □ Often □ Very often

20. Do you have a desire to eat when you are frightened?

□ Never □ Seldom □ Sometimes □ Often □ Very often

21. Do you have s desire to eat when you are disappointed?

□ Never □ Seldom □ Sometimes □ Often □ Very often

22. Do you have a desire to eat when you are emotionally upset?

□ Never □ Seldom □ Sometimes □ Often □ Very often

23. Do you have a desire to eat when you are bored or restless?

□ Never □ Seldom □ Sometimes □ Often □ Very often

External eating questions:

24. If food tastes good to you, do you eat more than usual?
□ Never □ Seldom □ Sometimes □ Often □ Very often
25. If food smells and looks good, do you eat more than usual?
□ Never □ Seldom □ Sometimes □ Often □ Very often
26. If you see or smell something delicious, do you have a desire to eat it?
□ Never □ Seldom □ Sometimes □ Often □ Very often
27. If you have something delicious to eat, do you eat it straight away?
□ Never □ Seldom □ Sometimes □ Often □ Very often
28. If you walk past the bakery do you have the desire to buy something delicious?
□ Never □ Seldom □ Sometimes □ Often □ Very often
29. If you walk past a snack bar or a cafe, do you have the desire to buy something delicious?
□ Never □ Seldom □ Sometimes □ Often □ Very often
30. If you see others eating, do you also have the desire to eat?
□ Never □ Seldom □ Sometimes □ Often □ Very often
31. Can you resist eating delicious foods?
□ Never □ Seldom □ Sometimes □ Often □ Very often
32. When you see others eating, do you eat more than usual?
□ Never □ Seldom □ Sometimes □ Often □ Very often
33. When preparing a meal are you inclined to eat something?
□ Never □ Seldom □ Sometimes □ Often □ Very often

3.5.3 State Anxiety Inventory

Participants were also instructed to complete the anxiety-state scale in the Spielberger State-Trait Anxiety Inventory (STAI) that comprised of 20 questions (see Table 3.2) according to Spielberger, Gorsuch & Lushene (1970). All the questions were assessed using a 4-point Likert scale that ranged from 1 (not at all) to 4 (very much so). Spielberger, Gorsuch & Lushene (1970) defined state anxiety as "the conscious and subjective feeling of discomfort and tension, which was accompanied or associated with the level of arousal or arousal caused by the autonomic nervous system". Besides, trait anxiety was defined as "a part of personality, a kind of motivation or acquired behavioral tendency, which made individuals regard many objective non-dangerous situations as threats or generate excessively strong state anxiety response to objective dangerous situations". Martens et al. (1990) further pointed out that state anxiety occurs when individuals consider the requirement of an objective situation as being a threat, which can be attributed to the inability of individuals to perceive themselves as meeting the requirement of an objective environment. Based on the above definitions, this study adopted the STAI-state questionnaire to

assess current anxiety state of participants.

Table 3.2 State Anxiety Inventory questionnaire (STAI-state; Spielberger, Gorsuch & Lushene, 1970)

1. I feel calm
2. I feel secure
3. I am tense
4. I feel regretful
5. I feel at ease
6. I feel upset
7. I am presently worrying over possible misfortunes
8. I feel rested
9. I feel anxious
10. I feel comfortable
11. I feel self-confident
12. I feel nervous
13. I am jittery
14. I feel "high strung"
15. I am relaxed
16. I feel content
17. I am worried
18. I feel over-excited and "rattled"
19. I feel joyful
20. I feel pleasant

3.5.4 Single – item stress scale

A previous study by Karvounides et al (2016) showed that the Stress Numerical Rating Scale-11 (SNRS-11) can be efficiently used to assess current stress levels in adolescents and adults. In this study, participants completed the SNRS-11 single-item stress scale to evaluate their degree of stress. The stress scale was used to determine stress when you feel tense, restless, overwhelmed or anxious. On a scale of 0 to 10, with 0 being no stress and 10 being worst stress possible, participants indicated their current level of stress. We hypothesized that participants might be stressed when completing tasks when eating, and that the changes in stress before and after meal under two different consumption conditions might help explain the differences in satiety and food pleasantness, if any.

3.5.5 Use of Visual Analogue Scales to measure satiety and food pleasantness

The use of visual analogue scales (VAS) is a valid approach to measure feelings such as satiety and pleasantness during food consumption as reported by Flint, Raben, Blundell & Astrup (2000). This scale has good repeatability between groups, which means that reproducible results can be obtained (Blundell et al., 2010). The changes in satiety and food pleasantness during food consumption were recorded using a 100 mm VAS anchored at each end with words that described the extremes of a unipolar question. Ten VAS were completed before and after the meal respectively. All these questions are presented in Table 3.3 and Table 3.4.

