The Reduction of Food Cravings and the Elaborated-Intrusion Theory of Desire

by

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A thesis submitted to Flinders University in partial fulfilment of the requirements for the degree of Doctor of Philosophy (Clinical Psychology)

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23rd November 2018

Summary

Food cravings are a strong desire to consume a specific food. They are frequently reported by individuals who are overweight or obese, and are thought to contribute to the over-consumption of high calorie foods. Food cravings have also been linked to binge eating and other forms of disordered eating. Therefore, there is a need to develop and test interventions to reduce food cravings and craving-related consumption. The Elaborated-Intrusion Theory of Desire (Kavanagh, Andrade, & May, 2005) proposes that cravings are a two stage process, by which initial intrusions (stage one) are elaborated with vivid, multi-sensory imagery (stage two). The overarching aim of the present thesis was to investigate interventions for reducing food cravings within the framework of the Elaborated-Intrusion Theory.

The thesis contains 4 empirical studies (two published, two under review). Study 1 was a systematic literature review, which evaluated the efficacy of existing psychological interventions for reducing food cravings. Overall, imagery-based techniques were most effective at reducing food cravings. Mindfulness techniques also showed promise, particularly if conducted over several sessions.

Study 2 investigated the role of craving-related thoughts and images in predicting craving intensity and craving-related consumption in an online study of Australian and American women. The results showed that craving-related images were more important in predicting craving intensity than craving-related thoughts. However, neither craving-related thoughts nor images predicted craving-related consumption, although craving intensity did.

Studies 3 and 4 were laboratory-based experiments which investigated whether cognitive defusion and guided imagery could reduce the underlying mechanisms they are theoretically proposed to target, namely craving-related thoughts and images, respectively. Study 3 recruited a sample of young women, and Study 4 a sample of regular chocolate cravers. Cognitive defusion reduced both the intrusiveness of craving-related thoughts and the vividness of craving-related

imagery, suggesting that targeting the initial thought stage of the craving process may prevent elaboration from occurring. Guided imagery only reduced the vividness of imagery in chocolate cravers. Both techniques reduced craving intensity, but neither reduced craving-related consumption.

Finally, Study 5 sought to investigate whether cognitive defusion and guided imagery could reduce naturalistic food cravings and related consumption in the field. The study was conducted over a two-week period consisting of a 7-day baseline and a 7-day intervention. The results showed that cognitive defusion and guided imagery were equally effective in reducing craving intensity and related consumption. Both techniques reduced the number of craving-related calories consumed across the intervention week. This suggests that the reduction in craving-related calories could potentially accumulate to a meaningful reduction in consumption across weeks and months.

Overall, the thesis contributed to our understanding of craving-related thoughts and images and their involvement in the food craving process. The thesis provided good evidence for both cognitive defusion and guided imagery as effective, brief, and easy-to-use techniques for reducing both craving intensity, and craving-related consumption in the field. The results in the present thesis support the predictions of the Elaborated-Intrusion Theory, and lend themselves to practical applications for dealing with problematic cravings in everyday life.

Declaration

I certify that this thesis does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

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Acknowledgements

I would like to acknowledge the funding I received from the Australian Government with the Australian Postgraduate Award and the Australian Government Research Training Program Scholarship. I would also like to thank Flinders University and the School of Psychology for providing me with funding to conduct my research and present the findings at conferences in Australia, Scotland and Italy. I would like to thank my supervisors Professors Eva Kemps and Marika Tiggemann for their support, suggestions and insights into my research throughout my candidature. I have learned and developed so much under your tutelage, and I am truly appreciative of the time and effort you put in to help me grow as a researcher.

Thank you to Sarah Hollitt, Paul Douglas, Ben Maddock and David Hall for their logistic and technical support when planning studies and collecting data. Thank to Paul Williamson for his statistical advice, and to the excellent administrative staff in the School of Psychology, including Janine, Tracey and Natalie. A huge thank you to Professor Michael Gradisar for his mentorship in both clinical and research spheres, I really appreciate your support.

To my PhD friends and colleagues, it has been a truly special experience going through this journey together. I will not forget the many laughs, hugs and tears we have shared. Thank you especially to my 'big sisters' Naomi, Rachel, Sam, Sue and Ashleigh who paved the way in the years before me, my office buddies Stacey and Ella who have been a huge support and source of laughter, plus the legendary Girl Cavers Jamie, Cele, CJ and Victoria. I would not have made it to the end without you all cheering me on. To my besties Lia, Emma and Ella, thanks for being such encouraging babes. Thanks to my biggest cheerleaders, my family, who have been there for me from the start. Thank you to my partner Shelvin: your support and encouragement means the world to me. Thank you for helping me gain perspective, see the bigger picture and look forward to life post-PhD! Finally, to the individuals who volunteered their time to participate in my research; this thesis would not be possible without you.

CHAPTER 1: GENERAL INTRODUCTION

Chapter Overview

This general introductory chapter aims to provide a brief background to food cravings and strategies for reducing them. First, food cravings are defined, along with their antecedents and consequences. Next, the Elaborated-Intrusion Theory of Desire, a theory of the food craving process, is outlined as a theoretical underpinning to the thesis. Existing strategies targeting eating behaviour and food cravings in particular are summarised, including imagery- and mindfulness-based strategies. Finally, the chapter outlines the main aims of the thesis and gives an orientation to the subsequent chapters.

Food Cravings and Their Consequences

Craving is the intense urge to ingest a particular food, which is difficult to resist (Weingarten & Elston, 1990). It is cognitive in nature, and has been described as a subjective, motivational state (Shiffman, 2000; White, Wisenhunt, Williamson, Greenway, & Netemeyer, 2002). Cravings are powerful in motivating individuals to obtain and consume the craved substance (May, Andrade, Panabokke, & Kavanagh, 2004). Craving is distinct from hunger. Whereas hunger can be satisfied by ingesting food in general, craving is for a specific type of food (Pelchat, 2002). Commonly craved foods are those high in fat, salt and sugar, with chocolate the most commonly craved food in Western society (Hill & Heaton-Brown, 1994; Kemps & Tiggmann, 2013; Weingarten & Elston, 1990; Weingarten & Elston, 1991).

The origins of food cravings range from the physiological to the psychological. Physiological origins include homeostatic irregularities (Wurtman & Wurtman, 1986), nutritional deficiencies (Wardle, 1987) and hormonal imbalances (Hill & Heaton-Brown, 1994), including menses in women (Rozin, Levine, & Stoess, 1991). Psychological origins include negative mood states (Hill, Weaver, & Blundell, 1991; Christensen, 2007) such as depression, stress and boredom (Davis et al., 2011; Sinha & Jastreboff, 2013; Weingarten & Elston, 1991). Food cravings have also been associated with bulimia nervosa (Waters, Hill, & Waller, 2001), binge eating (Gendall, Joyce, Sullivan, & Bulik, 1998; Mitchell, Hatsukami, Eckert, & Pyle, 1985), health problems arising from being overweight and obese (von Deneen & Liu, 2011; Wurtman & Wurtman, 1986), and poorer performance in cognitive tasks (Kemps, Tiggemann, & Christianson, 2008).

Potential consequences of particular concern are health problems associated with being overweight and obese. Global prevalence of overweight and obesity increased by 27.5% for adults from 1980 to 2013 (Ng et al., 2014). Currently, over two thirds of adults worldwide are classified as overweight or obese, with an increase from 857 million in 1980 to 2.1 billion in 2013 (Mitchell & Shaw, 2015; Ng et al., 2014). High body mass index has been consistently associated with illness and death from cardiovascular disease, cancer, diabetes, osteoarthritis and chronic kidney disease (Lim et al., 2013; Ng et al., 2014). Potential explanations for the global increase in body mass index revolve around increased calorie intake and changes to the contents of diets to include less fruit and vegetables and more processed foods high in fat, salt and sugar (Ng et al., 2014; WHO, 2018). Understanding eating behaviour is therefore essential in addressing what has been labelled a global obesity pandemic (Popkin, Adair, & Ng, 2012). Food craving has been proposed as a contributing factor to the consumption of high caloric foods (May, Andrade, Kavanagh, & Hetherington, 2012), not only for individuals who are overweight and obese, but also for individuals of healthy weight (Hofmann, Baumeister, Förster, & Vohs, 2012; Lafay et al., 2001). Historically, weight management approaches have also been inadequate. In light of the negative consequences associated with food craving, there is a need to develop and evaluate interventions to combat such cravings.

The Elaborated-Intrusion Theory of Desire

The Elaborated-Intrusion Theory of Desire (Kavanagh, Andrade, & May, 2005; May, et al., 2012) states that craving is a cyclical process which has two distinct stages. In the first stage, initially pleasurable, spontaneous thoughts about a target substance are triggered. In the second stage, these thoughts are elaborated with mental imagery. The theory postulates that the first stage of craving is when an initial food-related thought, or intrusion, comes to mind. Intrusions appear seemingly unconsciously and automatically, as the cognitive (e.g., thoughts), emotional (e.g., memories associated with the food) and physiological (e.g., hunger) cues and associations that trigger these thoughts are abundant in our environment. An intrusion about an appetitive food might be initially pleasurable and may have several positive cognitive and emotional connotations tied with pleasant past experiences and memories involving that food. As this experience is pleasurable, one begins elaborating upon it with vivid imagery to create a realistic representation of the target (e.g., a mental image of oneself breaking off and eating a piece of chocolate).

