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**COGNITIVE PROCESSES IN CRAVING: FROM THE LABORATORY TO
THE REAL WORLD.**

By

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A Thesis submitted to Plymouth University
in partial fulfilment for the degree of

DOCTOR OF PHILOSOPHY

School of Psychology
Faculty of Health and Human Sciences

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AUTHOR'S DECLARATION

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other university award without prior agreement of the Graduate Committee.

Work submitted for this research degree at the Plymouth University has not formed part of any other degree either at Plymouth University or at another establishment.

This study was financed and carried out with the aid of a studentship from Plymouth University. Ethics was applied for and granted for each experiment through the ethics committee.

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Cognitive Processes in Craving: from the laboratory to the real world.

Jessica Skorka-Brown

Abstract:

Elaborated Intrusion (EI) Theory posits that craving involves mental imagery in the same sensory modalities as the craved substance or activity. Visual imagery predominates, therefore craving should selectively interfere with performance on visual task, and conversely visual tasks should interfere with craving. This thesis reports tests of this prediction, both in the laboratory and real-world settings, to provide a basis for designing practical tasks for interfering with cravings in a natural environment.

Contrary to predictions, experiments 1 and 2 showed no effect of craving on visual or verbal task performance. There were, however, effects of task performance on craving in experiment 2. Experiment 3 found that playing Tetris reduced craving relative to a no-task control (watching a load screen), but was no more effective than digit recall or counting in ones. Experiments 4 and 5 both compared the effects of visual pattern recall with digit recall, with contradictory results. Experiment 4 showed an effect of low load visual task on craving, but not verbal; whereas Experiment 5 found no impact of either task. Overall, the findings are consistent with the assumption that craving involves controlled cognitive processes, but do not clearly support or disprove the hypothesis that visual processes are key. Experiment 6 focussed on interfering with naturally occurring cravings in a laboratory setting. Playing the computer game Tetris reduced cravings compared to a no task control. The final study of this thesis examined cravings in a natural environment. Participants were lent an iPod with either a questionnaire-only task, or a task with the questionnaire and Tetris installed on it. They were prompted by SMS to complete the task at pseudo-random intervals across the day over the course of a week. Mixed effects regression and multilevel growth curve modelling showed that Tetris was effective at decreasing naturally occurring cravings in a natural environment but the binary measure used, did not find a reduction in indulgence rates, however other more sensitive measures may. In contrast to the literature reviewed, the findings from this thesis are more consistent with craving involving general cognitive effort rather than modality-specific processes. Games such as Tetris appear to have potential as take-home tasks in future research and to help people manage their cravings.

Table of Contents

Introduction.....	1
1.0 Why is it important to research craving? What relevance does it have to current society? How will knowledge improve current trends in society?	1
1.1.The problem of Obesity	1
1.2.Obesity, food craving and hunger	2
1.3.Cravings and cognition	3
1.4.Cognitive Theories of Craving and Empirical Evidence	4
1.5.Relapse Prevention Model (Outcome Expectancy Model).....	5
1.6.Dual Affect Model	7
1.7.Tiffany’s cognitive model.....	7
1.8.Problems with Tiffany’s theory	12
1.9.Imagery and Cognition	13
1.10. Role of imagery in craving	15
1.11.Imagery in working memory	19
1.12.Verbal and visual working memory.....	21
1.13.Interfering with visuospatial working memory.....	22
1.14. Interfering with imagery	23
1.15. Empirical evidence, the findings and the application of theories	24
1.16. Methodologically relevant experiments.....	29
1.17. Scope of the research	30
Experimental Chapters:.....	31
Chapter 2: Experiments 1 and 2: An investigation into the effect of craving on visual and verbal memory tasks.	31
2.1 Experiment 1	31
2.2 Methods.....	36
2.2.1 Participants:.....	36
2.2.2 Materials:	37
2.2.2.1 Visual:.....	37
2.2.2.2.Verbal:.....	38
2.2.3 Design and Procedure:	39
2.3 Results.....	40
2.4 Discussion:	42

2.5 Experiment 2.....	43
2.6 Methods.....	45
2.6.1 Participants:.....	45
2.6.2 Materials:	45
2.6.2.1 Visual:.....	45
2.6.2.2 Verbal:.....	45
2.6.3. Design and Procedure:	45
2.7. Results.....	48
2.7.1. Effects of Craving on Cognitive Performance.....	48
2.7.2. Effects of cognitive tasks on craving.....	49
2.8. Discussion:	50
Chapter 3:.....	54
3.1. Experiment 3: The effect of visual and verbal tasks on craving strength.....	54
3.2. Methods.....	56
3.2.1. Participants.....	56
3.2.2. Materials:	57
3.2.2.1 Visual:.....	57
3.2.2.2. Verbal:.....	57
3.2.2.3. Craving Experience Questionnaire:	57
3.2.3. Design and Procedure:	58
3.3. Results.....	59
3.4. Discussion.	63
Chapter 4: Experiments 4 and 5, An investigation into the differentiation of task modality and task load.	66
4.1. Experiment 4:.....	66
4.2. Method:	67
4.2.1. Participants:.....	67
4.2.2. Materials:	67
4.2.2.1 Visual Tasks:.....	67
4.2.2.2. Verbal Task:.....	68
4.2.2.3. Craving Experience Questionnaire:	68
4.2.2.4. Design and Procedure:	68
4.3. Results:.....	69

4.4. Discussion	73
4.5. Experiment 5:Introduction	74
4.6. Methodology:.....	75
4.6.1. Participants:.....	75
4.6.2. Materials:	75
4.6.2.1. Craving Experience Questionnaire:	75
4.6.2.2. Visual Patterns Task:	75
4.6.2.3. Digit List:.....	76
4.6.2.4. Mind Wandering:.....	76
4.6.3. Design and Procedure:	76
4.7. Results:.....	77
4.8. Discussion	79
Chapter 5	83
5.1.Experiment 6: Playing ‘Tetris’ reduces the strength, frequency and vividness of naturally occurring cravings	83
5.2. Method	85
5.2.1. Participants.....	85
5.2.2. Design	85
5.2.3. Materials	85
5.2.4. Procedure:	86
5.3. Results:.....	87
5.4. Discussion	89
Chapter 6.....	94
6.1. Study 7: Playing Tetris decreases drug and other cravings in real world situations: The application of laboratory findings to ecologically valid settings.	94
6.2. Method	101
6.2.1. Participants and Design.....	101
6.2.2. Materials	101
6.2.3. Procedure	103
6.2.4. Data structure	103
6.2.5. Statistical methods	103
6.3. Results.....	104
6.4. Discussion:.....	107

Chapter 7:.....	113
7.1.Experiment Overview:.....	113
7.2. Discussion.....	116
7.2.1. How do the results of the laboratory based experiments with craving induction contribute to the literature?	116
7.2.2. What was the significance of examining natural cravings in a laboratory based setting?	122
7.2.3. Natural Cravings in Naturalistic Environments, Implications for future research and application.....	125
References.....	132
Appendix 1: CEQ Now	148
Appendix 2:CEQ Then	151

List of Figures and Tables:

Figure 1: Tiffany’s (1990) theory of craving attributes craving to the need to control non-automatic processes in response to the blocking of automatic acquisition processes9

Figure 2: The Elaborated Intrusion Theory of Desire attributes craving to the elaborative processes involved following an intrusive thought (reproduced from Kavanagh, Andrade & May, 2005).....16

Figure 3: A screen shot of the colour ring from which participants selected the colour that they had previously seen.....38

Figure 4: A screen shot of the computer game ‘Tetris’47

Figure 5: Change in craving over time while completing visual or verbal tasks, with error bars showing 95% confidence intervals (craving rating 1 as the baseline craving rating).....49

Figure 6: Change of craving strength over time by condition.....60

Figure 7: Three graphs depicting the means of craving strength, imagery and intrusiveness by condition.....62

Figure 8: Depictions of the visual patterns matrices for high and low memory load tasks....67

Figure 9: Change in craving over time by condition, using the single item measure of craving.....70

Figure 10: Three graphs depicting the means of the CEQ data of strength, imagery and intrusiveness by all conditions.....72

Figure 11: Change in craving over time by condition.....77

Figure 12: Three graphs showing the mean scores of each condition on the CEQ questionnaires.....79

Figure 13: Effect of playing Tetris on craving strength across the week. Solid line shows mean ratings before playing, dashed line shows mean ratings after playing Tetris. Error bars show 95% CI.....105

Table 1: Accuracy on visual and verbal short-term memory tasks, by craving status.....41

Table 2: Task performance means and standard deviations for visual and verbal tasks by craving status.....48

Table 3: A table to show the Means and Standard Deviations of the three conditions with measurable results.....60

Table 4: Means and standard deviations of task scores in each condition.....69

Table 5: Means (and Standard Deviations) of scores on the single-item craving measure before and after the load screen and Tetris conditions.....88

Table 6: Mean craving strength, imagery and intrusiveness reported in the CEQ-Snow, CEQ-Sthen, and CEQ-F. (\pm S.D.).....89

Table 7: A table with data broken down by item that the participant reported craving and by their assigned condition.....107

Introduction

1.0 Why is it important to research craving? What relevance does it have to current society? How will knowledge improve current trends in society?

1.1. The problem of Obesity

Obesity is of increasing concern in Western cultures. In 2012 almost 62% of adults in England were classified as overweight or obese (UK and Ireland Prevalence Trends, 2014). The total number of people classified as obese in 2012 was 25% of the population (UK and Ireland Prevalence Trends, 2014). Between 1993 and 2012 there has been an increase in obesity levels alone of over 10% in England (UK and Ireland Prevalence Trends, 2014). By 2050, it is predicted that 60% of adult men and 50% of adult women are going to be obese (UK and Ireland Prevalence Trends, 2014). In 2007 the cost to the NHS of treating obesity and obesity related illnesses was estimated to be a total of £4.2 billion (Obesity and Health, 2014). Obesity related illnesses vary greatly from illnesses such as diabetes, heart disease and some types of cancer and can greatly effect a person's quality of life (Risks of Obesity, 2014) and are also known to decrease life expectancy by 8 to 10 years (Public Health England, 2014). With the data predicting a continued increase in obesity, a number of different methods are therefore being instigated by the English government to try and combat this increase such as the Healthy Start Program and Change for Life (<http://www.healthystart.nhs.uk/>; <http://www.nhs.uk/change4life/Pages/change-for-life.aspx>).

The physical and financial impacts of obesity are not the only concerns: there are also concerns about the psychological (both social and emotional) impacts as well. Research has shown that there is a bi-directional relationship between being overweight or obese and a variety of mental health problems (National Obesity Observatory, 2011). Many of the psychological impacts are mediated by age, gender and ethnicity (Wardle & Cooke, 2005). Viner et al. (2006) found that in general young people who were classified as obese had a higher prevalence of psychological distress than those who were classified within normal weight boundaries. Wardle and Cooke (2005) found that African-American girls considered themselves more socially acceptable and attractive at a higher BMI than white girls.

A systematic review of obesity and psychological problems highlighted co-morbidity between depression and obesity (NOO, Obesity and Mental Health, March 2011). Again, mediating factors affected the co-morbidity rates for example age, gender, exercise levels and psychological factors (such as low self-esteem and negative thoughts). Kolotkin, Meter and Williams (2001) reviewed previous research focusing on obesity and quality of life, and reported that obese people tend to have lower life satisfaction ratings, lower self-esteem, suffer from greater levels of anxiety and perceive that they are perceived negatively by others, have employment difficulties and overall have a reduced quality of life. As obesity has an overwhelming bearing on lives, with both physical and mental impacts, it is necessary to examine factors which impede people's management of their weight.

1.2. Obesity, food craving and hunger

Mitchell, Hatsukami, Eckert and Pyle (1985) found that 50% of overweight women reported that food cravings impeded their weight loss. Cravings are not just limited to food; Shiffman et al. (2002) found that the largest influence on the likelihood of a person smoking was experiencing a craving rather than other factors such as other people smoking nearby. Tang, Fellows, Small and Dagher (2012) completed a meta-analysis comparing areas which were activated in the brain whilst participants were exposed to neutral, smoking or food related cues. The meta-analysis showed that the same areas (with the exception of the insula, which was only activated during high smoking cravings) were activated for food and smoking cue exposure but not for neutral cues. They concluded that naturally occurring and drug-related rewards activate the same regions of the brain. Cravings for smoking (nicotine) were found to activate the same areas as food cravings, suggesting that cravings for substances classed as non-addictive may behave in similar ways as those for addictive substances. Shiffman et al. (2013) also found that cravings were the biggest predictor of smoking behaviours compared to the smoking cue exposure itself. Gearhardt et al. (2011) reviewed research suggesting the possibility of food addiction being an underlying cause of obesity and making comparisons to drug addictions. This thesis therefore focusses on food cravings as cravings have been linked to the development of obesity (Schlundt, Virts, Sbrocco, & Pope-Cordle, 1993).

Food cravings are a common occurrence amongst the general population (Lafay et al., 2001); Hofmann, Baumeister, Forster and Vohs (2011) used ecological momentary assessments to investigate participant's cravings, which the most reported craving was for food (over 28%). They are also found to be a trigger of binge eating in both women with eating disorders (Walters, Hill & Waller, 2001) and the general populations (Gendall, Joyce, Sullivan & Bulik, 1998). Cravings have also been found to lead to early drop out from weight loss programs (Sitton, 1991). The Diagnostic and Statistical Manual of Mental Disorders (DSM-V, American Psychiatric Association, 2013) lists craving for nicotine, alcohol and drugs as a symptom of substance use disorder, but unlike the other diagnostic criteria, cravings can continue throughout withdrawal and beyond. Rozin and Stoess (1993) define craving as "...a strong desire, occurring at least a few times a month.". Craving is distinct from hunger as a craving is a powerful urge to ingest a particular substance (Norman, Miller & Goldsmith, 2001), whereas hunger should be able to be satiated with any variety of food, Pelchat (2002). This distinction is important as cravings and hunger can occur separately from each other as well as concurrently. Steel, Kemps and Tiggemann (2006) induced cravings in two different groups of participants – one which was hungry and the other was satiated. Although the cravings were stronger in the group which was hungry, there were still cravings present in both suggesting it is possible to experience a craving whilst not being hungry or whilst being hungry. It is also worth noting that cravings do not only have negative consequences: Pelchat and Schaeffer (2000) found that when participants were on a nutritionally adequate single food based diet, their cravings increased for foods that had different sensory qualities. It was concluded that these cravings occurred to promote a varied diet as an evolutionary advantage. Our predecessors would have been encouraged to find new sources of food and thus improve the variety in their diet and their nutritional intake.

1.3. Cravings and cognition

The distinction between food cravings and hunger suggests a cognitive component to craving that is supported by findings that cognitive loads reduce craving (Andrade, Pears, May & Kavanagh, 2012; Tiggemann, Kemps & Parnell, 2010) and would predict detrimental effects of craving on cognition. Hunger is generally associated with poor cognitive performance because of lowered blood glucose levels. For example, Benton

and Parker (1998) reviewed three papers that found memory is impaired when people do not eat breakfast compared to when they do. Similarly Rampersaud et al (2005) completed a meta-analysis of experiments which generally found that children and adolescents who ate breakfast had better memory, test grades and attendance at school relative to those who missed breakfast, thus suggesting breakfast consumption may improve cognitive functioning. However, limited research has focussed on the effect of craving on cognition (rather than the effect of hunger on cognition). Green, Rogers & Elliman, (2000) found that reaction times were slowed in participants who were craving compared to those who were not. Kemps, Tiggemann and Grigg (2008) reported that participants who were high trait cravers and experiencing an induced chocolate craving performed worse on a reaction time task and an operation span task than those who reported no current craving.

1.4. Cognitive Theories of Craving and Empirical Evidence

A strong theoretical basis was central to planning this thesis, to aid in the design of experiments and focus the experiments on food cravings initially, with the potential to include other types of craving at a later date (as cravings are not just limited to food, Tang, Fellows, Small and Dagher, 2012; Shiffman et al., 2002) and further explore the findings that cognitive loads reduce cravings (Andrade, Pears, May & Kavanagh, 2012; Tiggemann, Kemps & Parnell, 2010). Therefore different theories were explored as to their explanation of the interaction between craving and cognition. Most cognitive theories of craving focus on drug use, however as previously discussed there are many similarities between drug and food cravings, therefore the applicability of their crossover between the two domains will also be evaluated. This thesis focuses on cognitive theories of craving for several reasons; firstly cravings are found to occur long after the physical withdrawal from a substance has passed (Fletcher & Doll, 1969) which suggests that biological approaches to cravings are unable to fully explain cravings. Dar et al., (2010) investigated changes in cigarette craving levels in flight attendants on short and long haul flights, and found that craving strength was the same at the end of the flight regardless of length of the flight. They showed that craving increased more slowly on the longer flights in comparison to the shorter flights, regardless of the time elapsed since the person smoked their last cigarette. Again, this suggests that a different approach than biological is necessary.

Secondly, Shiffman et al (1997) found that when participants were withdrawing from nicotine their smoking urges decreased over time, rather than initially increasing and then decreasing (which is proffered by theories of conditioned withdrawal, (reviewed by Skinner & Aubin, 2010; Lowman, Hunt, Litten & Drummond, 2000; Tiffany, 1999). Shiffman et al, (1997) also reported cravings whilst participants were not abstinent, which again is inconsistent with theories of conditioned withdrawal which suggest that cravings only occur during periods of abstinence. Thirdly, as cravings are an everyday occurrence in the general population (Lafay et al, 2001) it would suggest that the applicability of theories which focus on conditioned withdrawal from a specific substance would be limited. Therefore, this thesis examined alternative theories to assess their applicability to the topic.

1.5. Relapse Prevention Model (Outcome Expectancy Model)

Lowman, Hunt, Litten and Drummond (2000) summarised the Relapse Prevention Model (Marlatt & Gordon, 1985) which is based within Cognitive Social Learning Theory. The model was designed to explain addiction and relapse behaviour, focusing on the interaction between behavioural, cognitive and environmental domains and the impact that would have on a person's response to different situations. Central to the theory is the classification of factors which underpin a relapse episode; these factors fall into two categories (Larimer, Palmer & Marlatt, 1999). The first is covert antecedents, for example urges, cravings and imbalances within a person's lifestyle. The second category is that of immediate determinants, for example outcome expectancies, coping strategies and the presence of high risk situations. As the names suggest, the reaction of the individual varies dependent on which category the possible trigger is in. The first step is to assess the emotional and environmental characteristics of a situation which may contribute or directly trigger a relapse. Analysis of the individuals' response to the situation then allows for targeted strengthening of areas where cognitive and behavioural responses were insufficient to prevent relapse. If a person repeatedly experiences a craving, then this may decrease their resolve to remain abstinent and thus a relapse may occur. The theory suggests that although mostly the words craving and urge are used interchangeably they actually describe two different instances. A craving is the desire to feel the effects of the activity such as having an alcoholic drink; whereas an urge is a sudden impulse to engage in the activity itself. Two processes can however

facilitate both cravings and urges: the first is a conditioned response to stimuli learned from previous gratification. The second is when gratification is anticipated, in which case cognitive processes such as outcome expectancies (e.g. immediate pleasure) can facilitate cravings and urges. Tiffany (1999) reviewed the Relapse Prevention Model, focussing purely on the outcome expectancy aspect of the model and suggested that there was little conclusive evidence to support this aspect of the theory. Tiffany (1999) posited that if craving was a desire to feel the effects of the activity (an expectancy), then there should be a correlation between expectancy and the amount of activity undertaken (such as alcohol consumption). Tiffany suggested that some research has found a correlation between the two (Goldman & Rather, 1993) but Cooney, Gillespie, Baker and Kaplan (1987) found mixed results. When alcoholics and non-alcoholics were exposed to drinking cues their outcome expectancies increased in both groups but not for all measures that were completed. Tiffany (1999) concluded that, the evidence in support of outcome expectancies within relapse behaviour was limited. Irvin, Bowers, Dunn and Wang (1999) performed a meta-analysis of the effectiveness of Relapse Prevention. The meta-analysis showed that relapse prevention is an effective therapy, primarily for alcoholism but can also be effective for some substance use disorders and to a small extent, smoking. Irvin et al (1999) also concluded that as a treatment (with the exception of alcohol) relapse prevention was less effective than alternative treatments for substances such as cocaine and smoking. The authors also reported that relapse prevention interventions only accounted for a small amount of the variance in a person's likelihood of relapse.. This thesis is principally focussed on food cravings but with the intention of making the findings applicable a variety of cravings. As the meta-analysis (Irvin et al, 1999) found discrepancies in its effectiveness when different substances were treated, this theory may not provide a reliable basis for investigating food cravings. Secondly, the Relapse Prevention Model in itself does not offer an explanation for craving and focused solely on addiction, suggesting that when a person experiences repeated cravings they are more likely to relapse. The main focus of the theory is on the stages needed to be undertaken to prevent a relapse, rather than the role that craving plays. As cravings are the focus of this thesis it is important to use a theory which explains the cognitive processes involved in craving. One theory which does explain the cognitive processes involved in urges is that of the Dual Affect Model (Baker, Morse & Sherman, 1986).

1.6. Dual Affect Model

The Dual Affect Model (Baker, Morse & Sherman, 1986) posits that an urge is an affect that increases the likelihood of consumption of the desired drug. They proposed that there are two memory networks, one positive and one negative, that moderate urges and inhibit each other. The positive network consists of positive affect information about the drug, such as the expectancy of pleasure in the effect of using the drug or anything that is positively related to the drug. Conversely, the negative network is associated with negative affect, not necessarily related to the drug, such as stress at work. However, both the networks induce craving experiences and drug seeking behaviour. This theory was reviewed by Skinner and Aubin (2010) and Tiffany (1999); who both highlighted again, the difficulty with evidence to support the theory. Tiffany (1999) reviewed research showing that some research supported some aspects of the theory. Zinser, Baker, Sherman & Cannon (1992) either asked participants to continue smoking normally or to abstain for 24 hours, they then asked participants to report information about their smoking urges and affect. They found that negative affect correlated with urges in smokers who were abstaining compared to those who were not abstaining. Other aspects of the theory were not supported, for example the dichotomy of the positive and negative networks. Maude-Griffin and Tiffany (1996) asked participants to listen to an audio tape focusing on positive, negative or neutral affect, urges or a combination of affect and urges. Participants were then asked to abstain from smoking until the next session which was either 6 or 24 hours later. There was a generalised increase in urges but they were not specifically related to affect. One theory which can explain this finding of why manipulating affect has no impact on urges is Tiffany's (1990) cognitive model. Instead of focussing on the manipulation of affect, Tiffany (1990) posits a model based on the inhibition of automatic processes which can be triggered by affect but are not reliant upon it.

1.7. Tiffany's cognitive model

Tiffany (1990) proposed a cognitive model of drug urges and drug-use behaviour, focusing on automatic and non-automatic processes. Tiffany (1990) theorised that cravings occur when an automatised action schema is activated, but it cannot be completed, and thus needs to be suppressed; the suppression of the schema leads to a craving experience.

A behaviour becomes automatic and unconscious through repetition (Tiffany, 1990), such as learning to ride a bike – a person has to concentrate on every aspect of the task when initially learning to ride, however when the action has been repeatedly undertaken accuracy improves and concentration on each individual aspect of the task is no longer necessary. In contrast, nonautomatic processes are slow, intention driven and require attention (Tiffany, 1990). Automaticity is thought to be the characteristic of cognitive functioning for most human daily activities, such as typing and walking (Tiffany, 1990). Tiffany (1990) suggests that there are four main characteristics of automatic processes which are relevant to drug behaviours; they are speed, autonomy, lack of control, effortlessness and lack of conscious awareness. When speed increases and variability decrease it shows the transition from nonautomatic to automatic processing (Shiffrin & Schneider, 1977), which allows for the processes to be initiated without a conscious intention (autonomy) to do so and once initiated it can be difficult to curtail (lack of control) (Tiffany, 1990). During the process, as it is well practised, it feels effortless and allows people to engage in the process without being fully aware of their actions (conscious awareness) (Tiffany, 1990). For example a person may get into the car to drive to a friend's house and instead find themselves driving to work without even realising it. A nonautomatic process however is considered the opposite to an automatic process (Tiffany, 1990). It is slow, without autonomy, controlled, effortful and fully conscious. Non automatic processes are used in situations when the responses from an automatic process are inappropriate (Tiffany, 1990); for example in a novel situation such as baking a cake for the very first time.

Tiffany (1990) posits that drug-use behaviour is an automatic process, however response to the urge is a nonautomatic process. It is the interaction of these two processes which is central to comprehending the underlying cognitive processes of drug-use behaviours (Figure 1). Tiffany (1990) postulated that drug-use behaviours become automatic due to repetition of the drug-seeking behaviours and are stored as automatized action schemata.

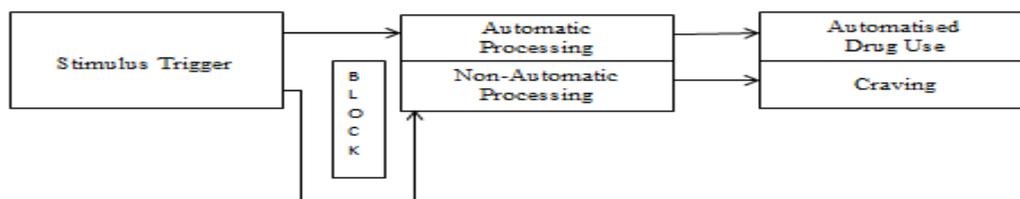


Figure 1: Tiffany's (1990) theory of craving attributes craving to the need to control non-automatic processes in response to the blocking of automatic acquisition processes

Tiffany (1990) posits that the automatized action schemata are stored as units of 'information' which can be activated and co-ordinate more complex behaviours with little conscious thought. Each action within the schema must be represented to allow for automaticity. The actions within the schema must also be co-ordinated to allow for ease of moving from one stage to the next. Contingency plans may also be incorporated within the action schema to allow for minor obstacles which prevent the normal course of completion. These obstacles would only have been incorporated if they had been encountered regularly and they were relatively easy to overcome. The more consistent the practice of the action components of the schemata, the more integrated and efficient the schema becomes. Several factors can influence the development such as the ease of procurement of the drug (as otherwise nonautomatic processes would need to be activated) and social, legal or situational constraints which may limit drug consumption. The positive reinforcing effects of the drug may lead to quicker development and better integration of the action schema.

Somatovisceral patterns of responses are also assumed to be encoded within the action schemata, but may become less pronounced over time due to less demanding and better co-ordinated behaviours being acquired. Physiological adjustments may occur in expectation of the intake of the drug, the physiological effect of the drug will vary dependent on the substance which is being used, for example nicotine or alcohol. Reductions in certain drug effects (tolerance) can be conditioned simply and the stimuli for these reductions are the same as the stimuli which trigger parts of the action schemata.

Either internal or external stimuli (which have been stored within the schema) initiate the drug-use behaviour pattern. Stimuli can vary greatly, from environmental cues (such as a smell or time of day) to internal cues (such as experiencing a particular mood

or physiological state). Stimuli may also be necessary for co-ordination of different aspects of the schema – for example feeling warmth on the back of the throat when smoking. Rose, Zinser, Tashkin, Newcomb, and Ertle (1984) found that anaesthetising participants' airways before asking them to smoke, led to a decrease in desirability ratings over the first few inhalations and also a decrease in cravings. Van der Wall and Van Dillen (2013) found that when participants completed a high memory load task (in comparison to a low load task) perception of taste was altered; participants preferred a stronger taste and consumed more of the substance (having rated it as less intense).

Tiffany (1990) postulates that it is not the automatized action schema which causes urges but the inhibition of the schema through nonautomatic cognitive processes. The inhibition can either be from an environmental factor impeding completion of the schema or it can be an explicit attempt by the individual to inhibit the schema.

Therefore urges are not necessary for drug-use behaviour to occur. The two different inhibitions will lead to two different types of nonautomatic processes being active, with different verbal, behavioural and possibly somatovisceral response groups being induced. When a person has an environmental factor impeding schema completion, the person will try to inhibit completion of an already activated schema; whereas when a person is explicitly trying to inhibit the schema they will be trying to stop it becoming activated to begin with. The behavioural responses to both these nonautomatic cognitive processes are urge responses.

The nonautomatic responses to resisting initial activation or being unable to complete the already activated automatized action schema would be maintained through the use of general cognitive resources, rather than unconscious processes (which would be expected if an action schema was active and its completion was uninhibited).

Therefore, if any cognitive task was completed concurrently when an urge was present, task performance would be worse than if they were not experiencing an urge. Tiffany (1990) describes the effect of using nonautomatized cognitive processes to stop completion of the schema as similar to that seen in Experiment 1 in Shiffrin and Schneider (1977). Participants completed trials in which they had to respond to target stimuli and ignore the distractor stimuli. Half way through the experiment, they were asked to ignore the previous target stimuli and respond to the stimuli which had previously been the distractor stimuli. Performance was lower after the swap in

response than when participants were unpractised at the task (at the beginning of the experiment). Therefore a person experiencing an activated action schema would be able to respond automatically to the schema and ignore distractions; however if completion of the schema was inhibited and focus was changed to the distracters, ability to deal with the distracters would be lower than normal as cognitive processes would be being used to inhibit the learnt response within the schema.

Tiffany (1990) postulates that nonautomatized cognitive processes have to inhibit learned responses to present stimuli as well as overcome the positive incentives of using the drugs as they were involved in the development of the schemata. Shiffman (1984, 1986) found that people who were trying to abstain from smoking were less likely to relapse if they had behavioural coping responses in comparison to those who did nothing, therefore the use of coping responses may aid in the management of overcoming the positive incentives of drug use as well as the inhibition of learned responses. Others opt to use cognitive coping strategies (Shiffman, 1984, 1986) such as focussing on the positive effects of abstinence or the negative consequences of relapsing, which also appear to be moderately effective. Brandon, Tiffany and Baker (1987) found that more than 70% of people who reported that their urges were affecting their life, reported disruption to their thinking or functioning. Tiffany (1990) posited that the findings from Brandon, Tiffany and Baker (1987) support the proposed theory of drug urges, as the urges were present in abstaining addicts and occurred at the cost of other nonautomatic processes.

Research has been undertaken to investigate Tiffany's (1990) proposition that there will be a working memory deficit when people are experiencing an urge as resources will be focussed on the inhibition of automatic action schema. Madden and Zwaan (2001) found that smoking urges affected cognitive performance for both maths and language problems, after craving was induced using imagery scripts (or a neutral imagery script for the control). Their results suggested that urges were short lived as the effect was only present for the first task but not the second, when the orders were counterbalanced. Zwaan and Truitt (1998) used an imagery script to induce craving in smokers (compared to a neutral script and a non-smoker control). They found that smokers who were experiencing a smoking urge showed a detrimental effect on their language comprehension abilities compared to the other conditions. Zwaan, Stanfield and

Madden (2000) again found similar results when smokers were compared to non-smokers who recalled verbal information after listening to an urge or neutral script. The smoker's accuracy decreased when exposed to the urge script compared to the other conditions.

Research showing interference with cognitive processes has not been limited to drugs, Kemps, Tiggemann and Grigg (2008) found participants (who were high trait cravers) performance was impaired when completing an operation span task and reaction time task compared to the no craving condition. Green, Rogers & Elliman, (2000) found that participants who were dieting or were highly restrained eaters had slowed reaction times when experiencing and induced craving compared to the no craving control and the low to medium restrained dieters. Research has also shown that there is a two way interaction between cravings and cognition; Van Dillen, Papies and Hofmann (2013) found that when participants completed a high load memory task (digit span) it reduced food cravings. Research has clearly shown that a craving involves cognitive processes, therefore when a craving is present there is an interaction between the craving and other cognitive demands. This overall finding support Tiffany's (1990) theory, however the research which is in support of Tiffany's theory examines the role of cognition as a whole. Without a more detailed analysis of the role of cognition in cravings, it is not possible to safely conclude that Tiffany's model is able to fully explain the interaction of craving and cognition.

1.8. Problems with Tiffany's theory

The central idea in Tiffany's theory, that drug use is driven by automatized action schemas, is challenged by Catley, O'Connell and Shiffmann (2000) who found that (using ecological momentary assessments) absent-minded smoking is rare. Other challenges to Tiffany's (1990) theory come from findings that some types of cognitive processing are more closely associated with craving than others. For example, visual imagery seems to be consistently reported as part of craving experiences. May, Andrade, Pannaboke and Kavanagh (2004) found that visual imagery was central to a craving experience, with olfactory information also being important within food cravings. May, Andrade, Kavanagh and Penfound (2008) undertook two studies, the first of which found that participants reported that imagining the smell or taste and picturing the item they craved was central to their craving experience. In experiment 2,

hockey players reported visual and auditory imagery were central to their craving, suggesting if noise is associated with the item or activity craved, it will be part of the craving experience. May et al. (2014) completed a confirmatory factor analysis of 12 experiments, to assess the Craving Experience Questionnaire's applicability to different consummatory targets. The analysis showed that imagery is a key cognitive feature in craving experiences. Tiffany (1990) discussed the use of imagery to induce a craving experience in participants, but does not address the issue of imagery occurring within a craving experience. These findings suggest that further research is needed to map the cognitive processes underpinning craving experiences.