Table 3.3 Satiety visual analogue scale

Questions	Anchors at each end	Reference
How hungry are you right now?	Not at all hungry and extremely hungry	Kral, Roe & Rolls, 2004
How full do you feel?	Not at all full and totally full	Hess, Wang, Kraft & Slavin, 2017
How strong is your desire to eat now?	Very week and very strong	Lau & Henry, 2017
How much pizza do you think you could consume right now?	Nothing at all and a large amount	Kral, Roe & Rolls, 2004
How satiated do you feel?	I am completely empty and I cannot eat another bite	Hess, Wang, Kraft & Slavin, 2017

Table 3.4 Food pleasantness visual analogue scale

Questions	Anchors at each end	Reference
How pleasant is the appearance of the pizza right now?	Not at all pleasant and extremely pleasant	Kral, Roe & Rolls, 2004
How pleasant is the odour of the pizza right now?	Not at all pleasant and extremely pleasant	Kral, Roe & Rolls, 2004
How pleasant did you find the pizza	Not at all pleasant and extremely pleasant	Kral, Roe & Rolls, 2004
How pleasant do you think this food would taste right now?	Not at all pleasant and extremely pleasant	Kral, Roe & Rolls, 2004
How much do you think you would enjoy eating this pizza?	Not at all and extremely	Kral, Roe & Rolls, 2004

3.5.6 Food intake

Participants were required to eat until they felt satiated. Pizza was weighed before and after each meal, and the amount of food intake was determined by the weight difference. Energy intake (kcal/kJ) was calculated and translated by the weight of the consumed pizza (g) based on the New Zealand nutritional value information provided on the Dominos website (https://www.dominos.co.nz/media/3550/nz-value-range-2017.pdf).

3.6 Statistical analysis

Data were pre-processed before statistical analysis. In terms of STAI-state questionnaire, pre-processing was done by adding up the scores of the twenty questions to obtain the SUM SAI. For DEBQ, participants who were either low- or high-restrained eaters had scored either three and less, or more than three in the restraint subscale respectively. As for satiety and food pleasantness visual analogue scales, SUM Hunger was the sum of scores for questions on fullness, desire to eat, predicted pizza consumption and satiation. Pre- AVE Pleasantness was obtained by the addition of scores for questions on appearance and odor. Post-AVE Pleasantness was obtained by the addition of scores for questions on overall pleasantness, appearance, odor and taste.

All statistical analyses were performed using XLSTAT (version 2018.5; New York, NY, USA). Analysis of covariance (ANCOVA) was carried out to explore the influence of physical characteristics (BMI, Waist, Age) and DEBQ scores (restrained eating, emotion eating, external eating) on energy intake. Besides that, separate Analysis of Variance (ANOVA) was performed on the results to examine whether significant differences exist between the control and work conditions in terms of state anxiety, stress, hunger, and pleasantness. Furthermore, ANOVA was implemented to identify the difference in energy intake between man and women and the difference in appetite ratings from pre-meal to post-meal. Additionally, independent t-tests were carried out to identify the pre vs post condition, and control vs work condition. Finally, a correlation test used by XLSTAT was carried out for state anxiety, stress, hunger and pleasantness to determine the degree of correlation between these factors.

Chapter 4 Results

All the participants completed their experiments successfully and strictly adhered to the study protocol. The analysis was performed on all the subject data for each meal.

4.1 Participant characteristics

Participants were 25.79±4.87 years of age, with an average BMI of 21.75±2.75 kg/m^2, and had a waist circumference of 76.08±7.25 cm.

DEBQ dietary restraint score was 2.46±0.77, DEBQ emotional eating score was 2.49±1.04, and DEBQ external eating score was 3.28±0.49. All data are reported as mean ± standard deviation (see Table 4.1).

Table 4.1
Participant demographics and DEBQ values

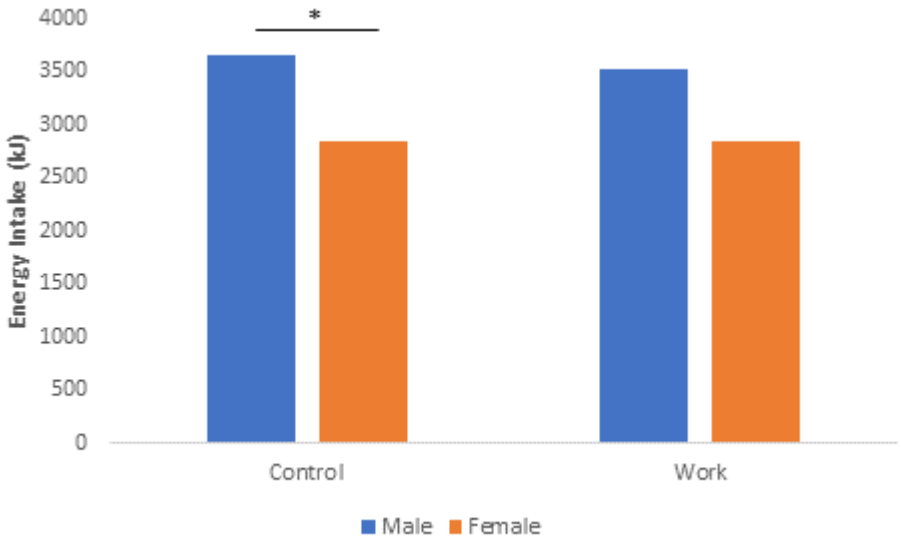
	Total (n = 43)	Male (n = 14)	Female (n = 29)
Age (years)	25.79±4.87 (19-24)	25.29±4.43 (20-38)	26.03±5.12 (19-41)
BMI (kg/m2)	21.75±2.75 (16.49-27.78)	22.28±2.59 (16.98-26.31)	21.50±2.83 (16.49-27.78)
Waist (cm)	76.08±7.25 (62-90)	79.79±6.72 (68-90)	74.29±6.90 (62-90)
DEBQ – restraint eating	2.46±0.77 (1-4)	2.34±0.90 (1-3.8)	2.51±0.71 (1.1-4)
DEBQ – emotional eating	2.49±1.04 (1-4.92)	2.36±1.26 (1-4.77)	2.56±0.94 (1-4.92)
DEBQ - external eating	3.28±0.49 (1.9-4.3)	3.38±0.43 (2.7-4.3)	3.23±0.52 (1.9-4.1)