Elaboration can involve multiple sensory modalities, such as sight, touch, smell and taste. Cognitive elaboration is intense, emotionally charged and can use limited cognitive resources, particularly if current resources are low. The experience of elaboration can be positive, but can become unpleasant if the intense desire for the substance cannot be satisfied. Dissonance grows between the individual’s goal (e.g., ingesting the substance) and reality (e.g., no access to the substance). Awareness of the target deficit can produce what feels like a downward spiral of worsening mood. To alleviate this negative state, a person must either consume the food or undertake some other activity (e.g., distraction or redirecting of thoughts) to break the cycle. However, even if the cycle is broken by a distracting task, the same triggers and cues remain and consumption may still result after a delay.

Studies have investigated the craving process, and showed that both intrusions and mental imagery play a key role in the development of cravings. The focus of many studies has been the second elaboration stage. For example, in a questionnaire study, May, Andrade, Panabokke and Kavanagh (2004) found that mental imagery was commonly reported as part of craving. Other research has supported the suggestion that imagery features prominently in cravings for a range of substances including food (Andrade, May, & Kavanagh, 2012; Kemps & Tiggemann, 2010; May et al., 2004; Tiggemann & Kemps, 2005). Tiggemann and Kemps (2005) further found that of the five sensory modalities, the visual, gustatory and olfactory modalities featured most prominently in food cravings. In addition, they showed that imagery vividness uniquely predicted craving intensity (Tiggemann & Kemps, 2005). May, Andrade, Kavanagh and Penfound (2008) found that in addition to craving-related imagery, sudden intrusions were commonly experienced during food cravings, showing further support for the Elaborated-Intrusion Theory's two-stage account of food cravings. A more recent, much larger study confirmed a three-factor structure of intensity, imagery and intrusiveness across a range of craved targets which included alcohol, cigarettes, chocolate and food (May et al., 2014). However, in general, few studies have focused on the initial intrusion stage of the craving process.

Interventions for Reducing Food Cravings

Interventions developed within the framework of the Elaborated-Intrusion Theory focus on interrupting or inhibiting one or both of the two stages of the process: craving-related thoughts and imagery. The majority of studies to date have used interventions to target the mental imagery component of food cravings. Most interventions aim to combat craving-related imagery with alternative imagery by using up limited cognitive resources associated with working memory. In laboratory studies, activities such as forming alternative images of objects (e.g., "imagine the appearance of a rainbow") or smells (e.g., "imagine the smell of freshly mown grass"; Hamilton, Fawson, May, Andrade, & Kavanagh, 2013; Harvey, Kemps, & Tiggemann, 2005; Kemps & Tiggemann, 2007), enjoyed activities (e.g., walking on the beach; Knäuper, Pillay, Lacaille, McCollam, & Kelso, 2011), modelling clay into pyramid and cube shapes with hands hidden from direct view (i.e., forming mental representations of the shapes; Andrade, Pears, May & Kavanagh, 2012), watching dynamic visual noise (a flickering, random pattern of black and white dots; Kemps, Tiggemann, & Hart, 2005; Kemps & Tiggemann, 2013; Kemps, Tiggemann, Woods, & Soekov, 2004; McClelland, Kemps, & Tiggemann, 2005) and even playing the computer game 'Tetris' (Skorka-Brown, Andrade, & May, 2014; Skorka-Brown, Andrade, Whalley, & May, 2015) have been shown to reduce cravings. Imagery-based craving reduction techniques have also been successfully translated into field settings, targeting naturally occurring cravings. Kemps and Tiggemann (2013), Knäuper et al. (2011) and Skorka-Brown et al. (2015) all found that their respective imagery-based techniques reduced cravings for food.

Studies which test imagery-based strategies for reducing cravings have mostly measured craving intensity as the key outcome measure. Fewer studies have tested the effect of those strategies on resultant consumption. Studies that assess craving-related consumption as an outcome measure are most often field studies that measure craving-related consumption with diary recordings and ecological momentary assessment (Kemps & Tiggemann, 2013; Knäuper et al., 2011; Skorka-Brown et al., 2015). Together, these studies provide mixed results in support of craving reduction techniques also resulting in reduced craving-related consumption. Whereas Kemps and Tiggemann (2013) found that dynamic visual noise reduced consumption, Skorka-Brown et al. (2015) and Knäuper et al. (2011) did not find that their respective imagery-based techniques impacted consumption. Craving reduction techniques would ideally reduce both craving strength and craving-related consumption. Therefore, the relationship between cravings and consumption is an important avenue for further research.

While the imagery component of the craving process has been the focus of a range of craving reduction techniques, fewer techniques have been designed to specifically target the initial intrusion stage of cravings. In their paper about the application of the Elaborated-Intrusion Theory specifically to food cravings, May and colleagues (2012) suggested that targeting the intrusion stage with mindfulness-based interventions could be an avenue for future research. They suggested that mindfulness-based techniques may allow individuals to accept and let go of their intrusions in order to prevent subsequent elaboration (May et al., 2012).

In support, mindfulness-based tasks have been used to reduce cravings and consumption of palatable foods. Mindfulness is understood as the practice of non-judgemental acceptance of the present state of being, including internal feelings, sensations and thoughts (Kabat-Zinn, 2003, Bishop et al. 2004). Key strategies from mindfulness therapies do not specifically aim to reduce or challenge negative thoughts, as in cognitive therapy (Baer, 2003; Moffitt, Brinkworth, Noakes, & Mohr, 2012). Instead they promote acceptance and willingness to experience what cannot be controlled or changed (Baer, 2003; Bishop et al., 2004), and encourage behaviour that is consistent with an individual’s long-term goals and values. Mindfulness strategies are designed to counter conditioned avoidance of uncomfortable or negative thoughts, and involve learning to accept thoughts without changing, challenging or judging them (Hayes, Luoma, Bond, Masuda, & Lillis 2006).

Mindfulness interventions have been used to improve maladaptive eating behaviours for overweight, obese and healthy weight individuals. Different mindfulness strategies focus on different targets, within a range of internal experiences, such as thoughts, bodily sensations, and emotions. For example, body scan and breathing exercises may focus on attending to and accepting bodily sensations, whereas decentering techniques may focus on distancing the self from verbal content (e.g., thoughts) or emotions. These interventions, which range from a single session to multiple sessions delivered over several weeks, have resulted in a range of positive outcomes, including reduced BMI (kg/m^2) for overweight individuals (Dalen et al., 2010; Lillis, Hayes, Bunting, & Masuda, 2009; Tapper et al., 2009), and reduced binge eating (Dalen et al., 2010; Kristeller & Hallett, 1999; Smith, Shelley, Leahigh, & Vanleit, 2006; Tapper et al., 2009), external eating (Daubenmeier et al., 2011) and other eating pathology (Jurascio, Forman, & Herbert, 2010; Wanden-Berghe, Sanz-Valero, & Wanden-Berghe, 2010).

Mindfulness interventions have also been used to target food cravings. One intervention in particular, cognitive defusion, is a type of decentering or disidentification strategy. Decentering is a task which increases meta-cognitive awareness of one's internal experiences (Papies, 2017). When practising cognitive defusion, individuals view the verbal content of their internal experiences (e.g., thoughts) as mental events rather than facts or truths to which they must respond or behaviourally enact (Papies, 2017). When applied to the food craving context, cognitive defusion is thought to reduce reactive responses to food cravings (e.g., consuming the craved food) by promoting greater acceptance of those internal experiences (Forman et al., 2007; Papies, 2017). Research has indeed shown that cognitive defusion successfully reduces cravings (Lacaille et al., 2014) and chocolate consumption (Jenkins & Tapper, 2014), as well as impulses toward appetitive food cues (Papies, Barsalou, & Custers, 2012; Papies, Pronk, Keesman, & Barsalou, 2015).

The Comparison of Craving Interventions

May, Andrade, Batey, Berry and Kavanagh (2010), and Hamilton and colleagues

(2013) sought to test the predictions of the Elaborated-Intrusion Theory by comparing the effects of a mindfulness strategy (thought to target the intrusion stage) and an imagery strategy (thought to target the elaboration stage). The mindfulness techniques were body scan and breath focus, and the imagery-based technique was guided imagery. Body scan is a technique which guides individuals to focus on bodily sensations in different parts of the body. Breath focus is an exercise designed to focus attention toward sensations associated with breathing. These strategies were each tested against guided imagery, a technique in which individuals were asked to imagine a walk through the woods, incorporating different sensory modalities. Across two experiments, May et al. (2010) first compared breath focus and a distraction technique (diverting attention away from thoughts), and then body scan with guided imagery. They found that breath focus, body scan and self-directed or guided imagery were no better at reducing cravings than a mind-wandering control task. Hamilton et al. (2013) used a similar protocol in one experiment which compared body scan and guided imagery with a control condition. They found that both body scan and guided imagery resulted in reduced cravings relative to the control condition.

Several methodological limitations of these two papers were considered when developing the overarching aim of the present thesis to test strategies for reducing food cravings within the context of the Elaborated-Intrusion Theory of Desire. First, in the studies presented here, a different mindfulness intervention was selected to target the intrusion stage, namely cognitive defusion. This technique was believed to be a better match to guided imagery as a comparison technique as it too is focused on purely cognitive components, rather than attention to physiological sensations (as in body scan and breath focus). Attention to particularly the abdomen area may also inadvertently alert individuals to sensations of hunger. Further, the studies in the present thesis tested strategies with commonly craved foods such as chocolate and other typically craved foods, in contrast to breakfast food items used by Hamilton and colleagues (2013).