1.9. Imagery and Cognition

Participants' experiences of imagery during craving episodes are reminiscent of reports of imagery within other areas such as motivation. As imagery has a central role in craving experiences it is important to briefly review the other areas in which imagery is thought to have a similarly significant role. Kavanagh, Andrade, May and Connor (2014) briefly discuss the importance of imagery within motivation. They have developed a technique which incorporates the essence of motivational interviewing but focusses on the importance of imagery throughout, as well as the development of self-help techniques. Research is currently underway which uses imagery techniques to focus individuals on positives of not drinking and uses imagery to pre-plan and guide their behaviour. Although this research has not yet been published, pilot trials are currently being completed to assess its effectiveness (Kavanagh et al., 2014). Ouellette, Hessling, Gibbons et al (2005) investigated the impact of health images on people's exercise behaviour. They found that images that were either prototypical of healthy people or a healthy self-image of the future increased a person's exercise level. Although they suggest that the vividness of the image may be central to the results, they concluded that without further research focussing on different levels of vividness of images it would not be possible to determine its full effect. These experiments (Kavanagh et al., 2014; Ouellette, Hessling, Gibbons et al., 2005) suggest that ongoing work is necessary to enable full comprehension of the complex nature of imagery and its role within motivation.

Another area in which imagery is also thought by many to have a central role is decision making. For example Patrick, Lancellotti and Hagtvedt (2009) investigated the

role of imagery in consumers who regretted not acting on a previous opportunity or purchase and therefore may intend to not repeat their actions if the opportunity arises. Participants were presented with a scenario where they had the opportunity to go to a theme park and were told they had declined (and regretted that decision) the previous year or they had accepted and enjoyed themselves the previous year. Participants were asked to rate how likely they were to purchase a ticket this year and rated how strongly they were imagining being at the theme park. The results showed that participants in the regret condition reported stronger imagery and were more likely to purchase a ticket.

Manipulation of imagery is also thought to aid adaptive decision making; Daniel, Stanton and Epstein (2013) discuss its role within decision making. They found participants (all of whom were overweight or obese women) who used imagery related to positive future events ate less when given the opportunity, compared to those who had neutral imagery. They concluded that episodic future thinking allowed overweight and obese women to decrease delay discounting (when smaller rewards sooner are seen as more appealing than larger rewards which are further away) and therefore decrease their energy intake from the food. They posit that this strategy may be useful for encouraging maintenance of a healthy weight.

It is conceivable that, in these studies, imagery influenced how much participants desired different possible outcomes. For comparison with Tiffany's (1990) theory, this thesis focussed on the Elaborated Intrusion Theory of Desire (Kavanagh, Andrade & May, 2005), which sees unwanted cravings as desires underpinned by the same cognitive processes as more adaptive desires to eat or exercise. Central to these cognitive processes is mental imagery and an attraction of focusing on imagery is it offers a route to developing clinical applications within the current movement to use imagery within cognitive therapy. Hackmann, Bennett-Levy and Holmes (2011) discussed the application of imagery within cognitive therapy to develop a comprehensive guide to allow clinicians to advance the use of imagery within their practice. The study of cravings within this thesis was designed to allow for the development of practical applications of the research, rather than focussing on furthering the theoretical basis. However, it is central to have a strong conceptual understanding of the interaction of cravings and cognition to ensure that the results found are due to the intended manipulations rather than unexplained variables. It is

therefore important that the role of imagery within craving is considered including both theoretical approaches and supporting empirical data.

1.10. Role of imagery in craving

The Elaborated Intrusion (EI) Theory of Desire (Kavanagh, Andrade & May, 2005) develops the importance of imagery within craving experiences. EI Theory (Figure 2) posits an explanation of the phenomenology of craving by distinguishing between the associative processes which trigger intrusive thoughts and the cognitive elaboration which occurs through controlled processes. EI suggests that sensory associations and the emotive imagery to which they are linked are central to the craving experience. Whilst a craving experience is under way, cognitive processes will prioritise the craving and therefore interference in other cognitive tasks may be found (Kemps, Tiggemann & Grigg, 2008; Tiggemann, Kemps & Parnell, 2010). Kavanagh, Andrade and May (2005) describe the importance of the involvement of the different sensory areas to provide the piquancy of the experience and motivation for the individual, who could be experiencing both relish and torture from the craving itself. The image itself provides pleasure (relish) but concurrently can increase the individual's awareness of the deficit related to the item they are craving and thus also give the sense of being tortured. The motivational impact of the craving is moderated by both internal and external factors such as availability of the item or competing cognitive tasks (Kavanagh, Andrade & May, 2005).

EI Theory defines desire as a conscious affectively charged episode in which an item or event is the focus of attention and is associated with pleasure or relief of discomfort. It differentiates desire from the antecedents (such as physiological deficit or environmental cues) of it, as although the occurrence of the antecedent may increase the probability of a craving episode it does not guarantee it and are not the experience itself (Kavanagh, Andrade & May, 2005). EI Theory posits an explanation of the phenomenology of all craving rather than limiting itself to explain only the phenomenology of psychoactive substances. EI Theory argues that rather than terminology limiting cravings to only very intense episodes (and desire to lower strength episodes), desire is a sliding scale on which all experiences fall, therefore no differentiation is necessary. May, Andrade, Pannaboke and Kavanagh (2004) found traits of craving experiences were similar across a variety of substances, such as alcohol

and food, which suggests that EI Theory's inclusivity, is an effective framework for explaining the phenomenology of craving.

EI Theory proposes that craving can be triggered by either an internal or external cue. Most of the time the trigger requires little cognitive processing, and so people perceive a sudden intrusive thought about the item or event. The trigger can be from classical conditioning, semantic or episodic in nature. These can vary from being a physiological deficit, to walking past a shop that you know sells chocolate. The trigger itself is not a craving thought, but can lead to an intrusive thought which is transitory in its nature; only if the person attends to the thought and retains it within working memory would a craving experience occur. If the person does not attend to it, the thought is vulnerable to distraction and other tasks take priority (Kavanagh, Andrade & May, 2005).

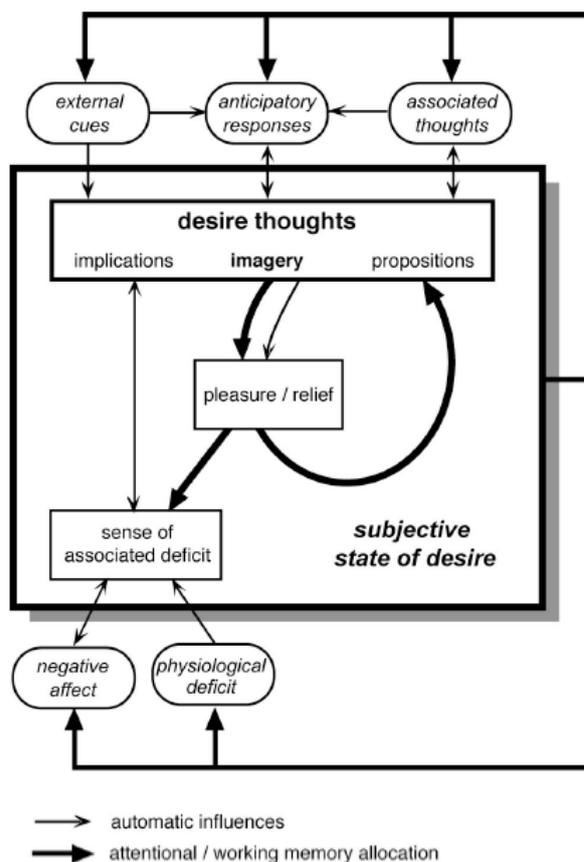


Figure 2: The Elaborated Intrusion Theory of Desire attributes craving to the elaborative processes involved following an intrusive thought (reproduced from Kavanagh, Andrade & May, 2005)

EI Theory postulates that if a sense of deficit or an affectively charged reaction is caused by the intrusive thought, then this will be the start of a craving episode and elaboration on the intrusive thought will occur. Elaboration of the intrusive thought requires conscious cognitive processes which focus on searching for and maintaining relevant internal and external information. This can include recalling past experiences of interacting with the item (such as eating chocolate), trying to ascertain if in the current situation it is possible to attain the desired item (for example, do I have enough money?) and imagining what it would be like to have the item now (for example, how would the chocolate taste as it melted in my mouth?), (Kavanagh, Andrade & May, 2005)

EI Theory argues that imagery is not only part of the craving experience, it is central to it. That although semantic processing is involved within craving, it is the imagery that provides the motivational power of the experience. The cognitive processes involved in craving will include the construction of sensory rich images that are vivid and will lead to a strong emotional impact which the craver will most likely experience both negative and positive emotions from (Kavanagh, Andrade & May, 2005). For example if the person was craving chocolate they may feel a strong sense of deficit whilst craving and not having, however they may also experience a sense of enjoyment from the imagery which they have created. EI postulates that most craving episodes are a negative experience. This is due to a person's awareness and frustration at not being able to procure the item immediately and the sense of deprivation the delay causes. If the person is also trying to resist the item then feelings associated with desiring the 'forbidden' item such as guilt and anxiety will also increase the negative emotion of the craving experience. (Kavanagh, Andrade & May, 2005)

Images are generated, maintained and manipulated using several important cognitive processes (Baddeley & Andrade, 2000). Images are generated in part from information retrieved from long-term memory. The retrieval process is controlled by executive processes (Rosen & Engle, 1997). This includes information which is generic about the item being craved such as the colour of the chocolate, sensory information such as the texture of chocolate and previous memories involved the craved item, such as eating chocolate in front of your favourite film, as well as expectancies of enjoying chocolate now. Information is also stored in the relevant working memory subsystems about

information in the current environment, such as ‘my nearest chocolate is in the cupboard’.

Kavanagh, Andrade and May (2005) propose it is the storage and manipulation of the retrieved information in the visuospatial sketchpad and auditory subsystems (Baddeley, 1986) that give the images their all-encompassing lifelike and vivid qualities. This continued elaboration of thoughts related to the craved item within the subsystems sustains the craving. The triggers of craving are not negated by elaboration but are brought more to consciousness as any target-related information is prioritised and incorporated within the elaboration. Although the numbers of intrusive thoughts can increase during a craving episode and therefore in turn increase elaboration, craving is not necessarily a self-sustaining cycle. Satiating the craving can mean that the imagery involved no longer provides pleasure or a sense of relief; or other cognitive processes become a priority (either through conscious choice or through associated thought processes diverting your attention) and therefore the intrusive thoughts are no longer attended.

EI posits that intrusive and elaborative thoughts can both lead to acquisition of the item attended. However the processes involved in acquisition are different. Intrusive thoughts can lead to the action being undertaken without much conscious awareness. For example if you had an open box of chocolates next to you, you may experience an intrusive thought and before you realise have picked a chocolate out from the box and been eating it. If however you were trying to resist eating another chocolate from the box you may attend the intrusive thought and elaborate on it before consciously choosing a chocolate from the box.

EI proposes that imagery within a craving experience is important as it provides motivation and activates an emotional response. Evolutionarily this is significant advantage as imagining possible scenarios where the desired item can be attained would allow for pre-planning. It also would ensure that desire for the item was maintained when there were no direct cues from their current environment and therefore encourage continued searching. A craving does not have to be present for consumption to occur; neither does experiencing a craving necessarily mean that the item will be attained, however as an increase in motivation and planning would be present there would be an increased likelihood of attaining the item.

Although desire is important, other internal and external factors will moderate indulgence behaviour (Kavanagh, Andrade and May, 2005). For example if you are in the desert and there is no chocolate available then you won't indulge. EI Theory proposes that craving is more likely to affect indulgence rates when other factors are less extreme for example if you were in your house with your favourite bar of chocolate in the cupboard and you craved it (and had no reason to resist it) you would be more likely to eat it.

Kavanagh, May and Andrade (2009) investigated the applicability of EI Theory to alcohol cravings during treatment for an alcohol disorder. They found that over 80% of participants reported imagery during a craving experience with just over two senses involved. Again, over 80% of participants reported transient intrusive thoughts. They concluded that the results showed support for the importance of imagery and the separation of automatic and controlled processes during a craving experience, and overall support for EI Theory. However, they suggest interpretation of the results should be cautious as the data was collected retrospectively, and although the results showed correlation, it was not possible to confirm causation. Therefore, during this thesis, a gradual progression from experimental laboratory work to ecological momentary assessments is of importance to ensure causality can be interpreted with relative confidence. These laboratory experiments used Baddeley's (2007) working memory model to test the assumption that imagery is a key cognitive process in craving.

1.11. Imagery in working memory

Baddeley (2007) reviewed the capability of the working memory model to cope with the complex nature of imagery and concluded with the addition of the episodic buffer it could explain a person's ability to maintain and rate the image at the same time.

Baddeley (2007) suggests that information in visuo-spatial working memory is gained from both actual perception (including tactile, visual and kinaesthetic) and long term memory (both episodic and semantic), either individually or combined. He reviewed a series of experiments focusing on self-report data of vividness of imagery and concluded that it was possible to obtain accurate data through the use of self-report.

Baddeley (2007) does not propose an individual theory of imagery but rather aims to explain the occurrence of imagery using working memory. Baddeley and Andrade

(2000) conducted a series of experiments which focussed on the vividness of imagery, they found that participants who were completing a concurrent task, reported a decrease in vividness when the image was in the same modality as the concurrent task (i.e. when participants were completing a visual task and being asked to create a visual image, the vividness was decreased compared to when the concurrent task was verbal, the opposite was true when participants were rating vividness of auditory images).

Baddeley (2007) reviewed other theories of imagery and highlighted that their focus on imagery being analogous to perception (Kosslyn, 1980; Kosslyn, 1994). For example, Kosslyn (1980) posits the idea that an image can be scanned in a similar way as a currently perceived scene. Pylyshyn (1973, 1981), posited that a mental image was not like a picture but rather a detailed mentalese (language of thought) description.

Although this area is of great debate, it is not the focus of this thesis. Therefore, specific imagery theories will not be examined in detail as Baddeley (2007) presents a workable theory which provides scope for investigating the relationship between imagery, cognition and craving. Baddeley (2007) proposed that there are four subsections of working memory; the visuospatial sketchpad, the phonological loop, the episodic buffer and the central executive. Each module has a specific role in maintaining and amalgamating information relevant to a person's current environment. The role of the visuospatial sketchpad is to maintain any visual information which needs to be retained in the short term; the phonological loop has a similar role in maintaining auditory information. However, without rehearsal the information stored will decay and not be able to be recalled. Information can also be recalled from long term memory and 'held' in short term memory by the episodic buffer. The role of the central executive is to coordinate information from the different areas of working memory into coherent information or episodes; it also 'shifts' attention from one task to another when necessary.

Some early research showed a simple task could interfere with verbal memory. Murray (1968), Levy (1971) and Peterson and Johnson (1971) found that when participants were asked to remember a list of items, recall ability was significantly lower if they made a repetitive sound whilst trying to retain the items. Subsequent research has shown that this interference is modality-specific, supporting the hypothesis of separate visuospatial and phonological processing systems.

1.12. Verbal and visual working memory

Both the visuospatial sketchpad and the phonological loop modules of working memory rehearse the information to ensure its retention within the module. When a competing task is undertaken retention of the information within its working memory module is reduced if the task interferes with the rehearsal processes (e.g., spatiomotor pattern tapping interferes with visual pattern recall – Quinn 1994 – and repetition of a sound or word interferes with verbal STM - Baddeley, 2007) or disrupts storage (as dynamic visual noise has been hypothesised to do with visual storage, Quinn & McConnell, 1996; and irrelevant speech with verbal storage (Salame & Baddeley, 1982).

Some of the most compelling evidence showing a double dissociation between visual and verbal working memory, is that of neuropsychology in which some patients have been found to have preserved digit span but impaired memory for visual tasks, whereas others have impaired memory for digit span tasks and preserved visual memory task ability (DeRenzi & Nichelli, 1975; Hanley, Young & Pearson, 1991; Basso, Spinnler, Vallar & Zanobio 1982).

There is also strong evidence of a double dissociation from non-clinical populations, showing that tasks can selectively interfere with one module of working memory. Logie, Zucco and Baddeley (1990) completed two experiments in which participants completed either a visual or a verbal task with a concurrent task which again was either visual or verbal. Experiment one results showed that the visual patterns task had interference from the visual task which involved manipulation of visual information; whereas the letter memory task showed significant interference from the concurrent arithmetic task. This was again supported by the findings in experiment two. Vogel, Woodman and Luck (2001) found that participants were able to remember around 3 to 4 visually presented objects (which could not be verbally named easily) whilst a verbal interference task was being used, whereas when participants were asked to recall visually presented letters, their ability to accurately recall the letters was decreased. These experiments show a clear double dissociation between visual and verbal working memory.

Miller (1956) reviewed several studies, which focused on the amount of information a person could accurately recall and concluded that verbal short-term memory was limited to around seven items (plus or minus two), however more recent evidence has

shown that this capacity is affected by factors such as length of the items needing to be recalled (Baddeley, Thomson & Buchanan, 1975). This difference in capacity, again suggests a dissociation between visual and verbal working memory. Vogel, Woodman and Luck (2001) found that regardless of number of features that the objects had (and participants were asked to recall), it was the number of objects that appeared to be limited within visual short-term memory, rather than the number of features of each object. Cowan (2010) addressed the issue of limits within working memory. Cowan (2010) posits that the limit is affected by many different factors, however it is the difference between working memory (processing of information) and storage of information is the subsystems (short-term memory) which is central to these differences. When processing of information is controlled, working memory has a capacity limit of 3 to 5 items, regardless of if they are singleton pieces of information or chunked.

Some evidence shows dissociations within visual working memory; suggesting that visual and spatial information may be maintained and stored independently within visual working memory.

1.13. Interfering with visuospatial working memory

Smyth and Pendleton (1989) found that a spatial suppression task did not interfere with a movement task and a movement suppression task did not interfere with a spatial task. However, the spatial suppression task interfered with the spatial task, and likewise the movement suppression task interfered with the movement task. Therefore, as this suggests there is a separation of visual and spatial processing, tasks were chosen with care during this thesis to ensure they were able to interfere with visual imagery.

McConnell and Quinn (2000) found that dynamic visual noise (DVN, a display of randomly changing black and white squares) interfered with a visual task, whereas a presentation of a static noise field (a static display of black and white squares) did not. These results have been found to be consistent with many experiments showing similar results. Quinn and McConnell (2006) found that if DVN was displayed during the encoding or recall period, there was no significant effect on words being learnt through rote instruction but there was significant interference on words being learnt using visual instruction. Darling, Della Sala and Logie (2009) found that a spatial tapping task interfered with location of object recall but did not interfere with memory for

appearance of the object. Conversely, DVN interfered with memory for appearance but not for location. Dean, Dewhurst and Whittaker (2008) found that DVN interfered with memory for alien skin textures (patterns that were not easily identifiable and therefore could not be named) but not with location. Dent (2010) also found DVN selectively interfered with memory for colour but not for location.

Some research has examined the possibility of using visual interference tasks to start to address real world problems, such as post traumatic stress disorder. Holmes, James, Coode-Bate and Deeproose (2009) found that participants who played Tetris (a visual based computer game) reported fewer flashbacks after watching a traumatic film than those who did not. Holmes, James, Kilford and Deeproose (2010) further tested this premise by again participants watching a traumatic film and then either playing Tetris, completing a 'Pub Quiz' or doing nothing. The results showed that Tetris decreased flashbacks in comparison to the other two conditions (in one experiment the 'pub quiz' increased flashbacks), suggesting that the action of merely doing something was not causing the decrease in flashbacks.

1.14. Interfering with imagery

Baddeley (2007), highlights a clear separation between visual and auditory working memory. This coupled with the theories posited by Tiffany (1990) and Kavanagh, Andrade and May (2005) dictated the starting point of this thesis. Although Tiffany (1990) does not explicitly state that all areas within working memory would be utilised during an urge experience, it is possible to deduce that it would involve all areas of cognition as suppression of automatic processes and activation of nonautomatic processes tend to involve cognitive processes as a whole. In contrast, Kavanagh, Andrade and May (2005) posit that visual working memory would be more central to a craving experience due to the role of imagery within craving, and therefore would show a greater effect. In this thesis, this dissociation between the two subsystems of working memory will be used to identify if interactions between working memory and craving are modality-general, as Tiffany's (1990) theory predicts, or modality-specific, as EI (Kavanagh, Andrade & May, 2005) theory predicts.

Although the main body of research that was undertaken during this thesis was centered around non-addictive substances, Elaborated Intrusion Theory (Kavanagh, Andrade and May, 2005) suggests that all craving episodes fall somewhere on the same scale.

Therefore any findings would hopefully be applicable to more than just the specific substance they were examining. Although Tiffany (1990) suggests that cravings occur when a learned behaviour is inhibited (such as eating), the theory focusses on drug addiction and does not explicitly extend the theory's application for cravings of other substances and their implications. However, as Tiffany (1990) posits a general modality involvement in craving, whereas EI (Kavanagh, Andrade & May, 2005) theory predicts modality specific involvement, the applicability of these two theories to the findings of this thesis will be discussed throughout.

1.15. Empirical evidence, the findings and the application of theories

Although one of the focusses of this thesis was the separation of Tiffany (1990) and EI Theory (Kavanagh, Andrade & May, 2005), relevant literature which did not differentiate between these was reviewed which used a variety of sensory tasks to interfere with craving, or to investigate if craving interfered with the task employed. Kemps, Tiggemann and Bettany (2012) found that when participants were asked to smell either a neutral (water), food (green apple) or non-food (jasmine) related odorant, the non-food related odorant reduced chocolate cravings in participants. This suggests that cravings are not limited to one area within short term memory, but suggests an involvement of olfactory senses. Several experiments have investigated the role of different sensory modalities in craving (May, Andrade, Pannaboke & Kavanagh, 2004; May, Andrade, Kavanagh & Penfound, 2008; May et al., 2014) the results of which support the position that sensory imagery is central to craving. With visual imagery consistently being present and other sensory imagery involvement when the sense is central to the craved item. Kemps, Tiggemann and Bettany (2012) do not differentiate by assessing the impact of other simple sensory information at interfering with cravings. This means that both Tiffany (1990) and EI Theory (Kavanagh, Andrade & May, 2005) are able to explain the findings. This however is an interesting experiment as it suggests something as simple as introducing a different smell to a participant can help reduce cravings.

Morewedge, Huh and Vosgerau (2010) used a more complex task to interfere with cravings. They found that participants who imagined eating lots of the chocolate 'M&M's' were found to eat fewer than those who imagined eating less, a different food or no food. They conclude that their findings are due to participants becoming

habituated to the action of eating ‘M&M’s’ (and thus decreased their motivation to obtain ‘M&M’s’) and therefore desired them less at the end of the imagery task. Again, this paper does not show support for either EI Theory (Kavanagh, Andrade & May, 2005) or Tiffany (1990). EI Theory would suggest that imagery would increase consumption (as a craving would be triggered and elaborated through the use of imagery), especially when only a small amount of the food was consumed imaginarily. Several studies have reported that scripts describing drug use situations are effective at inducing drug cravings (Tiffany & Drobles, 1990; Tiffany & Hakenwerth, 1991) but did not measure consumption of the substance after induction. Although, Morewedge, Huh and Vosegerau (2010) did measure consumption, the authors did not explicitly state how they asked participants to imagine the actions. If the imagined actions were tedious participants may become disengaged with the task after a short period of time, therefore the findings may be due to the manipulations within the experiment rather than as a clear finding showing imagery can decrease consumption. It was therefore important during this thesis that the craving induction was engaging for participants and was not overly repetitive.

One experiment that used a more engaging task (to induce a craving) was Kemps, Tiggemann and Grigg (2008), who induced a chocolate craving by asking participants to refrain from eating chocolate and chocolate based products for 24 hours before doing the experiment, and then exposing them to chocolate. Kemps, Tiggemann and Grigg (2008) then got participants to complete a reaction time task and in the second experiment they completed an operational span task. The results showed that only participants who scored highly on the trait craving scale were found to have an interference with the tasks. Although Kemps, Tiggemann and Grigg (2008) did not use tasks that differentiated between visual and verbal working memory, they concluded that their findings were in support of Tiffany’s (1990) theory of craving. However, Elaborated Intrusion Theory (EI) (Kavanagh, Andrade and May, 2005) could also explain the findings. EI posits a scale of desire and also proposes that although visual imagery is central to craving experiences, other areas within working memory are also involved. If a person experiences strong cravings, the level of involvement of other areas within working memory is also going to increase. Therefore, with the experimental design used it is not possible to differentiate which theory the findings are

in support of. However, the protocol used by Kemps, Tiggemann and Grigg (2008) was effective at inducing chocolate craving and so this was used as the basis for induction throughout this thesis.

Hamilton et al (2013) also investigated the effect of imagery on craving, they found that when participants craving strength decreased during completion of a visual imagery task (either guided imagery, picturing walking through the forest, or body scanning, where participants focussed on one part of their body) compared to a mind wandering task, but was not apparent on measures completed before and after the task. This paper does not differentiate between different subsystems within working memory (and therefore cannot show support for either theory) but clearly shows an effect of a concurrent task on craving strength. This paper is further evidence of an interaction between task and craving.

Some research has investigated the impact of completing a visual task compared to a non-visual task and therefore the findings differentiate between Tiffany (1990) and EI Theory (Kavanagh, Andrade & May, 2005). Kemps, Tiggemann & Hart (2005) investigated the susceptibility of chocolate images in self-reported cravers and non-cravers to visual interference compared with verbal interference. They found that participants who were cravers and non-cravers (but who still liked chocolate) reported experiencing a chocolate craving during the experiment which was reduced when a competing visual task (dynamic visual noise) was present in comparison to a verbal task (irrelevant speech). These findings suggest clear support for EI Theory as the tasks target separate areas within short term memory and show different effects, whereas this difference would not be predicted from Tiffany's (1990) theory.

Further research differentiating between visual and non-visual tasks was completed by Kemps and Tiggemann (2009) who completed a series of experiments investigating the impact a competing visual (Imagine the appearance of...) or olfactory (Imagine the smell of...) imagery task would have on craving for coffee in comparison to an auditory imagery task (Imagine the sound of...). They induced a coffee craving by asking participants to refrain from drinking their morning coffee and then exposed them to either images of coffee or an actual coffee. They found that the competing visual or olfactory imagery tasks were effective at decreasing craving in comparison to the competing auditory imagery task. This again supports EI Theory, that there are clear

differences in working memory used during a craving episode. EI theory posits that different areas are of different importance depending on the item being craved (May, Andrade, Kavanagh and Penfound, 2008; May, Andrade, Pannaboke & Kavanagh, 2004). May, Andrade, Pannaboke & Kavanagh (2004) reported that olfactory information as well as visual information was important within food cravings. This is supported by the findings of Kemps and Tiggemann (2009).

Andrade, Pears, May and Kavanagh (2012) also investigated the differences between visual and verbal tasks on craving. Experiment 1 showed that clay modelling reduced craving compared to participants letting their mind wander, or counting backwards in threes. When investigating the task loads they found that the verbal task load was greater than the modelling task on general resources, but had similar effects on visuospatial short-term memory. The authors posit this is due to the visual and motor components of the modelling task offsetting the smaller general load. Experiment 2 (Andrade, Pears, May & Kavanagh, 2012) expanded on Experiment 1 and used a simpler verbal task – counting aloud in ones at a rate of one per second. Craving was again, found to decrease after the modelling task in comparison to the counting task. This finding highlights the need for tasks to be well matched to ensure clear interpretation of the results. The results could be considered to be due to a general load effect, however as Experiment 1 found that clay modelling had a lower load than counting backwards in threes, this is less plausible. If the load is therefore modality-specific and the effect on craving is equally apparent across tasks (regardless of visual load being lower than verbal), it would suggest that craving is also modality-specific. The authors therefore concluded that the results supported EI theory (Kavanagh, Andrade & May, 2005) and that imagery drives craving.

Research into the effect of task on craving, has not been limited to food and drink; May, Andrade, Panabokke and Kavanagh (2010) investigated the use of imagery tasks to decrease cigarette cravings in participants who were abstaining from smoking through a series of experiments. They found that relative to an auditory control (imagine a telephone ringing), visual imagery (imagine cows grazing) was effective at decreasing cravings. They also found that when participants manipulated clay without being able to see it (therefore having to visualise the task) their craving decreased in comparison to an auditory task of counting down from 100. This finding again shows

support for EI Theory (Kavanagh, Andrade & May, 2005) by showing separate effects of visual and verbal memory on cravings.

Much research has been completed which examined the effect of task on craving strength, less has been undertaken which focussed on the reverse. I (Deas, 2009, unpublished undergraduate dissertation, UoP) started to examine the different impact of craving on interference in the visuo-spatial sketchpad and the phonological loop. Deas (2009) used the protocol laid out by Kemps, Tiggemann and Grigg (2008) to induce chocolate craving in participants. Participants then either completed a visual working memory task or a verbal working memory task. The visual working memory task involved participants using peg word mnemonics to remember and recall a list of words, whereas in the verbal task participants were asked to use rote learning to recall a list of words. Deas (2009) found a significant effect of craving on recall in the peg word condition but not in the rote learning condition. This suggested that visual working memory is more susceptible to interference from craving than verbal working memory. However, the tasks in question were not well matched in terms of their difficulty. Rote learning uses more basic levels of processing than peg word mnemonic which requires complex integration of imagery (Craik and Lockhart, 1972). Therefore it is not possible to conclude if the difference found was to selective interference within working memory or task difficulty. Other research has been published which investigated the impact of craving on cognitive tasks.

Tiggemann, Kemps and Parnell (2010) again aimed to assess the impact of craving on working memory tasks. During this experiment, they used tasks to differentiate between the visuo-spatial sketchpad, the phonological loop and the central executive. They found that participants performed worst on the visuo-spatial task whilst craving. However, no impairment was found during the other tasks. These findings suggest support for EI Theory (Kavanagh, Andrade and May, 2005), although the authors did not make this conclusion themselves they did discuss the findings supporting selective interference within working memory. However, the results are of interest, especially when the tasks which were used are examined. To measure visuo-spatial interference a Corsi Block task was used, digit span to measure the phonological loop and a double span task to measure the central executive. The double span task involved participants completing a task very similar to Corsi Blocks (participants saw and recalled a

sequence of words in locations on a 4x4 grid). However, as previously mentioned Tiggemann, Kemps and Parnell (2010) found no effect of craving on this task but did when Corsi Block task was undertaken alone. EI Theory (Kavanagh, Andrade and May, 2005) would suggest that the double span task would also show interference as there is a visual component to the task, as well as higher level cravings having a greater impact on a more complex task. Tiffany (1990) would also suggest that the double span task would show an effect of interference as well as the task would be more demanding. Tiggemann, Kemps and Parnell (2010) suggest that the findings are due to the central executive 'swamping' the visuo-spatial sketchpad and phonological loop as the task is primarily about coordination of the information. Without further investigation it is difficult to determine why the results found this difference.

1.16. Methodologically relevant experiments

The literature reviewed above, has focussed on the suppression of craving or interference of craving on task completion. The following experiments, however, indicated protocols to follow during this thesis to ensure that the methodologies were as robust as possible. Hetherington and MacDiarmid (1993) reported that chocolate was the most commonly craved food in Western cultures, whereas Komatsu (2008) reported that one of the most common cravings in Japan was for Sushi and Asian people reported cravings for rice. It is therefore important when manipulating cravings, that the item which is being used to manipulate the craving is a culturally salient item. For example if you were to offer a Hindu beef, it would be unlikely to induce a craving as cows are sacred within their religion. During this thesis, therefore, when cravings were manipulated, chocolate was used as the focal craving. One noteworthy addition to the differences in culture is that not all languages (for example Danish, Turkish and Uzbek) have an equivalent word for craving (Hormes & Rozin, 2010), Although it is not mentioned in the study as to whether or not this suggests that cravings are fewer or greater in different cultures, confusion over the meaning of the word is important during this thesis to allow participants to fully interpret what is being asked of them. Therefore, this thesis primarily used the homogenous student population from Plymouth University (most of whom were native or fluent English speakers) to ensure comprehension of the language being used during the experiments.

Gender differences are also apparent in cravings. Zellner, Garriga-Trillo, Rohm, Centeno & Parker (1999) found that men more commonly crave savoury foods such as cheese and crisps, whereas women tend to crave sweeter substances such as chocolate. Differences in age have also been found to have an impact on craving frequency; younger people tend to experience more frequent cravings than older people (Pelchat, 2002). Pelchat (2002) also reports that older participants can either resist the craving or replace it with another substance more easily than younger participants. Therefore, demographic information on age and gender were collected throughout this thesis to ensure if any anomalous or unusual craving results were collected, that they were not due to an atypical population.

1.17. Scope of the research

There is an abundance of evidence supporting the proposal that visual working memory is central to craving experiences and when a concurrent visual task is completed, craving strength is decreased. However, less research has focussed on the converse, by investigating the effect of cravings on task performance. This therefore was the starting point of this thesis – is the effect of cravings on task performance as pronounced as the effect of task on craving strength? The initial experiments of this thesis aimed to match the cognitive demands of the comparison tasks (visual and verbal) more closely than has been done in previous research. However, the results from the experiments were unclear. Later experiments therefore aimed to test the hypothesis that craving involves visual imagery by deploying visual and verbal tasks to interfere with cravings and thus demonstrate that craving experiences are modality-specific and not just due to differences in task load. The final study tested the effectiveness of cognitive interference on cravings in real-world settings, with the aim of developing a take-home task to interfere with cravings. This is to ensure that any laboratory findings were salient in everyday life.

Experimental Chapters:

Chapter 2: Experiments 1 and 2: An investigation into the effect of craving on visual and verbal memory tasks.

Experiments one and two were designed to examine the effect of chocolate craving on task performance. Participants completed either a chocolate craving induction or a control induction and completed their assigned task. Experiment two altered the tasks which participants completed to address possible problems in the methodology of Experiment one.

2.1 Experiment 1

Elaborated Intrusion Theory of Desire (EI) (Kavanagh, Andrade & May, 2005) proposes that visual imagery is a particularly important aspect of craving, involving elaboration of apparently spontaneous intrusive thoughts. Elaboration involves using information from internal and external sources to generate sensory images of the target of desire. This can include cues in the external environment, for example a picture of a chocolate bar, or an internal cue such as recalling from long term memory the last time you ate chocolate.