Values expressed as mean ± SD, and value range indicated in parentheses

4.2 Energy intake

Significant differences were observed for energy intake between male and female in control condition ($F(1,42) = 5.86$; $p < .05$) and marginal significance in work condition ($F(1,42) = 3.23$; $p > .05$; Figure 4.1). However, no significant differences were noted between two conditions in terms of energy intake response from the ANCOVA model. Besides, there is no significant difference between restraint participants and non-restraint participants.

Moreover, no significance was detected between the explanatory factors and energy intake, such as BMI, waist, DEBQ dietary restraint score, DEBQ emotional eating score and DEBQ external eating score. Furthermore, DEBQ dietary restraint score and DEBQ external eating score were positively related to energy intake, while BMI and DEBQ emotional eating score were negatively correlated with energy intake.

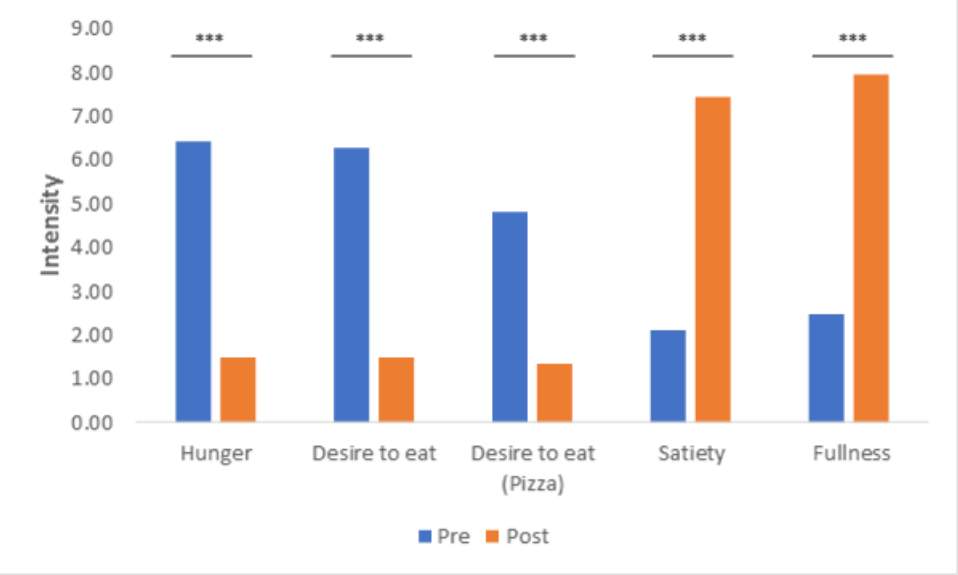


**indicates significant difference at 5% level*

Figure 4.1 Normalised energy intake under the control and work conditions.

4.3 Appetite ratings in the control condition

There were significant differences in terms of appetite ratings between pre and post-meal for the control group (Figure 4.2) on all measures: Hunger ($F(1,42) = 211.85$; $p < .01$), Desire to eat ($F(1,42) = 159.79$; $p < .01$), Desire to eat (Pizza) ($F(1,42) = 78.98$; $p < .01$), Satiety ($F(1,42) = 200.85$; $p < .01$), and Fullness ($F(1,42) = 188.17$; $p < .01$). Hunger rating and desire rating were significant lower after consuming pizza, while satiety and fullness were significant higher after consuming pizza.