Aim of the Present Thesis

The present thesis had one key overarching aim, which was to investigate interventions for reducing food cravings within the context of the Elaborated-Intrusion Theory of Desire. Under this broad aim, the individual studies described in each chapter had their own specific aims. Specifically, sub-aims included evaluating existing interventions for reducing food cravings (Study 1, Chapter 2), further investigating the craving process, and particularly the role of craving-related thoughts in predicting craving intensity and related consumption (Study 2, Chapter 3), and testing cognitive defusion and guided imagery as strategies for reducing laboratory-induced chocolate cravings (Studies 3 and 4, Chapter 4) and naturalistic food cravings in the field (Study 5, Chapter 5).

Overview of the Thesis

The first study sought to compare the relative efficacy of existing interventions for reducing food cravings. Chapter 2 presents the results of Study 1, a systematic literature review conducted on studies which used strategies to reduce food cravings, and discusses the relative efficacy of strategies which can be categorised into four main groups; (1) imagery-based, (2) mindfulness-based, (3) cognitive and (4) movement, as well as a combination or comparison of these techniques. The purpose of the systematic review was to help decide whether the following studies would focus on intrusions, elaborations, or both, as the target of interventions to reduce cravings. Further, in the following chapter (Chapter 3), the second study aimed to extend previous research into the process of food cravings, with a particular focus on the role of craving-related thoughts and images, the strategies individuals typically use to resist their cravings, and the relationship between these strategies and the likelihood of consumption subsequent to cravings. Chapter 3 presents Study 2, which was an online questionnaire exploring these aspects of the craving experience in a sample of women from Australia and the USA. This study was designed to investigate in greater depth the role of intrusions and elaborations on cravings and consumption.

Together, the findings from the first two studies provide a backdrop to the latter three studies in the thesis, which are experimental studies testing strategies for reducing cravings for a range of foods, in both laboratory and field settings. The broad sub-aim of these studies was to investigate whether two techniques, cognitive defusion and guided imagery, could reduce cravings and resultant craving-related consumption. Chapter 4 describes Studies 3 and 4, which tested whether cognitive defusion and guided imagery reduced the intrusiveness of thoughts and the vividness of imagery, as well as overall craving intensity and craving-related consumption of chocolate. Study 3 was conducted with a general sample of young women, and Study 4 replicated the method of Study 3 with a sample of regular chocolate cravers. The final empirical chapter (Chapter 5) presents Study 5, a two-week online diary study which tested whether cognitive defusion and guided imagery reduce naturalistic food cravings. Specifically, participants reported their daily food cravings and related consumption using an online diary over a one-week baseline period. Over a second week, participants listened to one of two 3-minute intervention audio clips (cognitive defusion or guided imagery) during each food craving.

The final chapter, Chapter 6, presents a general discussion of the main findings of each study and the implications for the main aims of the thesis. It discusses both theoretical and practical implications and provides recommendations for future research. All of the chapters in the current thesis (aside from Chapters 1 and 6) are formatted as manuscripts for publication. Chapter 4 (Studies 3 and 4) is published in *Appetite*, Chapter 5 (Study 5) is published in *Appetite*, and Chapters 2 (Study 1) and 3 (Study 2) are under review. There is some repetition of the background information in the Introduction sections of each chapter.

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CHAPTER 2: STUDY 1

Evaluating psychological interventions for food craving: A systematic literature review

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Statement of co-authorship: Sophie Schumacher and Eva Kemps formulated the concept and design of the review. Sophie Schumacher conducted data collection and analysis, as well as the initial first draft of the manuscript. Eva Kemps and Marika Tiggemann edited multiple revised versions of the manuscript.

This manuscript is currently under review.

Abstract

Food cravings are associated with several negative consequences, such as binge eating episodes, risk of weight gain, and feelings of guilt. Researchers have tested a range of techniques to reduce food cravings, but to date these have not been reviewed to determine their comparative efficacy. The aim of the present review was to systematically evaluate the effectiveness of food craving reduction techniques to identify the most effective technique(s), and under which conditions, thereby highlighting knowledge gaps and indicating avenues for future research. Databases (Scopus, Ovid, and Sage) were searched in January 2018 to identify suitable publications. Eligibility criteria included the use of human adult participants, the use of a technique to reduce food cravings, a measure of cravings, and the inclusion of a control or comparison condition. Forty publications comprising 49 individual studies were included in the final review. Results showed that imagery-based techniques most consistently reduced food cravings, followed by mindfulness-based techniques that were taught over several training sessions. Other techniques, such as cognitive reappraisal and physical activity, showed promise, but have not been widely researched. Many of the techniques successful in reducing cravings have the potential to be incorporated into daily life and clinical settings.

Introduction

Food cravings refer to an intense urge to consume a specific food, associated with the anticipation of consuming the desired target (Potenza & Grilo, 2014). These are a common experience, and are not necessarily problematic (Hofmann, Baumeister, Förster, & Vohs, 2012; Lafay et al., 2001). However, they can have several negative health consequences, such as binge eating (Verzijl, Ahlich, Schlauch, & Rancourt, 2018; Waters, Hill, & Waller, 2001) and negative emotional states (Bongers & Jansen, 2017). In addition, food cravings significantly predict eating behaviours and weight gain (Boswell & Kober, 2016). In the context of these negative outcomes, food cravings have become a focal point for the development of a range of intervention strategies. These interventions aim to reduce the frequency and intensity of food cravings, and to ultimately reduce craving-related consumption. Evaluating the efficacy of craving reduction techniques is an important next step to identify the most effective technique(s) and to determine areas for further investigation.

A substantial number of studies have tested imagery-based techniques for reducing food cravings. Imagery-based techniques are designed to replace craving-related imagery by loading limited working memory capacity with other imagery information, in line with the Elaborated-Intrusion Theory of Desire (Kavanagh, Andrade, & May, 2005). This theory suggests that cravings consist of two distinct stages. The first stage features an initial thought or intrusion about the craved food. The second stage involves elaboration of this intrusion with multi-sensory mental imagery. Imagery-based craving reduction techniques use the same limited cognitive resources (e.g., working memory) as those that support craving-related imagery (the second stage). In so doing, new imagery competes with craving-related imagery, thereby reducing the craving (Kemps & Tiggemann, 2010).

Imagery-based techniques can generally be categorised into two main types: imagery interference tasks that are relatively cognitively demanding, and more passive techniques that are less cognitively demanding. An initial wave of studies tested cognitively demanding imagery interference tasks which instructed participants to generate alternative visual or olfactory imagery in order to interfere with craving-related imagery in the same sensory modalities (e.g., imagine the sights or smells of being on a beach; Kemps & Tiggemann, 2010; Versland & Rosenberg, 2007). A subsequent wave of studies tested less cognitively demanding tasks, for example, watching dynamic visual noise (Quinn & McConnell, 1996), a series of black and white dots flashing on a screen (Kemps, Tiggemann, & Hart, 2005; Kemps, Tiggemann, Woods, & Soekov, 2004; McClelland, Kemps, & Tiggemann, 2006; Steel, Kemps, & Tiggemann, 2006), or smelling a non-food odour like a floral scent (Kemps, Tiggemann, & Bettany, 2012).

More recently, mindfulness-based techniques have been used to target food cravings (Alberts, Mulken, Smeets, & Thewissen, 2010; Forman, Hoffman, Juarascio, Butryn, & Herbert, 2013). Mindfulness strategies are thought to target the first (intrusion) stage of the craving process (May, Andrade, Kavanagh, & Hetherington, 2012), and may be useful for managing eating behaviours and weight (see Tapper, 2017 for a review). Although definitions vary (Tapper, 2017), mindfulness, and techniques derived from mindfulness practice, promote attention to the present moment and internal experiences (Bishop et al., 2004; Kabat-Zinn, 2003; Shapiro, Carlson, Astin, & Freedman, 2006) with an attitude of non-judgemental acceptance of physical sensations, thoughts and emotions (Bishop et al., 2004; Kabat-Zinn, 2003; Shapiro et al., 2006). They also encourage the process of decentering (also known as cognitive defusion), which involves viewing one’s thoughts and experiences as impermanent, separate from the self, and not necessarily true at all times (Bishop et al., 2004; Shapiro et al., 2006). These mindfulness components overlap and can reinforce one another, but they can also be utilised as isolated techniques to target cravings and consumption. Tapper (2018) recently reviewed mindfulness techniques for reducing cravings for addictive substances (including food). The present review aims to extend Tapper's (2018) review by examining the relative efficacy of a range of techniques, including but not restricted to mindfulness, in reducing cravings for food in particular.

In addition to imagery- and mindfulness-based strategies, a number of other cognitive strategies have been used to reduce food cravings, in particular, cognitive reappraisal and cognitive bias modification. Cognitive reappraisal, like imagery and mindfulness-based strategies, requires conscious, controlled processing. Cognitive reappraisal involves changing the meaning of a given emotion or internal event by re-framing or re-contextualising negative stimuli in less emotional terms (Buhle et al., 2014; Giuliani & Gross, 2009), and was initially designed to regulate negative emotions (Buhle et al., 2014). It has more recently been applied to down-regulate responses to appetitive food cues and cravings (Yokum & Stice, 2013). In this context, participants may, for example, be asked to think about the long-term health consequences of eating an energy-dense food (Giuliani, Calcott, & Berkman, 2013). By contrast, cognitive bias modification is a computer-based training protocol which targets the automatic, impulsive processes thought to drive cravings (and related consumption) of addictive substances, including food (Kakoschke, Kemps, & Tiggemann, 2017; Schumacher, Kemps, & Tiggemann, 2016; Wiers, Gladwin, Hofmann, Salemink, & Ridderinkhof, 2013). Cognitive biases, such as attentional and approach biases, involve the selective processing of relevant cues in the environment (e.g., appetitive food cues) over irrelevant cues (MacLeod & Mathews, 2012), directing attention and movement towards them. Cognitive bias modification retrains individuals to not attend to or to avoid appetitive food cues.