Self-report data shows that visual imagery features prominently in the phenomenology of craving for different substances and activities, whereas auditory imagery is generally less important. For example, May, Andrade, Kavanagh and Penfound (2008) examined self report questionnaires to assess what people reported as the main aspect of their craving experience. Participants recording their craving for food or drink reported that picturing it and imagining the taste or smell was central to the experience. May et al. (2008) also completed a second study which found that hockey players reported cravings to play hockey and the main feature of their craving experience was the visual aspect – they reported imagining themselves playing hockey more than the sounds and smells of playing.

May, Andrade, Pannaboke and Kavanagh (2004) investigated different food cravings (including soft drinks such as tea and coffee) and cravings for alcohol and cigarettes using self report questionnaires. They found that more than 60% of respondents reported tasting or visualising the item which they were craving, however only 9% of respondents reported ‘hearing it’. Kavanagh, May, & Andrade (2009) found that visual

imagery was reported by 59% of people when experiencing a craving for alcohol. Increased visual imagery frequency was also related to longer craving episodes. Therefore the results from the studies suggest that imagery is central to cravings, however it is unclear if imagery is a mechanism within a craving experience or just a side effect of the experience.

As discussed in detail during the introduction of this thesis, visuospatial working memory processes have limited capacity. Therefore when a vivid visual imagery task which requires visuospatial working memory processes (Baddeley & Andrade, 2000) is currently underway, and a craving is present, mutual interference between the two actions would be expected, if craving necessarily involves visual imagery. Thus, EI Theory (Kavanagh, Andrade & May, 2005) predicts that visual working memory should be more greatly impaired by craving than other aspects of working memory. However, Tiffany's (1990) theory implies that all aspects of working memory should be equally impaired. Tiffany (1990) suggested that drug use is a learnt behaviour which evolves into an action schema that can be triggered by drug-related cues. Craving is the experience that occurs when the action schema is triggered but stopped from being completed. Therefore it is the suppression of the schema which causes craving. This suppression involves general, top-down or 'executive' processing, consequently Tiffany's theory predicts that craving will be associated with general cognitive deficits rather than specific deficits which EI proposed. Much research has been completed showing the effect of visuospatial tasks on craving strength (May, Andrade, Panabokke & Kavanagh, 2010; Kemps & Tiggemann, 2009; Kemps, Tiggemann & Hart, 2005), however less has been completed showing the converse – the extent to which imagery during craving affects task performance. This is an important aspect to address as it is a critical test of EI Theory (Kavanagh, Andrade & May, 2005) compared to Tiffany (1990).

General cognitive studies have been undertaken to examine if craving affects cognition. For example, Kemps, Tiggemann and Grigg (2008) examined the effect of craving on cognition, using a reaction time task and an operation span task. They found that craving affected both the reaction time task and operation span task but only in participants who self-reported high trait levels of chocolate craving. These tasks use multiple areas within working memory rather than individual components. As this

study does not examine visual and verbal memory separately, so the results do not distinguish between Tiffany (1990) or EI Theory (Kavanagh, Andrade & May, 2005).

Deas (2009) compared the impact of craving on visual and verbal tasks. The tasks employed for participants to learn word lists were rote learning and Pegword Mnemonic (which used a visual learning process). Craving selectively interfered with the Pegword Mnemonic. As rote learning is considered a shallow learning process (the meaning may be encoded during rehearsal but it is not necessary to generate an image to aid recall) it may have a smaller working memory load than the Pegword task (which requires semantic information to be learnt and recalled to generate an image), even though the tasks were matched for difficulty in the sense of giving similar levels of performance (Craik & Lockhart, 1972). Therefore the results may be due to the difference in levels of processing and working memory load rather than craving selectively interfering with visual learning.

It was therefore a concern that the tasks had potentially very different working memory loads. The differential effects of craving may have been due to the disparity in sensitivity of the tasks to general working memory loads (consistent with Tiffany's (1990) theory) rather than selective interference of craving with visual working memory (consistent with EI theory, Kavanagh, Andrade & May, 2005). Consequently, to ensure this was not a confounding variable in the current studies, possible tasks were assessed for their working memory load to make certain that they were suitable.

A further study, by Tiggeman, Kemps & Parnell (2010), addressed this issue by comparing effects of craving on visual and verbal memory independently, but their results were contradictory. Participants completed either a digit span, Corsi Blocks or double span task whilst either experiencing an induced chocolate craving or not. Participants who were experiencing a craving had poorer performance on Corsi Blocks than the digit span task or the double span tasks (when baselines were matched) compared to participants who were not craving. As the double span task utilised both visual and verbal working memory it is unclear why there is no effect of craving on that task. Both Tiffany's (1990) theory and EI theory (Kavanagh, Andrade & May, 2005) would predict an effect. Another problem is that the tasks which were used may not have been purely been drawing upon the visual or verbal components of working memory. The Corsi Blocks task has been questioned as to its visual demands and is

considered to be a more spatially based than visually based task (Logie & Pearson, 1997; Pickering, Gathercole, Hall, & Lloyd, 2001) and previous research has suggested that there is a dissociation between spatial and visual working memory (Darling, Della Sala & Logie, 2009). As there are concerns about the methodology used, and the puzzle of why visual interference was apparent on Corsi blocks but not the double span task, Kemps and Tiggemann's study warrants replication.

This experiment therefore aimed to replicate the findings of Tiggemann, Kemps and Parnell (2010) using a working memory task that was more selectively visual than the Corsi block task and comparing it with a verbal task with similar task demands. For this study, previous literature was examined to find tasks that were purer measures of visual or verbal short term memory and therefore ensure they measured what they were intended to.

Different tasks were examined to assess the purity of their load on visual short-term memory and to check that their working memory load was similar to that of serial recall of digits, which was taken as a standard measure of verbal short-term memory.

Sensitivity to random visual interference (dynamic visual noise; DVN) was used as an indicator of purity of visual processing because DVN selectively impairs visual imagery but not rote learning (Quinn & McConnell, 1996) and several recent studies show that it selectively impairs short-term memory for visual but not spatial material. Dean, Dewhurst & Whittaker (2008) used dynamic visual noise to interfere with memory for location matrices and coloured textures. They found that dynamic visual noise interfered with memory for coloured 'alien skin textures' but not memory for the location matrix, suggesting that the colour texture memory task provided a purer measure of visual STM. However, as the colour texture task is relatively new and there have been limited experiments using it, it is difficult to assess its robustness. Therefore, other tasks were also scrutinised.

Darling, Della Sala & Logie (2007) investigated the effect of dynamic visual noise on memory for the letter 'P' in different fonts and locations. Participants were presented with a single letter 'P' in different locations and fonts and were asked to correctly recognise either the font or the location. During the delay participants either did nothing, tapped on the desk or watched dynamic visual noise on a computer screen. Dynamic visual noise did not interfere with recall accuracy of location or appearance.

However, tapping did interfere with memory for location. The results showed that there was an effect of dynamic visual noise on reaction time for appearance but not for location when a longer delay between viewing and recalling the item was present, the converse was true for the tapping task. Therefore (Darling, Della Sala, & Logie, 2007) results concluded that there is a dissociation between visual and spatial memory. Darling, Della Sala & Logie (2009) completed a similar study, this time participants were presented with several different 'P's (simultaneously or sequentially), rather than a single 'P', and were asked to remember either location or appearance of the 'P'. After a delay (in which they either did nothing, watched dynamic visual noise or did a tapping task) they were shown a 'P' and asked to state whether or not it was a 'P' that they had been asked to remember. When presented in this manner it was found that dynamic visual noise significantly impaired recognition accuracy, not just response time.

Darling, Della Sala and Logie (2007) did not find an effect of dynamic visual noise on recall accuracy, only on response time. However, by manipulating the presentation of the task slightly, Darling, Della Sala and Logie (2009) did. Although two experiments have been undertaken using similar tasks, the findings, suggest that a small amount of variance in the task can reduce the effect of visual interference on the task and suggest that the task may not be very reliable. Therefore this task was deemed unsuitable as the robustness of the task was questionable and other tasks which had been replicated more successfully were reviewed.

Dent (2010) designed a task in which participants were asked to recall a colour shade (from a selection of colours) which they had seen previously. Recall could not easily be supported by verbal working memory as there were several shades of the same colour. Therefore, unless a person was highly skilled at differentiating between colours and applying verbal labels to them, the colour has to be remembered purely using visual memory. The task (Dent, 2010) also appeared to be robust as similar tasks have been repeated successfully (Wilken & Ma, 2004; Zhang & Luck, 2008). Dent found that dynamic visual noise interfered with memory for the colour but not memory for location, suggesting that the colour task loads visual but not spatial working memory. Therefore Experiment 1 of this thesis used the colour shade task as a comparison with immediate serial recall of digits to test whether craving exerts a general cognitive load

or a predominately visual load. Dent (2010) found that participants were accurate to within 1.324 colour shades in the control condition (out of a possible 27 colour shades away), when the participants viewed the colour shade for 2 seconds and then had a 5 second delay. Following pilot work, the time delay between exposure and recall on the task was lengthened and the original length of time that the participants saw the colour for were reduced to decrease accuracy, to ensure that a ceiling effect was not present in the visual condition. The dependent variable was the percentage of the colour shade away from the correct colour (from the total possible number of colour shades away within each trial, 27). The pilot data originally found participants were achieving 100% accuracy, however when the delay was increased and exposure time was decreased, accuracy decreased to 78%.

Visual and verbal task performances were aimed to be matched. Andrade & Donaldson (2007) found recall accuracy of around 80% when a six item digit list was presented verbally to participants at a rate of one item per second, therefore this length and presentation format was utilised as the basis for the digit memory condition. As the task used by Dent (2010) requires a person to remember and recall the colour (and not any semantic information related to it) it would appear to require similar levels of processing (and thus be well matched) to immediate serial recall of numbers. When a pilot study was completed (to investigate participants immediate serial recall of numbers) it found that participants were achieving 79% accuracy rate when presented with 6 digits and 65% accuracy when asked to recall a seven item digit list. However, many of the participants were able to recall all the lists with a 100% level of accuracy when presented with the 6 item digit lists which could possibly skew results; therefore, participants were tested using a seven item digit list.

2.2 Methods

2.2.1 Participants:

Sixty participants (nine males) were recruited from Plymouth University Psychology Undergraduate Participant Pool (as they had to collect points as part of their course credits). They were aged between 18 and 45, ($M = 22.9$, $S.D. = 7.6$). Participants were recruited on the basis that they had no visual problems (except wearing glasses).

2.2.2 Materials:

2.2.2.1 Visual:

A fourteen inch LCD computer screen with a 1280x1024 pixel resolution was used for the visual task to display the task. Participants sat with their eyes approximately 50cm away from the screen.

A coloured circle was presented centrally on the screen within a square frame which measured 15.3cm x 15.3cm and 1 pixel in width. The circle itself measured 1.6cm in diameter (40 pixels). RGB colour space was used to define the colours. The maximum value for each channel was 255 and the minimum value for each channel was 30 To do this a set of equations was used, where n is the colour number (between 0 and 53)¹ This was done for all three channels – two being held constant and the third changing. The colour for each trial was chosen randomly from the 54 colours available without replacement. After presentation of the coloured circle participants were asked to select the correct colour from a ring of the 54 colours surrounding a blank circle (1.6cm in diameter) in the centre of the screen. The ring measured 19cm in diameter and was 3.8cm wide. The colours were presented so that the colour gradients merged into one another. The circle appeared in a set position regardless of the location of the colour target.

¹The equations used to produce the 54 colours for the colour wheel (reproduced from Dent, 2010),

255, 30 + 25n, 30] For $0 \leq n \leq 9$
255-25(n-9), 255, 30] For $10 \leq n \leq 18$
30, 255, 30 + 25(n-18)] For $19 \leq n \leq 27$
30, 255-25(n-27), 255] For $28 \leq n \leq 36$
30 + 25(n-36), 30, 255] For $37 \leq n \leq 45$
255, 30, 255-25(n-45)] For $46 \leq n \leq 53$

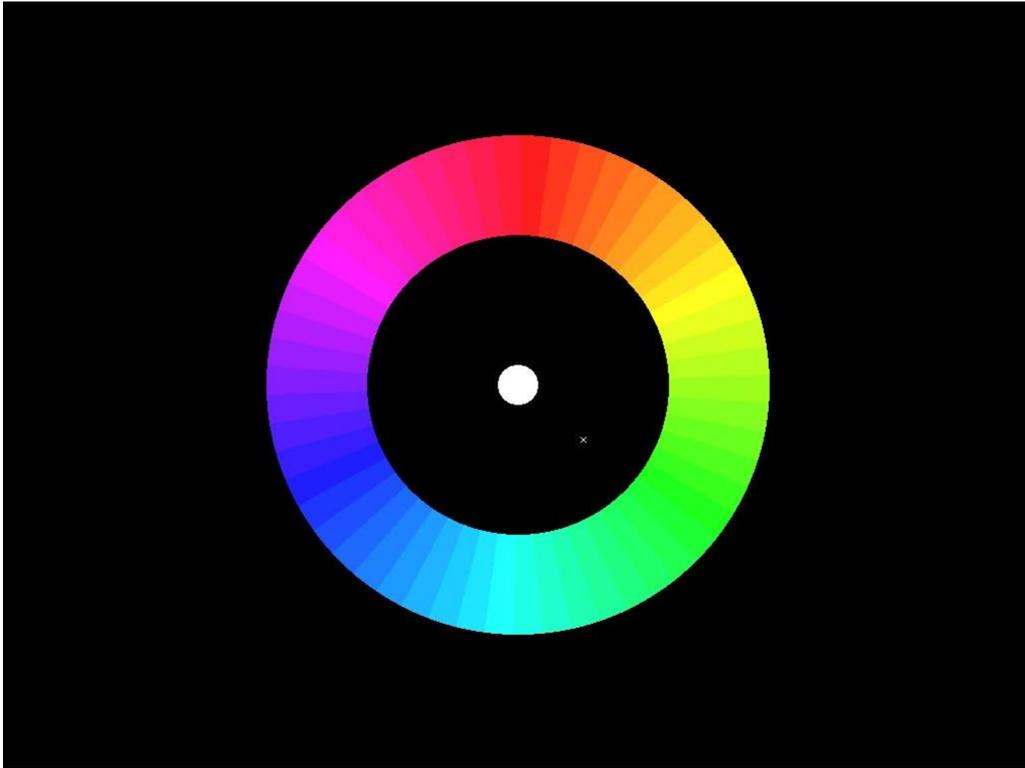


Figure 3: A screen shot of the colour ring from which participants selected the colour that they had previously seen

The start of each trial was indicated by a fixation cross presented centrally on the screen for 1 second. This was followed by a coloured circle presented for 2 seconds. The screen then went blank for 10 seconds. The participants were then presented with a blank circle in the centre of the screen which had a ‘ring’ of colours surrounding it (see Figure 3). When participants selected a colour from the ring (by using the mouse cursor to select it) the white circle on the screen was filled with their selected colour. A ‘button’ then appeared at the bottom of the screen which allowed participants to move on to the next trial once they were happy with their selection by pressing the ‘space bar’. Participants completed a total of four practice trials and 40 real trials.

2.2.2.2. Verbal:

The digit memory task was presented using pre-recorded lists on an Olympus DM-20 digital recorder. One syllable digits between 1 and 9 (excluding 7) were presented at a rate of 1 per second, with seven items per list. There was then a ten second delay between presentation of the last digit and recall. Participants then recalled the digits in the order in which they were presented. The lists were randomly generated without

repeating digits within the list. Obvious sequences were discounted from the selection of lists and repeated sequences across lists were removed. Each digit appeared approximately equally often across lists. Participants completed a total of three practice trials and 30 real trials.

2.2.3 Design and Procedure:

The design was a 2 (craving status) x 2 (memory test) between subjects experimental design, with four conditions to which equal numbers of participants were assigned. The participants were randomly allocated to either craving or not craving and to either the visual or the verbal memory test.

Participants assigned to the chocolate craving condition were sent an email 48 hours before the experiment asking them to refrain from eating chocolate or chocolate flavoured food for 24 hours before the experiment. They were also asked if they had any allergies which may stop them from being able to partake in the experiment (such as peanut allergy) and if that is the case to email back as soon as possible so that they could be reassigned to a different condition. No participants reported needing to be reassigned; therefore all participants remained in the condition to which they were originally assigned.

Participants in the non-craving condition were not emailed before the experiment or exposed to chocolate during the experiment. Participants were tested in the afternoon when craving levels are typically higher (Hill, Weaver & Blundell, 1991). Participants first filled in a questionnaire about their demographic information. Participants in the chocolate craving condition then underwent a chocolate induction protocol based on the protocol designed by Kemps, Tiggeman and Grigg (2008). Participants were asked to choose a chocolate from a selection of sixteen wrapped chocolates (Quality Street). There were eight different types of chocolates laid out in pairs. Once they selected a chocolate, they unwrapped it and put it to their right on the desk. Participants then described the chocolate in two or three sentences and rated how much they wanted it on a scale of 1 to 100, from 'Not at all' to 'Very Much'.

Participants in the control condition completed a similar task. They first selected a marble from a choice of eight matching pairs, which differed only in the colours inside them, and put it to the right on the desk, this was similar to the task used by Kemps,

Tiggemann and Grigg (2008) who asked participants to choose a coloured block (from a selection of eight matching pairs) and rate how much they liked the colour. In the current experiment participants then described the marble and rated how warm they were currently feeling on a scale of 1 to 100, from 'Extremely Cold' to 'Extremely Hot'.

After the participants had completed their first chocolate or control induction, their assigned task was described to them, and they completed the practice trials. After the practice trials, for both the digit memory task and the colour shades task, and between each block of tests, participants completed their assigned (marble or chocolate) induction. Each condition repeated their induction after every 8 trials, a total of 6 times during the experiment, to ensure craving levels remained high in the craving condition.

Participants in the visual task condition completed 4 practice trials and 40 experimental trials, presented in blocks of 8. Participants in the verbal task condition completed 3 practice trials and 30 experimental trials, presented in blocks of 6, to match the visual condition on length of time.

At the end of the experiment participants completed a short questionnaire. The control group were asked if they were craving anything (if so, what they were craving) and rated how much they were craving that specified product on a scale of 1 to 100, from 'Not at all' to 'Very Much'. The aim was to rule out participants in the control condition who were experiencing craving for any substance even if they were not craving chocolate.

After being debriefed, participants in the experimental condition took their chocolates with them and participants in the control condition were offered a chocolate.

2.3 Results.

Firstly, the results from the chocolate induction protocol were examined to check if the induction had been effective. The initial craving rating scores for the craving group were compared to the craving score given by the control participants in their end questionnaire using an independent t-test. Chocolate craving was significantly higher in the craving condition ($m=66.37$, $S.D.=16.14$) compared to the non-craving condition ($m=17.52$, $S.D.=25.64$), $t = 8.48$, $d.f. = 44.35$, $p < .001$, one tailed (equal variances not assumed).

The visual scores were converted into percentages by calculating the percentage of the colour shade away from the correct colour (from the total possible number of colour shades away within each trial, 27). The digit task was scored by converting the correct number of digits recalled (in their correct location within the list) into a percentage. The mean and standard deviation of each of the conditions are presented in Table 1. In Table 1 the number of accurate trials was whether or not the participant selected the correct colour or not (a binary measure). Whereas mean accuracy is the percentage away from the correct colour (the number of colour shades away from the correct answer converted into a percentage). Thus, participants in the craving condition had fewer correct trials (9.9) than the not craving condition (11.8) but had more trials which were closer to the correct answer (93.6%) than the not craving condition (92.4%).

Table 1

Accuracy on visual and verbal short-term memory tasks, by craving status.

		Accurate trials (/40)	Mean shade error (/27)	Mean Accuracy (%)	Accuracy SD (%)
Craving	Visual	9.9	1.7	93.6	1.8
	Verbal	26.4	--	66.0	13.4
Not Craving	Visual	11.8	2.0	92.4	3.1
	Verbal	26.8	--	67.0	19.1

The effect of craving on the colour wheel task was then compared to the effect of craving on the digit memory task using a 2x2 ANOVA. Performance on the two STM tasks differed significantly, $F(1, 56) = 75.86, p < .001, \eta_p^2 = 0.575$, with higher scores on the colour memory task compared with digit memory. There was no main effect of craving, $F(1, 56) = .001, p = .98, \eta_p^2 < 0.001$. The interaction between craving and task was also not significant ($F(1, 56) = .138, p = .71, \eta_p^2 = 0.002$). Non-homogeneity of variance in the memory scores weakens the conclusions that can be drawn from the ANOVA (Levene's test $p < 0.001$) but the mean scores clearly show no detrimental effect of craving on colour shade memory. The data was transformed (using several

different transformations, including the arcsine transformation) to improve homogeneity of variance within memory scores, however Levene's still remained significant ($p < 0.001$) and therefore this was not analysed any further.

The results from the visual task were examined focussing on the number of incorrect trials, rather than the size of the errors (using an independent t-test). This was to examine if participants were more prone to making errors (regardless of size) whilst craving, compared to not craving. The mean number of incorrect trials was 28.4 for non-cravers, and 29.9 for cravers. There was no significant effect of craving on error rates ($t = -1.278$, d.f. = 28, $p = .106$, one tailed). The results from the visual task were also examined (using an independent t-test) in terms of the number of trials on which the participant had extreme scores (greater than 15 shades away from the correct colour). This was to examine if participants were more prone to forgetting the colour or not seeing it to begin with when craving compared to not craving. The mean number of trials with extreme scores was 0.2 for the craving condition and 0.71 for the control condition. There was no significant effect of craving on levels of forgetting or distraction ($t = .381$, d.f. = 28, $p = .380$, one tailed).

2.4 Discussion:

It is clear from the results that the craving induction successfully induced craving. However, the results of the colour wheel task and the digit memory tasks showed no impact of craving on short-term memory, in contrast to findings reported in the literature of detrimental effect of craving on short-term memory (Kemps, Tiggemann & Grigg, 2008; Tiggemann, Kemps & Parnell, 2010). If the craving induction was a success yet no differences were found, was this because craving does not affect cognition, was it because the particular tasks utilised were unaffected by craving or that craving was suppressed by task completion.

The digit memory task appears to be a valid and consistent technique for measuring other forms of verbal interference (Andrade & Donaldson, 2007; Schendel & Palmer, 2007). Therefore, as participants averaged 67% and 65.9% correct recall (in non-craving and craving conditions respectively) it would imply that the findings from the digit list suggest that craving does not interfere with this particular verbal memory task. Again, in the next experiment digit recall was employed as the verbal task due to the robustness of the task and, again a visual task used was aimed to match the verbal task

in difficulty, however due to the differences in task performance a different visual task was used.

Perhaps the visual task was too easy and did not fully load the visuospatial sketchpad during the completion of the task, therefore craving could not interfere. However, Dent (2010) found that dynamic visual noise selectively interfered with colour memory but not memory for location. If a simple visual distracter, such as dynamic visual noise interferes with colour memory then a more complex cognitively demanding distracter such as craving should also interfere with colour memory. However this was not found. Participants may have given priority to the memory tasks rather than to their craving, in which case the visual colour task or verbal task may have suppressed craving rather than craving suppressing cognitive performance. As working memory is limited, competition for resources may lead to craving being suppressed and the visual or verbal task becoming dominant and therefore being unaffected by craving. Such a finding would be consistent with demonstrations in the literature of craving being suppressed by competing visual (but not verbal) tasks (e.g., Kemps & Tiggemann, 2007; May, Andrade, Pannabokke & Kavanagh, 2010; Versland & Rosenberg, 2007).

During this current experiment, participants reported their craving levels directly after each induction to ensure that their craving levels remained high throughout the experiment. This meant it was not possible to examine if craving was suppressed during task completion. Therefore the next experiment altered the methodology of craving induction to assess both if completing a visual task or verbal task suppresses craving, and if cravings interfered with the task. This was to evaluate the possibility that cravings were being suppressed by task completion, rather than craving interfering with the task.

2.5 Experiment 2

To allow for further analysis of the interaction between craving and cognition, this experiment was designed to test mutual effects of craving and cognitive performance in different modalities. To do this the chocolate craving induction designed by Kemps, Tiggeman and Grigg (2008) was altered. Specifically, the point at which participants reported their craving strength was altered to allow the effect of the task on craving to be examined as well as the effect of craving on the task. This was done by asking

participants to rate their craving before repeating the chocolate craving induction (with the exception of the first rating which was after the induction to check its effectiveness). Therefore, the craving strength they were reporting was their craving strength after task completion rather than their craving strength immediately after completing a craving induction, thus allowing the effectiveness of the task at decreasing craving to be assessed.

To differentiate between EI Theory (Kavanagh, Andrade & May, 2005) and Tiffany (1990), visual and verbal tasks were used as measures of memory. In Experiment 1, a colour memory task (Dent, 2010) showed no effect of craving on accuracy of colour recall. Therefore other potentially more sensitive tasks were examined to assess their ability to interact with craving.

Holmes, James, Coode-Bate & Deeproose (2009) investigated the effect of playing the computer game 'Tetris' on reducing flashbacks after witnessing a trauma. They found that flashback frequency was significantly reduced in participants who played 'Tetris' compared to those who did not, suggesting that playing 'Tetris' interfered with the consolidation of visually rich memories. Holmes, James, Kilford and Deeproose (2010) also found that Tetris interfered with flashbacks compared to other distraction tasks, such as completing a 'pub quiz'. Davies, Malik, Pictet, Blackwell and Holmes (2012) again found playing Tetris interfered with intrusive visual memories after viewing a film compared to a no task control. These findings would suggest that Tetris is a robust tool for interfering with visual working memory.

An advantage of the computer game 'Tetris' instead of the colour memory task (Dent, 2010) is that it requires mental manipulation of the shapes as well as retention of information about the shape rather than retention of the information alone, therefore it imposes a greater visual working memory load. It is also an easy to access task which would mean that if it is found to be effective at reducing craving, it would potentially be suitable as a self help task for reducing cravings. As a long term aim of this overall research is to find an effective way to interfere with craving using a take-home task, 'Tetris' was therefore used as the visual task in this experiment.

The verbal task used in this experiment as a standard measure of verbal working memory was a seven item digit list, as it has been found to be a valid measure of verbal memory (Andrade & Donaldson, 2007; Schendel & Palmer, 2007). Tiggemann, Kemps

and Parnell (2010) found that when participants were experiencing a craving (compared to a no craving control) their performance was impaired on a Corsi block task but not on a digit span task.. Also previous experiments have found that verbal memory is unaffected by a competing visual task (Quinn & McConnell, 2006) so should be unaffected by craving if craving involves visual but not auditory imagery. Digit lists were therefore used as the second memory task during this experiment.

2.6 Methods

2.6.1 Participants:

One hundred and seventeen participants (twenty-five males) were recruited from the Plymouth University Psychology Undergraduate Participation Pool, aged between 18 and 50 ($M = 20.2$, $S.D. = 3.2$). Participants were recruited on the basis that they had no visual problems (excluding wearing glasses) and on the basis that they had not completed Experiment 1.

2.6.2 Materials:

2.6.2.1 Visual:

The visual task was playing the computer game 'Tetris'. This was played on a Samsung N130 notebook with a screen size of 10.1 inches. The computer game Tetris (marathon version) was downloaded from www.80smusiclyrics.com/games/html. Participants sat approximately 50cm from the screen.

2.6.2.2 Verbal:

As in Experiment 1, an Olympus DM-20 digital recorder was used to present the digit memory lists. Again, only one syllable digits between 1 and 9 (excluding 7) were presented in seven item lists at a rate of 1 per second, as Experiment 1 found this gave a 66.5% level of correct recall. The same lists were used as Experiment 1.

2.6.3. Design and Procedure:

A 2 (craving status) x2 (memory test) between subjects experimental design was used. Participants were randomly allocated to either craving or not craving conditions and to either the visual or the verbal memory test.

As in Experiment 1, participants who were assigned to the chocolate craving condition were emailed 48 hours before they were due to take part in the experiment asking them

to refrain from eating chocolate or chocolate flavoured products for 24 hours and to ensure that if they had any allergies they could be reassigned to a different condition before the experiment.

Participants in the non-craving condition were not emailed before the experiment or exposed to chocolate during the experiment. Participants were tested in the afternoon when craving levels are typically higher (Hill, Weaver & Blundell, 1991).

Participants in the chocolate craving condition then underwent a chocolate induction protocol (based on the protocol designed by Kemps, Tiggeman & Grigg, 2008). This protocol was the same as the induction protocol in Experiment 1. Participants chose a chocolate out of a selection, described it and then rated how much they wanted the chocolate.

The control condition was also the same as Experiment 1. Participants chose a marble out of a selection, described it and rated how warm they were feeling.

After the participants had completed their first chocolate or control induction the task they were assigned to was described to them, and they completed the practice trials. After the practice trials for both the digit memory task and the Tetris task and between each block of tests the chocolate craving induction or the control induction was repeated. However, the timing of the craving rating (for the following inductions) was altered from Experiment 1; participants were now asked to rate how much they were craving chocolate before choosing another chocolate and describing it. The chocolates were put into boxes and out of sight to stop participants looking at the chocolates when rating their craving.

To match this alteration in timing, participants in the control condition were asked to rate how warm they were feeling before choosing and describing another marble. Each condition repeated the induction with this timing after every trial block, a total of 6 times including the initial induction.

At the end of the experiment participants completed a short questionnaire. The control group (as in Experiment 1) reported if they were craving anything and if so how much.

After being debriefed, participants in the experimental condition took their chocolates with them and participants in the control condition were offered a chocolate.

For the visual task, participants played the computer game 'Tetris'. Shapes move down the screen which can be rotated and moved left or right using the arrow keys on the keyboard. The aim of the game is to make the shapes fit together to form lines (see Figure 4). When a complete line is made, it then disappears and the blocks will shift down the screen. If a line is not completed and the space to complete it is blocked by another shape, the line will not disappear. If this happens repeatedly, the lines reach the top of the screen and the game is over.

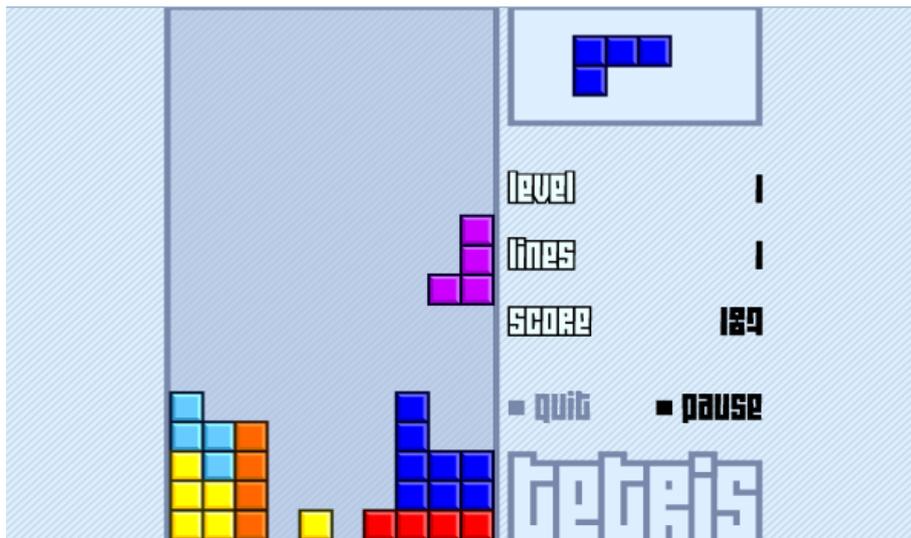


Figure 4: A screen shot of the computer game 'Tetris'

Participants played Tetris for two minutes, during the practice and each trial block, at which point their game was ended and their score recorded. The computer program Tetris calculated the score based on the shape (ie if it was a square it received fewer points than an asymmetric shape) and how many shapes it took to complete one line (ie if nine shapes had been placed before a line was completed they would receive a lower score for the line than if five shapes had been placed to form a line). A score was given per shape placed as well as per line completed. If multiple lines were completed with one shape placement, a higher score was given than if only one line at a time was completed. At the beginning of each trial, participants started a new game of Tetris. They played Tetris a total of 6 times for two minutes at a time, including the practice. As Experiment 1, in the digit memory task participants listened to a list of 7 digits presented at a rate of 1 per second. There was a 10 second delay between presentation and the participant being asked to recall the digits. The participants then freely recalled the digits in the order in which they were presented.

Participants completed 3 practice trials and 30 experimental trials, presented in blocks of 6, again to match timings of the visual task.

2.7. Results.

Firstly, to ensure that the chocolate induction had been effective, results from the chocolate induction protocol were analysed. The base rate scores of the craving condition were compared to the base rate scores of the participants in the non-craving condition (from the questionnaire asking if they were currently craving anything) using an independent t-test. It was found that chocolate craving was significantly higher in the craving condition ($m=59.93$, $S.D.=28.02$) compared to the non-craving condition ($m=8.52$, $S.D.=18.43$; $t=11.744$, $df = 100.486$, $p < 0.001$, one-tailed, equal variances not assumed).

2.7.1. Effects of Craving on Cognitive Performance

Table 2

Task performance means and standard deviations for visual and verbal tasks by craving status.