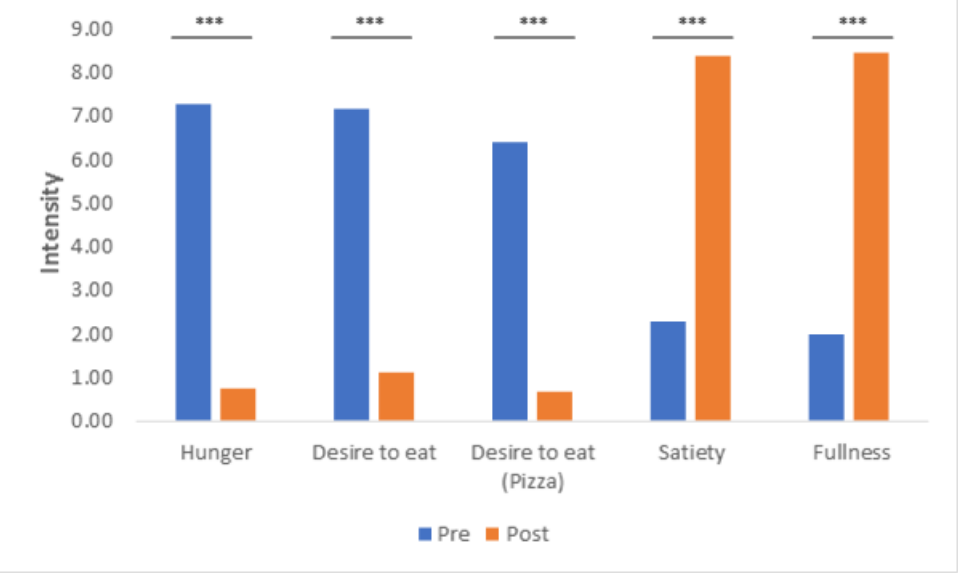


****indicates significant difference at 0.1% level*

Figure 4.2 Appetite ratings in the control condition

4.4 Appetite ratings in the work condition

Significant differences were observed for appetite ratings in pre and post-meal for the work group (Figure 4.3) on all measures: Hunger ($F(1,42) = 504.62$; $p < .01$), Desire to eat ($F(1,42) = 317.02$; $p < .01$), Desire to eat (Pizza) ($F(1,42) = 281.02$; $p < .01$), Satiety ($F(1,42) = 309.41$; $p < .01$), and Fullness ($F(1,42) = 363.65$; $p < .01$). Hunger rating and desire rating were significant lower after consuming pizza, while satiety and fullness were significant higher after consuming pizza.



****indicates significant difference at 0.1% level*

Figure 4.3 Appetite ratings in the work condition

4.5 Least Squares Means for STAI, stress, hunger and pleasantness

Table 4.2 shows the Least Squares Means (LS means) of STAI, stress, VAS rated hunger, pleasantness, and enjoyment. Pre-eating STAI did not differ ($p = 0.169$) between control and work condition. Besides, pre-eating stress, hunger and pleasantness also did not show significant ($p > 0.05$, results not shown) differences between pre-eating under two conditions. However, post-eating stress was significant higher in the work group when comparing to the control group. Similarly, post-eating hunger was also significantly higher ($p < 0.001$) in the work group when comparing to the control group. In addition, post-eating pleasantness was significant lower ($p < 0.01$) in the work group when comparing to the control group.

Rating dimensions	N	Control		Significance of effect[a]	Intervention		Significance of effect[a]	Mean inter-item correlation	Cronbach Alpha	KMO[b]
		Pre	Post		Pre	Post				
STAI- state trait	20	26.09		No significant difference	28.83		t(170) = 2.98	0.36	0.91	0.79
Stress	1	3.34	1.25	t(84) = 19.78***	3.92	7.68	t(84) = 58.36***	No significant difference	No significant difference	No significant difference
Hunger	5	32.88	13.79	t(84) = 280.21***	31.21	19.47	t(84) = 159.58***	0.09	-0.24	0.63
Pleasantness	2	6.15	4.47	t(84) = 31.06***	6.57	3.70	t(84) = 65.08***	0.28	0.38	0.48

[a] *Values of t-scores derived from pre and post comparison in each group, * indicates significance at 5% level, ** 1% level, and *** .1% level.*

[b] *Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy*

Table 4.2 Mean scores on STAI, stress, hunger, and pleasantness ratings in this study. Independent t-tests were carried out to determine the pre vs post session, and control vs intervention condition.

4.6 Pearson's correlations for stress, hunger and pleasantness

Pearson Correlation coefficients were investigated between stress, SUM hunger (calculation of scores for questions on hunger, fullness, desire to eat, predicted pizza consumption and satiation) and AVE pleasantness (the average of scores for questions on overall pleasantness, appearance, odor and taste). It can be seen that SUM hunger and stress had the significant highest positive correlation. Moreover, stress and AVE pleasantness were negatively significant correlated. Some variables were also negatively correlated but failed to reach significance, including SUM STAI and AVE pleasantness, and SUM hunger and AVE pleasantness, while other pairs of variables were positively correlated.

Correlation matrix (Pearson):

Variables	STAI	Stress	Hunger	Pleasantness
Stress	0.231*			
Hunger	0.205	0.603**		
Pleasantness	-0.151	-0.309*	-0.012	

**showed significant correlation between subscales items; p < .05*

***showed significant correlation between subscales items; p < .01*

Table 4.3 Inter-subscale Pearson's correlations for the scales used in the study (n = 85)

Chapter 5 Discussion

The main purpose of this research was to determine the influence of eating while working on a computer on current satiety in terms of energy intake and self-reported appetite ratings. Besides, the relationship between restraint eating behaviour and energy intake was also assessed. Before the experiment, participants were asked to eat breakfast and fast for two hours. This ensured all participants were able to eat pizza for lunch, making it possible to assess their feedback on food and food intake correctly. The stress scale produced a range of scores from 0 to 10. The higher scores indicate greater stress. Besides that, the total scores of state anxiety inventory produced a range of scores from 11 to 52, with higher scores indicating greater state anxiety. The stress caused by working on a computer was confirmed by no significant differences in the state anxiety inventory (SAI) and single-item stress scale between participants in the work and control conditions before the experiment but differed significantly in single-item stress scale between these two groups after eating pizza.