Finally, movement techniques have been used to reduce cravings. These techniques have sometimes been investigated in multi-outcome studies that have examined the benefits of physical exercise programs on a range of health outcomes. Physical activity has been shown to successfully reduce cravings for cigarettes (see Haasova et al., 2013 for a meta-analysis). More recently, it has been tested as a way of reducing food cravings, among other health outcomes, such as increasing mood and energy levels (Bergouignan et al., 2016). While the mechanism by which physical activity reduces cravings is unclear, there is some evidence to suggest that it may stimulate the nervous system and other neurological processes, or act as a distraction or an alternative reinforcer to yielding to a craving (see Ussher, Taylor, & Faulkner, 2014). Movement techniques range from whole body to specific muscle movements. For example, facial movements (e.g., moving muscles to smile or frown) are thought to regulate experiences of negative and positive emotions, respectively (Söderkvist, Ohlén, & Dimberg, 2018), which may also affect the experience of craving. In contrast, orosensory techniques such as chewing gum or using mouthwash have been proposed as novel techniques to modify the sensory properties of a recent meal to prevent post-meal craving and snacking (McCrickerd & Forde, 2015).

A systematic review is needed to evaluate and compare the efficacy of existing psychological strategies for reducing craving. Such a review would help determine which techniques are most effective. Further, it would identify areas that require further investigation.

Method

The search strategy and screening process was conducted following the Preferred Reporting Items for Systematic Review (PRISMA) guidelines (Moher, Liberati, Tetzlaff, & Altman, 2009). Relevant articles were identified through searching three online databases (Scopus, Ovid and Sage) in January 2018. The keywords ‘food’, ‘craving(s)’, ‘intervention’, ‘curb’, ‘technique’, ‘unwanted’, ‘reduction’, and ‘suppress’ were used in various combinations to search for publications related to interventions for reducing food cravings. The reference lists of articles were also studied, and additional relevant articles were included. Included studies were peer-reviewed empirical papers for which the full-text was available, with data collected between the years 1990 and 2018. Included articles had to report original research, and use human adult participants. Studies also had to describe their methods in sufficient detail to identify the type of manipulation employed. Studies had to implement an intervention specifically for food cravings and include a craving measure. Studies also had to include a control condition or comparison group with which to compare the effect of the intervention. Studies were excluded if they were non-peer-reviewed, literature reviews, non-empirical conceptual articles, or unpublished dissertations and theses. Biological, chemical and dietary interventions were also excluded.

Results and Discussion

A total of 1739 papers were retrieved from the literature search. After removing duplicates, 1003 study titles were screened for eligibility. Based on the eligibility criteria, 901 articles were excluded because they used animal subjects, examined cravings for substances other than food, had no control condition, were non-peer reviewed, did not contain original research, or were unpublished dissertations or theses. Abstracts of the remaining 102 articles were screened, which led to the exclusion of a further 61 articles. Finally, full texts of the remaining 41 papers were examined, resulting in one further paper being excluded. Therefore, 40 publications comprising 49 studies were included in the final literature review. Figure 1 gives details of each step of the literature search and selection. Final studies were coded first on technique, and then on target food, laboratory or field setting, sample characteristics, intervention and comparison task, craving-related outcome measure, and results. The details of these studies are summarised in Table 1.

There were 3332 participants across the final included studies. Of the 49 individual studies, 22 used imagery-based techniques, 7 used mindfulness-based techniques, 6 used cognitive techniques, 7 used movement techniques, and 7 combined or compared several techniques. Most studies were conducted in laboratory settings (*n* = 35). Samples mostly consisted of unselected university students (*n* = 31), community members (*n* = 2) or both (*n* = 2).

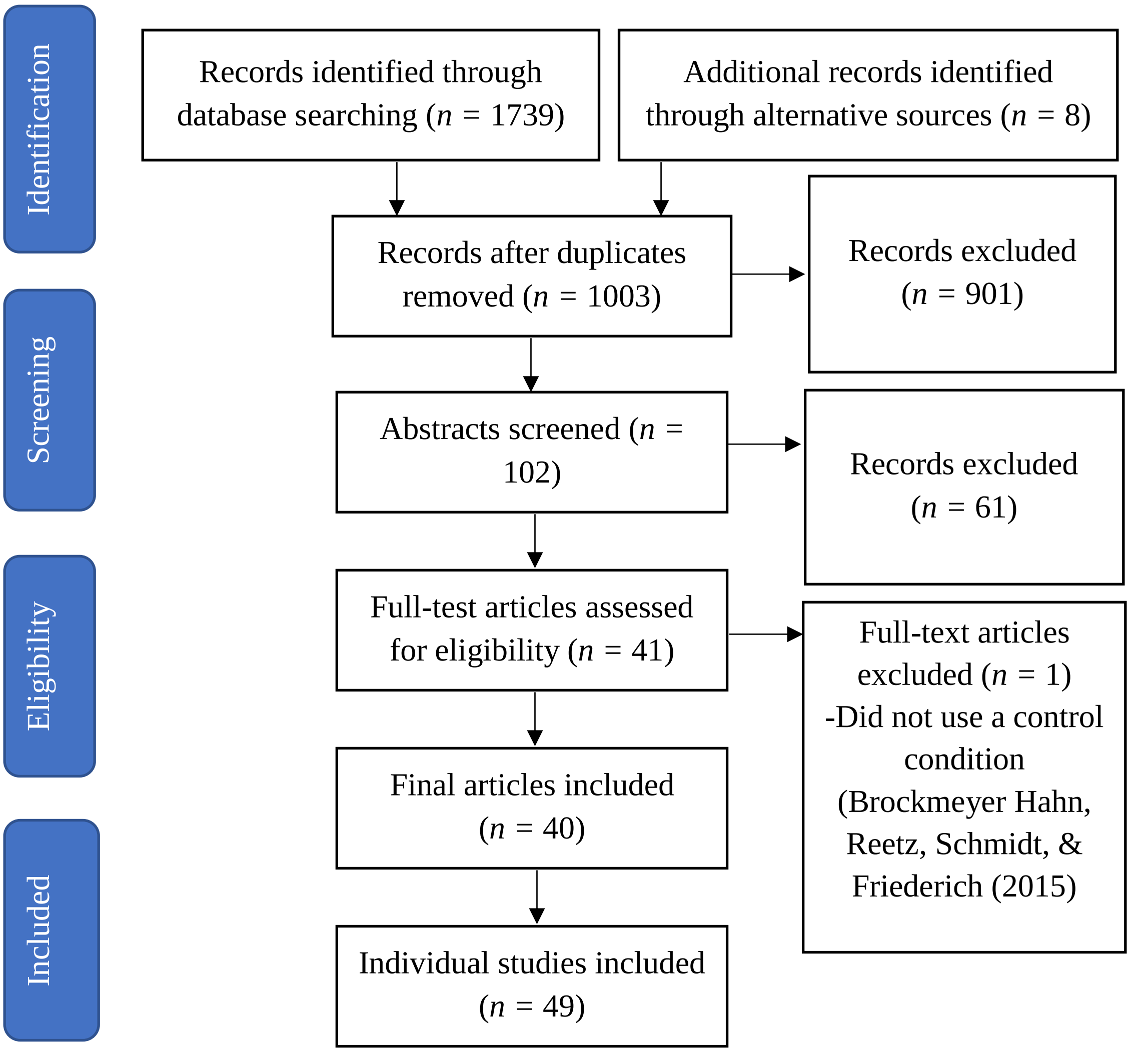

Figure 1. Flow diagram for search, inclusion and exclusion of studies in the literature review.

Table 1

Characteristics and Effect Sizes of Studies Included in the Literature Review.

Authors (year)	Technique	Lab/ field setting	Target food	Sample size[a]	Sample details	Gender (% female)[b]	Intervention task	Comparison condition/s	Craving measure	Results with Effect Sizes (E.S.)
*Andrade, Pears, May, & Kavanagh (2012)	Imagery	Lab	Chocolate	63	E1a: University students and staff (aged 18-70 years).	70%	E1a: Clay modelling	E1a: Counting backwards, Mind wandering E2: Control (counting aloud)	E1a: Craving measured with 3 100mm visual analogue scales, taken at baseline, during the task and post-task.	E1a: Sig. time x condition interaction for craving scores (η_p^2 = .096). Craving change scores calculated: sig. differences between control and clay modelling (*d* = 0.77), and control and counting backwards (*d* = 0.66) Modelling and counting n.s. diff.
				87	E2: University students (aged 18-49 years).	85%	E2: Clay modelling		E2: Craving Experience Questionnaire (measuring intrusiveness, vividness and overall strength), measured at baseline and 10 minutes post- intervention.	E2: Sig. time x condition interactions for craving strength (η_p^2 = .05) and imagery (η_p^2 = .06), showing greater reductions in craving strength and imagery over time in the modelling condition compared with control. Post-intervention, there was less frequent craving in the modelling condition (η_p^2 = .06), less frequent craving imagery (η_p^2 = .07) and less frequent intrusive thoughts (η_p^2 = .07) compared with the control condition.