		Mean (raw score)	Standard Deviation (raw score)	Mean (Z score)	Standard Deviation (Z score)
Craving	Visual	870.2	417.1	0.036	0.928
	Verbal	59.8	14.1	-0.164	0.937
Not Craving	Visual	809.1	449.6	-0.037	1.084
	Verbal	66.8	16.1	0.164	1.051

The digit task was scored by converting the correct number of digits recalled (in their correct location within the list) in to percentage raw score. The score for Tetris was the score calculated by the computer program. The Tetris and verbal data were transformed into Z scores to make the data comparable and to satisfy Levene's homogeneity of variance ($p=0.760$). A 2 (craving status) x2 (visual or verbal task) ANOVA (of the Z scores) found that there was no main effect of task ($F(1, 116) < 0.001$, $p = 0.997$, $\eta_p^2 < 0.001$) or craving status ($F(1, 116) = 0.475$, $p = 0.492$, $\eta_p^2 = 0.004$) and there was no interaction ($F(1, 116) = 1.167$, $p = 0.282$, $\eta_p^2 = 0.010$). In other words, craving did not impair visual or verbal cognitive performance.

2.7.2. Effects of cognitive tasks on craving

To examine if the tasks differentially decreased craving (for participants in the craving condition) from the initial base ratings a 2 (task) x 6 (time) repeated measures ANOVA was completed. Mauchly's test of Sphericity was violated ($p < 0.001$). Therefore the following results are interpreted with caution, using Greenhouse-Geisser. There was a main effect of time ($F(2.403, 136.974) = 5.900, p = 0.002, \eta_p^2 = 0.094$). There was no main effect of task ($F(1, 57) = 0.064, p = 0.801, \eta_p^2 = 0.001$). There was also no interaction between task and time ($F(2.403, 136.974) = 1.590, p = 0.203, \eta_p^2 = 0.027$): craving did not decline more in the visual task condition than the verbal. This finding is presented visually in Figure 5.

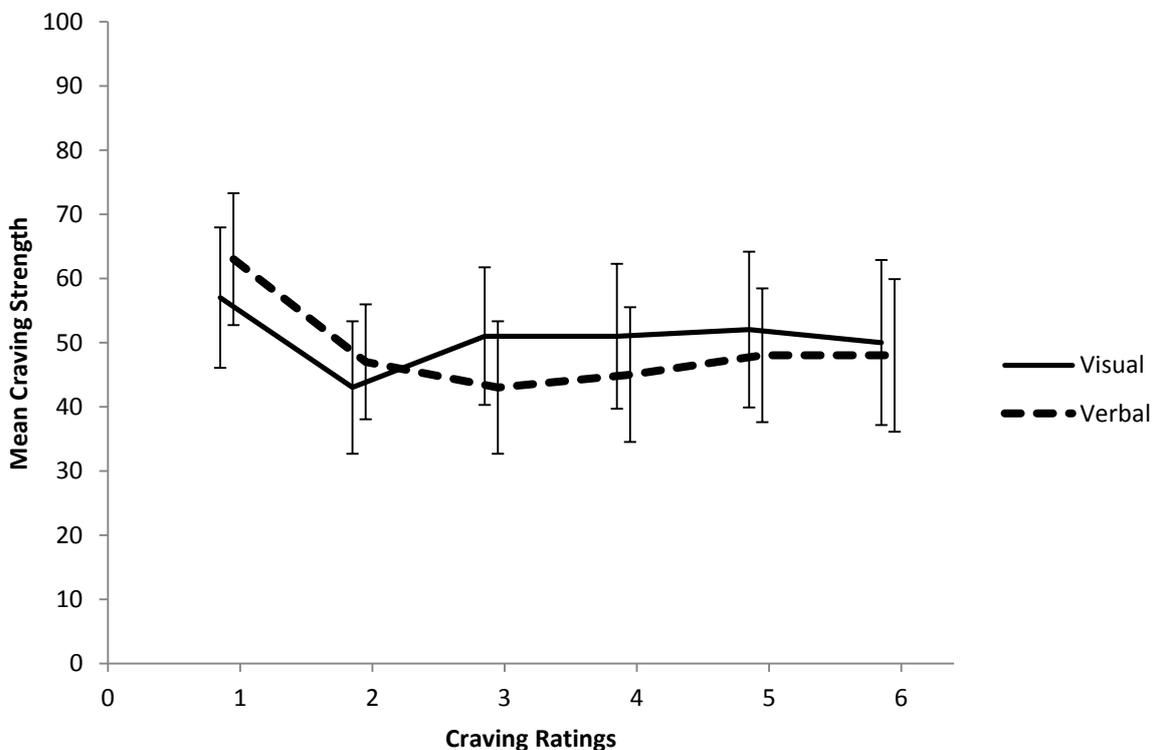


Figure 5: Change in craving over time while completing visual or verbal tasks, with error bars showing 95% confidence intervals (craving rating 1 as the baseline craving rating)

Pairwise comparisons were used to examine where the change in time was significant, collapsing across conditions, comparisons were made between all time points.

Participants' base rate cravings were higher than the first two experimental craving ratings (craving ratings two and three on Figure 5), $p < 0.001$ and $p = 0.037$ respectively. However there was no significant difference between any other time points (all $p > 0.102$). This suggests that there is an initial drop in craving but thereafter craving stabilises, at close to the baseline levels. It is worth noting that although there is no longer a significant difference between the base rate craving score and craving rating 4 (on Figure 5) onwards, there is also no difference between any of the experimental craving ratings.

2.8. Discussion:

The results show that the craving induction was effective as participants in the induction condition reported higher craving levels than those in the control induction condition. Craving decreased from the initial base rate level in both the visual and verbal conditions (in the craving induction condition). However, the base rating was taken before participants had completed their practice of the task. It is not clear whether it is the tasks that were causing craving to decrease, or the interaction between the participant and the experimenter during the practice session, or the novelty of the tasks. From the initial craving rating to the first experimental rating (after block one task completion) craving decreased significantly, as it did from the initial craving rating to the second experimental rating, however when the initial craving rating was compared to the third, fourth and fifth craving ratings, there was no difference. This could be due to participants learning that they will be given another chocolate, and anticipating that when they are rating their craving, or the tasks alone being insufficient to suppress craving once practised. To avoid participants anticipating their next chocolate during the trial, future experiments should use one craving induction (as in Andrade, Pears, May & Kavanagh, 2012; May, Andrade, Panabokke & Kavanagh, 2010; Kemps & Tiggemann, 2007) rather than repeated inductions (Kemps, Tiggemann & Grigg, 2008). It is also worth noting that although the craving rating was no longer lower than the initial craving rating, it was also no significantly higher than experimental ratings one or two. It is possible that more effective interference tasks could produce a prolonged general lowering of craving strength.

The prediction from Elaborated Intrusion Theory (Kavanagh, Andrade & May, 2005) that craving would decrease more in the visual condition than in the verbal, was not supported by these findings. The results are more consistent with Tiffany's (1990) theory that cravings are the result of using controlled processes to inhibit substance-use action schemas. Tiffany's theory therefore predicts that craving would interfere with all aspects of controlled cognition rather than selective components of working memory. However, as both the visual and the verbal conditions showed a significant decrease in craving it is not possible to confirm if this is due to the tasks interfering with craving or if it is a natural change over time. Therefore the following experiments needed to address this issue by adding a third condition that does not have a large cognitive load but where the initial interaction with the experimenter still occurs.

Kemps, Tiggemann and Grigg (2008) found that participants who reported high trait chocolate craving levels showed interference in task completion but no other participants did. Tiggemann, Kemps and Parnell (2010) also found that participants had worse performance for a visual task when craving compared to participants who were not craving. Experiments 1 and 2 of this thesis, however, did not find that cognitive tasks were prone to interference from cravings. Although it is possible that it was experimental design that caused the apparent differences in findings, many of the controls used by Kemps, Tiggemann and Grigg (2008) and Tiggemann, Kemps and Parnell (2010) were replicated during the experiments of this thesis, such as testing during the afternoon. This would suggest it was the tasks themselves that produced the differences in the findings. As discussed in the introduction to experiment one, if small variances in task design yield varying results (Darling, Della Sala & Logie, 2009; Darling, Della Sala & Logie, 2007), it would suggest that the task itself was not consistent at producing this effect and perhaps, therefore craving does not interfere with the task in the way in which it is being interpreted. It is also possible that this phenomenon only occurs under stringent controls which are difficult to replicate. The design of the experiments was primarily to ensure measurement of task performance not craving strength; the design focussed on one visual and one verbal task for each experiment. This meant that the tasks had to be fit for purpose, As only two different visual tasks were used it is plausible that the tasks were not fit for purpose and did not have the sensitivity necessary to measure an effect of craving. As it was not possible to

draw definite conclusions from the null results of experiments one and two in comparison to the findings of Kemps, Tiggemann and Grigg (2008) and Tiggemann, Kemps and Parnell (2010), the possible causes and ramifications on this thesis were therefore considered.

Experiments 1 and 2 mainly focussed on the effect of craving on task performance. However, the results showed very little evidence of an effect of craving on task, and there are relatively few studies in the literature to help elucidate the discrepancy between these findings and those of Kemps et al (2008) and Kemps et al (2010), whose procedure was followed closely. Madden and Zwaan (2001), Zwaan and Truit (1998) and Zwaan, Stanfield and Madden (2000) found smokers had cognitive deficits when experiencing a craving compared to those not craving, or to non-smokers. The cognitive deficits were found for maths, language ability and verbal recall. From an EI Theory (Kavanagh, Andrade & May, 2005) perspective cravings are considered to fall on a scale of desire, therefore smoking cravings may be stronger than food cravings and thus an effect is found. It is possible with less consuming cravings, that in a laboratory situation, participants choose to focus on the task in hand, rather than allowing their craving to become overwhelming. Kemps et al (2008) found that only participants who were high trait cravers showed a general working memory deficit. Green, Rogers and Ellimann (2000) also found that differences in peoples eating behaviours affected task performance; highly restrained eaters and dieters had slowed reaction times in comparison to low to medium restrained eaters. These finding supports the proposal that some participants choose not to allow their craving to become all consuming, but those who experience higher levels of craving may be less adept at suppressing doing this. It is also possible that an induced craving is more susceptible to interference than a naturally occurring craving, so while cravings may feel distracting outside the laboratory, they can be easily disrupted in the laboratory because of the specific task constraints and because the cravings have been induced by the experimenter rather than by physiological hunger, for instance. The difficulty of replicating the published findings on effects of craving on visual task performance cast some doubt on the robustness of these findings too, and specifically on the choice of tasks. Within the time constraints of this thesis, it was decided that it would not be possible to develop the techniques necessary to extricate these difficult variables which are innate to so many

laboratory studies examining craving. In contrast to the rather sparse literature on the impact of craving on performance of visual and verbal cognitive tasks, there is considerable evidence that visual tasks reduce the strength of induced cravings in the laboratory (Kemps, Tiggemann & Hart, 2005; Kemps & Tiggemann, 2007; Kemps & Tiggemann, 2009; Kemps & Tiggemann, 2013; van Dillen & Andrade, in preparation; Hamilton et al, 2013; Versland and Rosenberg, 2007; Andrade, Pears, May & Kavanagh, 2012; May, Andrade Panabokke & Kavanagh, 2010). Therefore, the focus of this thesis altered and examined in greater depth the effect of task completion on craving strength, with the long term aim of developing a useful take home tool to help in the management of cravings.

Chapter 3:

3.1. Experiment 3: The effect of visual and verbal tasks on craving strength.

Elaborated Intrusion Theory (EI) (Kavangh, Andrade & May, 2005) predicts that a competing visual task will have a greater effect on craving than a competing verbal task, as research has shown (Andrade, Pears, May & Kavanagh, 2012; Kemps & Tiggemann, 2007; Kemps & Tiggemann, 2009; Kemps, Tiggemann & Hart, 2005; Kemps, Tiggemann & Parnell, 2010; May, Andrade Pannaboke & Kavanagh, 2010; Versland & Rosenberg, 2007) that craving experiences rely heavily on elaboration and maintenance of visual imagery. However, Tiffany (1990) theorised that it was the suppression of an action schema that instigated craving and therefore it was a general working memory process that any working memory task could therefore interfere with. Initial work had failed to find any effect of craving on task performance and so this experiment focussed on the different effects of visual and verbal tasks, and of low and high load cognitive loads, on craving with the aim of providing an effective take home tool for managing craving, and adding to the body of research which suggests that imagery is pivotal to the craving experience.

Ideally, a take home tool needs to target craving effectively while disrupting other cognitive activity as little as possible. Laboratory research such as that reported in this thesis can help identify candidate processes for targeting and candidate tasks to do so. This experiment aimed to determine whether selectively targeting visual processes was more effective than an equivalent verbal load. The choice of experimental tasks was also driven by the need for a take home tool to be something that the person wishes to engage with and is easy to use in everyday life. May et al. (2010) found visual imagery decreased cigarette craving, relative to verbal imagery. This methodology could be problematic in non-laboratory settings as it requires the person to concentrate on internally generated cognitions and not be distracted by their surroundings. Andrade et al. (2012) found participants cravings were decreased when they modelled clay. This manipulation is perhaps easier for a person to use throughout their day, but it relies upon the person having an appropriate malleable object upon them. If a tool could be developed which was easy to employ, and did not require the person to ensure it was in their possession, but rather used the tools that many people would generally carry with them it would allow for easier management of cravings.

Experiments 1 and 2 had both used a non-craving control group to compare against a craving group, but as this next experiment focussed on the effect of tasks on craving, a non-craving control condition was not needed. Experiments 1 and 2 also used repeated inductions but this may have caused participants to learn to expect another chocolate, therefore the experimental design was altered so craving was only induced once during the experiment. The chocolate craving induction was based on the induction used by Kemps, Tiggeman and Grigg (2008), who asked participants to retrospectively rate their cravings once the experiment was completed. The current experiment altered this one aspect and asked participants to rate their craving at set time intervals during the experiment to ensure that craving ratings were as accurate as possible and without the possibility of retrospective interference.

In Experiments 1 and 2 visual and verbal tasks were used to compare the interaction of craving and cognition. Digit lists were also used during the current experiment to assess the effect of verbal working memory on craving as digit lists are considered a valid measure of verbal working memory (Andrade & Donaldson, 2007; Schendel & Palmer, 2007). Again, 'Tetris' was used as a visual working memory task as there is some evidence that playing 'Tetris' interferes with other visual tasks (Holmes, James, Kilford & Deepro, 2010; Holmes, James, Coode-Bate & Deepro 2009). A low-load control condition was included for each task.

If two tasks differ in their effects on craving, this finding can be interpreted as showing that one task more effectively blocks specific cognitive processes underpinning craving – for example that it blocks imagery by imposing a higher visual load - or because it imposes a higher general load (see Andrade, Pears, May & Kavanagh, 2012 for discussion). We used minimal-load control conditions in both auditory and visual modalities to try and separate modality-specific and general effects on craving. For one of the control task conditions, we chose to use a low verbal-load count-aloud task which has been previously used as a control condition in Andrade, Pears, May and Kavanagh (2012). Andrade et al. (2012) asked participants to count aloud at a rate of one digit per second, starting at one. Participants were told they were being left alone for 10 minutes whilst completing this task and would be prompted during that time to record the number that they had reached to ensure that they were doing the task. This task was adapted for the current experiment to match the other conditions on time and

environment (the experimenter remained present throughout). Participants were asked to count up in one's starting at one at a rate of one digit per second but were asked to count 'in their heads' rather than aloud. This was to ensure they did not receive any cues from the experimenter about the way in which they were counting.

A second control condition was introduced, based on the task used by Holmes, James, Kilford & Deepro (2010) who used a 'no task' control, to allow for no interference, and found traumatic flashbacks were significantly higher than in the experimental condition. Van Dillen and Andrade (in preparation) also used a no task control in which they told participants the computers in the laboratory were old and they may have to wait before continuing with the experiment. We adapted this control condition as it provides some minimal visual input.

During the current experiment participants were told that they were waiting for a program ('Tetris') to load, however the program never loaded and showed a 'Load Error' message after a set time.

Experiments 1 and 2 asked participants how strong their craving was on a scale of 1 (not at all) to 100 (very much). This scale was used in the current experiment. However, very little insight could be gained from this scale about the participants' experience whilst craving. Therefore, a further questionnaire was introduced which asked participants about different aspects of their craving before and after completing their assigned task. These questionnaires were early versions of the 'CEQ Now' and the 'CEQ Then' used by Andrade, Pears, May and Kavanagh (2012). Andrade, Pears, May and Kavanagh (2012) used the questionnaires to examine different aspects of craving including frequency, strength and imagery. May, Andrade, Kavanagh et al (2014) completed a confirmatory factor analysis of the CEQ questionnaires which reported a Cronbachs alpha rating of over 0.90 for each scale.

3.2. Methods

3.2.1. Participants

A total of 111 participants (42 males), aged 18 to 66 ($m=25.2$, $S.D.=10.4$) were recruited using the Plymouth University Undergraduate Participant Pool and Plymouth University Paid Participant Pool.

3.2.2. *Materials:*

3.2.2.1 *Visual:*

A Samsung N130 Netbook (with a screen size of 10.1 inches) was used by participants to play the computer game Tetris. The computer game Tetris was downloaded from www.80smusiclyrics.com/games/html.

Participants in the low visual load condition were shown a program made to look like it was Tetris loading. This was done using Microsoft PowerPoint on a timed slide show, ending with a slide saying 'Load Error'. The screen appeared (to participants) to be black, other than the word Tetris in the middle of the screen with a 'bar' below that loaded slowly (it had six segments) and consecutive segments appeared 'filled' at pseudo-random intervals. When the bar was almost completely 'loaded', it disappeared and a message appeared saying 'Load Error'.

3.2.2.2. *Verbal:*

As in Experiments 1 and 2, an Olympus DM-20 digital recorder was used to present the digit lists. One syllable digits between 1 and 9 (excluding 7) were presented at a rate of 1 per second, with seven items per list. This length was selected based on Experiment 1 which found that a digit list of seven items gave a performance rate of 66.5% accuracy. The lists were randomly generated without repeating digits within the list. Obvious sequences were discounted from the selection of lists. Also repeated sequences across lists were removed. Each digit appeared approximately equally often across lists.

3.2.2.3. *Craving Experience Questionnaire:*

Two versions of a Craving Experience Questionnaire (CEQ) were used, precursors to those reported in Andrade, Pears, May and Kavanagh, 2012 and May et al, 2014. The first was the CEQ Now which asked participants to rate different aspects of their current craving on an 11 point scale, including items on craving strength, imagery and intrusiveness. A typical question was 'Right now, how vividly are you picturing chocolate?' The second was the CEQ Then, which had two distinct parts. The first set of questions (CEQ Then) asked participants to rate aspects of their craving strength since doing the CEQ Now (during the experimental period). It asked similarly phrased questions to the CEQ Now, but they were phrased retrospectively. A typical question was 'At that time, how vividly did you picture eating chocolate?' The second, asked

participants to rate the frequency (CEQ Often) of different aspects of their craving since doing the CEQ Now (again during the experimental period). This focussed on the frequency of different aspects of cravings, with similarly phrased questions to both the CEQ Now and the CEQ Then. A typical question was ‘How often did you picture eating chocolate?’. May et al (2014) completed a confirmatory factor analysis, using data from twelve different studies which used varying, later versions of the CEQ questionnaires and concluded that they are robust and accurately measure intensity, frequency and pertinence of cognitive events during a craving episode, including imagery and intrusive thoughts. The coefficient alpha’s for the CEQ Now and CEQ Then was 0.91, and for the CEQ Often it was 0.94.

3.2.3. Design and Procedure:

The design was a between subjects 2 (high load v low load) x 2 (visual x verbal) experiment. Participants firstly confirmed that they had no food allergies and had refrained from eating chocolate or chocolate based products for the past 24 hours (which they were prompted, in the sign-up information). Participants then completed a chocolate induction. This involved participants choosing a chocolate out of a selection of 16 (presented in 8 pairs of Quality Street). They then described the chocolate and then rated their craving for chocolate on a scale of 1 to 100 (not at all to very much). Participants then completed the ‘CEQ Now’ questionnaire which has 17 questions (see Appendix 1) about different aspects of their current craving for chocolate.

After, participants completed one of four tasks (to which they were randomly assigned). The participants in the high load visual condition played the computer based game Tetris for three minutes, and their scores were recorded at the end of the session. Before they started to play they were given instructions explaining the keys needed to manipulate the shapes and also that the aim was to make the shapes fall so that the lines at the bottom of the screen are completed and disappear. A score was given by the game, depending on the shape placed, how many shapes it took to complete each line and how many lines were completed by the placement of one shape.

Participants in the high load verbal condition completed a digit memory task – they heard a digit list, there was a delay of 10 seconds and then the participant recalled the list in the correct order, completing a total of 7 lists. The total percentage correct was recorded for each participant.

In the low load visual condition, participants were told that they were going to play the computer game Tetris. They were given the same instructions as the high load visual condition. The participants were then shown a computer screen showing a load screen for the Tetris computer game. The screen showed that the game was loading but slowly. After three minutes a 'Load Error' message appeared and participants were informed that there must be an issue with the computer game and therefore that part of the experiment would be discontinued and that they would move on to the next part. No score was recorded for the participant.

Participants in the low load verbal condition were asked to count up in 1's (in their head) at a rate of 1 per second starting at 1 until asked to stop. They were stopped after three minutes and were asked state the number which they had reached, which was then recorded.

After the participants had completed their assigned task they rated their craving level again on a scale of 1 to 100 (not at all to very much). They then completed the 'CEQ Then' questionnaire (see Appendix 2) which asked them to rate different aspects of their craving during the experiment.

Participants were then debriefed. All participants were asked if they were aware what condition they were in. This was to ensure that the participants in the low load conditions were unaware that they were in control conditions.

3.3. Results

A total of 96 participants' data was included in the analysis. Data from 15 of the participants was removed due to either them being aware of what condition they were assigned to or them repeatedly not following instructions correctly.

The results of digit lists were converted into percentage correct overall. However, as the other tasks had no upper limit to their scores they were unable to be converted into a comparable measure. The mean and standard deviations of each memory task score are shown in Table 3; however as the load screen did not have a measure no score will be presented for it:

Table 3

A table to show the Means and Standard Deviations of the three conditions with measurable results.

Task	Mean	SD
Tetris	1471	1130
Digit Memory	59.4%	22.1%
Counting	129	35.0

Craving scores were measured before and after participants had completed their assigned task. This data is presented graphically in Figure 6:

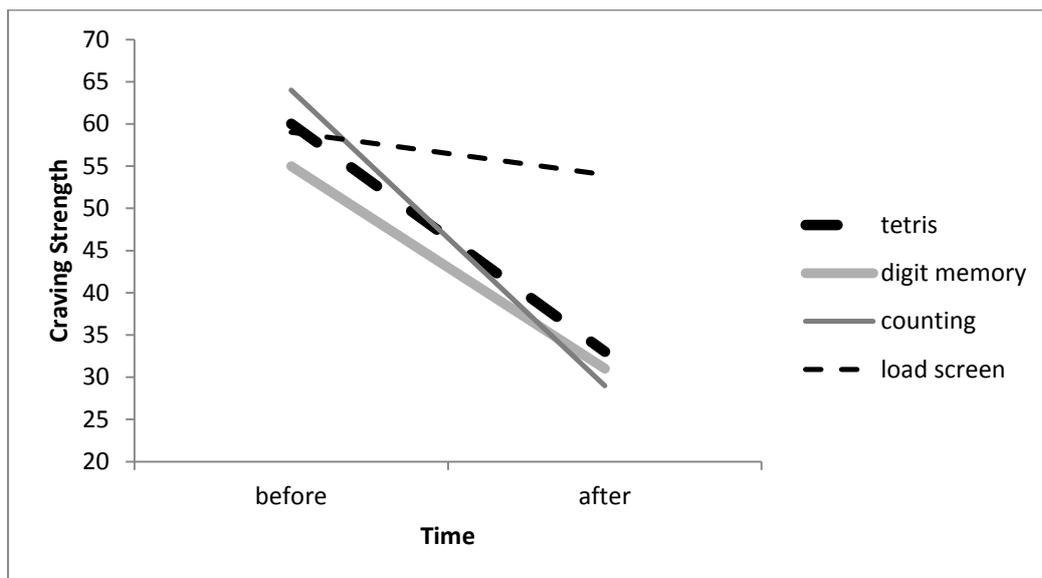


Figure 6: Change of craving strength over time by condition

The effect of load and task were examined using a 2 (high or low load) x 2 (visual or verbal) repeated measures ANOVA. Craving was found to decrease over time ($F(1, 92) = 46.195, p < 0.001, \eta_p^2 = 0.334$) with the greatest decreases being seen in Tetris, digit memory and counting. The interaction between time and task was significant ($F(1, 92) = 4.609, p = 0.034, \eta_p^2 = 0.048$), with larger decreases with the verbal tasks. There was no main effect of task ($F(1, 92) = 2.358, p = 0.128, \eta_p^2 = 0.025$) or load ($F(1, 92) = 2.295, p = 0.133, \eta_p^2 = 0.024$) and the interaction between task and load was not

significant ($F(1, 92) = 1.016, p = 0.316, \eta_p^2 = 0.011$). The interaction between time and load ($F(1, 92) = 0.990, p = 0.322, \eta_p^2 = 0.011$) was also not significant, and neither was the three way interaction between time, task and load ($F(1, 92) = 2.828, p = 0.096, \eta_p^2 = 0.030$).

Low cravers were then removed from the analysis as it is not meaningful to analyse the effect of completing the task on craving levels if the initial craving level is low. The effect of load and task were again examined using a 2 (high or low load) x 2 (visual or verbal) repeated measures ANOVA, with participants reporting their initial craving to be less than or equal to 20, removed. As before craving decreased over time ($F(1, 75) = 49.785, p < 0.001, \eta_p^2 = 0.399$) with the greatest decreases being seen in Tetris, digit memory and counting. Again, the interaction between time and task was significant ($F(1, 75) = 5.648, p = 0.020, \eta_p^2 = 0.070$), with the largest decreases with the verbal tasks. As before, no main effect of task ($F(1, 75) = 1.459, p = 0.231, \eta_p^2 = 0.019$) or load ($F(1, 75) = 3.428, p = 0.068, \eta_p^2 = 0.044$) were present and the interaction between task and load was again, not significant ($F(1, 75) = 0.013, p = 0.910, \eta_p^2 < 0.001$). The interaction between time and load ($F(1, 75) = 0.625, p = 0.432, \eta_p^2 = 0.008$) was also not significant. However, unlike before, the three way interaction between time, task and load almost reached significance ($F(1, 75) = 3.952, p = 0.050, \eta_p^2 = 0.050$).

Post hoc comparisons were made to assess where the differences between conditions occurred, using paired t-tests and excluding low cravers. Craving decreased in the high verbal load condition ($t=4.150, df=20, p<0.001, one-tailed$), the high visual load task ($t=3.511, df=20, p=0.001, one-tailed$), and the low verbal load task ($t=4.379, df=17, p<0.001, one-tailed$), but not in the low visual load task ($t=1.504, df=18, p=0.075, one-tailed$). From Figure 6 and the statistical analysis it can be seen that craving decreases in the Tetris, digit memory and counting conditions more than it decreases in the load screen condition.

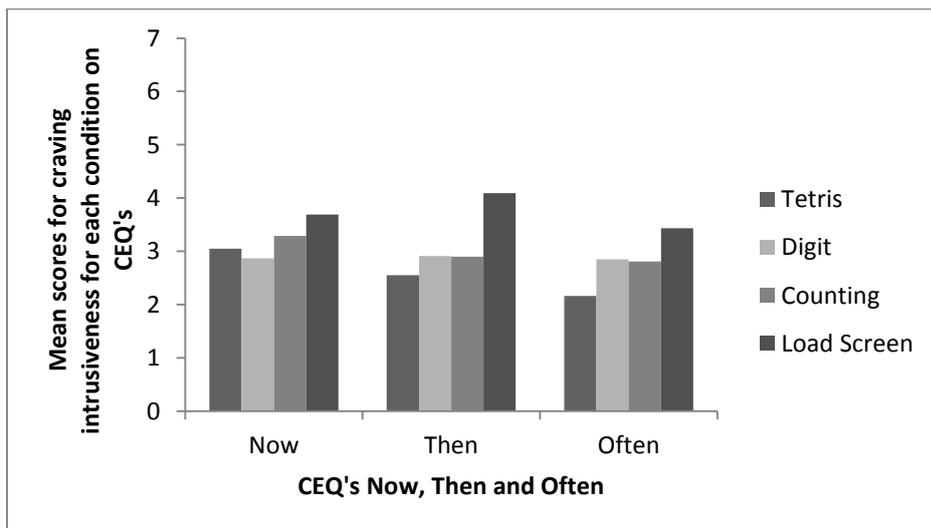
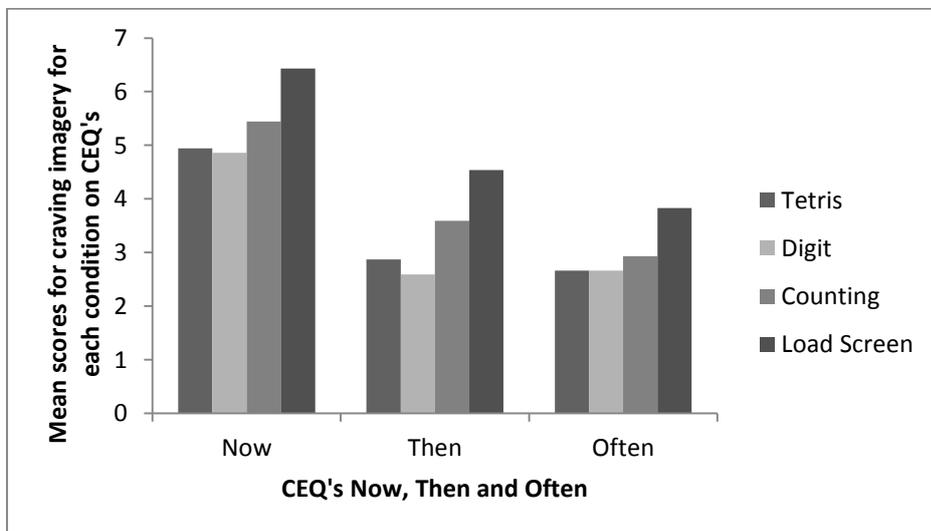
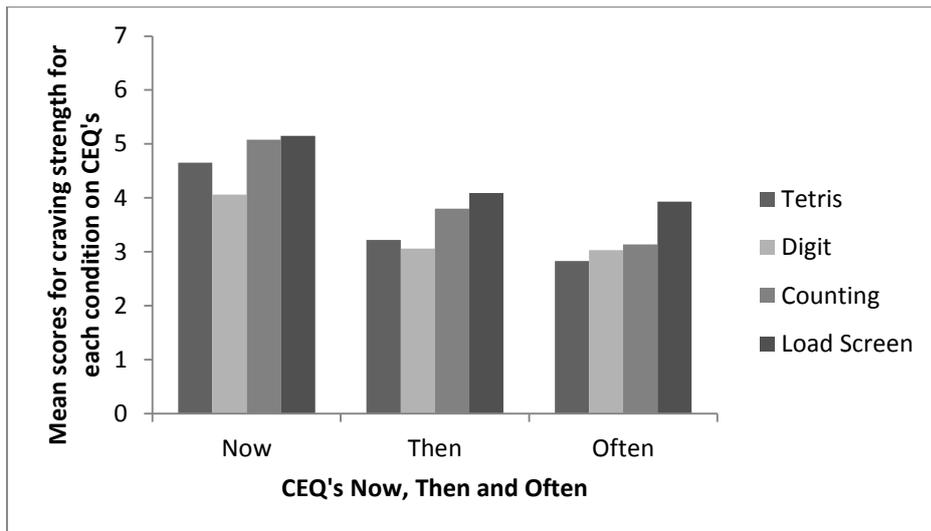


Figure 7: Three graphs depicting the means of craving strength, imagery and intrusiveness by condition

Finally the results from the CEQ were examined. The means for each condition can be seen in Figure 7. A 2(time)x 2(load) x 2(task) ANOVA was completed for the CEQ-Now and CEQ-Then . Craving strength ($F(1, 91) = 29.539, p < 0.001, \eta_p^2 = 0.245$) and imagery ($F(1, 91) = 68.220, p < 0.001, \eta_p^2 = 0.428$) decreased over time. There was a main effect of task load on craving strength ($F(1, 91) = 6.266, p = 0.014, \eta_p^2 = 0.064$), imagery ($F(1, 91) = 9.926, p = 0.002, \eta_p^2 = 0.098$) and intrusiveness ($F(1, 91) = 4.842, p = 0.030, \eta_p^2 = 0.051$) during the experiment but none of the other interactions or main effects on craving strength, imagery or intrusiveness were significant (smallest $p = 0.064$). A one way between subjects ANOVA was completed to assess differences between groups from the CEQ-Often data. Task load decreased the frequency of craving strength ($F(1, 91) = 4.264, p = .042, \eta_p^2 = 0.045$) craving imagery ($F(1, 91) = 4.984, p = .028, \eta_p^2 = 0.052$) and craving intrusiveness ($F(1, 91) = 4.824, p = 0.031, \eta_p^2 = 0.050$), but there were no effects of task nor any interactions.

3.4. Discussion.

This experiment examined the effect of different tasks on induced craving levels in a laboratory setting. The results showed that participants experiencing a mid to high strength craving, and who completed memory tasks or counting in their head, reported lower craving in comparison to those who watched the load screen.

As both visual and verbal tasks high load tasks had an equal effect on craving, the results do not support Elaborated Intrusion Theory (Kavangh, Andrade & May, 2005) which posits that imagery is central to craving and therefore development, maintenance and elaboration occur primarily in visuo-spatial working memory. Although Tiffany (1990) posits that all areas of memory will be equally involved in craving suppression, as craving occurs when an action schema cannot be completed. It is unlikely Tiffany (1990) would be able to explain the finding that even a very low load task can affect craving strength as although Tiffany (1990) posits all areas of working memory would be involved in the suppression of craving; a low memory load task would not engage cognitive resources fully and therefore should be unable to suppress a craving experience.