5.1 Eating while working increased stress

The current study extended previous research on the relationship between stress and eating by determining the role of working on a computer on eating behaviour. The results from this study showed that participants required to complete tasks on a computer while eating pizza for maximum of twenty minutes had significantly greater stress, while participants who did nothing while eating pizza had significantly less stress. This finding illustrated that eating while working could effectively result in increased stress, which confirmed the findings of previous studies. Studies have reported that various stressors, including anagram (Royal & Kurtz, 2010; Zellner et al., 2006), reading-writing task (Chaput & Tremblay, 2007; Chaput et al., 2008; Salama, Drapeau, Tremblay & Pérusse-Lachance, 2016), mathematical test (Born et al., 2010) and mental arithmetic task (Rutters et al., 2009) significantly increased stress.

5.2 Energy intake in normal weight participants between work and control conditions was not different

This study tested the hypothesis that energy intake in the work group would be higher than the control group due to stress-induced eating. However, no significant difference in energy

intake was found between the work and control conditions. The fact that there was no significant increase in energy intake under stress condition, this was in keeping with results reported by Lemmens, Rutters, Born & Westerterp-Plantenga (2011), who claimed no significant difference in terms of energy intake between normal weight subjects who did a math test and those who had a rest, although those doing the math test felt significantly more stressed than those at rest. However, in their study, visceral overweight subjects under the stress condition consumed significantly higher energy than those who under the rest condition (Lemmens, Rutters, Born & Westerterp-Plantenga, 2011). Similarly, Rutters et al. (2009) assessed energy intake of participants using a solvable and an unsolvable maths problem in the control and stress conditions respectively. They demonstrated that overweight people had significantly higher energy intake in sweet snack food in the stress group when comparing to those who in the control group. Recently, Siervo, Gan, Fewtrell, Cortina-Borja & Wells (2018), who recruited obese male participants, also found that the participants playing violent video game experienced significantly more stress and had significantly higher energy intake than participants watching non-violent television. This suggests that food intake is more likely to get out of control for obese individuals when they are under stressful condition when comparing to normal weight people.

Taken together, the results from this study and previous studies concluded that acute psychological stress did not affect energy intake of normal weight participants. However, for obese individuals, stress resulted in increased energy intake. It has been explained that under no stress condition, the homeostatic system controls eating to maintain energy balance, while the reward system increases intake of energy dense and palatable foods under stress conditions in visceral overweight participants when comparing to normal weight participants (Zellner et al., 2006; Lemmens, Rutters, Born & Westerterp-Plantenga, 2011). Besides that, although stress usually drive people to consume more food, normal weight people can consciously control how much they eat in order to maintain their body shape. The average body mass index of participants in the current study was 21.75±2.75 kg/m^2, within the normal range of 18-25, which meant they all successfully maintained their body shape. This finding supported the concept that successful management of body weight involved a complicated interplay of both situational factors and internal traits (Royal & Kurtz, 2010). From this view, the current findings in this research require further confirmation regarding the impact of stress caused by working on a computer on food

intake with obese participants to confirm results found in previous studies that demonstrated increased energy intake.

Some studies have reported contrary findings to our results that normal weight participants with stress ate significantly more food than those who without stress. Chaput & Tremblay (2007) reported that participants who had completed reading-writing tasks had significantly more energy intake than those who had a rest. Later, Chaput et al. (2008) replicated this result, and further found no difference in energy intake between two different working conditions: reading-writing and computerized test. These contradicting findings can be explained by the cognitive task being either a within-meal distraction or independent distraction before the meal. In studies conducted by Chaput & Tremblay (2007) and Chaput et al. (2008), participants were required to complete cognitive tasks before food consumption, while in the present study, participants performed the mental task while eating. Ogden et al. (2013) explained that people might forget to eat when they engage in a cognitive task. In fact, the behavior related to food consumption requires some cognitive effort. With increased distraction, participants have less cognitive ability when eating. Participants in the current study were urged to do as much of the tasks as possible while eating, which might greatly distract them from eating. However, in the study conducted by Chaput & Tremblay (2007) and Chaput et al. (2008), food was provided after performing cognitive tasks, which did not exist the situation that cognitive task occupied participants' eating cognitive capacity. This may explain why participants consumed significantly more after completing mental tasks in the Chaput & Tremblay (2007) and Chaput et al. (2008) studies.

Royal & Kurtz (2010) and Zellner et al. (2006) also explored the effect of mental work on current snack food consumption while doing solvable and unsolvable anagrams. Royal & Kurtz (2010) pointed out that participants with more stress had significantly higher energy intake than those who with less stress. Moreover, Zellner et al. (2006) reported that people would consume significantly more unhealthy food under stress conditions, such as chocolate, and less unhealthy food, such as fruits. One problem here is that the food intake in these two previous studies tested were both afternoon snacks such as M&M's and peanuts rather than a meal, while the present study required participants to eat lunch. Whether there are underlying reasons on how a meal or snack consumed when performing a task influences energy intake is yet unclear.