Christian, Miles, Kenyeri, Mattschey, & Macrae (2016)	Imagery	Lab	Food	91 125	E2: University students. E3: Individuals recruited from Amazon's Mechanical Turk.	55% 38%	E2: Third-person imagery task E3: Third-person imagery task	E2: First-person imagery task, Control E3: First-person imagery task	Desire for chocolate was rated after the imagery task on an analogue scale (16cm line).	E2: Controlling for pre-imagery ratings of liking, differences between third-, first-person and control n.s. (p = .07, η_p^2 = .06). E3: Third-person perspective decreased desire for tempting foods, but not for non-tempting items, through its impact on sensory experience.
*Firmin, Gillette, Hobbs, & Wu (2016)	Imagery	Lab	Chocolate foods	92	University students (aged 18-22 years).	100%	Exposure to a citrus/mint 'fresh' scent	Control (exposure to a vanilla 'sweet' scent, or water)	100mm visual analogue scales used to assess craving level for each of 12 images.	Fresh scent sig. lower than sweet scent (d = 4.97), and fresh scent also sig. lower than control (d = 2.11).
Giacobbi et al. (2018)	Imagery	Field	Food (also physical activity, psychological	35	University students and community members, (BMI of ≥ 25 kg/m^2).	100%	Multi-behaviour intervention including 35-day intervention period of using personalised guided imagery scripts	Waitlist control	G-FCQ-T (Trait food cravings questionnaire; Nijs et al., 2007) measured at pre- and post-test.	Significant group x time interaction (p = .023, information for E.S. not reported), resulting in a sig. reduction in trait food cravings over time for intervention, compared with control condition.
*Harvey, Kemps, & Tiggemann (2005)	Imagery	Lab	Food	120	University students (60 dieters) aged 18-35 years.	100%	Visual imagery task	Auditory imagery task	Cravings rated before and after task on 100mm visual analogue scales.	Sig. time x imagery task and sig. time x induction scenario interactions. Craving ratings decreased to a greater extent for visual imagery task than auditory imagery task (ps and means not reported). Greater reduction in cravings after food induction for visual imagery (d = 0.88), than for auditory imagery (d = 0.34; ps not reported).
Kemps & Tiggemann (2007)	Imagery	Lab	E1: Food E2:	90 90	E1: University students.	100% 100%	E1: Visual imagery, Olfactory	E1: Auditory imagery	Cravings rated before and after task on 100mm visual analogue scales.	E1: Sig. time x imagery task interaction (f = .31). Interaction contrasts showed a medium sized interaction (f = .36) when

			Chocolate E3: Chocolate	 96	E2: University students. E3: University students.	 100%	imagery E2: Visual imagery, Olfactory imagery E3: Visual imagery, Olfactory imagery	E2: Auditory imagery E3: Auditory imagery		comparing visual and auditory tasks, as with olfactory vs. auditory imagery (*f* = .27) in reducing cravings. The visual vs. olfactory interaction did not yield a large effect (*f* = .11). E2: Sig. medium sized time x imagery task interaction (*f* = .35). Interaction contrasts showed medium to large effect size for visual vs. auditory tasks (*f* = .41) and auditory vs. olfactory tasks (*f* = .29) but not for visual vs. olfactory tasks (*f* = .07). E3: Sig. time x imagery task interaction (*f* = .32). Again, contrasts showed medium effect for visual vs. auditory (*f* = .31), olfactory vs. auditory (*f* = .36) but not visual vs. olfactory (*f* = .11).
Kemps & Tiggemann (2013a)	Imagery	Field	Food	48	University students (aged 18-29 years), experienced >7 food cravings per week.	100%	Dynamic visual noise	Control	Craving intensity rated on a 100mm visual analogue scale	Craving intensity sig. lower after watching the dynamic visual noise than before (*d* = 1.09). Pre-intervention craving intensity n.s. between control and intervention.
*Kemps & Tiggemann (2013b)	Imagery	Lab	E1: Food E2: Chocolate	56 57	E1: University students (aged 18-34 years). E2: University students (aged 18-30 years).	100% 100%	E1 and E2: Smell non-food odorant, listen to irrelevant speech	E1 and E2: Look at blank computer screen	Craving intensity rated on a 100mm visual analogue scale	E1: Sig. effect of condition (*f* = .51); craving ratings sig. lower for olfactory than auditory (*d* = 0.36) and control (*d* = 0.61). Auditory and control n.s. different. E2: Sig. effect of condition (*f* = .59), craving ratings sig. lower for olfactory than auditory (*d* = 0.36) and control (*d* = 0.64). Auditory sig. lower than control (*d* = 0.26).
*Kemps, Tiggemann, & Bettany (2012)	Imagery	Lab	Chocolate	67	University students (aged 18-35).	100%	Smelling non-food odorant (jasmine)	Food odorant (apple), Control (water)	Craving intensity rated on a 100mm visual analogue scale	Sig. effect of condition (*d* = .45), craving ratings sig. lower for non-food odorant than food (*d* = 0.16) and control conditions (*d* = 0.26).

*Kemps, Tiggemann, & Christianson (2008)	Imagery	Lab	Food	40	Participants aged 20-57, 20 recruited from Weight Watchers, 20 were non-dieters from the community.	100%	Dynamic visual noise (DVN)	Thought suppression, Control	Craving intensity rated on a 100mm visual analogue scale	Sig. effect of task (*d* = 1.46), craving ratings sig. lower in thought suppression than control (*d* = 0.62) and DVN than control (*d* = 0.79). For dieters, DVN was superior to thought suppression and control, but not for non-dieters (means not reported).
*Kemps, Tiggemann, & Hart (2005)	Imagery	Lab	Chocolate	48	University students (24 cravers), aged 18-35 years.	100%	Dynamic visual noise (DVN), Irrelevant speech	Control	Craving intensity rated on a 100mm visual analogue scale	Sig. effect of concurrent task, craving ratings sig lower for DVN than control (*d* = 0.46) and DVN than irrelevant speech (*d* = 0.22). Irrelevant speech also sig. lower than control (*d* = 0.23) No interaction with craver status.
*Kemps, Tiggemann, Woods, & Soekov (2004)	Imagery	Lab	Food	48 56	E1: University students (18-35 years), 24 dieters. E2: University students (aged 18-33 years) 28 dieters.	100% 100%	E1 and E2: Saccadic eye movements, Dynamic visual noise (DVN), Spatial tapping	E1 and E2: Control	Craving intensity rated on a 100mm visual analogue scale	E1: No effect of dieting status on craving. Sig. visuospatial x stimulus type interaction. Ratings for food images sig. lower for eye movement than control (*d* = 0.21) and DVN than control (*d* = 0.15). Spatial tapping did not differ from control. E2: No effect of dieting status. Sig. visuospatial task x stimulus type interaction. Sig. effect of task on craving ratings for food images, but not neutral images. Ratings for food images sig. lower in eye movement than control (*d* = 0.13), DVN and control (*d* = 0.19), and spatial tapping and control (*d* = 0.22).
Knäuper, Pillay, Lacaille, McCollam, & Kelso (2011)	Imagery	Field	Food and drinks	91	University students and staff.	76%	Implementation intentions plus activity imagery (II + AI)	Goal intention, Implementation intentions, Implementation intentions plus cognitive/ distraction task	Craving intensity and craving vividness were measured with 4-point Likert scales	Sig. time x condition interaction (η_p^2 = .09), diff between pre-post craving intensity only sig. in II + AI (η_p^2 = .10), not in any other condition. The decrease in craving intensity was fully mediated by a decrease in the vividness of craving-related imagery.

Littel, van den Hout, & Engelhard (Study 1; 2016)	Imagery	Lab	Food	89	University students (42 dieters).	100%	Eye movement task (EM)	Control (Co)	Craving intensity rated pre- and post-intervention on 100mm visual analogue scale. General State Food Cravings Questionnaire (G-FCQ-S) was used at pre and post intervention.	Sig. time x condition interaction ($\eta^2 = .05$) for craving VAS measure, sig pre-post decrease for eye movement condition (*d* = 0.51), n.s. diff for control (*p* = .09, *d* = 0.42). Trend for condition x time x group interaction (*p* = .07, $\eta^2 = .04$), non-dieting group showed pre-post increase in craving for Co (*d* = 0.70), craving decrease in EM condition (*d* = 0.57). No effects for dieters. Sig. time x condition interaction for G-FCQ-S ($\eta^2 = .05$), Control sig. increased pre-post (*d* = 0.71), EM remained stable over time (*d* = 0.04). No effect for dieting status.
McClelland, Kemps, & Tiggemann (2006)	Imagery	Lab	Food	50	University students.	100%	Eye movement, Dynamic visual noise, Spatial tapping, Forehead tracking	Control	Craving intensity rated for each image on 100mm visual analogue scales	Sig. task x time interaction (*f* = 0.30). All visuospatial tasks reduced craving intensity relative to control (eye movement *f* = 0.70; dynamic visual noise *f* = 0.62; forehead tracking *f* = 0.83). Forehead tracking was significantly more effective than spatial tapping (*f* = 0.48), others n.s. from spatial tapping.
*Steel, Kemps, & Tiggemann (2006)	Imagery	Lab	Food	42	University students (aged 18-33 years). 21 were food deprived for 4h, 21 asked to eat just prior to the session.	100%	Dynamic visual noise (DVN)	Control	Craving intensity measured using a 100mm visual analogue scale.	Sig. main effect of concurrent task, intensity lower for DVN than control. This pattern occurred across both hungry (*d* = 0.79) and not hungry (*d* = 0.94) conditions.
*Alberts, Mulkens, Smeets, & Thewissen (2010)	Mindfulness	Field	Food	19	Overweight and obese individuals enrolled in a dietary group treatment.	89%	7-week acceptance-based manualised training.	Dietary treatment as usual (T.A.U.)	General Food Craving Questionnaire Trait (G-FCQ-T), measured at pre- and post-treatment.	Sig. time x condition interaction for total G-FCQ-T scores ($\eta^2 = .32$), n.s. pre-post change for control (*d* = 0.27), sig. pre-post decrease for intervention (*d* = 0.93).