The results from the CEQ Now and Then show that craving strength and imagery both decreased over time, however there was no difference in their change over time compared to the load screen condition. Intrusiveness however remained unaffected over time. These results show that detailed measures of craving were no different in the experimental conditions compared to the control. This is problematic when interpreting the results as it would be expected that the CEQ data would show support for the single measure of craving strength and provide more detail of the craving experience.

However, the single measure of craving may provide a more accurate measure as a single momentary assessment as it does not require the participants to think in detail about their craving experience which could in turn increase the individuals craving strength. Therefore, this thesis will continue to use both the single measure of craving and the CEQs to ensure as much information about the craving experience can be gathered whilst ensuring that a quick measure which does not give participants the opportunity to concentrate on their craving (and thus possibly increase its piquancy) is still present.

The results from this experiment show a very clear effect of completing a task on craving strength, consistent with the general idea put forward by both Tiffany (1990) and EI Theory (Kavanagh, Andrade & May, 2005) that craving is a cognitive phenomenon. However, the relative impact of the task load rather than task modality is less clear, as the intended low-load verbal task reduced craving as much as the putative high-load tasks, and more so than the low-load visual task. Apart from digit memory, the working memory loads imposed by the tasks have not been assessed in previous research. Counting up in one's in your head appears to be a relatively simple task, however, anecdotal evidence from participants suggested that sustaining concentration for three minutes was quite difficult. It is therefore unclear whether verbal tasks interfere particularly well with craving, because even the low-load counting task had an impact, or whether load is the critical variable and any moderately taxing task – including counting in your head – will reduce craving, regardless of modality. This is an important issue, because previous studies have either compared a visual task against no task (e.g. Hamilton et al, 2013; Holmes, James, Coode-Bate & Deeproose, 2009; Kemps & Tiggemann, 2013; Skorka-Brown, Andrade & May, 2014) or they have compared a visual and an auditory task where the general loads imposed by each are

unknown (e.g Caselli & Soliani, 2013; Kemps & Tiggemann, 2007; Kemps & Tiggemann, 2009; Knäuper et al., 2011; .May, Andrade, Panabokke & Kavanagh, 2010, Versland & Rosenberg, 2007). In some cases the task demands seem well matched (for example, May et al. (2010) compared visual and auditory imagery), but this is not always the case (such as comparing plasticine modelling with a counting task (Andrade et al, 2012)) and in some the auditory task is clearly demanding (such as the serial sevens task used by Versland and Rosenberg, 2007), making it difficult to draw general conclusions. Task load and modality are thus confounded in the literature and further work is needed to tease them apart and clarify the results of the current experiment.

In conclusion, although the results show clear evidence completing a task requiring, even low working memory load, decreased craving in comparison to a minimal load task, it is not possible to differentiate the impact of the tasks on craving, due to the novelty of the tasks themselves. Further work is needed, using more robustly tested tasks to confirm or disprove the findings from this experiment.

Chapter 4: Experiments 4 and 5, An investigation into the differentiation of task modality and task load.

Experiments four and five were designed to address differences in cognitive load and the effect on craving. Experiment five was a continuation of experiment four with the task loads being more closely matched and examined the longevity of the effect.

4.1. Experiment 4:

This experiment focussed on the effect of varying the load of verbal and visual cognitive tasks on craving strength, to try and separate the influence of modality and task load. Experiments 1, 2 and 3 tried to use verbal and visual tasks which were matched in working memory load. However the tasks used were relatively novel to the literature (with the exception of digit memory task) and difficulty between tasks was not consistent within the experiments. It is possible that that task difficulty is more important than whether the task is visual or verbal, so this was explored in this fourth experiment

In the previous experiments, 7-digit lists were used to load verbal working memory (Andrade & Donaldson, 2007; Schendel & Palmer, 2007). To allow for an examination of verbal task difficulty and its effect on craving in this experiment, 4-digit lists were also used as shorter digit lists have a lower working memory load.

Experiments 2 and 3 used Tetris to interfere with the visual aspects of craving. However as the task was novel, has an undefined scoring method and it is a common game which some participants have had greater exposure to than others, it is problematic to assess the details of the interaction with craving. Therefore, for this experiment we looked for an established task in which manipulation of task difficulty was possible.

The Visual Patterns Task (VPT) has been found to be a reliable measure of visual working memory (Della Sala, Gray, Baddeley, Allamano and Wilson, 1999). Logie, Zucco and Baddeley (1990) found similar tasks (to VPT) could be interfered with when a competing visual task was completed but not a competing verbal task, supporting the idea that the VPT imposes a selective visual load. Variants of the task have been used effectively in a variety of experiments, such as asking participants to recall shapes presented in a grid (Thomas, Bonura, Taylor & Brunye, 2012). Participants in the

current experiment were consequently presented with either easier or more difficult VPTs to allow for assessment of visual task difficulty on craving.

Kemps, Tiggeman and Grigg's (2008) method of inducing chocolate craving in participants was used in the previous experiments. The adaptation used in Experiment 3 was again used in this experiment, with craving strength being measured immediately after participants had completed their assigned task.

The adapted 'CEQ Now' and the 'CEQ Then' (Andrade, Pears, May and Kavanagh, 2012) from Experiment 3, were again used in the experiment to gather more information about the participants' experience of craving.

4.2. Method:

4.2.1. Participants:

A total of 122 undergraduates (14 males) aged between 18 and 52 ($m=20.5$ years, $S.D.=4.7$), were recruited using the Plymouth University Undergraduate Participation Pool. They were recruited on the basis that they had no food allergies to anything that may be in chocolate. Participants were randomly assigned to visual or verbal conditions, and to high or low load within each condition.

4.2.2. Materials:

4.2.2.1 Visual Tasks:

A Samsung 10.1 inch Netbook was used to display the Visual Patterns Test (VPT) using a timed Microsoft PowerPoint slide show. The VPT matrices were either low or high working memory load. The low working memory load version used grids of 9 squares (3x3) with 4 squares blacked out. The high working memory load version used grids of 22 squares (5x5 with 2 additional squares on top) with 11 squares blacked out, these can be seen in Figure 8.



Figure 8: Depictions of the visual patterns matrices for high and low memory load tasks

Participants were shown a fixation cross for 1 second, and then presented with a low or high working memory load VPT (dependent on the condition to which they had been assigned) for 3 seconds. The screen then went blank for 10 seconds and then a message appeared, prompting participants to recall the visual pattern that they had seen and to complete the blank grid by filling in the corresponding squares.

4.2.2.2. Verbal Task:

The digit lists were presented on an Olympus DM-20 Digital Recorder. The lists were either high (7 item lists) or low (4 item lists) working memory load. For both, digits were presented at a rate of 1 item a second. There was then a delay of 10 seconds and participants were prompted to recall the digits in the correct order. The digit lists used numbers 1 to 9 (with the exception of 7), without repetition of digits within the lists or repetition of patterns between lists.

4.2.2.3. Craving Experience Questionnaire:

As in Experiment 3, the same two previous versions of the Craving Experience Questionnaire (CEQ) were used, (Andrade et al. 2012; May, Andrade, Kavanagh et al, 2014) to provide detailed information on craving.

4.2.2.4. Design and Procedure:

A 2 (visual or verbal) x2 (high working memory load or low working memory load) between subjects design was used. Participants firstly answered some basic demographic questions. They then completed a chocolate craving induction (based on Kemps, Tiggeman and Grigg, 2008). Participants choose a chocolate out of a selection of 8 pairs (of Quality Street Chocolate); describing it and rating on a scale of 1 (not at all) to 100 (very much) how much they wanted the chocolate. Participants then completed the CEQ-Snow which asked questions about the strength of their current craving experience. Participants then completed their assigned memory task (to which they were randomly assigned).

Participants in the visual memory task completed 7 trials in both the high and low load conditions. Participants in the digit memory task completed 7 trials in the high working memory load condition but 10 trials in the low working memory load condition, to ensure that the tasks were matched in duration. Participants completing the VPT had

their answer booklet face down and only turned it over when asked to recall the visual pattern.

After participants had completed their assigned task they were asked to rate their current craving on a scale of 1(not at all) to 100(very much). They then completed the CEQ-Sthen and CEQ-F to assess the strength and frequency of craving during the experiment.

4.3. Results:

Five participants' data was removed from analysis due to repeatedly following instructions incorrectly during the experiment, leaving 117 for analysis.

Table 4

Means and standard deviations of task scores in each condition

Task	Load	Mean (%)	Standard Deviation (%)
Visual	High	84.73	9.00
	Low	97.81	6.84
Verbal	High	58.26	15.81
	Low	97.5	3.12

The results of the digit lists and the matrix tasks were converted into percentage correct so a comparison could be made between tasks, as can be seen in Table 4. From Table 4 it can be seen that the low memory load tasks are well matched, however the high memory load tasks are not, with considerably higher performance on the high load visual task than the high load digit task and consequently a smaller difference between high and low load for the visual patterns task. A 2x2 ANOVA was found that the disparity was significant; as expected there was a significant difference between the scores of easy and difficult tasks ($F(1,119) = 215.193, p < 0.001, \eta_p^2 = 0.644$). There was also a significant effect of whether the task was visual or verbal on task performance ($F(1,119) = 56.39, p < 0.001, \eta_p^2 = 0.322$). Finally, there was a significant interaction between memory load and if the task was visual or verbal ($F(1,119) = 53.774, p < 0.001, \eta_p^2 = 0.311$). From Table 4 and the results of the ANOVA it can be

seen that the difference is from the high load digit task scores compared to the high load visual task scores.

The effect of task on craving was examined using a 2 (Task: Visual or Verbal) x 2 (Load: high or low) x 2 (Time: Before or After task) ANOVA, where Task and Load varied between subjects and Time varied within subjects.

Craving was found to decrease over time $F(1, 113) = 50.2, p < .001, \eta_p^2 = .308$, and an interaction between time and load was also significant $F(1, 113) = 8.7, p = 0.004, \eta_p^2 = 0.072$, with greatest decreases being seen in the high load conditions (see Figure 9). There was a three way interaction between time, task and load that almost reached statistical significance, $F(1, 113) = 3.9, p = 0.050, \eta_p^2 = 0.034$, with the greatest decrease in craving (-24.8) being in the high verbal load condition, and the lowest decrease (-6.9) in the low verbal load condition, with the high visual (-14.9) and low visual conditions (-12.1) being intermediate. No interaction was found between time and task ($F < 1$).

The analysis was repeated with three participants craving less than or equal to 20 on the 1-100 scale removed from the analysis, ($F(1, 110) = 8.939, p = 0.003, \eta_p^2 = 0.075$) and the same pattern of results was found.

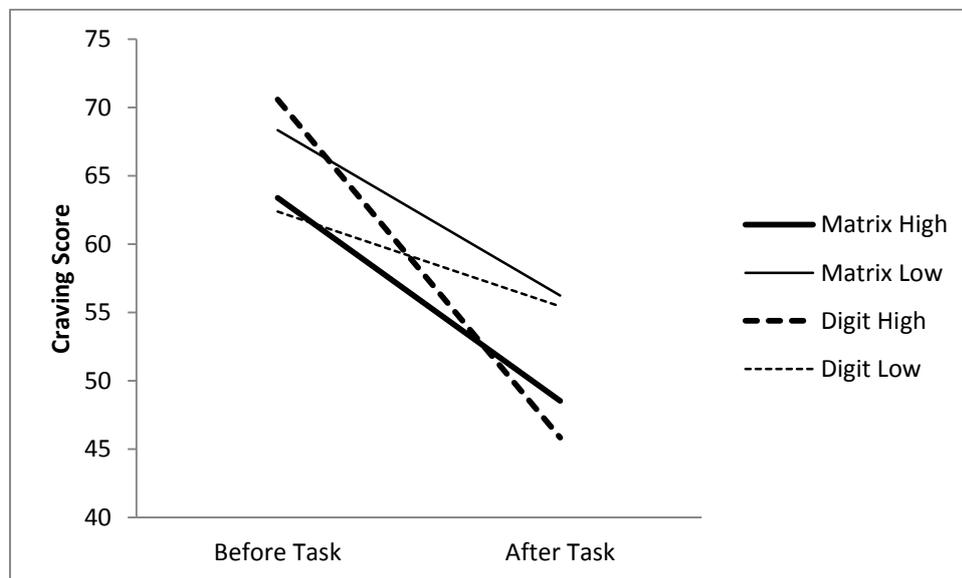


Figure 9: Change in craving over time by condition, using the single item measure of craving

Follow-up tests were completed to examine the interactions. Paired t-tests showed that craving decreased in the high verbal load condition ($t=5.674$, $df=28$, $p<0.001$, one-tailed), the high visual load task ($t=3.466$, $df=27$, $p=0.001$, one-tailed), and the low visual load task ($t=3.449$, $df=29$, $p=0.001$, one-tailed), but not in the low verbal load task ($t=1.288$, $df=25$, $p=0.105$, one-tailed).

Participants' craving ratings before and after the tasks were correlated in the low visual load task ($r=0.586$, $N=30$, $p<0.001$, one-tailed), the low verbal load task ($r=0.597$, $N=26$, $p<0.001$, one-tailed) and the high verbal load task ($r=0.457$, $N=29$, $p=0.0065$, one-tailed) but not for the high visual load task ($r=0.282$, $N=28$, $p=0.073$, one-tailed). The difference between participants before and after craving scores were not correlated with their task score for any condition (smallest $p=0.241$).

Finally the results from the CEQ were examined. The means for each condition can be seen in Figure 10. A 2(time)x 2(load) x 2(task) ANOVA was completed for the CEQ-S(now and then). Craving strength reduced during the experimental task ($F(1, 110) = 49.424$, $p < .001$, $\eta_p^2 = 0.310$) as did imagery strength ($F(1, 110) = 86.773$, $p < .001$, $\eta_p^2 = 0.441$) but there were no effects of load or task nor any interactions, and there were no effects upon intrusiveness (all $F < 1$).

A one way between subjects ANOVA was completed to assess differences between groups from the CEQ-F data. Increasing the task difficulty reduced the frequency of strong cravings ($F(1, 110) = 5.367$, $p = .022$, $\eta_p^2 = 0.632$) and craving imagery ($F(1, 110) = 5.109$, $p = .026$, $\eta_p^2 = 0.610$), but there were no effects of task nor an interaction. There were no effects of task or load upon frequency of intrusions.

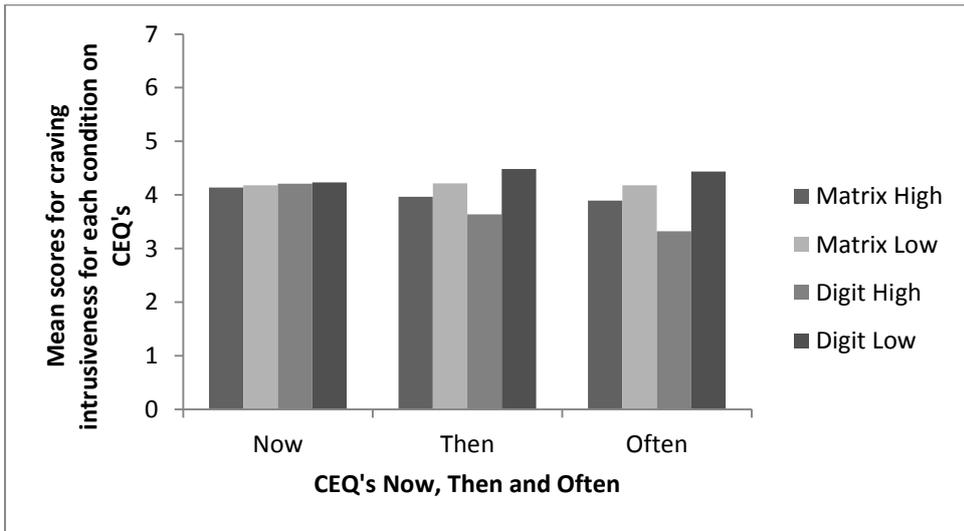
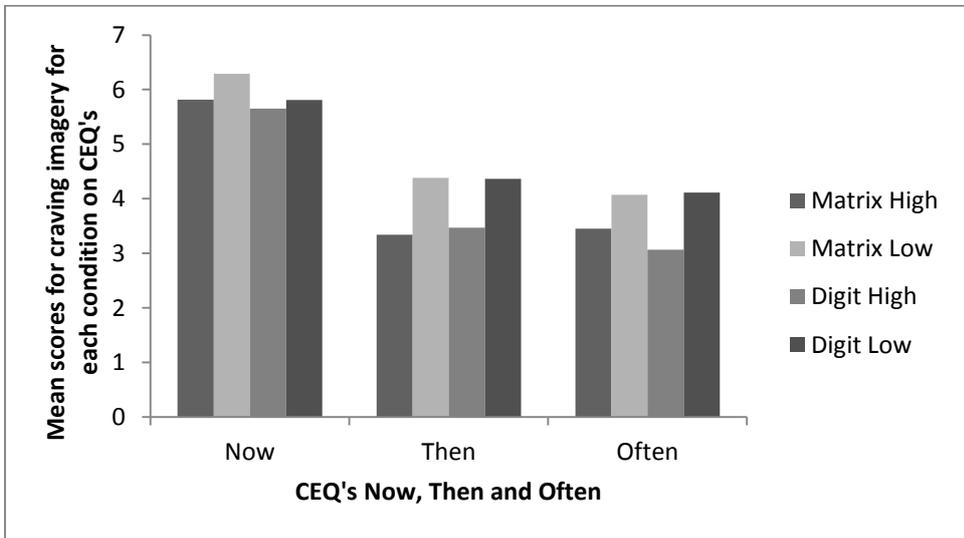
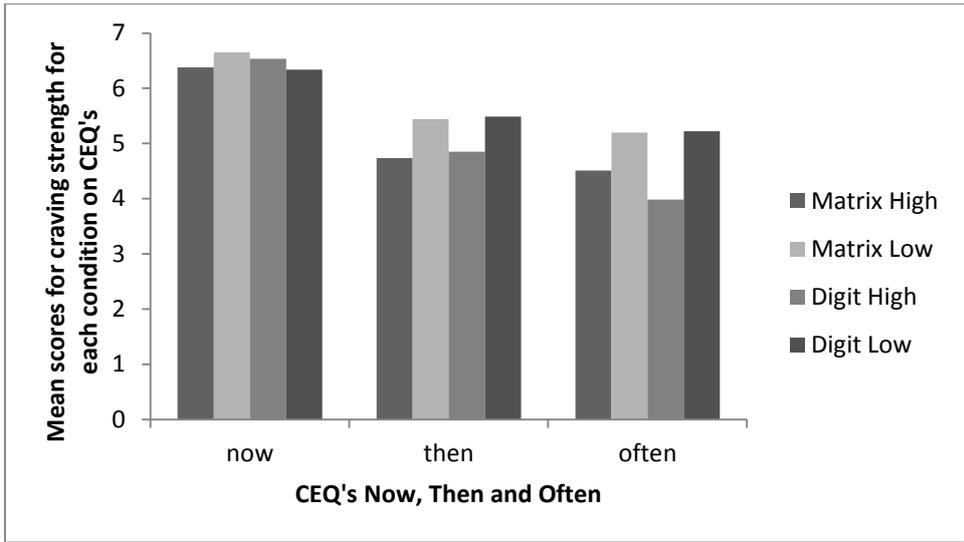


Figure 10: Three graphs depicting the means of the CEQ data of strength, imagery and intrusiveness by all conditions

4.4. Discussion

This experiment assessed the effect of visual and verbal tasks and high and low working memory loads on induced cravings in a laboratory setting, and suggested that even at low working memory load a visual task decreases craving over time, whereas a low working memory load verbal task does not. Unfortunately, task performance scores suggested the high load verbal task was rather more difficult than the high load visual task, therefore it is possible, that if the verbal high load task difficulty was as ‘easy’ as the visual high load task, it may have a smaller effect on craving strength than the visual task, but this is purely speculative.

Craving scores after performing the high load digit task and the low load visual task, were correlated with cravings scores before the task, whereas this correlation was non-significant for the high load visual task. This could be an indication that the high load visual task more substantially disrupted or altered the cognitive processes supporting craving, although the mean craving scores were not consistent with this interpretation.

The findings from the CEQ showed a decrease in strength and imagery over time, however no effect on intrusiveness was found. There was no differential effect of different tasks on strength, imagery or intrusiveness. Task difficulty, was however found to affect craving strength and imagery. This finding is in line with the findings from experiment 3, which also found there was no effect of task on intrusiveness of craving related thoughts, but there was an effect on strength and imagery. Both Elaborated Intrusion Theory (Kavanagh, Andrade and May, 2005) and Tiffany (1990) suggest intrusive thoughts are automatic and have unconscious triggers, it is therefore unsurprising that completing a short task does not affect their recurrence as intrusive thoughts appear to be spontaneous, often without a conscious trigger. EI posits that intrusions can also be triggered by elaborated images, therefore prolonged interference should result in a decrease in intrusions, both the current experiment and experiment 3 were short interventions and so the impact on intrusions may have been limited. The results from the strength and imagery sections of the craving experience questionnaires provide further weight to the findings of the one-off craving strength measure, as they also show an effect of task difficulty.

When interpreted in terms of Baddeley’s working memory model (2007) the results show some support for EI Theory’s contention that visual imagery is more important in

craving than verbal imagery. If a high load memory task is completed, other aspects of cognition would also experience interference; a high load verbal task can also affect visual imagery through its demands upon the central executive. At low memory load, neither task loads the central executive and so only the visual task interrupts craving. Further work should aim to match the task difficulty level for the high memory load tasks to ensure that the results found are not due to this difference. These findings are important as they show tentative support for EI theory (Kavanagh, Andrade & May, 2005) and also highlight the differences between the impact of high and low load memory tasks on craving and the importance of visual memory in craving experiences.

4.5. Experiment 5: Introduction

In Experiment 4 we found an effect of completing difficult verbal tasks on craving, which was explained as being due to the high task load affecting other cognitive components, rather than the verbal tasks affecting craving directly. With low loads, the verbal task did not affect craving, but the visual task did. This experiment builds on the low load finding from Experiment 4 to investigate the robustness and longevity of the effect. The longevity of the effect was examined to assess if the effects found in experiment four were transient or were present for a longer period of time and if craving continued to decrease to the point where the participant was not any longer craving.

Digit lists were again used with lengths of 3, 4 or 5 digits as pilot work showed a 97% level of accuracy in recall. For the Visual Patterns Tasks, participants were shown a 3x3 grid with either 3, 4 or 5 squares blacked out. Pilot work showed a 99% level of accurate recall with this configuration. At these levels of accuracy, the tasks should not demand resources beyond the verbal and visual slave systems, respectively.

As a control task participants were asked to listen to mind wandering instructions which directed them to follow their thoughts wherever they were going using a variety of different phrases. The track used was based on the protocol applied by May, Andrade, Batey, Berry and Kavanagh (2010). This protocol was used, rather than the previous load screen control due to the length of the experiment. Participants were required to complete more than one trial of their assigned task – if the computer repeatedly

appeared not to load, participants may have become aware that it was designed not to load. Therefore by using a mind wandering control, minimal task load was present.

All participants underwent a chocolate craving induction based on the protocol used by Kemps, Tiggeman and Grigg (2008) to try and ensure craving levels were high. Instead of re-inducing craving throughout the experiment, craving was only induced at the beginning and then participants were asked to rate their craving level throughout the experiment to see the effect of task completion over time. The participants completed their assigned task in blocks, reporting craving between each block.

Participants were also asked to complete the CEQ-S twice, after initially rating their craving and after their final craving rating, and the CEQ-F once, after their final craving rating.

4.6. Methodology:

4.6.1. Participants:

A total of 91 participants (27 males) aged between 18 and 66 ($m=28.7$ years, $S.D.=12.2$), were recruited using Plymouth University Paid Participation Pool. They were recruited on the basis that they had no food allergies to anything that may be in chocolate.

4.6.2. Materials:

4.6.2.1. Craving Experience Questionnaire:

As in Experiment 4, two versions of the Craving Experience Questionnaire (CEQ) were used, (Andrade, Pears, May and Kavanagh, 2012; May, Andrade, Kavanagh et al, 2013). The questionnaires used were identical in nature to Experiment 4.

4.6.2.2. Visual Patterns Task:

A Samsung 10.1 inch Netbook was used to display the Visual Patterns Test (VPT) using a timed Microsoft PowerPoint slide show. The VPT used grids of 9 squares with 3, 4 or 5 squares blacked out. Participants were shown a fixation cross for 1 second and then a VPT was presented for 3 seconds. The screen then went blank for 10 seconds and then a message appeared, prompting participants to recall the visual pattern that they had seen and to complete the blank paper based grid by filling in the corresponding squares.

4.6.2.3. Digit List:

The digit lists were presented on an Olympus DM-20 Digital Recorder. The lists were 3, 4 or 5 item lists chosen without repetition from the digits 1 to 9, excluding 7. Digits were presented at a rate of 1 item a second. There was then a delay of 10 seconds and participants were prompted to recall the digits in the correct order. The list order was randomised.

4.6.2.4. Mind Wandering:

The mind wandering track instructed participants to follow their thoughts for three minutes using different, brief phrases, such as ‘Let any thought come into your head’ and ‘Thinking about anything your mind wants to.’ every 20 seconds. The mind wandering task track was played via Windows Media Player over a speaker, with the volume adjusted if the participants requested it.

4.6.3. Design and Procedure:

A between participant design was used, with participants allocated to visual, verbal or mind wander control groups. Participants firstly answered some basic demographic questions. They then completed a chocolate craving induction (based on Kemps, Tiggeman & Grigg, 2008). This involved participants choosing a chocolate out of a selection of 8 pairs (of Quality Street Chocolate); describing it and rating on a scale of 1(not at all) to 100(very much) how much they wanted the chocolate. Participants then completed the CEQ-Snow which asked questions about their current craving experience. Participants then completed their assigned memory task.

Participants were asked to sit and listen to the mind wandering track and follow the instructions, and were told it was not necessary to make an outward response to the instructions. Participants in the visual memory task were presented with a total of 28 VPT. Participants in the digit memory task were presented with a total of 40 digit lists to match the visual, verbal and mind wandering tasks on timings. The VPT were presented in blocks of 7, the digit lists were presented in blocks of 10 and the mind wandering track was played for 3 minutes at a time, to equate the duration of each block across conditions.

Between each trial block participants were asked to rate their craving on a scale of 1 (not at all) to 100 (very much). Participants completing the VPT had their answer booklet face down and only turned it over when asked to recall the visual pattern. After participants had completed their assigned task they were asked to rate their current craving on a scale of 1(not at all) to 100(very much). They then completed the CEQ-Sthen and the CEQ-F to assess their craving strength and frequency during the experiment.

4.7. Results:

All participants were included in the analysis. The results of the digit lists and the matrix task were converted into percentage correct so a comparison could be made between tasks. The memory tasks did not differ in accuracy (visual task: $M=94.2\%$, $SD=2.7\%$; verbal task: $M=97.6\%$, $SD=3.8\%$; $t(53)=-0.831$, $p=0.2045$).

The effect of task on craving was examined using a 5 (time) x 3(task) repeated measures ANOVA. Mauchly's test of Sphericity was violated, therefore the following results are interpreted with caution using Greenhouse-Geisser. Craving was found to reduce significantly over time ($F(2.029, 164.365) = 48.859$, $p < .001$, $\eta_p^2 = 0.376$). No interaction between time and condition was found ($F(4.058, 164.365) = 48.859$, $p = 0.713$, $\eta_p^2 = 0.013$). This can be seen in Figure 11.

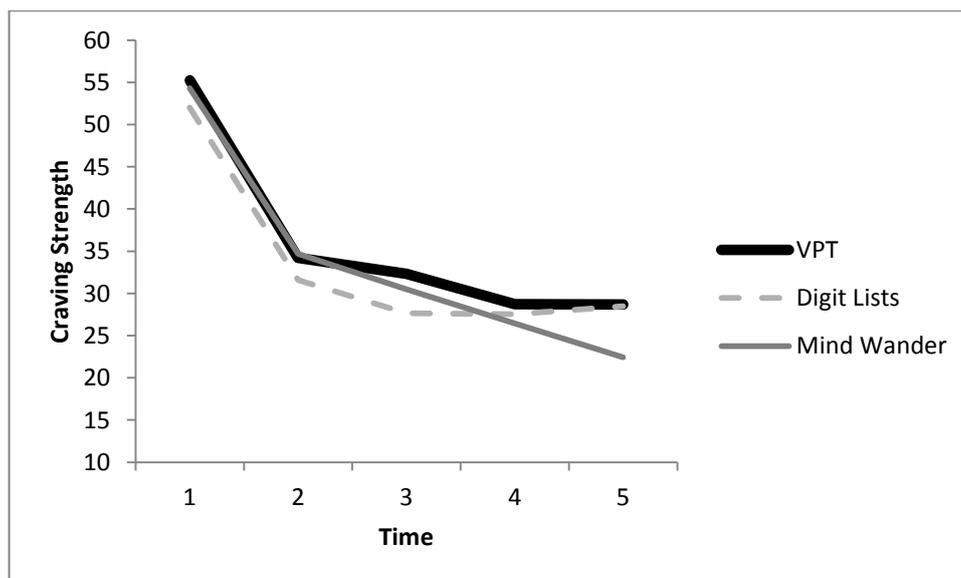
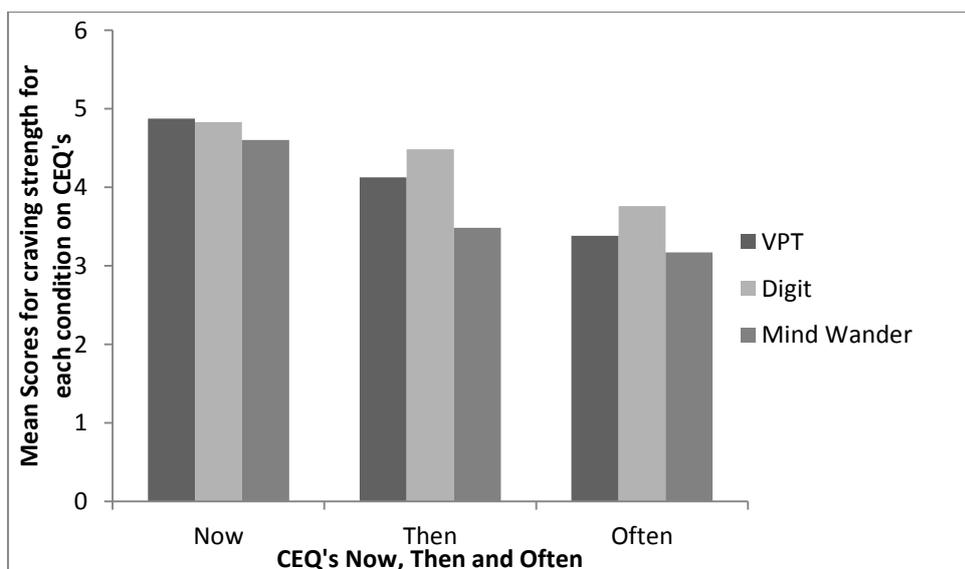


Figure 11: Change in craving over time by condition

The effect of task on craving was examined again using a 5(time) x 3(task) repeated measures ANOVA, however participants with an initial craving rating of less than or equal to 20 were removed. Mauchly's test of Sphericity was again, violated; therefore the following results are interpreted with caution using Greenhouse-Geisser. Again craving reduced over time ($F(2.303, 163.495) = 53.436, p < .001, \eta_p^2 = 0.429$) and there was no interaction between time and condition ($F(4.605, 163.495) = 0.476, p = 0.779, \eta_p^2 = 0.013$).

Finally the results from the 'CEQ Now' and 'CEQ Then' were examined, the means can be seen in the graphs in Figure 12. A 2(time) x 3(conditions) repeated measures ANOVA was used to analyse the data from the CEQ-Snow and the CEQ-Sthen, with the data from the CEQ-F being analysed for between condition differences using a one way between subjects ANOVA.

Craving strength ($F(1, 88) = 10.159, p = 0.002, \eta_p^2 = 0.883$) and imagery ($F(1, 88) = 46.553, p < .001, \eta_p^2 = 1.000$) decreased over time but there was no effect on intrusiveness ($F(1, 88) = 1.214, p = 0.274, \eta_p^2 = 0.193$). None of the interactions between time and condition were significant for strength, imagery or intrusiveness ($p > .198$). The results of the one way ANOVA for the CEQ-F data showed no significant difference between conditions for craving strength, imagery or intrusiveness ($p > .468$).