Generally, it is known that when people do high level cognitive tasks, their ability to monitor how much they consume is impaired, leading to increased food intake than those who do not complete cognitive tasks (Bellisle & Dalix, 2001; Mitchell & Brunstrom, 2005; Hetherington, Anderson, Norton & Newson, 2006). A possible explanation why the stress condition in the current study may not have been sufficient to trigger stress-eating is the fact that people do not eat more at a sitting but rather eat more often. Thus, future study may need to investigate the effect of different stressors of varying stress level. Besides that, it would be useful to monitor 24-hour food intake of participants who complete mental tasks rather than just focusing on the current meal intake.

The differences in energy intake between genders were also examined in this study. There was no difference between the control and work groups for either male or female participants in terms of energy intake. Similarly, Rutters et al. (2009) concluded that gender of participants (65 male and 64 female) did not significantly affect energy intake after doing solvable and unsolvable mental arithmetic tasks. In contrast, Salama, Drapeau, Tremblay & Pérusse-Lachance (2016) who reported that females had significantly higher energy intake after completing a reading-writing task compared to those who had a rest, while energy intake for males tended to be lower, with a significant decrease in dessert consumption, after the reading-writing task. The authors concluded that women reacted differently after mental work and explained that when under a stressed situation, females tend to eat food in order to escape the stressed feeling, while males preferred to consume alcohol and tobacco (Torres & Nowson, 2007). However, Torres & Nowson (2007) specifically stated that food intake related to stress was only significantly related to obese women. Therefore, the effect of mental task on dietary intake still needs to be confirmed as results by Rutters et al. (2009) and the current study were different from Salama, Drapeau, Tremblay & Pérusse-Lachance (2016).

In addition, in the current study, energy intake in the control condition was significantly higher for male participants compared to female participants, while in the work condition, no significant differences were noted in energy intake between male and female participants. This finding was in line with Hetherington, Anderson, Norton & Newson (2006) and Salama, Drapeau, Tremblay & Pérusse-Lachance (2016), who also found that in all the conditions, male had significantly more energy intake than female. This difference in gender can be due to the fact that

women tend to eat less to appear more feminine, while men perceive eating as a sign of power and masculinity (Papies, Stroebe & Aarts, 2008).

5.3 Post-eating hunger level was higher in the work condition compared to control

Hunger scores were not significantly different between the work and control groups before the consumption of pizza. This result supports a state of satiety amongst participants, which is in line with all previous research (Bellisle, Dalix & Slama, 2004; Mitchell & Brunstrom, 2005; Brunstrom & Mitchell, 2006; Hetherington, Anderson, Norton & Newson, 2006; Chaput & Tremblay, 2007; Rutters et al., 2009; Bellisle et al., 2009; Born et al., 2010; Higgs & Donohoe, 2011; Long, Meyer, Leung & Wallis, 2011; Ogden et al., 2013). It was necessary to ensure that participants' appetite was at the same level between the work and control conditions before food consumption when measuring subsequent energy intake and satiety after food consumption.

The second hypothesis in this research was that satiety would differ after consuming pizza between work and rest groups. In this study, the work group had significantly higher post-meal hunger level than the control group, which supported our hypothesis. This finding was similar to the study carried out by Born et al. (2010), who pointed out that participants doing an unsolvable mathematical test had significantly less post-meal satiety scores than those doing a solvable mathematical test. Moreover, no difference in energy intake was detected between participants in these two conditions. Hence results in the current study and Born et al. (2010) inferred that people who were stressed had similar food intake but were significantly less full after eating compared to those who were not stressed. It has been hypothesized that increased post-meal appetite after performing a stressful cognitive task may be due to impaired satiety signals or stress-induced rewards (Chaput et al., 2011). Chaput et al. (2008) also concluded that demanding cognitive tasks have the potential to change satiety signals and can exacerbate the disorder between food consumption and appetite sensation. This further indicated that psychological factors related to stress were strongly correlated with the urge to eat compared to the actual amount eaten. This finding supported the notion that subjective hunger motivation could be enhanced by emotional stress (Chaput et al., 2008), and perceived stress was related to greater hunger (Groesz et al., 2012). Another potential explanation for the post-meal difference in fullness of participants between

mental work and non-work conditions was that distraction limited the capacity of subjects to pay attention to visceral sensations produced by food consumption, which may result in less fullness (Oldham-Cooper et al., 2010). It can also be explained that once the mental work ended, the hunger perceived during the task, not being converted into eating because of stress level, would lead to a priming effect that made participants feel hungry after food consumption (Ogden et al., 2013).