Alberts, Thewissen, & Middelweerd (2013)	Mindfulness	Lab	Food	65	University students, food deprived for 3h.	80%	Acceptance task	Suppression task, No task	General-Food-Craving Questionnaire State (G-FCQ-S) measured at baseline, post-exposure to food and 20-min follow-up.	Sig. time x condition interaction for G-FCQ-S scores (η^2 = .023). At post-exposure, control condition had sig. lower cravings than suppression (η^2 = .18) and acceptance (η^2 = .32) conditions, who were not different from one another. At follow-up, control condition had sig. lower levels of craving than suppression (η^2 = .17) and acceptance (η^2 = .33), who again were no different from each other.
*Alberts, Thewissen, & Raes (2012)	Mindfulness	Field	Food	26	Individuals from the community, had disordered eating behaviour (aged 18-65 years).	100%	8-week MBCT (Mindfulness-based Cognitive Therapy) eating intervention	No task	General Food Craving Questionnaire Trait (G-FCQ-T), measured before and after the treatment.	Sig. time x condition interaction for total G-FCQ-T scores (η^2 = .29), n.s. pre-post change for control (*d* = 0.14), sig. pre-post decrease for intervention (*d* = 1.19).
Forman Hoffman, Juarascio, Butryn, & Herbert (2013)	Mindfulness	Field	Food	48	Overweight individuals recruited from the community.	100%	Acceptance-oriented intervention	Cognitive reappraisal/ distraction intervention	Food Craving Questionnaire-State (FCQ-S) was used.	N.s. between group difference in state cravings, (*p* = .15, *d* = .43), trend toward acceptance-based coping strategy reporting lower cravings than cognitive reappraisal group.
Forman et al. (2007)	Mindfulness	Field	Food	98	University students (aged 18-60 years).	48%	Acceptance-based coping strategies	Control-based coping strategies, No intervention	15-item Food Craving Questionnaire-State (FCQ-S), 5 single-item measures also used to assess frequency, temptation, intensity, difficulty resisting and distress, measured at 24h and 48h after the chocolate abstinence period.	Group x Power of Food Scale interactions were n.s. for FCQ-S scores (*p* = .07, η_p^2 = .06), craving frequency (*p* = .06, η_p^2 = .06), and difficulty resisting (*p* = .07, η_p^2 = .06) but sig. for temptation (η_p^2 = .10) and distress (η_p^2 = .10). Acceptance-based group showed lower craving scores relative to other two groups only for participants with greatest susceptibility to presence of food.

Hooper, Sandoz, Ashton, Clarke, & McHugh (2012)	Mindfulness	Field	Food	47	University students.	Not reported	Thought defusion	Thought suppression, Control	Daily questionnaire included a question about how many cravings were experienced that day.	N.s. main effect of condition on chocolate cravings (p = .09, η_p^2 = .10) but trend toward defusion condition experiencing more cravings than thought suppression and controls.
Lacaille et al. (2014)	Mindfulness	Field	Chocolate	126	University staff and students.	Not reported.	2-week mindfulness interventions: Awareness, Awareness + Acceptance, Awareness + Disidentification, Awareness + Acceptance + Disidentification	Active control (distraction)	Trait chocolate cravings measured before and after 2-week training period using Attitudes to Chocolate Questionnaire.	Sig. time x condition interaction (η_p^2 = .09), sig. pre-post diff for Aw + Dis condition only (means not reported). Aw differed from control, whereas Aw + Acc and Aw + Acc + Dis did not differ from control.
*Giuliani, Calcott & Berkamn (2013)	Cognitive	Lab	Energy dense foods	82	Sample /recruitment description not reported, except for age (*M* = 19.76, *SD* = 3.51).	66%	Cognitive reappraisal condition asked to use regulation strategy to reduce their desire to eat the depicted food.	'Look' condition asked to look at food pictures, imagine eating them.	After each trial, desirability rated on the 1-5 Likert scale ('How much do you desire to eat this food?' 1 = not at all, 5 = very much)	Sig. main effects of stimulus (craved, non-craved food) and task (CR and 'look'), qualified by sig. interaction. CR successfully reduced self-reported desire to consume the craved and non-craved foods compared to the Look cue, but to a greater extent for Craved foods (Look Craved sig. higher than CR Craved, d = 1.93; Look Non-Craved sig. higher than CR Non-Crave, d =1.07).
Kemps, Tiggemann, Martin, & Elliot (2013)	Cognitive	Lab	E2: Chocolate	96	University students (aged 18-25 years).	100%	Implicit association task (avoid chocolate)	Implicit association task (approach chocolate)	Chocolate craving measured with 100mm visual analogue scale at pre- and post-training	Sig. condition x time interaction (η_p^2 = .05), such that chocolate cravings sig. increased from pre- to post-training for approach condition (d = .16), but no change from pre- to post-training for avoid condition.

Kemps, Tiggemann, Orr, & Grear (2014)	Cognitive	Lab	E1 and E2: Chocolate	E1: 110 E2: 88	University students (aged 18-26 years). University students (aged 17-25 years).	100% 100%	Attentional bias training (avoid chocolate condition)	Attentional bias training (attend chocolate condition)	100mm visual analogue scale used to assess chocolate craving at pre- and post-training	E1: No sig. interaction or main effects. E2: (Same procedure, with novel, untrained images): Main effect of time (η_p^2 = .08) and sig. condition x time interaction (η_p^2 = .38): cravings sig. increased for attend chocolate condition (*d* = .44), sig. decreased for avoid chocolate condition (*d* = .24).
*Siep et al. (2012)	Cognitive	Lab	High calorie foods	14	University students.	100%	Cognitive reappraisal	Suppression, Up-regulation, Passive viewing.	Single item 100mm VAS (‘I have cravings for one or more specific foods’ 0 totally disagree to 100 totally agree).	Sig. main effect of cognitive control strategy on food cravings, where craving was sig. higher for up-regulation than cognitive reappraisal (*d* = 1.12) and suppression (*d* = 0.99). No difference between suppression and reappraisal (*d* = 0.11).
Svaldi et al. (2015)	Cognitive	Lab	Food	23	University students who were restrained eaters.	100%	Cognitive reappraisal	Passive viewing of food, Suppress craving, Neutral object	Visual analogue scale used to assess craving after each picture trial (I have cravings for food: 0 = I totally disagree, 100 = I totally agree	Sig. main effect of condition (η_p^2 = 0.475), craving was sig. higher for food passive viewing than reappraisal condition (*d* = 1.33) and to the suppression condition (*d* = 0.92). Suppress craving condition sig. higher cravings than reappraisal condition (*d* = 0.53). Craving sig. lower in neutral object viewing than food passive viewing (*d* = 1.37).
*Hetherington & Boyland (2007)	Movement	Lab (4 sessio ns)	Sweet and salty snacks	60	University staff and students (age *M* = 21.7 years) who were regular gum and snack consumers.	66%	Gum chewing between lunch and a 3h post-lunch snack	No gum between lunch and a 3h post-lunch snack	Desire to eat measured on 100mm visual analogue scale	Sig. time x condition interaction (means and E.S. not reported) showed that chewing gum reduced desire to eat sweet snacks relative to no gum. This effect was not found for salty snacks.
*Hetherington & Regan (2011)	Movement	Lab	Sweet and salty snacks	60	Restrained eaters recruited from university campus (aged 18-54 years).	88%	Gum chewing between lunch and a 3h post-lunch snack	No gum between lunch and a 3h post-lunch snack	Desire to eat measured on 100mm visual analogue scales	Main effect of condition showed that cravings for sweets were lower in the gum than no gum condition (*d* = 0.62). Time x condition interaction showed that increase in cravings for sweet snacks was sig. less in gum condition compared with control. Main effect of condition showed that desire