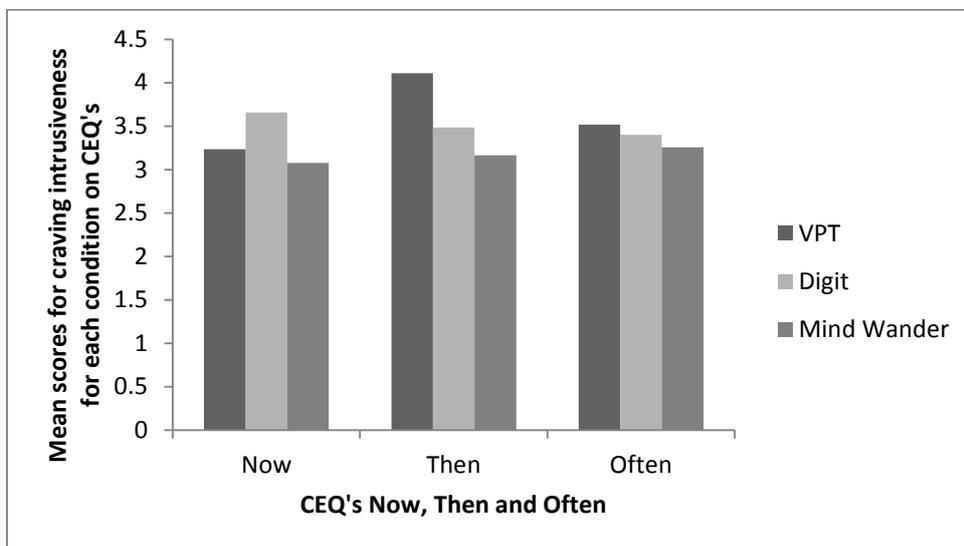
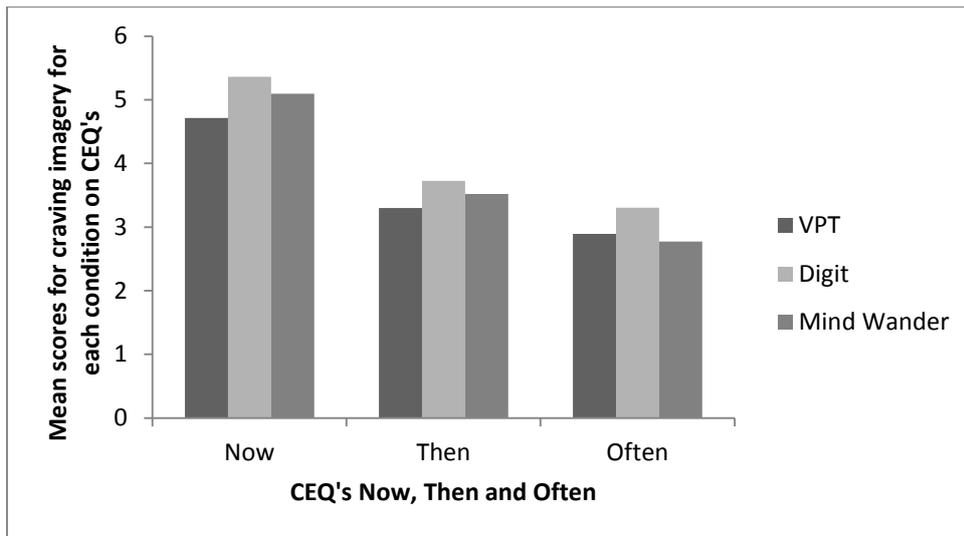


Figure 12: Three graphs showing the mean scores of each condition on the CEQ questionnaires

4.8. Discussion

This experiment assessed the longevity of the impact of doing an easy visual task compared to a verbal task on craving strength. Experiment 4 found that completing an easy visual patterns task decreased craving, however completing an easy digit memory task did not. This experiment aimed to expand on that finding and to test its reliability.

The results from this experiment found that neither easy visual patterns tasks nor easy digit memory tasks had a greater impact over time than the control condition, even when people with initially low craving were removed. As this finding does not support the results of Experiment 4 it is not possible to tell which the anomalous result is.

In experiments 3 and 4, participants only completed their assigned task once, rather than repeatedly. This experiment induced craving once but asked for several craving ratings. The results showed that participants initial craving dropped in all conditions but then their craving did not change much after the initial drop, but maintained a low level craving. This result suggests that although craving can be reduced it cannot be eliminated completely by undertaking a working memory task. However, being able to reduce a craving to a manageable level in a short period of time, rather than having to do something repeatedly is an important finding as it suggests the application of brief interference tasks may be possible and effective in real world situations.

The findings of this experiment, suggesting that craving in all conditions decreases equally, is anomalous when comparing the results to experiments 3, 4 and 6 which all found their control conditions did not decrease significantly in relation to the experimental conditions. Therefore it is possible that the results from this experiment have been confounded by an unknown variable.

Another possibility is that completing a simple task like listening to the mind wandering track may be enough to interfere with craving. However, this task has been used in previous craving experiments and has been found to not affect craving (May, Andrade, Batey, Berry and Kavanagh, 2010, Andrade et al, 2012). This would again suggest that there is an unknown variable affecting the findings of this experiment. Also, the digit memory task and the visual patterns tasks affected cravings equally, whereas in experiment 4 only the visual patterns task had an effect on craving. The current experiment has found that two tasks previously ineffective at reducing cravings were effective. This again, suggests an unknown confounding variable and therefore any results from this experiment need to be interpreted with great caution.

In conclusion, this experiment does not clarify the differences found in Experiment 4 but further complicates the findings. The results from Experiment 4 could have been influenced by small factors which may have become confounding variables in the current experiment. This suggests that the results from this experiment and Experiment 4, were not robust. However, as only two experiments have been completed which show opposing findings it is not clear which the anomalous finding is. Further research needs to be completed using similar methodology to allow full interpretation of the findings.

An abundance of previous research, however, has found clear effects of visual task completion over verbal task completion. May, Andrade, Pannaboke and Kavanagh (2010) found that over several experiments visual tasks decreased craving more than auditory tasks. Knäuper, Pillay, Lacaille, McCollum and Kelso (2011) found that when participants were asked to make alternative positive imagery when experiencing a craving, craving intensity and vividness were significantly reduced compared to the control conditions which included a cognitive verbal task (reciting the alphabet backwards) which is a cognitively demanding task. Andrade, Pears, May and Kavanagh (2012) found that completing a visual task over a verbal task, again had a significant effect on craving. Andrade et al. (2012) used simpler tasks (counting in ones and manipulation of clay) rather than high load tasks. Kemps et al (2005) asked participants to retain chocolate-based images whilst completing a concurrent task (either watching dynamic visual noise or listening to irrelevant speech). They then rated their craving strength and vividness of the retained image. Kemps, et al. (2005) found that participants who watched the dynamic visual noise reported lower craving strength and decreased vividness after, compared to the irrelevant speech and the no task control. These tasks were well-matched, low load tasks as little interaction was needed with the task and support the hypothesis that a low load visual task is effective at decreasing cravings. Kemps and Tiggemann (2007) also used well matched visual and auditory conditions, asking participants to either imagine a visual or auditory scenario, again they found that visual imagery decreased craving strength more effectively than the auditory condition (although their tasks presented a greater memory load than Kemps, Tiggemann and Hart, 2005). Again, Kemps and Tiggemann (2009) found that a competing visual image was more effective at decreasing craving strength (for coffee) than a competing auditory image. As many experiments have shown that when using well matched visual and verbal tasks, the visual task is more effective at decreasing craving than the verbal, this may suggest it is the results of Experiment 5 that are anomalous rather than the results from Experiment 4. If Experiment 5 is the anomalous result, it would imply that visual tasks with low memory loads are able to decrease craving, whereas low load verbal tasks are ineffective. Therefore, it is possible to tentatively suggest that Elaborated Intrusion Theory (Kavanagh, Andrade and May, 2005) is more effectively able to explain this difference.

The aim of this thesis was to gather more detailed information about cognitive processes in craving with the long term aim of developing an effective take-home task for interfering with craving. By teasing apart the cognitive processes underpinning craving experiences it was hoped to provide evidence in support of either Tiffany (1990) or EI Theory (Kavanagh, Andrade & May, 2005). The data from this thesis is not consistent throughout but provides scant support for the proposal of EI theory (Kavanagh, Andrade & May, 2005) that visual tasks would be more effective at decreasing craving strength than verbal. However, the findings do not show overwhelming support for Tiffany (1990) either. The results are problematic as other experiments (Andrade, Pears, May & Kavanagh, 2012; Kemps & Tiggemann, 2009; Kemps, Tiggemann & Hart, 2005) have been more consistent in showing an effect of visual task interfering with craving strength compared to other tasks. As discussed within each experiment, there are several factors which may have affected the findings, (such as poorly matched task difficulty in Experiment 4) and the results do not appear to be reliable. As many other experiments have found that visual tasks are consistent in interfering with craving (and other visual imagery tasks), whereas verbal are not, it was decided that the greater strength of the published work outweighed the possible confounding variables within this thesis' experiments. From a theoretical view, both EI theory (Kavanagh, Andrade & May, 2005) and Tiffany (1990) would posit that a visually based task would be effective. Therefore, to ensure continued development towards the final goal of this thesis to develop a take-home technique, the next stage was to examine the ability of a task to interfere with naturally occurring cravings, and not just induced cravings. This was also to ensure that interference found within the laboratory setting (using induced cravings) was not due to the fragility of the induced craving, but rather the nature of the craving itself. The task needed to be both effective, loading strongly on working memory and ideally involving visuospatial processing too and engaging to participants to ensure that they wanted to participate fully with the task. Visual patterns tasks were anecdotally reported by participants to be 'boring' and unengaging, whereas 'Tetris' was reported to be 'fun', thus 'Tetris' was used in Experiment 6 to interfere with naturally occurring cravings, rather than the visual patterns tasks.

Chapter 5

5.1. Experiment 6: Playing 'Tetris' reduces the strength, frequency and vividness of naturally occurring cravings²

As discussed in Experiment five, the focus of the current experiment was to the ability of a cognitive task to decrease naturally occurring cravings to aid in the development of a take-home task. Van Dillen and Andrade (2014) used the visuospatial task of playing the computer game Tetris to block craving for food. Holmes, James, Coode-Bate and Deeptose (2009) found similar reductions in intrusive imagery when Tetris was played after viewing the traumatic material. In Van Dillen and Andrade's study, Tetris reduced attentional biases to food pictures, reduced craving, and led to fewer participants choosing chocolate or marzipan as a reward rather than a piece of fruit. Experiments two and three of this thesis also found Tetris to be effective at decreasing craving, however not more so than the verbal memory tasks employed in the experiments. Tetris is assumed to load heavily on visuospatial working memory because it requires the player to rotate and move geometric shapes rapidly in order to complete rows of shapes without leaving gaps. It is easy to access over the internet, giving it the potential to be used as a take-home task to help people manage craving or traumatic imagery. Anecdotal evidence from participants suggested that they preferred to play 'Tetris' (Experiments 2 and 3) than complete visual patterns task (Experiments 4 and 5), therefore it was used in this current experiment to interfere with cravings.

The current experiment aimed to replicate van Dillen and Andrade's (2014) finding, with an important difference. Previous studies of craving in the laboratory, including those cited above, have induced cravings when participants have come into the laboratory. For example, Andrade, Pears et al. (2012) asked participants to inspect and evaluate chocolates; van Dillen and Andrade (2014) asked participants to select items from a menu. The reasoning behind craving inductions is that the novelty and cognitive demand of the laboratory setting may itself reduce cravings, even when participants have abstained from the substance prior to taking part in the study. There is a risk, though, that working memory loads are doing nothing more than removing an

² A version of the chapter was published; see Skorka-Brown, J., Andrade, J. & May, J. (2014). Playing 'Tetris' reduces the strength, frequency and vividness of naturally occurring cravings, *Appetite*, 76, 161-165

artificially induced desire. Therefore, the current experiment recruited an unselected sample and aimed to measure and manipulate any naturally occurring cravings that participants were experiencing.

Naturally occurring cravings might be more resistant to intervention because they are triggered by physiological deficit or conditioned cues. Therefore, the current experiment wanted to maximize the chance of finding an effect of visuospatial interference by comparing Tetris against a condition with minimal working memory demands, but at the same time it needed a control condition that would ensure that participants did not become distracted by anything else in their environment and would not be aware that they were in the control group. The control that was used in Experiment 3 and by van Dillen and Andrade (2014) fulfilled those criteria. Van Dillen and Andrade (2014) used a 'wait' condition, where participants were told that the computer was old and the programme might take a while to load. They looked at a blank screen while waiting. In this current study (as in Experiment 3), participants saw a fake load screen that appeared to be showing Tetris loading, but never actually loaded.

Van Dillen and Andrade (2014) used behavioural measures of craving, that is, response biases to tempting foods and food choices at the end of the experiment, and a four-item craving scale. The current experiment used the Craving Experience Questionnaire (CEQ; Andrade, Pears, May & Kavanagh, 2012; May et al., 2014) developed from the Alcohol Craving Experience questionnaire (Kavanagh, May & Andrade, 2009; Statham et al., 2012), to assess craving phenomenology in the control and intervention conditions. The CEQ provides a measure of craving strength, imagery, and intrusiveness. The current experiment also asked participants if they were under the influence of alcohol (including being hung-over) to check if this was a confounding variable, because Burton and Tiffany (1997) found that when people had consumed alcohol they had a general increase in craving compared to when they had not.

5.2. Method

5.2.1. Participants

A total of 121 (27 males) participants from Plymouth University Undergraduate Participation Pool were recruited, aged between 18 and 30 years ($m = 19.7$ years, $S.D. = 1.9$), in partial fulfilment of a course requirement to participate in research.

5.2.2. Design

The design was a between subjects quasi experiment. Participants were randomly assigned to one of two conditions (experimental or control) prior to taking part. They were then allocated to either a craving or not craving group depending on the craving level they reported on entering the lab.

5.2.3. Materials

A Samsung 10.1 inch Netbook was used to display the load screen. This 'program' was written in Microsoft PowerPoint and used a timed slideshow to show a 'load bar' slowly progressing, and then a message saying 'Load Error'.

Tetris was played on a 15 inch computer monitor with a standard keyboard. The computer game 'Tetris' was downloaded from www.80smusiclyrics.com/games/html

Participants rated their craving on a single-item scale of 1 (not craving at all) to 100 (craving something very much). More detailed information about craving phenomenology was collected using the Craving Experience Questionnaire (CEQ; Andrade, Pears et al., 2012; May et al., 2014), adapted to encompass any sort of craving rather than just craving for chocolate. The CEQ-Snow asked participants to rate the strength, imagery vividness, and intrusiveness of their current craving on an eleven point scale anchored 'Not at all' and 'Extremely'. A typical question for assessing craving strength was 'Right now, how strongly do you want it?', for imagery 'Right now, how vividly do you picture it?', and for intrusiveness 'Right now, how hard are you trying not to think about it?'. This questionnaire provided a snapshot of craving experience immediately before the experimental period began. The CEQ-Then assessed craving experience during the experimental period (load screen or Tetris). It had two sections, one asked retrospective questions, the CEQ-Sthen (which were similar to the CEQ-Snow) about the person's craving and the other used, again, similarly phrased

questions asking about frequency (CEQ-F) of different aspects of craving, in relation to the period since participants completed the CEQ-Snow during which they were playing Tetris or watching the load screen. For example, in the CEQ-Sthen, the imagery item became ‘During that time, how vividly were you picturing it?’. The CEQ-F used similarly phrased questions to ask participants to rate the *frequency* of their cravings, images, and intrusive thoughts during the period since doing the CEQ-Snow, on an eleven point scale anchored 'Not at all' to 'Constantly', for example, ‘During that time, how often did you picture it?’. The ‘Sthen’ and ‘F’ versions of the CEQ were used to assess changes in craving experience while participants were playing Tetris, rather than taking a snapshot of craving once the game ended, to avoid contamination by a re-kindling of craving once the interference ended. Andrade, Pears et al. (2012) and May et al. (2014) reported Cronbach’s alpha ratings over 0.90 for each scale.

5.2.4. Procedure:

Participants were tested between 9am and 4.45pm, to allow for variance in cravings across the day (Hill, Weaver & Blundell, 1991). Participants were also tested in pairs to control for time of day effects, with one person in each pair assigned randomly to each task.

After being briefed, participants completed a short questionnaire asking for their demographic information. They were then asked what, if anything, they were craving and completed the CEQ-Now in relation to their craved substance or activity.

Participants then either played ‘Tetris’ or waited for a screen to load, according to their random allocation. The ‘load screen’ program was designed so that ‘Tetris’ never loaded and ended with a ‘Load Error’ message. Both tasks took 3 minutes. To ensure that the participants did not realise that the ‘load screen’ was a control measure it was loaded on a Netbook and then passed to the participant with the ‘program’ having started. Participants in this control condition were told that the experimenter had written the program to run ‘Tetris’ with features that the ‘normal Tetris’ did not have.

Next, participants completed the CEQ-Then and CEQ-Often to assess their craving experience during the load screen or Tetris period. Finally, they were asked if they were aware of the condition to which they had been assigned. Note that participants who

reported not craving anything, still completed all parts of the experiment, answering N/A to craving questions.

5.3. Results:

A total of 121 participants were tested. Two people reported being aware of their assigned condition and their results were removed from the analysis. Of the 119 participants remaining, 80 reported craving something (58 food or drink, 10 caffeine, 12 nicotine) and 39 were not craving anything. Data from participants who reported no craving are not analyzed further. Hill, Weaver and Blundell (1991) found that cravings were typically higher in the afternoon compared to other times of day, but a chi-square analysis found no relationship between time of day and number of participants reporting craving: $\chi^2(1, N=119) = 0.280, p = .299$, therefore time of day is not analysed further.

Craving was measured by a single-item scale before and after participants had completed their assigned task (Table 5).

Table 5

Means (and Standard Deviations) of scores on the single-item craving measure before and after the load screen and Tetris conditions

Condition	N	Craving Before	Craving After	Difference	% change
Load	42	57.90 (21.37)	54.74 (25.04)	3.17 (20.57)	-5.5%
Tetris	38	58.82 (20.61)	44.84 (25.75)	13.97 (19.94)	-23.8%

The effect of task on craving was examined using a 2(time) x 2(task condition) repeated measures ANOVA. Craving reduced over time, $F(1,78) = 14.26, p < .001, \eta_p^2 = .16$. The main effect of condition was not significant, $F < 1$, but there was the predicted interaction between condition and time with greater reduction in craving for the Tetris condition than for the load screen condition, $F(1,78) = 5.67, p = .020, \eta_p^2 = .07$. The interaction remained significant after removing nine participants with weak craving defined as a score below 20 on the single-item craving scale ($N = 3$) and/or who reported being under the influence of alcohol ($N = 7$), $F(1,69) = 5.17, p = .026, \eta_p^2$

= .07, and when only participants' craving food or drink were considered, $F(1,56) = 12.17, p = .001, \eta_p^2 = .18$.

To obtain a more detailed picture of craving change, participants' responses on the CEQ-Snow, CEQ-Sthen and CEQ-F were averaged across factors, to give scores for craving strength, imagery, and intrusiveness (see Andrade, Pears et al., 2012; May et al., 2014). These data (Table 6) were subjected to 2(time) x 2(task condition) repeated measures ANOVAs.

Table 6

Mean craving strength, imagery and intrusiveness reported in the CEQ-Snow, CEQ-Sthen, and CEQ-F. (\pm S.D.)

Craving factor	Condition	CEQ-Snow	CEQ-Sthen	CEQ-F
Strength	Load	4.13 (2.20)	3.74 (2.66)	3.27 (2.86)
	Tetris	4.96 (3.00)	2.63 (2.37)	1.76 (1.94)
Imagery	Load	4.14 (2.40)	3.25 (2.81)	3.27 (2.60)
	Tetris	4.88 (2.36)	1.92 (2.25)	1.28 (1.70)
Intrusiveness	Load	3.30 (2.64)	2.43 (2.29)	2.43 (2.53)
	Tetris	3.00 (2.52)	1.58 (2.14)	1.39 (2.17)

A 2(time) x 2 (condition) repeated measures ANOVA was used to compare before (Snow) and after (Sthen) scores from the CEQ questionnaires. The main effect of condition on craving strength was not significant, $F < 1$. Craving strength reduced over time, $F(1,78) = 18.71, p < .001, \eta_p^2 = .19$, and the interaction showed that this reduction was larger for the Tetris condition, $F(1,78) = 9.60, p = .003, \eta_p^2 = .11$. Craving imagery showed a similar null effect of condition overall, $F < 1$, and reduction over time ($F(1, 78) = 39.02, p < .001, \eta_p^2 = .33$) and interaction between time and condition ($F(1, 78) = 11.29, p = .001, \eta_p^2 = .13$). Craving intrusiveness also showed no main effect of condition, $F(1,78) = 1.46, p = .23, \eta_p^2 = .02$, and a significant reduction over time, $F(1,$

78) = 20.73, $p < .001$, $\eta_p^2 = .21$, but the interaction did not reach statistical significance, $F(1, 78) = 1.17$, $p = .28$, $\eta_p^2 = .02$).

A one way ANOVA of scores on the CEQ-F showed that participants experienced less frequent cravings and less frequent craving imagery while playing Tetris than while watching for the load screen, $F(1, 78) = 7.53$, $p = .008$, $\eta_p^2 = .09$, and $F(1, 78) = 15.91$, $p < .001$, $\eta_p^2 = .17$ respectively. The frequency of craving-related intrusive thoughts differed in the same direction but the difference fell just short of statistical significance ($F(1, 78) = 3.80$, $p = .055$, $\eta_p^2 = .05$).

5.4. Discussion

This study examined naturally occurring cravings and to our knowledge is the first experimentally-controlled laboratory manipulation of natural rather than artificially-induced cravings. Kemps and Tiggemann (2013) recently reported that a visual interference task reduced naturally-occurring cravings for food in the field, but did not include a control condition to test that the craving reductions exceeded those that would happen naturally during the time taken to complete the task. The load-screen condition in the present study performed this function.

The findings show that studying naturally-occurring cravings, rather than inducing cravings artificially, is a viable option for laboratory research. Around two-thirds of participants reported craving something at the time of completing the experiment and their mean craving levels were reasonably high, around the mid-way point on the baseline single-item craving and CEQ measures. It is possible that our predominately young, female, undergraduate sample experienced stronger cravings than the general population because cravings decrease in strength and frequency with age and women typically experience more cravings than men (Lafay et al., 2001; Pelchat, 1997). In an ecological momentary assessment study of a somewhat broader sample (73% university students), participants reported a current desire on 50% of the sampling occasions and a recent desire on a further 28% of occasions. As in the present study, desires to eat or drink were the most frequently reported (36.7%; Hofmann, Baumeister, Förster, & Vohs, 2011). In contrast to previous research (Hill, Weaver and Blundell, 1991), there was no change in craving frequency across the day.

Playing Tetris for 3 minutes reduced craving strength and craving image vividness compared with watching a load screen. This finding supports Elaborated Intrusion Theory (Kavanagh et al., 2005), which posits that imagery is central to craving and that the development, maintenance and elaboration of craving images requires working memory resources, and in particular visuospatial working memory. Van Dillen and Andrade (2014) found that Tetris reduced behavioural indices of craving following a craving induction, specifically attentional biases to food pictures and choice of high calorie rather than fruit snacks, as well as self-reported craving. The present study extends their findings by showing that Tetris weakens naturally occurring cravings, with the implication that other previous studies of effects of working memory loads on craving (e.g., Andrade, Pears, May & Kavanagh, 2012; Kemps & Tiggemann, 2007; May, Andrade, Panabokke & Kavanagh, 2010) should also generalise to ecologically valid cravings.

The findings support the prediction of EI theory that visuospatial tasks weaken cravings via effects on craving imagery, by showing that playing Tetris reduced the vividness and frequency of craving imagery. However, they do not rule out an interpretation that any working memory load would have the same effect, regardless of sensory modality. Tiffany (1990) posits that it is the suppression of an activated action schema that leads to a craving experience. Therefore, all subsections of working memory would be involved in the suppression of the action schema. The design of this current experiment is not able to provide a definitive answer as to which of the craving theories it is in support of. It remains to be conclusively tested whether the effects of Tetris on craving are due specifically to visuo-spatial interference, or to general task demands.

Experiments 2 and 3 in this thesis favoured the general task demands explanation, as concurrent verbal tasks reduced craving just as much as playing Tetris did. However, previous research has shown effects of visual tasks over non-visual working memory tasks assumed to impose similar executive processing loads. For example, May, Andrade, Panabokke and Kavanagh (2010) reported reductions in cigarette craving when participants imagined neutral visual scenes compared with when they imagined neutral sounds. In the field, Knäuper, Pillay, Lacaille, McCollam, & Kelso (2011) showed that positive visual imagery reduced food cravings over a four-day period compared with reciting the alphabet backwards, a reasonably demanding verbal

working memory task. These findings suggest that the visuospatial component of playing Tetris might give benefits over and above those of an equally difficult verbal task (in contrast to the earlier findings of this thesis), but this prediction has not yet been tested with naturally occurring cravings.

There is a risk that temporary reductions in craving might lead to later increases. Distraction tasks can increase the 'ironic' effects of thought suppression, leading to behavioural rebound (Erskine, 2008). Although we did not test the long-term impact of playing Tetris, we think it is unlikely to lead to increased craving or consumption in the longer term, for three reasons. First, there is evidence that other visuospatial interference tasks reduce craving and consumption over periods of weeks (Kemps & Tiggemann 2013; Knäuper et al., 2011). Second, participants did not receive the thought suppression instructions that are typically associated with rebound effects. Third, Caselli, Soliani and Spada (2013) incidentally included Tetris as a resting phase following manipulations of thought focus in the laboratory. Overall, craving did not increase over the next three days, during which participants continued using their assigned thought focus strategy, suggesting that Tetris did not lead to a rebound. There appeared to be an increase in craving in one 'distraction' condition, where participants focused their thoughts on geographical locations. Caselli et al. did not report how often participants used this distraction technique over the three days, or whether they thought about locations associated with their desired activity. Nonetheless, this finding raises the concern that any distraction might lead to increases in craving over time because, as Caselli et al. suggest, participants can learn to use it as a thought avoidance strategy. The current experiment suggests that the two tasks are rather different, with Caselli's directing people's thoughts to a neutral topic and the current experiment specifically loading the visuospatial working memory processes that people need for elaborating craving images. Future research should test the long-term impact of craving interventions and test whether that impact differs according to the type of distraction employed. Elaborated Intrusion theory predicts that tasks that specifically load working memory processes needed for craving imagery will help break the vicious cycle of desire-related thoughts leading to desire imagery, which leads to more desire thoughts. Predictions about the effects of more general distractions are mixed: Instructions to think about other things may help cue neutral images, which would interfere with desire

imagery, or they may be interpreted as a tool for suppressing desire thoughts, which could be counter-productive.

Although playing Tetris did not completely suppress craving, decreasing it by around 24%, this reduction could be sufficient to help people manage their cravings, as suggested by van Dillen and Andrade's (2014) finding that people were less likely to choose a high-calorie snack after playing Tetris. Future research could test if manipulating the duration and difficulty of Tetris can increase its effects on craving. Kemps and Tiggemann (2013) found a similar 23% reduction in craving intensity when women watched a visual interference display known to disrupt visual imagery (Andrade, Kemps, Wernier, May & Szmalec, 2002). Women who were given the opportunity to watch the display when they craved food reported fewer craving-related thoughts than those in the control condition who just kept a food diary. We predict that playing Tetris will have similar benefits for consumption in field settings, particularly because, anecdotally, participants said they enjoyed playing Tetris, which is important if using it as a take-home task to help people manage their cravings.

Although this study tested an unselected sample of undergraduates, we expect the findings to generalise to people trying to control their consumption because there is evidence that other visuospatial tasks are effective when people are motivated to control rather than indulge their cravings (e.g., Kemps, Tiggemann & Christianson, 2008). In a comparison of craving phenomenology across different substances, May et al. (2013) found similar mean scores for craving strength across chocolate (mean CEQ-Snow and CEQ-Sthen = 4.40), cigarettes (4.54), and food (4.68), with the mean for an outpatient sample meeting DSM-IV-TR criteria for current alcohol dependence being somewhat higher (5.22) but within the range reported by participants in the present study. Further research would be needed to examine the effectiveness of Tetris to decrease cravings in a clinical population.

The Craving Experience Questionnaires showed that craving strength and imagery both decreased more when participants played Tetris than when they watched the load screen. Craving intrusiveness changed over time but not differentially by condition. This finding is consistent with EI theory's assumption that elaboration loads working memory and will be inhibited by concurrent working memory loads, whereas intrusive thoughts result from automatic, associative processes that are not dependent on working

memory. However, EI theory also predicts that the process of elaboration will stimulate further intrusive thoughts, so we predict that over longer periods, the effects of playing Tetris on craving would eventually lead to reductions in intrusions too.

In conclusion, the current experiment has shown that playing Tetris for a brief period is sufficient to reduce naturally occurring cravings that participants were already experiencing when they entered the laboratory. Tetris reduced the vividness and frequency of craving imagery, as well as craving intensity. This is an important finding for generalising previous tests of EI theory with induced cravings to naturally occurring cravings for food and drink, and possibly for addictive substances too, and a step towards developing a take-home task for helping people to reduce cravings to tolerable levels.

Study 7 took the next step of testing brief games of Tetris as a tool for reducing cravings in real-world settings over a period of one week. The longer test period gave two advantages, allowing us to test if the effects of Tetris wore off once the novelty of the task had waned and allowing us to collect more data on less common everyday cravings including those for drugs and sex as well as cravings for food and drink. This is an important extension because EI Theory (Kavanagh, Andrade & May, 2005) posits that similar cognitive processes underpin addictive cravings and everyday desires. The extended time period required changes to the way of assessing cravings and delivering the Tetris task, so chapter 6 gives an overview of the literature on ecological momentary assessment as well as explaining the rationale for the next study.

Chapter 6

6.1. Study 7: *Playing Tetris decreases drug and other cravings in real world situations: The application of laboratory findings to ecologically valid settings.*³

Do you ever find yourself thinking about a big mug of steaming hot coffee and wondering how you are ever going to concentrate on work until you have one? Hofmann, Baumeister, Forster and Vohs (2011) showed that cravings like this are a common occurrence. On almost 50% of occasions sampled, participants reported a current craving, and just under half of these cravings caused conflict for the person experiencing them. An effective strategy for tackling cravings could have a potentially large impact on a person's life. This is particularly the case for someone with an addiction who is trying to reduce or quit drug use. Craving has been introduced as a criterion for substance use disorders in the DSM-V and is recognised as clinically significant across addictions (Diagnostic and Statistical Manual of Mental Disorders 5th edition (DSM-V), 2013), contributing to continuation of drug use (Piasecki, Richarson & Smith, 2007) and relapse after quitting (Shiffman et al, 1997). As discussed in Chapter 1, craving also plays an important role in diet and weight management (Lafay et al., 2001; Mitchell, Hatsukami, Eckert & Pyle, 1985; Schlundt, Virts, Sbrocco, & Pope-Cordle, 1993; Shiffman et al., 2013)

Elaborated Intrusion (EI) theory (Kavanagh, Andrade & May, 2005) explains the cognitive processes underpinning craving, and assumes these processes operate across cravings for different substances and activities. Psychological strategies for managing cravings should also act across diverse cravings. This chapter reports the first test of this prediction in a naturalistic setting with a broad range of craving targets, including addictive substances (nicotine, alcohol, caffeine), food and drink, and physical activities (sex, exercise).

³ This chapter is an extended version of:
Skorka-Brown, J., Whalley, B., May, J. & Andrade, J. (2014). Playing Tetris decreases drug and other cravings in real world situations: The application of laboratory findings to ecologically valid settings. *In preparation*

EI theory is supported by evidence on phenomenology of cravings, where sensory imagery features in cravings for a range of addictive and everyday targets, including alcohol (Kavanagh et al, 2009; Statham et al, 2011, May et al, 2014), food (Harvey Kemps & Tiggemann, 2005; May, Andrade, Panabokke & Kavanagh, 2004; May, Andrade, Kavanagh & Penfound, 2008; May et al., 2014), cigarettes (May et al, 2004; Salkovskis & Reynolds, 1994), and sport (Hall, Rodgers, Wilson, & Norman, 2010; May et al, 2008). Craving imagery is associated with behaviour, for example with alcohol use (Connor et al, 2014) and exercise frequency (Gammage, Hall, & Rodgers, 2000).

Imagery loads limited-capacity modality-specific and general working memory processes (Baddeley & Andrade, 2000). Consistent with the hypothesis of a role for imagery in craving, laboratory research has shown that cravings can be suppressed by completing a working memory load (Van Dillen, Papiés, & Hofmann, 2013). Tasks that involve visuospatial or olfactory processing tend to be more effective than auditory tasks across a range of craving targets including cigarettes (May, Andrade, Panabokke & Kavanagh, 2010, Versland & Rosenberg, 2007), food (Andrade, Pears, May & Kavanagh, 2012; Kemps & Tiggemann, 2007), and coffee (Kemps & Tiggemann, 2009), supporting the assumption that craving involves sensory imagery in the same modalities as the desired activity.

These laboratory findings point the way to new interventions for tackling problematic cravings. Cravings should be reduced by cognitive tasks that target the working memory processes that support craving imagery. Experiments 1 to 5 in this thesis suggested that any working memory load should suffice to reduce craving, but relevant published studies to date have shown a role for visual imagery – or at least visual cognitive processing – in all cravings studied (May et al, 2014). It therefore seems sensible to focus on interventions that target visual imagery as well as imposing a general cognitive load.

Laboratory findings do not always translate perfectly to real-world settings. For example, Wall, McKee and Hinson (2000) investigated the effect of expected alcohol outcomes in a laboratory setting compared to a naturalistic setting (a student bar). They found that participants in the naturalistic setting had more pronounced alcohol outcome expectancies than those in the laboratory setting. Participants drinking in the bar

expected greater pleasurable disinhibition than those drinking in the laboratory. This highlights the importance of testing in a naturalistic setting because although exposure to the sight and smell of alcohol increases craving in various settings (Cooney et al., 1997; Kaplan et al., 1985, 1983; Monti et al., 1987; Pomerleau et al., 1983), the effect was significantly more pronounced in the naturalistic setting than in the laboratory setting. Therefore naturalistic investigation into the interaction between craving and cognition is paramount.