Some studies showed no significant difference in post-meal satiety between mental work and no work conditions. Chaput & Tremblay (2007) pointed out that no significant difference in hunger levels after eating between participants who completed the reading-writing task and those who had a rest. However, subjects consumed significantly more after doing cognitive task than those who did not. Besides that, Siervo et al. (2018) also similarly concluded that post-meal hunger level was not different between video game playing participants who experienced more stress compared to the television viewing participants, although participants playing violent video games ate significantly more than those watching television.

Contrary to findings in this study, Born et al. (2010), Chaput & Tremblay (2007), and Siervo et al. (2018) suggested that people who were more stressful would consume more food to reach similar satiety to those who were less stressful, and if not, stressful people would feel more hungry. The reason for this discrepancy in findings is unclear. Indeed, when attention is focused on a concurrent work at a meal time, appetite sensation and eating behaviour tend to interplay in a complicated way (Brunstrom & Mitchell, 2006).

5.4 Hunger levels decreased from pre-eating to after-eating for both working and non-working conditions

Findings in the present study also showed that hunger levels decreased significantly from pre-eating to after-eating for both working and non-working conditions. Previous studies have also reported that rated hunger decreased significantly after consuming food (Blass at el., 2006; Hetherington, Anderson, Norton & Newson, 2006; Rutters et al., 2009; Higgs & Woodward, 2009; Born et al., 2010; Long, Meyer, Leung & Wallis, 2011; Ogden et al., 2013). This indicates the effect of food intake on appetite because hunger levels are signals for fasting and satiated. The standard model of regulated food intake stated that people started to eat when they were hungry

and would stop eating when they were satiated (Benelam, 2009). In other words, satiety is the reason why people stop eating.

5.5 Energy intake did not differ between restrained and non-restrained eaters

Dietary restrained eaters always tend to eat less and lose weight. However, the present study found no significant differences in energy intake between low and high restrained consumers, which was consistent with Royal & Kurtz (2010), who also used DEBQ and found no significant relationship between restrained state and energy intake whether in the low-stress (completing solvable anagrams) or the high-stress condition (completing unsolvable anagrams), while eating snacks. Besides, Salama, Drapeau, Tremblay & Perusse-Lachance (2016) used TFEQ and concluded that there was no interaction between restraint eating behaviour and food intake in both rest and reading-writing conditions. Moreover, Rutters et al. (2009) employed TFEQ and concluded that dietary restraint status was not correlated to food intake in both control (doing solvable mental arithmetic task) and stressed (doing unsolvable mental arithmetic task) conditions. Studies involving environmental stimuli rather than cognitive tasks also reported no significant association between restrained status and energy intake. Hetherington, Anderson, Norton & Newson (2006) concluded that no correlation between dietary restraint scores was observed for both TFEQ and DEBQ when consuming food while eating alone, watching TV, eating with same sex friends and eating with same sex strangers. It has been known that dietary restrained people would control their food intake even when they are hungry. However, these findings indicated that participants with lower energy intake did not certainly have specific dietary restriction eating traits. One possible explanation is that dietary restriction might only exist in overweight people, because they always try to limit their food consumption for losing weight. Besides, normal weight people are also likely to have this behaviour as they often concentrate on their body shape and appearance (Salama, Drapeau, Tremblay & Pérusse-Lachance, 2016).

Finding in this study is contrary to some previous studies. Zellner et al. (2006) adopted Restraint Scale and stated that restrained eaters working on stressful, unsolvable anagrams ate significantly more than those working on no-stress, solvable anagrams. It can be explained that for restricted eaters, their close monitoring of food intake can be abandoned in some cases such as being distracted that can result in increased food intake relative to non-distracted restricted eaters

(Herman & Mack, 1975). Another explanation is that people with higher dietary restriction may be more susceptible to distracted situations, which may result in overeating in restrained eaters (Hetherington et al., 2006; Ward and Mann, 2000). Ward and Mann (2000) further stated that besides overeating, restricted eaters might not know how much food they had eaten under pressure. In study conducted by Zellner et al. (2006), participants were provided snack foods in both stress (doing unsolvable anagrams) and no-stress (doing solvable anagrams) conditions. The authors assumed that restricted eaters would not only consume more food under stressful condition but would also behave worse when they recalled how much they had consumed. As expected, there was a significantly increased unhealthy food intake for restrained eaters when they were stressed, and they behaved a little worse at recalling how much they ate, although not significant.

However, previous research on the impact of various distractors failed to yield unified conclusion that dietary restricted people were particularly susceptible to distraction. Chaput & Tremblay (2007) raised the possibility that dietary restricted eaters were vulnerable to lose control on food consumption, particularly in a stressful environment. They used restraint subscale of TFEQ and reported energy intake was negatively correlated with dietary restraint for both rest and reading-writing conditions. Besides that, Ogden, Oilonomou & Alemany (2017) employed DEBQ and pointed out that participants with high restrained eating scores consumed significantly less snacks after watching television compared to those with low restrained eating scores.