										to eat a salty snack were lower in gum vs. no gum control. Time x condition interaction showed that the increase in cravings for salty snacks over time was sig. lower in the gum condition compared with no gum control condition (*d* = 0.57).
Hutchings, Horner, Dible, Grigor, & O'Riordan (2017)	Movement	Lab	E2: Potato crisps	36	Individuals recruited from a university campus (aged 18-32 years)	50%	Menthol mouthwash immediately after eating potato crisps	1. No mouthwash 2. Water mouthwash	Desire rated at pre- and post-mouthwash on 100 visual analogue scale (‘Take a look at the crisps beside you, how strong is your desire to eat (taste, chew and swallow) more crisps right now?’).	Sig. differences in desire for more crisps between conditions at time 2 (means/E.S. not reported) and time 3 (means/E.S. not reported). Sig. lower desire after menthol mouthwash than water and no mouthwash conditions.
*Ledochowski Ruedl, Taylor, & Kopp (2015)	Movement	Lab	High calorie sugary snacks (e.g., chocolate)	47	Recruited through hospitals and weight management support groups. Ps had to have a BMI between 25-30 and consume 100g high calorie sugary snacks per day.	62%	Active condition: 15 minute brisk walk	Passive condition: Sit for 15 minutes	State food cravings questionnaire (FCQ-S) adapted for sugary snacks was rated pre- and post-treatment, pre- and post-Stroop task, pre- and post-chocolate exposure	Sig. condition x time interaction (η^2 = 0.392) for cravings at 3 time points (pre-, mid- and post-treatment), sig. between condition diffs at mid- and post-treatment. Sig. reductions for active condition at mid-treatment (*d* = 0.92), and post-treatment (*d* = 0.74) not for control. Cravings increased at pre- and post-Stroop and pre- and post-chocolate exposure for both conditions.
Meule & Kübler (2017)	Movement	Lab	Food	65	University students.	100%	10 mins of paced breathing (6 breaths per minute) while looking at picture of desired food	10 mins of paced breathing (9 breaths per minute)	Food Cravings Questionnaire-State (FCQ-S) completed at 4 time points: baseline, after 10-min resting period (pre-intervention), after paced breathing (intervention), and 10-min resting period post-intervention	Main effect of time (η_p^2 = 0.15), such that cravings decreased after first relaxation period, increased after paced breathing and decreased again after second resting period. No main effect of condition, and no interaction.
*Oh & Taylor (2013)	Movement	Lab	Chocolate	41	Chocolate consumers (20 normal and 21 overweight with	100%	15 minute brisk walk on a treadmill, at a moderately	Sit passively for 15 minutes with no access to books,	Single item 100mm VAS (‘how much do you crave chocolate at this very moment?’ measured	Conditions (normal or overweight, Lent abstainers) did not moderate condition x time interactions for chocolate craving. Significant condition x time interaction for

					temporary chocolate abstinence, 17 with > 1 week chocolate abstinence). Ate > 100g chocolate per day.		intense pace.	computers or phones.	immediately after treatment, and at 5m and 10m post-treatment.	chocolate craving (E.S. not reported). Craving sig. lower after exercise compared with control at immediately post-task (d = 0.54), and at 5m (d = 0.55) and 10m post-task (d = 0.57).
Schmidt & Martin (2017)	Movement	Lab	Food	60	University students (aged 19-37 years).	100%	Positive facial feedback	Negative facial feedback	Cravings were measured before and after the task, using 100-point visual analogue scales.	Sig. time x condition interaction (f = 0.28), state cravings sig. increased for the negative group (f = 0.30), and remained constant for the positive group. Effects were moderated by emotional eating (e.g., for emotional eaters +1 SD above the mean, positive facial feedback reduced cravings).
Rodríguez-Martín, Gómez-Quintana, Díaz-Martínez, & Molerio-Pérez (2013)	Combined	Field	Food	80	Overweight or obese individuals recruited from the community (aged 19-72 years). Ps had problems controlling their food cravings, had >1 food craving per day.	73%	Self-Help Manual (targeting intrusive thoughts and food cravings, using imagery and non-imagery techniques)	Intention-Control (asked to do their best to control cravings using willpower)	Food Cravings Questionnaire-Trait was measured at baseline, one-month and three-month follow-up	Significant time x condition interaction effect for trait food cravings (η_p^2 = .31), such that the intention-control condition remained stable across baseline, one- and three-month follow up, whereas the SH condition reduced cravings at 1- (d = 0.76) and further at 3- month follow up (d = 0.34).
Hamilton, Fawson, May, Andrade, & Kavanagh (2013)	Compared	Lab	Food (breakfast items)	98	University students.	77%	Body scanning Guided imagery	Mind wandering	Single item craving measure (0 = no craving, 10 = intense craving) rated 10 times during task. CEQ-S and CEQ-F rated pre- and post-task	Sig. group x time interaction on cravings (η_p^2 = .04). Significant increase in cravings for mind wandering control condition (η_p^2 = .10), no change for the experimental conditions on any of the measures.
May , Andrade, Batey, Berry, & Kavanagh (2010)	Compared	Lab	Food	E1: 48 E2: 49	E1: University students. E2: University students.	81% 63%	E1: Breath focus E2: Body scan	E1: Imagery diversion, Thought suppression, Control E2: Guided Imagery,	E1 and 2: 100mm visual analogue scale was used to rate craving intensity at baseline, intervention and post-task.	E1: Sig. time x condition interaction (η^2 = .15), craving intensity increased across time for all conditions except thought suppression (where craving decreased during task). E2: No main effect of time or condition, no interaction.

								Control		
Moffitt, Brinkworth, Noakes, & Mohr (2012)	Compared	Field	Chocolate	110	Chocolate cravers (aged 18-82 years) recruited from the community.	85%	1. Cognitive defusion 2. Cognitive restructuring	Waitlist control	State cravings measured with 5 items (frequency, temptation, intensity, difficulty resisting and distress). Trait cravings measured with 2 subscales of the Food Cravings Questionnaire-Trait, assessed lack of control over eating and thoughts/ preoccupation with food.	N.s. condition x time interaction for state and trait cravings. Both CD and CR had sig. lower ratings of temptation (η_p^2= 0.10), intensity (η_p^2 = 0.11), and difficulty resisting (η_p^2 = 0.11), lack of control over eating (η_p^2 = 0.27) and thoughts/preoccupation with food (η_p^2 = 0.09).
Schumacher, Kemps, & Tiggemann (2017)	Compared	Lab	Chocolate	94 97	E1: University students and individuals from the community (aged 17-26 years). E2: University students (aged 17-25 years), had > 1 chocolate craving per day, wished to reduce chocolate consumption.	100% 100%	E1 and E2: Cognitive defusion, Guided imagery	E1 and E2: Control (mind-wandering)	E1 and E2: Craving intensity measured with a 100mm visual analogue scale at pre-intervention, post-intervention and 10m post-intervention	E1: Sig. condition x time interaction (η_p^2 = 0.088), sig. decrease from pre- to post-intervention for defusion condition (*d* = 0.57), which was maintained at 10m post-intervention. N.s. change for imagery and control. E2: Sig. condition x time interaction (η_p^2 = 0.056), sig. pre- to post-intervention decrease in intensity for defusion (*d* = 0.68) and imagery conditions (*d* = 0.79), n.s. for control.

[a] sample calculated based on final sample used for analyses; [b] percentages rounded; * effect sizes calculated

Other more selected samples included participants who were overweight or obese (*n* = 3), chocolate cravers/eaters (*n* = 3), food cravers (*n* = 1), restrained eaters or dieters (*n* = 5) and individuals with disordered eating behaviour (*n* = 1). Sample sizes ranged from small (*n* = 14; Siep et al., 2012) to moderate (*n* = 126; Lacaille et al., 2014). Craved targets were most often ‘food’ (*n* = 26), or ‘chocolate’ (*n* = 16). Other more specific targets were high calorie foods (*n* = 3), sweet and/or salty snacks (*n* = 2), or specific foods like potato crisps (*n* = 1) or breakfast items (*n* = 1). The most common craving measure was a visual analogue scale or author-designed Likert scale, where participants were asked to rate the strength or intensity of the craving (*n* = 34). Validated state and trait measures such as the General Food Craving Questionnaire (Nijs, Franken, & Muris, 2007) or the Food Craving Questionnaire (Cepeda-Benito, Gleaves, Williams, & Erath, 2000) were the next most common (*n* = 8). Other studies used the Attitudes to Chocolate Questionnaire (*n* = 1), the Craving Experience Questionnaire (*n* = 1) or a combination of multiple state and trait measures (*n* = 4). One study examined craving frequency (Hooper, Sandoz, Ashton, Clarke, & McHugh, 2012).

Imagery-based Techniques

The largest number of craving reduction studies used imagery-based techniques (*n* = 22). These can be divided into those that used more cognitively demanding imagery interference tasks (*n* = 10) and those that used other relatively less demanding tasks (*n* = 12). Cognitively demanding tasks involved instructing individuals to generate alternative imagery in a range of sensory modalities, in particular visual and olfactory. Visual interference tasks included imagining objects or scenes (Knäuper, Pillay, Lacaille, McCollam, & Kelso, 2011), taking a third-person perspective (Christian, Miles, Kenyeri, Mattschey, & Macrae, 2016), or picturing shapes in which to model clay out of sight (Andrade, Pears, May, & Kavanagh, 2012). Olfactory interference tasks involved imagining a particular smell such as freshly mown grass (Kemps & Tiggemann, 2007). Each of these tasks produced craving reductions, with effect sizes ranging from moderate to large. In four studies which compared tasks of different sensory modalities, visual imagery interference was consistently more effective at reducing food cravings (moderate to large effect sizes) than olfactory interference (moderate effect sizes; Harvey, Kemps, & Tiggemann, 2005; Exp. 1-3, Kemps & Tiggemann, 2007). Most studies were undertaken in laboratory environments (*n* = 8). Two field studies found that their respective strategies could reduce naturally occurring cravings, with moderate to large effects (Giacobbi et al., 2018; Knäuper et al., 2011).

The subcategory of studies that used less cognitively demanding imagery-based tasks (*n* = 12) included smelling a non-food odorant (*n* = 4), making eye movements (*n* = 1) and watching dynamic visual noise, a screen filled with densely situated black and white flashing dots (*n* = 7). These tasks were less effortful as they did not require participants to generate anything. Smelling non-food odorants reduced cravings across all four studies, with mostly small to moderate effect sizes. Dynamic visual noise reduced cravings in both laboratory (*n* = 6) and field settings (*n* = 1) with effect sizes which were predominantly moderate to large.