Three studies have tested the impact of EI theory-based interventions on food craving in naturalistic settings. Kemps and Tiggemann (2013) used paper diaries to measure craving, and a passive visual interference task called dynamic visual noise to interfere with it. Dynamic visual noise reduces craving for cigarettes (May et al, 2010, experiment 2) and food (Kemps, Tiggemann & Christianson, 2008) in the laboratory. Kemps and Tiggemann (2013) found that it also reduced food craving and consumption in the field. Knäuper et al (2011) recruited participants who reported strong cravings for specific food or drinks (commonly chocolate and coffee) and wanted to reduce those cravings. As predicted by EI theory, participants who vividly imagined a favourite activity whenever cravings struck reported weaker cravings than those who recited the alphabet backwards. Finally, Hsu et al (2014) tested a mobile application for improving snacking behaviour based on Elaborated Intrusion theory. Participants who used their iCrave application – to track snacking, prompt vivid, neutral imagery, and record successful abstentions – reported less snacking and great ease of abstaining than those who simply used an app to track their snacking.

Laboratory studies suggest that visuospatial tasks will block drug cravings in a similar way to food cravings, with a few studies showing reductions in cravings for cigarettes (May et al, 2010; May, Andrade, Willoughby & Brown, 2012; Versland & Rosenberg, 2007) and caffeine (Kemps & Tiggemann, 2009), and one study of naturally occurring cravings that included cravings for caffeine and cigarettes (Skorka-Brown, Andrade & May, 2014, reported in previous chapter).

The present study extends this research to a wide range of cravings, including drug cravings, to test if a visuospatial load reduces craving strength and decreases indulgence of cravings in naturalistic settings. We used Tetris as the intervention task because it is an easily accessible, engaging task with a strong visual component

including brightly coloured shapes, movement, and a need to mentally rotate shapes to test if they will fit the spaces. Tetris blocks development of distressing intrusive images (Holmes, James, Coode-Bate & Deepro, 2009; Holmes, James, Kilford & Deepro, 2010) and weakens naturally occurring cravings in a laboratory setting (Skorka-Brown, Andrade & May, 2014, reported in previous chapter). Participants were asked if they were under the influence of alcohol (including being hungover) as previous research (Burton & Tiffany, 1997) has shown that when people had consumed alcohol they experienced an increase in their general cravings. It is not known whether these cravings are more or less resistant to effects of cognitive interference.

Testing in field settings and over extended periods of time requires different ways of assessing craving, as the experimenter is not on hand to administer questionnaires. Retrospective questionnaires risk introducing memory errors and biases, whereas daily diaries require participants to remember to complete them. These issues have led some authors (e.g., Piasecki, Hufford, Solhan & Trull, 2007) to advocate sampling the variable of interest frequently using so-called ecological momentary assessments (EMA). EMA techniques can range from simple responses to SMS messages, diary completions prompted electronically, to paper diaries completed without prompting. Like laboratory experiments it is important to ensure that the method of data collection used is adept at measuring its intended outcome and remains uninfluenced by extraneous and confounding variables. The method of data collection for the current experiment was therefore carefully reviewed.

Using ecological momentary assessments (EMA), Carels, Douglass, Cacciapaglia and O'Brien (2004) investigated the effect of relapse crises in dieting post-menopausal women. Participants completed pen and paper diaries when they were randomly paged and within the first fifteen minutes of being tempted or having lapsed. The diaries were designed with different sections for temptation, lapse and random prompt sections. The participants were also informed that if they were having any problems there would be an experimenter available throughout the week for them to discuss the diaries with. Participants recorded the date and time of the temptation or lapse and the intensity of the temptation. Multiple rating scales were utilised to assess the participant's level of hunger, information about previous eating behaviours and contextual information. There were different rating scales for temptation ratings which examined what the

participant did to try and control the temptation. At the end of the experiment participants were asked to subjectively rate how much they felt they had completed the diary in terms of at the correct times as well as how many entries did they not complete. They were also asked if the diary had an effect on their eating behaviours. In terms of using EMA, the findings were encouraging. Seventy percent of participants reported skipping fewer than 2 random diary entries over the week and 53% reported that they completed fewer than 2 temptation or lapse entries more than 15 minutes after it had occurred. Participants reported that keeping a diary made them more aware of their eating behaviours and 21% reported their eating behaviours were directly influenced by the diary.

The findings from this study show that is viable to complete research using ‘take home’ measures and if you provide reminders for the participants to complete the diaries. To allow more than self-report data to be measured in an EMA setting, techniques were developed to incorporate interactive materials.

Waters and Li (2008) investigated the feasibility of administering a reaction time task on a personal digital assistant (PDA) in an EMA setting. They compared smokers and non-smokers over a period of one week. During the week, the participants were paged 4 times randomly each day to complete a “random assessment” task (RA). The participants were also asked to press a button marked “AA” (anxiety assessment) if they felt anxious at any time. The RA and AA tasks included rating variables which were subjective, pharmacological and contextual. The participants then completed a Stroop task which was either the classic stroop, emotionally cued or smoking-cued. Waters and Li found that 81.2% of RA’s were responded to and the majority (62.4%) of these were reported to have been completed uninterrupted and took an average of 4.44mins to complete. Waters and Li found (as expected) the emotional stroop was affected by state anxiety, the classic stroop was affected by age and the smoking-cued stroop was affected by nicotine dependence scores. The results from this study suggest that the use of PDA’s in EMA settings is feasible and effective. The development of EMA techniques has increased the practicability of using ‘take home’ measures to assess both self-report data and quantitative data however, EMA techniques have different disadvantages to laboratory controlled techniques and it is therefore important to understand those disadvantages and control for them whenever possible.

Different EMA techniques pose different problems, which can affect the reliability of the results from the experiment. Piasecki, Hufford, Solhan & Trull (2007) reviewed the benefits and costs of using electronic diaries as an ongoing diagnostic tool in clinical assessments compared to retrospective data gathering. They found that retrospective assessment led to rounding of information (for example the numbers of cigarettes a person smoked in a day) rather than exact numbers. Thus diaries which are completed retrospectively, at a set time each day, records less accurate information than if the participant is required to complete the diary each time the monitored event occurs. Shiffman et al (1997) showed that only 23% of participants who lapsed when trying to stop smoking could retrospectively recall correctly the first day that it happened, and this included five percent who recalled the relapse episode occurring before the date that they actually quit. The retrospective data was collected 12 weeks later, whereas the relapses were monitored (both daily and at the time of occurrence) for the first 25 days after the participant quit smoking. Also, recall of the contextual and emotional information which led to the lapse was very poorly correlated with momentary assessment reports.

Piasecki, Hufford, Solhan and Trull (2007) reinforce the importance of this finding and the influence it has on trying to stop more relapses in people with substance abuse problems. As many therapies rely on retrospective information to identify antecedents to the lapse, incorrect information about the antecedents may lead to incorrect treatments. However, Piasecki, Hufford, Solhan and Trull (2007) posit that it is important to ascertain what the intended measure is, due to some measures being more accurate when retrospective data is collected. Redelmeier and Kahneman (1996) compared retrospective recall of pain during medical procedures and pain reported during the procedure itself. They found that recall correlated only with the highest level of pain reported and pain reported in the last three minutes of the procedure, thus recall of pain is likely to be more important for a patient to decide if they wish to undergo future treatment than pain reported during the experience. Wirtz, Kruger, Scollon and Diener (2003) examined real-time experiences and recalled experiences of spring break holidays on the desire of the student to take a similar holiday in the future. Recalled experiences were predictive of the desire to repeat the holiday, whereas real-time experiences were not. Thus, although retrospective data can interfere with recall, the

impact on future decisions may outweigh the cost to accurate recall. This experiment was focussing on the immediate effect of task on craving and indulgence, therefore it was decided that a real-time task was more appropriate than a delayed recall task.

Piasecki, Hufford, Solhan and Trull (2007) highlight key issues with using diaries for data collection. The first of these is that although diaries stop the problem of retrospection from a long time after the event, there is still the issue that some retrospection will occur over the brief time that the person is reporting about (although it is plausible that the retrospection is less than if recall is more greatly delayed). Another concern with the utilisation of diaries is that the task will be repeated and therefore the reports of the data rely on the participants to utilise the response format in the diary in the same way each time. A further issue with pen and paper diaries is that there is no guarantee that the participant has filled in the diary at the time that they were meant to, only around 11% of participants were found to have filled in diaries at the correct time (Stone et al., 2002). This problem is overcome by using an electronic diary, with a time and date stamp, by using a prompting system to remind participants to fill in the diary and by giving participants a limited time interval to fill in the information (Stone et al., 2002). Broderick et al. (2003) completed a follow-up study to Stone et al. (2002), finding that a reminder alone increased compliance but not up to an acceptable level (29%). Green et al. (2006) investigated the effect of asking participants to record the time that they wrote the diary entry, after being 'bleeped' on a watch with which the non-compliance rate dropped to 4.4%.

The recent study by Kemps and Tiggemann (2013), cited above, examined the effect of task completion on craving ratings using an EMA tool. They used dynamic visual noise to try and reduce food cravings and consumption in naturalistic environment.

Participants were recruited on the basis that they had at least 7 food cravings a week and their cravings and consumption were studied over a four week period. For the first two weeks, all participants had their baseline cravings and consumption measured, they were asked to complete the task any time they experienced a food craving. During a second two week period (directly after the first) all participants were again asked to complete their assigned task any time they experienced a food craving. The experimental condition rated their craving baseline, watched dynamic visual noise and then re-rated their craving strength. The control condition continued to record data as

before. Participants were asked to enter information into a paper diary, pertaining to their craving and eating behaviour. Participants in the experimental condition were given a PDA to allow them to view the dynamic visual noise for the experimental phase of the experiment.

A major issue with this experiment is the lack of confirmation that the participants reported the data (and completed the intervention) when the paper diary said that they did. If the information was completed at a different time to the time that was reported the data collected is not a true sampling and thus may not have measured the intended effect. The study by Stone et al. (2002) suggests there is a genuine risk of this problem. This therefore, means that the data which was collected cannot be used as strong evidence for support of an effect of visual interference being an effective task at decreasing cravings in a natural environment but rather warrants a similar experiment being run with stricter controls to ensure participant compliance.

Rather than rely on participants to perform a task and complete craving diary spontaneously, as previous studies have done, we used an ecological momentary assessment protocol with SMS messages to prompt reporting of craving and engagement with the intervention task on portable devices (iPods) carried by participants. The devices recorded the time and date of reports and task completions, allowing us to track compliance.

6.2. Method

6.2.1. Participants and Design

A total of 31 (7 males) undergraduate psychology students took part in partial fulfilment of a course requirement to participate in research. They were aged between 18 and 27 ($m=20.6$ $SD=2.3$). Participants were randomly assigned to either 'Tetris' or 'Monitoring only' conditions, (16 Monitoring, 15 Tetris).

6.2.2. Materials

Two different models of iPod Touch were used (first and second generation models, manufactured by Apple), with 3.5 inch multi-touch display. The program was written in Objective-C, and utilised the Cocos2D library.

In the Monitoring only condition, participants completed a questionnaire about craving following each prompt. Participants were asked ‘Have you indulged in the item you reported craving previously?’ (response options: Yes/no/was not craving previously); how much are you under the influence of alcohol? (five-point scale, from not at all to very much); are you currently craving anything? (yes/no). If they responded yes to the current craving question, they were asked to state what they were craving and how strongly they were craving it on a 0-100 scale.

In the Tetris condition, participants completed the same questionnaire and then played Tetris for 3 minutes (manipulating coloured basic shapes to form rows that would then disappear allowing for game play to continue; if the screen became full, a new game started). Participants played Tetris even if they had reported no craving. After 3 minutes, participants re-stated their craving strength, on the same 0-100 point scale, for the item they had previously stated that they were craving, with an option of responding that they were not craving.

A retrospective measure of the strongest episode of craving over the prior week was obtained at the start and end of the study period using the strength form of the Craving Experience Questionnaire (CEQ; May et al, 2014), with the instruction ‘Think about the time you most craved something during the past week’. The 11-item CEQ asks participants to rate their craving on three factors derived from Elaborated Intrusion theory: intensity (e.g., How much did you want it?), imagery (e.g., How vividly did you picture it?), and intrusiveness (e.g., How intrusive were the thoughts?). With the exception of two questions that asked what the person had most craved over the past week, and how long the craving had lasted, items were rated on a scale of 0 (not at all) to 10 (extremely). May et al. (2014) reported a high coefficient alpha of .91 for the scale, consistent factor structure across substances, and robust associations with other measures of desire and dependency.

Participants also completed the 39-item Food Craving Questionnaire - Trait (FCQ-T, Cepeda-Benito et. al., 2000) to assess their attitudes towards food. Statements such as ‘I often feel guilty for craving certain foods’, ‘Eating calms me down’, or ‘Once I start eating I have trouble stopping’ were rated on a six-point scale of ‘never’ to ‘always agree’.

6.2.3. Procedure

Participants came to the laboratory on a Wednesday morning and completed a short demographics questionnaire, the CEQ, FCQ-T and were shown how to use the iPod. Participants were asked to complete their iPod task whenever they received a SMS message prompting them to do so. They were given written instructions to take away with them.

Participants carried the iPod with them for the week. They were texted on a pseudo-random sampling schedule across each day. They received 7 texts a day between the hours of 9am and 10pm. The day was broken into 7 sections (9am-10.30, 10.30-12.30, 12.30-2.30, 2.30-4.30, 4.30-6.30, 6.30-8.30, 8.30-10pm) and participants were texted once within each timeslot, but not within the final 30 minutes of a section, to allow participants the minimum of 30 minutes to do the task. The text they received gave a deadline for completing the task, of 30-60 minutes depending on proximity to the next time section. Participants were told that it was important to complete the task within the specified timeslot. The iPod recorded the time that the task was done.

Participants returned to the laboratory the following Tuesday late afternoon to return their iPod and complete the CEQ. Participants missed 1-3 sections on the first and last day of the study due to the timings of these sessions.

6.2.4. Data structure

Craving strength data was structured such that each measurement represented a row in the dataset. Participants in the Tetris condition provided two measurements in response to each prompt: before and after playing Tetris. Control participants provided a single measurement. Indulgence was also measured at each prompt for both groups, i.e., whether the participant had indulged a craving reported at the previous prompt.

6.2.5. Statistical methods

The monitoring only group was included in the design to provide a comparison baseline measure for both craving strength and indulgence rates. Indulgence was compared between intervention groups for the effect of different types of craving. The intervention groups were also compared for FCQ-T and the CEQ completed during the laboratory sessions. Stata 13 (StataCorp, 2013) was used to analyse craving strength data by mixed-effects regression, where craving scores were nested within individuals.

In our primary analyses of data from the Tetris group only, fixed effects estimated the difference in craving strength before and after game completion, to obtain a Tetris-effect parameter. Secondary analyses on these participants i) included random effects for the Tetris-effect parameter, ii) estimated the covariance between the random intercept and this random slope, to test if the effect of Tetris correlated with individuals' average craving levels; and iii) stratified the effect of playing Tetris as a function of craving type (whether the person was craving a drug, activity, food, etc). In a final analysis on all participants we used multilevel growth curve models to estimate changes in craving strength from baseline over the course of the week as a function of group allocation: We compared craving strength after each initial prompt (i.e., for the Tetris group this was the response made *before* playing the game) between participants in the Tetris and control conditions, estimating the effect of group allocation at day 1 and day 7. This analysis tested whether the availability of Tetris as a tool for managing cravings reduced the strength of cravings over the longer-term.

Indulgence was recorded as a binary variable indicating whether or not the participant had indulged their last-reported craving, and analysed using mixed-effects regression with a logit link function. Probability of indulgence was first estimated as a function of group assignment. All analyses were conditioned on reported current influence of alcohol.

6.3. Results

Participants were deemed compliant if they completed the iPod task within the allotted time. Out of 43 possible trials, participants completed an average of 34.3 trials, with a standard deviation of 7.50; at 80% this level of compliance is similar to rates elsewhere (e.g. Hofmann, Baumeister, Forster & Vohs 2011; Water & Li, 2008).

Mixed-effects regression of occasions where the Tetris participants indicated they were experiencing a craving showed that craving strength was on average 13.06 points lower after playing Tetris (mean = 57.58) than before playing (mean = 70.64; 95% CI = -20.1 to -4.7), a medium effect size of $f^2 = 0.11$. This effect did not vary over the week $\chi^2(6)=1.98$, $p = 0.921$ (Figure 13). Follow-up analyses included a random slope for the effect of playing Tetris and participant-level residuals. The fixed effect of playing Tetris was unchanged but there was significant variation in the effect of Tetris between individuals (SD=12.5, 95% CI= 7.8 to 20.0) and no relationship between random slopes

and intercepts $r=-0.33$ (95% CI = -0.75 to 0.29). Thus Tetris benefited individuals experiencing mild and more intensive cravings.

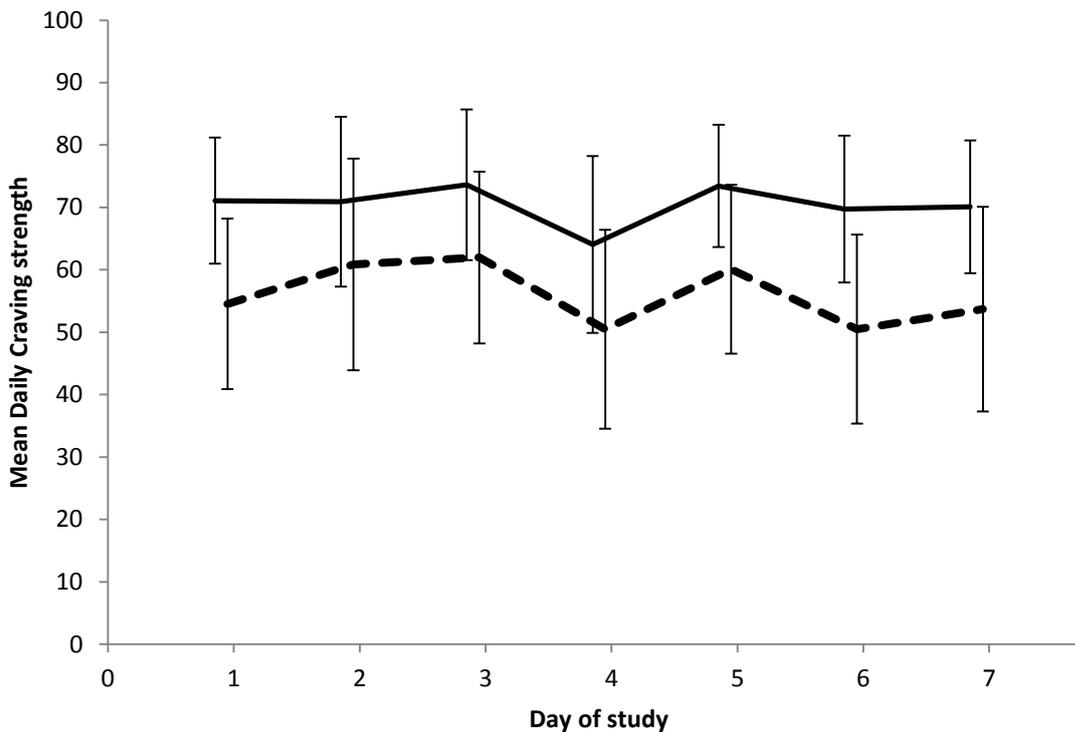


Figure 13: Effect of playing Tetris on craving strength across the week. Solid line shows mean ratings before playing, dashed line shows mean ratings after playing Tetris. Error bars show 95% CI.

There was a trend for different types of craving to differ in strength $\chi^2(2)=5.53$, $p=0.063$ (see Table 7). Pairwise comparisons showed that cravings for addictive substances (nicotine, alcohol, caffeine, mean=75) were reported as significantly more intense than cravings for food or drink mean=68; $\Delta = 6.245$, $p = 0.039$, but not stronger than cravings for the ‘other’ category, which included exercise, sex, and gaming, mean=76; $\Delta = 0.650$, $p = 0.864$. We tested whether the effect of playing Tetris on craving strength differed between types of craving (addictive substances/food or drink/other): Allowing for this interaction did not significantly improve the model, $\chi^2(4) = 6.51$, $p=0.164$, indicating that the effect of Tetris was similar across the different craving types.

The influence of alcohol (dichotomised as none (mean = 71.56, SD=20.25) vs. any influence; mean=70.48, SD=22.48) did not predict craving strength, $\chi^2(1) = 1.08$,

$p=.298$. Participants under the influence of alcohol benefited from playing Tetris as much of those who were not $\chi^2(1) = 2.23$, $p=0.136$, although our dataset of 1063 observations included only 67 when participants were mildly influenced by alcohol and only 44 when participants were more than mildly influenced.

Contrary to our prediction, multilevel logistic regression found no difference in the propensity of participants in the different intervention (Tetris or monitoring only) groups to indulge, $OR = 0.96$, $95\% CI = 0.402$ to 2.292 $p=0.463$ (one-tailed); $\chi^2(1)=1.32$, $p=0.250$. Participants under the influence of alcohol showed a trend of being more likely to indulge than those who were not, $OR = 8.772$, $95\% CI = 0.838$ to 91.799 , $p=0.0735$ (one-tailed) $\chi^2(1)=3.77$, $p=0.052$. Again, playing Tetris did not appear to have a protective effect on indulgence for those under the influence of alcohol, ($OR = 0.189$, $95\% CI = 0.012$ to 2.892 $p=0.115$ (one-tailed), $\chi^2(1)=1.43$, $p=0.232$). Indulgence rates increased under the influence of alcohol (91%) compared to not under the influence (55%) in the monitoring only condition. In the Tetris condition indulgence rates did not increase as much under the influence of alcohol (66%) compared to not being under the influence (54%).

The type of craving reported on the previous occasion was a predictor of subsequent indulgence ($\chi^2(2)=6.93$, $p=0.031$). The probability of participants indulging was 63% if their craving was for an addictive substance, 49% if their craving was for food or drink and 74% if their craving was within the other category. However there was no effect of Tetris $\chi^2(1)=0.01$, $p=0.917$ or interaction between the two $\chi^2(2)=2.85$, $p=0.240$.

A one-between, one-within ANOVA (Between factor of Group: Tetris, Monitoring; Within factor of Time: Before, After) showed no effects for the CEQ 'strongest episode' measures of craving strength, intrusiveness and imagery scores at baseline or follow-up (smallest $p = 0.055$). A one-way ANOVA found that none of the measures from the FCQ-T differed between conditions ($p>0.256$), thus baseline trait food cravings were matched between conditions.

Baseline craving strength did not differ between conditions ($t=0.822$, $df = 318$, $p = 0.206$, one-tailed, equal variances assumed), either overall or within each craved item category (see Table 7; smallest $p=0.285$, equal variances assumed). Contrary to our prediction, multilevel growth curve models showed no protective effect of Tetris on

baseline craving strength across the week, when each day was compared to day one (smallest $p=0.136$, one-tailed).

Table 7:

The means and standard deviations for craving strength by substance craved for each condition and across conditions.

Craved Items	Mean (& SD) craving strength before Tetris	Mean (& SD) craving strength after Tetris	Monitoring Only craving strength
Addictive Substances	75.79 (20.38)	62.36 (25.10)	74.28 (19.63)
Food/Drink	67.43 (21.87)	52.18 (25.83)	68.62 (21.79)
Other	74.73 (20.52)	65.21 (31.00)	77.36 (14.59)
Mean Across Substances	72.65 (20.93)	59.92 (27.31)	73.36 (18.67)

6.4. Discussion:

Playing Tetris for 3 minutes decreased craving strength for addictive substances (such as nicotine, caffeine and alcohol), food and drink, and other cravings (such as sex, gaming, exercise and social interaction) by around 13 percentile points throughout the 7-day study period. This is the first demonstration that visual cognitive interference can be used repeatedly in the field to reduce cravings for a range of substances and activities. This finding replicates and extends that of Skorka-Brown et al (2014; see chapter 4), who reported that craving strength was reduced by a similar amount (14 points using the same scale, medium effect size $d = .39$) when participants played Tetris in the laboratory, but not when they watched a fake loading-screen. Using a working memory task to interfere with cravings appears to be as effective in the field as in the laboratory.

Previous studies have shown that craving reduction effects of visuospatial tasks such as neutral visual imagery (Kemps & Tiggemann, 2007) and dynamic visual noise (Kemps et al, 2008) translate to field settings when food craving is the target (Knäuper et al,

2011; Kemps & Tiggemann, 2013). Our findings suggest that the effectiveness of these tasks on nicotine cravings in the laboratory (May, Andrade, Panabokke & Kavanagh, 2010, Versland & Rosenberg, 2007) will also generalise to field settings and other drug targets.

The impact of Tetris on craving was constant across the week. This finding is important and shows the potential of Tetris as a tool to tackle cravings in the early days of a quit attempt, and possibly for much longer, whereas an intervention that worked solely because it is novel would have diminishing benefits as the novelty wore off. However, Tetris did not have a protective effect on baseline craving strength across the week. This finding was unsurprising as participants only completed the task for one week and, because they were prompted to complete it at specific times, would be unlikely to have completed it for all their cravings. Longer-term studies, with participants for whom cravings are unwanted, are needed to test if a tool for managing cravings helps to reduce the incidence and strength of all cravings or, as in the present study, only weaken the cravings while it is being used.

In contrast to the effect of Tetris on craving, there was no effect of Tetris on the binary measure of indulgence rates compared to the control condition. This result suggests that the relationship between craving and indulgence may be more complex than one where a craving leads directly to indulgence. Previous research (Shiffman et al, 2002; 2013) has clearly shown that people report cravings to be related to indulgence, either impeding weight loss or being the biggest predictor of indulgence behaviour, but there are several reasons why the relationship is weaker in this study. Firstly, participants were asked to recall whether or not they indulged in their craving after a time delay. Some of the data showed incorrect reportage from participants, such as stating that they had not had a craving previously when they had previously reported a craving. This suggests that the delay may have impeded accurate recall and affected the data. Future research needs to account for this possible confounding variable by ensuring reportage of indulgence occurs directly after the indulgence itself.

Secondly, indulgence in the current experiment focused on consumption of the specific item, rather than consumption generally. Knäuper et al. (2011) also focused on specific consumption and found no effect of task on indulgence. Kemps and Tiggemann (2013) and Hsu et al (2014) examined consumption levels generally and their visual

intervention tasks were found to decrease consumption. This may be an important difference in the results and something which future research ought to address by measuring both general consumption and specific consumption to assess the interaction between the two areas of consumption. One aspect of specific craving that was not measured in this study was the quantity in which people indulged in their craving. It is possible that the amount that participants indulged decreased when they played Tetris, compared to the monitoring only condition, rather than stopping the indulgence altogether. Kemps and Tiggemann (2013) found that participants' calorific intake decreased after their visual intervention but they did not record what the participants' intake comprised of, therefore it is possible that although their intake was lower it still consisted of the item that they were craving.

Thirdly, the current study recruited participants without limitation related to diet or cravings, however Kemps and Tiggemann (2013), Hsu et al. (2014) and Knäuper et al. (2011) all recruited participants on the basis that they had a high number of food cravings, wanted to reduce their snacking behaviour or reduce their cravings. The lack of effect of task on indulgence may therefore have related to the sample coming from the general population rather than a specific population. The specific populations used by the aforementioned research may have had a stronger motivation to decrease their cravings and indulgence rates than those in the general population. The general population may also be contented with their indulgence rates and thus even if their craving strength had decreased may still have chosen to indulge their craving. This suggests that whilst a take-home tool is in development, targeted populations should be used which experience high craving levels or wish to reduce a particular behaviour.

Finally, laboratory based studies and meta-analyses have found inconsistencies in the relationship between craving and consumption (Gendall, Joyce, Sullivan & Bulik, 1998; Schlundt, Virts, Sbrocco, & Pope-Cordle, 1993; Shiffman et al., 2002; 2013, Tiffany & Wray, 2012; Wray, Gass & Tiffany, 2013). A meta-analysis by Wray, Gass and Tiffany (2013) examined the relationship between pre-quit craving, post-quit craving and relapse for 62 smoking cessation studies. They concluded that there was scant evidence of a relationship between pre-quit craving with either post-quit craving or relapse and inconsistent findings for the relationship between post-quit craving and relapse. However, throughout the analysis they highlight that a variety of methods were

used to assess cravings and were done so at different time-points pre and post quit times, some as long as two years after cessation. They also highlight in their conclusion that the relationship between cravings and relapse would be found to be significant far less (only 1 in 20 experiments) than their analysis found if the two variables were truly unrelated. They also concluded that post-quit measures were more likely to find an association with relapse than pre-quit measures of craving. This suggests that it is only when a person is actively trying to resist a substance that decreasing cravings may be effective at decreasing consumption. Gendall et al. (1998) found that both in a randomly selected sample and a sample of women who specifically reported food cravings, people were more likely to binge eat if they had higher levels of dietary restraint, had a higher body mass index and more frequent diagnosis of bulimia nervosa. This tentatively suggests that cravings might be associated with binge eating but only when accompanied by dietary restraint. Conversely, Schlundt et al. (1993) found little difference between consumption with and without craving: women who were dieting and reported high craving levels actually consumed a very similar diet (including during episodes of craving, impulsive eating and overeating) to those who were dieting but reported infrequent cravings. Mood was associated with craving: high cravers were bored more regularly, less stressed and less happy than the low cravers. Craving sweets was also associated with impulsive and overeating for both populations. This supports the earlier proposal that previous research shows cravings are associated with general tendencies to indulge, rather than a specific link between an episode of craving and subsequent indulgence of the craved item (Hsu et al., 2014; Kemps & Tiggemann, 2013).

Similar associations are reported in the addiction literature. Shiffman et al (2002) found that smoking urges were strongly related to indulgence and only modestly related to situational factors such as the presence of other smokers, using a population who were recruited for a smoking cessation study. Participants reported that they were about to smoke by pressing a single key on an electronic diary to report their indulgence. On randomised occasions (during each day) they were also asked to complete a short questionnaire. They were also prompted to complete the questionnaire on several occasions during the day when they were not craving, to provide non-smoking comparison data. When other influences (such as situational factors) on indulgence are

controlled, the odds of participants smoking increased by 33% for every one point increase in smoking urge (on a 1-10 point scale), up to seven points, where the effect did not increase significantly in strength. Shiffman et al. (2013), using a smoking population who were not trying to decrease their smoking habit, found that craving strength predicted indulgence, but cue exposure did not. Cigarette craving could be considered likely to induce stronger cravings than cravings for food as there would also be physiological cues from withdrawal, thus a relationship between craving and indulgence was found directly from craving to indulgence, rather than in the food craving studies, which have found a correlation from craving to general indulgence.

Tiffany and Wray (2012) reviewed literature related to cravings in a clinical setting and concluded that although currently craving is not sufficient to predict relapse, with continued research we should be able to identify conditions in which craving and substance use is more strongly correlated. These findings suggest that although the relationship between craving and indulgence is complex, there is a relationship which is therefore worth investigating. Future research need to focus on populations where the correlation is likely to be strongest (such as dieters or people trying to quit smoking) to investigate and interfere with the relationship before applying the findings to populations where the correlation may be weaker.

In this study, participants under the influence of alcohol did not report an increase in craving strength (in contrast to Burton & Tiffany, 1997) but did have higher indulgence rates. However, the number of reports of cravings under the influence of alcohol was low (111) compared to the total number of trials completed (1063) so these results may be unreliable. The population used for the current study were students for whom a culture to go out in the evenings is common; to ensure compliance with the task, times at which participants reported cravings (when they were prompted, within set timeslots) were limited within the current study. Future research could include asking participants to complete their task later into the evening, when an increased effect of alcohol may be more common and provide a larger sample for analysis.

Playing Tetris did not appear to change participants' retrospective evaluation of their worst craving experience from the baseline, compared to the follow-up (using the CEQ), regardless of intervention assignment; but then this craving often would not have coincided with one of the seven daily prompts to play Tetris.

Taking all of these findings into account, playing Tetris seems to weaken a current craving but it did not have a general effect in weakening the initial strength of cravings that occurred over the week, and the effect was constant, neither wearing off nor accumulating. As a support tool, Tetris could help people manage their cravings in naturalistic settings and over extended time periods. This finding is consistent with theories such as Elaborated Intrusion Theory (Kavanagh et al, 2005) and Tiffany's cognitive theory of craving, which view cravings as conscious states supported by limited capacity cognitive processes. Laboratory research on the effects of working memory loads on craving has focused primarily on food cravings. The present study shows that this research generalizes to naturalistic settings and to cravings for addictive substances and activities that do not involve consumption.

Chapter 7:

7.1. Experiment Overview:

This aim of this thesis was to firstly explore the interaction between craving and cognition, both the impact of cognitive tasks on craving and the effect of craving on cognitive task performance, to compare Tiffany's (1990) theory and Elaborated Intrusion theory (Kavanagh, Andrade & May, 2005). The longer term aim was to develop a theory-based take-home technique to support people in managing their cravings.

The first five experiments tested a critical hypothesis that distinguishes EI theory from Tiffany's, that there will be greater mutual interference between food craving and visual cognition than between craving and auditory cognition. Experiment 1 examined the effect of craving on visual and verbal cognitive tasks. A visual 'colour wheel' task and digit memory tasks were employed. There was no effect of craving on either task when chocolate craving had been induced (based on Kemps, Tiggeman and Grigg, 2008) compared to a no-craving control.

Experiment 2 extended Experiment 1 by testing mutual interactions between craving and cognition. A similar chocolate craving induction protocol was used based on Kemps et al. (2008) but it was altered to measure the influence of the task on craving strength. Digit memory task was again used as the verbal task, but the computer game 'Tetris' was introduced as the visual task. As before, there was no effect of craving on task performance, but craving decreased in both conditions from the initial rating. This suggested that perhaps, craving imagery was more susceptible to interference than performance on the cognitive tasks.