The relationship between dietary restraint score and food intake have been investigated in several studies conducted by Bellisle. Bellisle and Dalix (2001) reported that cognitive restraint assessed by the restraint subscale of TFEQ, was positively correlated with increased energy intake under the distraction condition (eating and listening to a recorded story) when comparing to the control condition. However, Bellisle, Dalix & Slama (2004) failed to replicate this result and found no correlation between participant's energy intake and their levels of dietary restraint in television viewing and story listening conditions. They explained that participants recruited in the Bellisle and Dalix (2001) study were little older, and the average restraint score was slightly higher than subjects in the Bellisle, Dalix & Slama (2004) study. Bellisle et al. (2009) further confirmed that energy intake for people with low dietary restraint scores did not differ from people with high dietary restraint scores when eating alone, watching television with and without food cues, listening to a story and group eating. The authors raised the possibility that some specific external

distractors can offset people's restraint mechanisms, leading to overeating, but it is important to consider the actual situation. Taken together, there is no unified and precise conclusions on the relationship between dietary restraint status and energy intake. Interestingly, Stice, Sysko, Roberto, & Allison (2010) also showed little difference in food intake between subjects with high and low dietary restriction. In addition, they further claimed that the TFEQ-restraint scale and Restraint Scale were not valid measures for dietary restriction. Thus, valid measures for dietary restriction and longer-term effects of restraint and mental work distraction on energy intake should be further investigated.

Chapter 6 Conclusion

This study was set out to assess the effects of carrying out mental tasks while working on concurrent meal intake, and to determine if restrained eating behaviour influenced energy intake under a stressful condition. The results of this investigation showed that eating while working on a computer affected satiety, through significantly lower post-meal hunger scores compared to those who did nothing while eating. Hence, this research supports the idea that eating while working can affect people's eating behaviour. The contribution of this study has been to confirm that energy intake of normal weight participants was not significantly influenced by mental work when eating while working. Furthermore, results indicated that there were no association between individual restraint eating behaviour and energy intake. Further work should be done to establish the long-term effects of eating while working by monitoring 24-hour food intake of participants who complete mental tasks rather than just focusing on the current meal intake. Besides 24-hour food intake, the impact of stress caused by working on a computer and food intake with obese participants need to be further investigated. One of the strengths of this study is that it represented a comprehensive examination of how state anxiety, stress level, and individual eating trait profile influenced energy intake and appetite rating. This particular research finding also points to the need for exploring the effect of mental tasks and other environmental distractions concurrently on energy intake.

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Appendix 1

Ethics Application: 18/179 How is satiety affected when consuming food while working on a computer

Thank you for submitting your application for ethical review. I am pleased to advise that a subcommittee of the Auckland University of Technology Ethics Committee (AUTEC) approved your ethics application, subject to the following conditions:

1. The committee notes that the use of the screening component in this study involves collecting identifiable data prior to obtaining consent. Please revise this aspect, perhaps eliminating it altogether by ensuring suitable exclusion and inclusion criteria are described clearly on the Information Sheet. If the screening questionnaire remains, then every question needs to be relevant to the research, and informed consent needs to be obtained prior to filling it in. Why, for example, do you need to know about a history of depression?

2. Clarification of the role that deception plays in this research. Although it is mentioned in section D.3 of the application form, it is not addressed specifically in section J.2, and the current Information Sheet makes it fairly clear that the question is about the modifying role working on the computer has on satiety. The committee might support use of deception in this instance if the researchers could justify it in terms of scientific validity and an opportunity to debrief participants was provided;

3. Justify the use of a pork product in the meal option since this effectively excludes persons with cultural or religious reasons not to consume pork. The committee anticipates that alternative substitutes (e.g. chicken) are available which offer a greater opportunity for equality in participation;

4. Although the useful flow chart indicates that there are two separate visits to the lab, this fact is not mentioned in the Information Sheet or the recruitment poster;

5. Amendment of the Information Sheet as follows:

    a. Thoroughly review for specificity according this research protocol ensuring that all relevant information that a reasonable person would need in order for consent to be informed is provided. This includes, for example, information about the 2 visits, the BMI measuring, the location of the testing and the nature of all questionnaires;

    b. Statements relating to counselling support and ACC compensation may be removed as well as the phrase "You will be required to wear, listen...";

    c. Please also explain whether the testing will occur in private or with other participants, as this effects the degree of privacy that can be offered.

Please provide me with a response to the points raised in these conditions, indicating either how you have satisfied these points or proposing an alternative approach. AUTEC also requires copies of any altered

documents, such as Information Sheets, surveys etc. You are not required to resubmit the application form again. Any changes to responses in the form required by the committee in their conditions may be included in a supporting memorandum.

Please note that the Committee is always willing to discuss with applicants the points that have been made. There may be information that has not been made available to the Committee, or aspects of the research may not have been fully understood.

Once your response is received and confirmed as satisfying the Committee's points, you will be notified of the full approval of your ethics application. Full approval is not effective until all the conditions have been met. Data collection may not commence until full approval has been confirmed. If these conditions are not met within six months, your application may be closed and a new application will be required if you wish to continue with this research.

To enable us to provide you with efficient service, we ask that you use the application number and study title in all correspondence with us. If you have any enquiries about this application, or anything else, please do contact us at ethics@aut.ac.nz.

I look forward to hearing from you,

Yours sincerely

Kate O'Connor
Executive Manager
Auckland University of Technology Ethics Committee