Experiment 3, therefore examined the effect of task on craving that had been found in experiment 2, addressing a problem in the literature that effects of task modality and task load are often confounded. A total of 4 different tasks were employed in a between subjects design. Participants either watched a screen loading (having been told that the computer was running slowly but would load eventually), counted up in one's in their head, completed a digit memory task or played 'Tetris'. In all conditions, except for the load screen, craving decreased significantly from the initial craving rating.

As Experiment 3 used relatively untested tasks, for Experiment 4 more robustly tested measures were employed. Visual Pattern Tests were used as the visual task and digit memory was again used as the verbal task. Participants completed either a low memory load or a high memory load version of the task. Both visual and verbal high memory load tasks were effective at suppressing craving. However, only the visual task was effective at a low memory load. This provides some evidence for selective visual interference but only when cognitive loads are low. High load cognitive tasks reduce cravings regardless of modality. This suggests that tasks used to reduce cravings should have a high cognitive load and ideally, but not necessarily, use a visual modality.

Experiment 5 examined the findings from experiment 4 further. The visual patterns task and digit memory were once again employed, however only low memory load versions were used. A mind wandering condition was also used as a control measure. This time there was no effect of selective visual interference and no significant differences were present for any of the conditions. Conceivably, only high cognitive loads influence craving, but this interpretation does not explain the impact of a simple counting task in Experiment 3 or of a low-load visual patterns test in Experiment 4. In Experiments 2, 3, and 4 verbal and visual cognitive loads reduced craving, but mutual interactions between craving and cognitive performance were absent in Experiments 1 and 5. Despite testing a variety of cognitive loads and replicating the methodology of published studies, we were unable to either replicate the greater impact of visual compared with verbal loads reported in the literature (supporting EI theory, Kavanagh, Andrade & May, 2005) or to produce clear evidence that craving was affected equally by working memory loads in different modalities (supporting Tiffany, 1990). We were unable to identify reasons for these discrepancies and decided to move on to testing the impact of cognitive tasks on craving in real world settings, using a cognitively demanding visuospatial task where both theoretical positions would predict reductions in craving.

As a prelude to testing cognitive interference in real-world settings the design for experiment 6 tested naturally occurring, rather than induced cravings in a laboratory setting. Participants played 'Tetris' or watched a screen loading (having been told they were waiting for a program to be ready). Playing 'Tetris' for 3 minutes reduced craving in comparison to watching the load screen.

Study 7 used an EMA protocol to test the effect of playing 'Tetris' on natural cravings in a natural environment compared to a basic questionnaire control . Tetris was still effective at reducing craving in the field but did not have concomitant effects on indulgence of cravings, using the binary measure of this study, however more sensitive measure may have found an effect.

7.2. Discussion

7.2.1. How do the results of the laboratory based experiments with craving induction contribute to the literature?

The results from Experiment One showed that the chocolate craving induction was successful (based on Kemps, Tiggemann and Grigg, 2008). However, no interference of craving on either the visual (colour memory) or verbal (digit memory) working memory task was found. This null result contrasts with detrimental effect of craving on general cognitive performance reported by Kemps, Tiggemann and Grigg (2008) and the selective effects on visuospatial performance reported by Tiggemann, Kemps and Parnell (2010). This discrepancy led to the question of whether it was a problem with the design of the experiment or if there was no effect to find.

Therefore Experiment Two used a different task to load visual working memory - the computer game 'Tetris'. The verbal working memory task, however, stayed the same as digit memory has previously been found to be a valid and consistent measure of working memory (Andrade & Donaldson, 2007; Schendel & Palmer, 2007). For Experiment Two, the craving induction was altered slightly from Kemps, Tiggemann and Grigg's (2008) original design to further examine the nature of the interaction between craving and cognition. By measuring craving after task completion and before craving was re-induced, it was possible to test if the task decreased craving rather than the task performance being depleted by craving. Again, no effect of craving on task performance was found, however, there was an initial drop in craving, but then craving strength stabilised. The initial drop in craving was similar regardless of whether participants completed the verbal or visual task, in contrast to previously reported findings of stronger effects of visual tasks (Andrade, Pears, May & Kavanagh, 2012; Kemps & Tiggemann, 2007; Kemps, Tiggemann & Hart, 2005; Tiggemann, Kemps & Parnell, 2010; May, Andrade, Panabokke & Kavanagh, 2010).

Experiment Three, thus aimed to quantify the effect found in Experiment Two. Participants completed their visual or verbal assigned task once, rather than completing their assigned task repeatedly. Participants completed a craving induction before starting their assigned task and reported their craving strength after completing the task. The high load visual task (playing Tetris) and both the high (digit recall) and low (counting in one's) load verbal tasks decreased craving strength in comparison to the

low load visual task (watching a load screen). The effect of the low load verbal task was unexpected as previous research (Andrade, Pears, May & Kavanagh, 2012) has shown no effect of the task on craving strength. Participants reported anecdotally that counting up in one's silently required constant concentration, so the assumption that this was a low-load task may have been mistaken. Much research has shown an effect of visual task over verbal task on decreasing craving strength (Andrade, Pears, May & Kavanagh, 2012; Kemps & Tiggemann, 2007; Kemps, Tiggemann & Hart, 2005; Tiggemann, Kemps & Parnell, 2010; May, Andrade, Panabokke & Kavanagh, 2010). Experiment 3 however, did not find a difference in the effectiveness of visual and verbal tasks. Holmes, James, Coode-Bate and Deeproose (2009) used Tetris as an experimental intervention for traumatic memories, as well as comparing it to a 'Pub Quiz' (Holmes, James, Kilford and Deeproose, 2010). Tetris was effective at decreasing intrusive thoughts of a film participants had watched. It was also found to be more effective at decreasing intrusive thoughts than the Pub Quiz. Tetris was therefore chosen as the high load visual task as previous research had shown it to be an effective intervention. In Experiment 3, Tetris was found to decrease craving strength, however not more so than the verbal task. This could be due to the participants finding that playing Tetris was more engaging than completing digit list recall. It may also be due to the task loads not being matched properly and therefore the results could be due to a difference in task load rather than in task modality.

Experiment Four matched the task requirements of four cognitive tasks as closely as possible, so any impact on craving could be unambiguously attributed to either load or modality, rather than aspects such as novelty. The verbal task remained the same for Experiment Four, however, participants were asked to memorise either easy (short) or difficult (long) digit lists. For the visual memory condition participants were asked to memorise either easy (small) or difficult (large) visual patterns matrices. Both the difficult, high memory load tasks effectively decreased craving, however only the visual version of the easy task decreased craving over time. Experiment Five aimed to reproduce and extend the findings of Experiment 4, using only the low memory load tasks. Unfortunately, the results were not replicated – neither the visual nor the verbal task reduced craving- and it is not possible to identify which experiment has produced the anomalous result.

The culmination of these experiments highlights the complex nature of craving and cognition. The results show clearly that completing a high memory load task (regardless of which module of working memory is utilised) is effective at decreasing craving. This result does not clarify which of the two theories is correct in their explanation of craving. Tiffany (1990) proposed that if someone was experiencing a craving then all areas within their working memory would be affected as they were trying to suppress an activated action schema. Elaborated Intrusion Theory (Kavanagh, Andrade and May, 2005) posits that all areas within working memory have a role within craving; however visual working memory has a greater role than other areas, as imagery is pivotal in a craving experience. EI also proposes that if a task is engaging or demanding enough, craving can be suppressed to prioritise the task. Therefore, either theory would expect high memory load tasks (within any working memory sub-system) to suppress craving. Some evidence from these experiments suggests that there may be different effects with low memory load visual and verbal tasks, however as these results are unclear, it is not possible to draw a firm conclusion.

Previous research has however, found clear effects of visual task completion over verbal task completion (Andrade, Pears, May & Kavanagh, 2012; Kemps & Tiggemann, 2007; Kemps, Tiggemann & Hart, 2005; Tiggemann, Kemps & Parnell, 2010; May, Andrade, Panabokke & Kavanagh, 2010). This suggests that it is the result of Experiment Five, rather than Experiment Four, which is anomalous. A tentative conclusion could be drawn from previous research, suggesting that low load visual tasks are more able to decrease craving than low load verbal tasks. The results from Experiment Three do not however, support this conclusion, as it was a low load verbal task which was found to decrease craving strength and not the low load visual task. The verbal task was anecdotally reported by participants to require constant concentration and therefore may not have been a low load task. Thus, disregarding the tentative conclusion that low load visual tasks are more effective at decreasing craving than low load verbal tasks, would be ill-advised. The results of Experiment 4, and the aforementioned research would support the proposal of EI Theory (Kavanagh, Andrade & May, 2005) that imagery is central to craving, and therefore a task which uses the visuospatial sketchpad will be more effective at decreasing craving than an equivalent verbal task. Although this thesis and previous research suggests that EI Theory may be

a more plausible explanation of craving, it is important that before any solid conclusions are drawn further research is completed which runs a series of experiments examining and continuing to control for memory load and the impact it has on craving, whilst manipulating visual and verbal working memory through a series of different tasks.

During this thesis, the focus of the laboratory experiments moved from solely investigating the effect of craving on task performance, through briefly trying to investigate the possibility of a two-way interaction, to concentrating exclusively on the effect of task completion on craving strength. The focus changed throughout the thesis for one main reason, Experiments One and Two showed no effect of craving on task completion (two experiments do report an effect – Tiggemann, Kemps & Parnell, 2010; Kemps, Tiggemann & Grigg, 2008), but there are, many experiments which do show an effect of task completion on craving strength (Andrade, Pears, May & Kavanagh, 2012; Kemps & Tiggemann, 2007; Kemps, Tiggemann & Hart, 2005; Tiggemann, Kemps & Parnell, 2010; May, Andrade, Panabokke & Kavanagh, 2010). The investigation of craving and cognitive tasks in a laboratory setting may mean that participants choose to prioritise their limited cognitive memory to their assigned task rather than their craving, suggesting that cravings are vulnerable to interference. Kemps, Tiggemann and Grigg (2008) found that cognitive deficits were present when participants were experiencing a craving. The experiment however, only found this deficit in participants who reported to be high trait cravers of chocolate who showed slowed reaction times and decreased ability in an operational span task. Kemps, Tiggemann and Grigg (2008) therefore concluded the results showed support for Tiffany (1990). This finding was apparently post-hoc and limited to only people who experienced high trait chocolate cravings and cannot be applied to the general population. Elaborated Intrusion Theory (Kavanagh, Andrade & May, 2005) is also able to explain the results, as people who report themselves as high trait cravers are more likely to experience strong cravings and thus a greater effect on cognitive functioning is likely to be found. Tiggemann, Kemps and Parnell (2010) found selective interference in participants who were craving and completed a Corsi Block task (remembering the order in which squares were highlighted in a grid), but not on a digit span task or double span task (remembering the order that words appeared on a grid and the location in which they appeared). The digit

span task and Corsi Block task would appear to have fairly well matched task loads, but the double span task must impose a greater task load than either the Corsi Block or digit span task alone. The finding of Tiggemann, Kemps and Parnell (2010) is inconsistent with EI (Kavanagh, Andrade & May, 2005) and Tiffany (1990) which would both suggest a task with a greater cognitive load (double span task) would have greater interference than a lower load task. The finding is also inconsistent with that of Kemps et al (2008), as this time there was no effect of trait chocolate craving levels on task performance. Tiggemann, Kemps and Parnell (2010) propose that it is the necessity of combined recall demanded by a double-span task that loads primarily on the central executive. Due to the need to recall the items concurrently, the use of the visuospatial sketchpad and phonological loop is limited. They also posit that it could be that the verbal labels that participants were recalling aided in the recall for location. However, this thesis found that a low visual load cognitive task can interfere with craving (experiment Four), therefore even a minimal effect of using the visuospatial sketchpad during a task should show an effect if the effect was consistent.

As only two papers have reported findings showing an effect of chocolate craving on task, one of which only found this in a group of participants who were reported to be high cravers, it is not unreasonable to suggest that cravings are fragile to interference of cognitive tasks, more so than tasks are susceptible to interference from craving. Therefore the attention changed during this thesis to ensure effective development of a take-home technique rather than focussing on the complex intricacies of the interference of craving on cognitive tasks. Thus this thesis concentrated on the effect of cognitive task on craving strength. One area within the effect of cognitive task on craving strength, to which this thesis gave attention, was the teasing apart the effect of task modality on craving strength, compared to the effect of task load on craving strength. This was to ensure that the most effective take-home task could be employed. Previous research (Andrade, Pears, May & Kavanagh, 2012; Kemps & Tiggemann, 2007; Kemps, Tiggemann & Hart, 2005; May, Andrade, Panabokke & Kavanagh, 2010; Tiggemann, Kemps & Parnell, 2010) has compared visual and verbal tasks, but not all experiments provided well matched task loads for their visual and verbal conditions. For example, May et al. (2010) compared neutral visual or auditory imagery which offers a fair comparison (although untested for load); however Andrade et al.

(2012) compared the effect of plasticine modelling with counting, which does not offer a fair comparison, as the task demands differ considerably and their impact on a target cognitive task had not been assessed.

One factor which needed further assessment was the possibility of the fragility of induced cravings in a laboratory setting to interference compared to naturally occurring cravings; this was an important step in this thesis, to ensure the findings of the laboratory experiments were not due to the nature of induced cravings.

7.2.2. What was the significance of examining natural cravings in a laboratory based setting?

One of the aims of this thesis was to develop a take-home technique that would assist people trying to control their cravings in doing so. As was apparent from the previous findings, high memory load tasks were more effective and consistent at interfering with cravings. Therefore it was clear that the take-home technique needed to be a task which had a high load. It was also necessary to focus on tasks that participants would find engaging and would be willing to complete regularly to ensure that whenever a craving occurs they would want to undertake the task as a self-help measure rather than be put off by the idea of completing it. After much deliberation, it was decided that the computer game 'Tetris' was both a high memory load task and engaging enough to maintain interest in it. It has also been used in other research where it was found to be effective in decreasing unwanted visual imagery (Holmes, James, Coode-Bate and Deepro, 2009; Holmes, James, Kilford and Deepro, 2010). Therefore, the initial aim was to examine natural cravings in a controlled environment to ensure that the results were not due to any uncontrolled, confounding variables.

After an extensive literature review it was concluded that natural cravings had not been studied previously in a laboratory setting and so undertaking this research was a novel task that would bring a new methodology to the field. It is a necessary step in the study of cravings to test the applicability of results showing interference in induced cravings to naturally occurring cravings and ensure the results found are not due to induced cravings being more susceptible to interference. It is possible that induced cravings are 'weaker' - for example because the experimental triggers are temporary whereas physiological or natural environmental triggers might last longer - and therefore more prone to interference than naturally occurring cravings. The results would also confirm whether the use of induced cravings is possible within future research or whether all experiments need to use naturally occurring cravings. Experiment 6 showed that it was possible to decrease natural cravings in a laboratory based setting. This suggests that the reason that an effect of task completion was found in previous experiments (such as Experiments Two, Three, Four and Five) was not due to the craving itself being liable to degrade because it had been induced rather than occurring naturally. This confirmation of the effectiveness of tasks to interfere with craving suggested that

studying natural cravings in a natural environment would be the next logical step, using a similar method to that undertaken during Experiment Six. One conclusion that can be drawn from Experiment Six is that, when studying cravings in a laboratory setting, experimentally-induced cravings mimic naturally occurring cravings. This finding is consistent with both Tiffany (1990) and Elaborated Intrusion Theory (Kavanagh, Andrade and May, 2005) which both posit that cravings can be triggered both internally and externally. Exposure to an item can lead to a craving occurring for the item, but regardless of the trigger of the craving, the craving experience will be dictated by the person's environment and internal cues and coping mechanisms rather than by the trigger itself.

Anecdotally, during the development of Experiment Six, the original methodology was aimed at testing participants using iPods as a further step towards studying natural cravings in a natural environment. Due to technological problems it was not possible to do so. Therefore, the tasks were adapted to be completed on laptop computers, nevertheless, this led to a more fully developed take-home task for studying cravings in the iPod Study (Study 7). It also highlighted the current limitations with technology when there are limited monetary budgets. This factor is something which is likely to always limit the application of interference with craving and so must be accounted for in developing tools. For example, although an App could be developed to install on participants phones, Apps are specific to the type of smart phone and would therefore need to be developed for a variety of operating systems. Work is currently being undertaken in Brisbane to address the drinking culture in teenagers. Part of the work is the development of an App. Although their budget is comparatively large, they still have to limit the App development to one make of phone operating system. Rather than developing a mediocre app for all phones, they are developing a well-targeted app for one make of phone. Until syntax for developing App's for all phone operating systems becomes simpler, or universal (or someone is given an unlimited budget), this need to focus resources is likely to be ongoing and may limit possible craving interference tools and techniques. These possible limitations were allowed for in the development of the Study Seven, in which technology was designed to allow for accurate measuring of craving experiences in natural environments. Whilst piloting Experiment 6, participants were stopped by the experimenter and asked to complete a very brief questionnaire and

task whilst they were on campus. It was noticed that most participants continued to indulge in their craving (such as smoking or eating) whilst completing the task even when asked to purely focus on completing the task, or they declined to take part because they were on their way to indulge their craving. This anecdote was important in the development of Study 7, as it highlighted the necessity of ensuring participants engaged in completing the task and paused their current activity whilst doing so. This is also an important factor to account for in future experiments.

7.2.3. Natural Cravings in Naturalistic Environments, Implications for future research and application.

The culmination of this thesis was to investigate natural cravings in a natural environment. This provided an important test of the generalizability of laboratory findings and a step towards developing take-home interventions for managing cravings during weight management or drug quit attempts. Participants were asked to document their cravings on iPod's when prompted, with the experimental condition also playing the computer game Tetris and then reporting their craving strength again. The results clearly showed that 'Tetris' was effective in naturalistic environments, as it was in the laboratory at decreasing craving. However, playing Tetris did not decrease the likelihood of indulgence in the desired item, using a binary measure, however other more sensitive measures may have found an effect.

Kemps and Tiggemann (2013) used dynamic visual noise (DVN) to interfere with cravings in naturalistic settings, by asking participants to watch DVN after completing a paper-based diary in response to their cravings. DVN decreased craving strength for naturally occurring food cravings in comparison to a questionnaire only control. Hsu et al. (2014) found that participants reported that they had experienced fewer cravings generally and for unhealthy foods specifically in post-intervention surveys compared to pre-intervention surveys. Knäuper et al (2011) used a visual imagery technique to interfere with craving compared to other control conditions such as a verbal control. The imagery technique decreased craving in comparison to the other tasks. In Study Seven (of this thesis) when participants played Tetris their craving was successfully decreased, however, their likelihood to indulge remained unaffected. Knäuper et al (2011) were also unsuccessful at reducing indulgence through the use of an imagery intervention, compared to three non-imagery based interventions. These two studies do not support the proposition that when a person is craving they are more likely to eat the item they are craving. However, Kemps and Tiggemann (2013) did find that dynamic visual noise reduced consumption, compared to a monitoring only control. Again, Hsu et al. (2014) found unhealthy snacking decreased when participants completed an imagery intervention compared to a monitoring only control. Study Seven and Knäuper et al (2011) measured consumption of the specific item craved, whereas Kemps and Tiggemann (2013) and Hsu et al. (2014) measured general consumption after craving.

This may have led to the data collected showing two different aspects of indulgence and thus the difference in the findings. The two studies which examined consumption of the item craved (Study 7; Knäuper et al., 2011) suggest that actual intake is more difficult to interfere with than the craving itself. Therefore future research ought to continue to measure specific consumption as not all cravings can be generalised (for example someone craving a cigarette whilst trying to quit, may not be able to provide a general substitute to decrease) and although a general decrease is positive for many substances (such as food), many also need to be decreased specifically (such as nicotine).

Another difference may have again, been between our methodologies rather than it being the effectiveness of the task. Kemps and Tiggemann (2013) asked participants to complete paper based diaries which have no way of tracking when the participant completed the diary, so is possible that participants were completing them retrospectively (Stone et al, 2002) and thus the data would be less accurate (Shiffman et al, 1997). Shiffman et al (1997) did not posit that only one condition would be affected by retrospective recall and thus both the control and experimental condition would be likely to have been affected. The data still supported the proposed hypothesis that craving episodes would be affected by DVN, compared to the questionnaire only control. Although this experiment found selective interference, the combination of retrospective recall and participants possibly being aware of the intended effect of the DVN (having provided their own baseline data, completing the questionnaire only task for 2 weeks) may have selectively skewed the recall of the experimental condition, if participants were expecting it have had an effect.

It is also possible that, as participants were asked to complete the task whenever they had a craving (Hsu et al., 2014; Kemps and Tiggemann, 2013; Knäuper et al., 2011) rather than only when prompted (Study Seven) they were reporting on a greater number of their craving experiences and thus the data provided a greater depth of information for analysis. Hsu, et al (2014) found that participants who completed an imagery task and snack tracking task in comparison to completing a snack tracking task alone, reported lower indulgence rates (their unhealthy snacks decreased from four a day, to two). This design also allowed participants to review their previous behaviours and whether they chose an unhealthy snack, a healthy snack or no snack after experiencing

a craving. The use of a mobile phone ‘app’ meant that participants were likely to have it with them at all times, with no added inconvenience, this methodology should be applied whenever possible in the future as it also allows accurate timing and measurement of participation to be tracked. Kemps and Tiggemann (2013) and Hsu et al (2014) show that indulgence in the craved item is decreased when a visual task is implemented compared to a no task control. Although four studies have demonstrated the effectiveness of a visual task at decreasing craving, further research should aim to combine positive aspects of each study. This could be the use of an app to monitor task completion (Study Seven; Hsu et al., 2014) and asking participants to report on all cravings (Hsu et al., 2014; Kemps and Tiggemann, 2013; Knäuper et al., 2011), rather than only when prompted (Study Seven) and allow for instances when it was not a food craving that the participant was experiencing (Study Seven). This would provide more detailed information about cravings in a naturalistic environment and aid in the development of effective interventions.

One main concern with Study Seven (as it was with Kemps & Tiggemann, 2013) was the lack of a second measure of craving strength in the control condition. Nevertheless, it was decided that this was the best design for a number of reasons. Firstly, the control condition would need a task in which participants were doing nothing. Secondly, participants would need to not be aware that they were doing nothing. Thirdly, the task would have to be designed so that participants would not be able to be distracted by anything else (to ensure that it was the intervention that was being measured, not their surrounding environment). The previous experiments in this thesis used a load screen to ensure that these criteria were met. This was not a suitable task for repeated use as participants would conclude that it was not meant to load after it had ‘failed’ a second time. The results from this thesis suggest that using a control condition such as counting (Experiment Three; Andrade, Pears, May & Kavanagh, 2012) may not provide as clear results as having a second task which is a ‘do nothing’ control, without participants being aware of this fact. Future research would again need to try and resolve this problem. It may be possible to use a no task control in which participants hear a ‘beep’ and then respond to the final question, repeating the craving strength measure again. This would need controls put in place to ensure participants were not continuing with their previous activity (or starting to indulge in their craving) during the delay whilst

waiting for the ‘beep’. This could include asking participants to insert headphones whilst completing the task.

Study Seven has shown it is possible to measure and interfere with cravings in a natural environment. It has also shown that laboratory data can be replicated in the field. This replication is paramount as it confirms the robustness of the interference techniques being used.

The iPod experiment was not designed to address the differences between EI Theory (Kavanagh, Andrade and May, 2005) and Tiffany (1990). Therefore it does not add to the previous discussion about any conclusions that can be drawn from these experiments. However, this again could be further investigated in future experiments by the addition of a further experimental condition, which uses a verbal task (such as digit memory) rather than visual. The experiment would need to control for the effect of working memory load on the effectiveness of the task at decreasing craving. Other research could also benefit from the addition of a verbal condition to address the differences between EI Theory (Kavanagh, Andrade & May, 2005) and Tiffany (1990). Kemps and Tiggemann (2013) used dynamic visual noise to interfere with cravings, which is a passive form of interference, requiring participants to watch but not interact with it. The authors could provide evidence for either EI Theory (Kavanagh, Andrade & May, 2005) or Tiffany (1990) by using a passive verbal task as a second experimental measure, such as irrelevant speech which participants would listen to but again not interact with. Hsu et al. (2014) used visualizations to interfere with craving and consumption. The more vivid the image (visualized by the participant) the more effective the app at improving snacking choice. By adding a condition which required participants to produce auditory imagery (similar in nature to the visualizations) their experiment could have also differentiated between EI Theory (Kavanagh, Andrade & May, 2005) and Tiffany (1990). Knäuper et al., (2011) had an auditory control condition in which participants recited the alphabet backwards. A more appropriate auditory task could have been to have participants produce auditory imagery in a similar manner to the visual imagery task. This would ensure that the task loads were similar.

The technology which is now available to use has allowed previous issues with data collection to be addressed. The iPod experiment used date and time stamps on the data files collected to check if participants were compliant and completed their task within the time assigned. This meant that the data and therefore the results collected were more reliable; whereas previously Stone et al, (2002) found that much fewer diary entries were completed at the correct time than participants reported. As previous research has shown that information recalled retrospectively can be incorrect (Shiffman et al, 1997) it is important that information is collected during the event itself. This use of technology should be applied in future research to ensure participant compliance.

During the introduction to this thesis, the role of imagery within different cognitive areas (such as decision making and motivation) was briefly reviewed. This thesis adds some scant evidence to previous research suggesting that visually based cognition has an important role in everyday life. When participants played Tetris, they reported fewer intrusive thoughts than those who did not (Holmes, James, Coode-Bate & Deeproose, 2009) and again playing Tetris reduced intrusive thoughts in comparison to participants completing a pub quiz (Holmes, James, Kilford & Deeproose, 2010). In this thesis, Tetris was found to decrease cravings compared to a no task control both in a laboratory setting and when used in a natural environment, with naturally occurring cravings. This suggests when a visually based cognitive task is completed; emotionally laden thoughts can be interfered with. Van Dillen, Papies and Hofmann (2013) found that temptation was reduced when a cognitive loading task was being completed. They measured participant's attention to stimuli whilst asking participants to complete a digit span task, and concluded that control of temptation would facilitate self-regulation. Van Dillen and Koole (2007) found participants reported a less negative mood in response to a negative stimulus when completing a high working memory load task in comparison to low and no load tasks. It is plausible that this is a common relationship between cognitive tasks and emotion; emotions are cognitively interpreted and the interpretation cannot occur (and the emotion cannot be experienced) without cognitive resources. The role of emotive cognition has many applications within psychology, such as cognitive behavioural therapy, which allows a person to methodically work through emotion issues by the use of cognitive interventions. The research into the

interaction between craving and cognition adds to this body of evidence, showing that cognition and emotion can influence one another.

Further development and investigation is needed to design a fully functioning take-home task. The interference technique would need to be interesting enough to keep participants engaged over longer periods of time. It would also need to be tested on a variety of substances, to ensure that the findings from this thesis were reliable. The use of technology ought to be maintained for several reasons. Firstly, it provides a methodology for assessing compliance. Secondly, as technology improves it provides more techniques for examining and interfering with craving. And thirdly, as technology is at the forefront of the current world it is important that the development of the interference techniques allow for this and 'fits' with people's everyday life to ensure their continued use.

During this thesis, the investigation of craving has not lead to a definitive answer as to which of the theories originally discussed provides a clear explanation for all the nuances of craving. It is clear that if a task has a high working memory load, regardless of the subsystem on which it relies, it is effective at decreasing craving. The results from lower load working memory tasks are less clear and warrant further investigation. The wealth of evidence, with some support from the findings of this thesis, shows that imagery is central to craving experiences which suggest that EI Theory (Kavanagh, Andrade & May, 2005) provides a more thorough explanation of craving experiences than Tiffany (1990). One aspect, however that does need further development within the theory is why evidence showing interference with cognitive tasks during a craving experience is lacking compared to the many experiments showing that visual tasks interfere with craving experiences. Although the theory does discuss it being an interaction, the implication is that there would be effects both on cognitive tasks and craving strength which is not evident. Limited research has currently been completed with participants who were dieters and thus may experience stronger cravings (Kemps & Tiggemann, 2005; Kemps, Tiggemann & Marshall, 2005; Kemps, Tiggemann, Wade, Ben-Tovin & Breyer, 2006; Vreugdenburg, Bryan & Kemps, 2003). The dieters performed poorly in comparison to the non-dieters on a variety of cognitive tasks. Only two experiments have found an effect of cravings on cognitive tasks in non-dieters (Kemps, Tiggemann & Grigg, 2008; Tiggemann, Kemps & Parnell, 2010). This

suggests the effect of craving on cognition may be limited. If cravings are more susceptible to interference from competing cognitive tasks, rather than cognitive tasks being susceptible to interference from cravings it would support the aim of this thesis, to provide a take-home cognitive task to interfere with cravings within the general population.

This thesis also focussed on the development of the take-home technique which used a high load task which was engaging to participants, thus 'Tetris' was employed for this purpose. Tetris clearly decreased cravings in a natural environment, although it was not effective at decreasing indulgence rates in comparison to a no task control. Experiments 6 and 7 also showed that it is possible to interfere with naturally occurring cravings as effectively as induced cravings and that the interference shows similar effects.

Therefore, although further work is needed, this research has provided a strong foundation for the development of cognitive strategies for managing cravings and for the applicability of laboratory findings to real-world settings.

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Appendix 1: CEQ Now

Think about your feelings towards chocolate NOW

Right now...

01...how <u>strongly</u> do you <u>want</u> some chocolate?		1 (not at all)	6	(Extremely) 11
02...how much do you <u>feel</u> like you <u>need</u> to eat chocolate?		1 (not at all)	6	(Extremely) 11
03...how <u>strong</u> is the <u>urge</u> to eat chocolate?		1 (not at all)	6	(Extremely) 11
04...how <u>hard</u> is it to <u>think</u> about anything else?		1 (not at all)	6	(Extremely) 11
05...how <u>hard</u> is it to <u>get</u> other things done?		1 (not at all)	6	(Extremely) 11

Right now, how vividly are you...

06...<u>imagining</u> some chocolate?		1 (not at all)	6	(Extremely vividly) 11
07...<u>picturing</u> chocolate?		1 (not at all)	6	(Extremely vividly) 11
08...imagining its <u>taste</u>?		1 (not at all)	6	(Extremely vividly) 11

09...imagining its smell? | | | | | | | | | | | |
 1 (not at all) 6 (Extremely vividly) 11

10...imagining what it feels like in your mouth? | | | | | | | | | | | |
 1 (not at all) 6 (Extremely vividly) 11

11...imagining how your body would feel if you had some chocolate? | | | | | | | | | | | |
 1 (not at all) 6 (Extremely vividly) 11

Right now, when you're thinking about chocolate...

12...how unpleasant or distressing are the thoughts? | | | | | | | | | | | |
 1 (not at all) 6 (Extremely) 11

13...how guilty or worried are you about the thoughts? | | | | | | | | | | | |
 1 (not at all) 6 (Extremely) 11

14...how much worse do you think things would be if you had some chocolate? | | | | | | | | | | | |
 1 (not at all) 6 (Extremely) 11

15...how hard are you trying not to think about chocolate? | | | | | | | | | | | |
 1 (not at all) 6 (Extremely) 11

16...how intrusive are the thoughts? | | | | | | | | | | | |
 1 (not at all) 6 (Extremely) 11

17. How much pleasure do you feel when you | | | | | | | | | | | |

10. **imagine how your body would feel if you had chocolate?** | | | | | | | | | | | |
 1 (not at all) 6 (Extremely) 11

At that time, when you thought about chocolate...

11. **how hard were you trying not to think about chocolate?** | | | | | | | | | | | |
 1 (not at all) 6 (Extremely) 11

12. **How much pleasure do you feel when you imagine doing it?** | | | | | | | | | | | |
 1 (not at all) 6 (Extremely) 11

13. **How much relief do you feel when you imagine doing it?** | | | | | | | | | | | |
 1 (not at all) 6 (Extremely) 11

*Now, we want you to answer some similar questions. But this time, please answer HOW OFTEN these things happened over the TEN MINUTES.
Over the last ten minutes, HOW OFTEN did you ...*

14. **...want chocolate?** | | | | | | | | | | | |
 1 (not at all) 6 (Constantly) 11

15. **...think about needing chocolate?** | | | | | | | | | | | |
 1 (not at all) 6 (Constantly) 11

16. **...have an urge to eat chocolate?** | | | | | | | | | | | |
 1 (not at all) 6 (Constantly) 11

17. **...find it hard to think about anything else?** | | | | | | | | | | | |
 1 (not at all) 6 (Constantly) 11

<i>Over the last 10 minutes, how often did you...</i>			
18. <u>picture eating</u> chocolate?		1 (not at all)	6 (Constantly) 11
19. ...imagine what it would <u>taste</u> like?		1 (not at all)	6 (Constantly) 11
20. ...imagine what it would <u>smell</u> like?		1 (not at all)	6 (Constantly) 11
21. ...imagine what it would <u>feel</u> like in you mouth or throat?		1 (not at all)	6 (Constantly) 11
22. ...imagine <u>how your</u> <u>body would feel</u> if you had chocolate?		1 (not at all)	6 (Constantly) 11

When you thought about chocolate over the last 10 minutes, how often...

23. ...were you trying <u>not</u> <u>to think about chocolate?</u>		1 (not at all)	6 (Constantly) 11
24. ... were the thoughts <u>intrusive?</u>		1 (not at all)	6 (Constantly) 11
25. ... <u>did you have a</u> <u>strong urge to have</u> chocolate?		1 (not at all)	6 (Constantly) 11
26. ...How much <u>pleasure</u> do you feel when you imagine doing it?		1 (not at all)	6 (Constantly) 11

**27. ...How much relief do
you feel when you
imagine doing it?**