Overall, tasks which used visual imagery to interfere with food cravings generally yielded greater effects (moderate to large) than tasks which used olfactory interference (small to moderate). Where tested, results were largely unaffected by dieting status (Kemps, Tiggemann, Woods, & Soekov, 2004), hunger status (Steel, Kemps, & Tiggemann, 2006) or craving status (Kemps, Tiggemann, & Hart, 2005).

Mindfulness-based Techniques

Seven studies examined mindfulness-based techniques, with one conducted in the laboratory (Alberts, Thewissen, & Middelweerd, 2013) and six field studies conducted on naturally occurring food cravings (Alberts et al., 2010; Alberts, Thewissen, & Raes, 2012; Forman et al., 2013, Forman et al., 2007; Hooper et al., 2012; Lacaille et al., 2014). The single laboratory study found that a mindfulness task did not reduce cravings relative to control (Alberts et al., 2013). Four field studies examined strategies over 1-3 day periods (Forman et al., 2013; Forman et al., 2007) or over one to two weeks (Hooper et al., 2012; Lacaille et al., 2014). In addition, two field studies looked at broader mindfulness-based programs adapted for reducing cravings over a 7- or 8-week period (Alberts et al., 2010; Alberts et al., 2012).

The studies that evaluated programs with multiple mindfulness techniques and principles over several weeks had larger effects (Alberts et al., 2010; Alberts et al., 2012) than those that trained individual mindfulness strategies in a single session (Forman et al., 2013; Forman et al., 2007; Hooper et al., 2012; Lacaille et al., 2014). Specifically, the two studies with programs that spanned 7-8 weekly sessions (Alberts et al., 2010; Alberts et al., 2012) found that groups receiving mindfulness-based training experienced significant reductions in craving intensity from pre- to post-treatment, whereas control conditions (or treatment as usual) did not. In contrast, Hooper et al. (2012) found no significant difference between their single-session mindfulness-based intervention and a comparison condition, and Lacaille et al. (2014) found that only one mindfulness condition (disidentification, the ability to separate oneself from one’s thoughts) differed from control. Forman et al. (2013) found that a mindfulness-based intervention was no different from the control condition, although Forman et al. (2007) showed a positive effect for individuals who were more susceptible to the presence of food (an individual difference variable similar to external eating).

Altogether, there was mixed evidence for different mindfulness-based training programs, but there was also variability between studies in the training content and program duration. The more effective interventions were those that trained participants with multiple strategies over multiple sessions. However, these interventions also included homework exercises and thus it is unclear whether the better outcomes were due to extra practice, the use of a combination of techniques, or both. Future studies would need to explore these issues. Tapper's (2018) review of mindfulness-based reduction strategies for cravings for a broad range of substances also concluded that strategies that were continually practised over longer periods tended to be more successful. In another review of mindfulness-based techniques for predicting eating- and weight-related outcomes, Tapper (2017) concluded that more research is needed to test individual mindfulness skills to isolate particular mechanisms of change.

Cognitive Techniques

A small group of laboratory-based studies tested two key cognitive techniques, cognitive reappraisal (n = 3), a technique involving explicit cognitive control, and cognitive bias retraining (n = 3), an implicit cognitive technique. In studies that tested cognitive reappraisal (Giuliani et al., 2013; Siep et al., 2011; Svaldi et al., 2015), participants were asked to think about target foods differently (e.g., thinking about the negative consequences of eating the food in the context of health or weight). Giuliani et al. (2013), Svaldi et al. (2015) and Siep et al. (2011) all found that such cognitive reappraisal produced significant large reductions in craving relative to their respective control conditions.

Three studies examined the efficacy of cognitive bias modification, an implicit computer-administered training task, for reducing food cravings. Kemps, Tiggemann, Orr and Grear (2014) and Kemps, Tiggemann, Martin and Elliot (2013) found mixed results for attentional and approach bias retraining programs for reducing food cravings. Kemps et al. (Exp. 2, 2013; Exp. 1, 2014) found that neither approach nor attentional bias retraining reduced chocolate cravings. In contrast, attentional bias retraining did reduce cravings in another study, although the effect was small (Exp. 2, Kemps et al., 2014). Overall, there was little evidence for cognitive bias modification for reducing food cravings. Taken together, the findings suggest that tasks that target controlled cognitive processes, like cognitive reappraisal, may be more effective at reducing food cravings than tasks that target implicit processes. However, further investigation would need to test this suggestion.

Movement Techniques

A small number of studies (n = 6) examined whether movement (e.g., physical activity, breathing and facial movements) can effectively reduce food cravings. These were predominantly conducted in the laboratory. Oh and Taylor (2013) found that chocolate cravings were significantly lower after a 15-minute brisk walk compared with a control condition, and these effects were maintained at 5- and 10-minute follow-up. This finding was supported by Ledochowski, Ruedl, Taylor and Kopp (2015), who showed that a 15-minute brisk walk reduced cravings for high calorie snacks, but only during and immediately after exercise; the effect was not maintained during a subsequent stressful task or a snack exposure task. Both Oh and Taylor (2013) and Ledochowski et al. (2015) found that physical activity reduced cravings with moderate effect sizes. In contrast, Meule and Kübler (2017) found no effect of paced breathing on cravings; in fact, cravings increased during this exercise. There was also no evidence that facial movements (e.g., smiling and frowning) reduced cravings: food cravings increased for the frowning group, and remained relatively stable for the smiling group (Schmidt & Martin, 2017). However, the findings were moderated by emotional eating, whereby individuals with high levels of emotional eating experienced significant reductions in food cravings from positive facial feedback.

In addition to facial movements, orosensory strategies also reduced food cravings. Hetherington and Boyland (2007), and Hetherington and Regan (2011) demonstrated that although cravings gradually increased between lunch and an afternoon snack, chewing gum produced a slower increase in cravings for sweet (Hetherington & Boyland, 2007; Hetherington & Regan, 2011) and salty snacks (Hetherington & Regan, 2011) compared with not chewing gum, with moderate effect sizes. In addition, using menthol mouthwash after eating potato crisps reduced cravings for more crisps (Hutchings, Horner, Dible, Grigor, &

O'Riordan, 2017). Overall, of the techniques based around movement, physical activity interventions showed the most promise in reducing cravings.

Combined Techniques

One study combined a range of techniques to form a self-help manual designed to reduce naturally-occurring food cravings over a three-month period (Rodríguez-Martín, Gómez-Quintana, Díaz-Martínez, & Molerio-Pérez, 2013). Skills included visual and olfactory interference, implementation intentions with healthy alternative replacement statements, repeated visualisation of eating a food to encourage habituation and prevent consumption, performing an enjoyable activity, writing about goals and values and remaining alert while food is prepared. Rodríguez-Martín et al. (2013) found that this multi-skill approach reduced food cravings at one- and three-month follow up, with moderate effect sizes, whereas cravings in the control condition remained stable over time.

Comparison of Techniques

Finally, six studies compared several techniques within the same study. Most were laboratory studies (n = 5), and one examined naturalistic food cravings (Moffitt, Brinkworth, Noakes, & Mohr, 2012). Examining multiple techniques within the same study is an important step in the field of craving reduction, as it enables easy comparison of techniques to determine their relative efficacy. Several laboratory studies compared the effect of multiple techniques from the perspective of the Elaborated-Intrusion Theory of Desire (Hamilton, Fawson, May, Andrade, & Kavanagh, 2013; May, Andrade, Batey, Berry, & Kavanagh, 2010; Schumacher, Kemps, & Tiggemann, 2017).

In their first experiment, May et al. (2010) compared a mindfulness technique (breath focus: focusing on physiological sensations during breathing) and an imagery technique (imagery diversion: diverting attention away from thoughts about a craved food) against a mind-wandering control technique. They found that neither of these techniques reduced cravings during the 10-minute experimental period. In their second experiment, May et al. (2010) compared body scan (a mindfulness technique that involved focusing on internal sensations in specific parts of the body) with guided imagery and a mind-wandering control condition, and again found that neither technique reduced craving intensity. Hamilton et al. (2013) also compared body scan with guided imagery and mind-wandering control conditions, and conversely found that both techniques resulted in reduced cravings compared with the control condition. In two experiments, Schumacher et al. (2017) compared guided imagery with cognitive defusion (a mindfulness technique also known as decentering, or thought distancing). They found that cognitive defusion reduced chocolate cravings relative to control in Experiment 1, and both guided imagery and cognitive defusion reduced cravings in chocolate cravers in Experiment 2, with moderate effect sizes. Finally, Moffitt et al. (2012) compared cognitive defusion with cognitive restructuring (like cognitive reappraisal) and found that both cognitive defusion and cognitive restructuring performed similarly in reducing cravings compared to waitlist control with small to moderate effect sizes.

Overall, there was no evidence of food craving reduction from breath focus and little evidence for body scan. There were, however, moderate craving reduction effects following cognitive defusion and guided imagery across several studies, as well as cognitive restructuring in one study (Moffitt et al., 2012). The inconsistency in findings across these studies may have occurred due to different mindfulness techniques having slightly different aims. For instance, body scan and breathing exercises used in Hamilton et al. (2013) and May et al. (2010) primarily encourage awareness of thoughts, feelings and body sensations. In contrast, cognitive defusion, used in Schumacher et al. (2017) and Moffitt et al. (2012), is a decentering strategy which focuses specifically on distancing the self from the verbal content of thoughts. Therefore, although these techniques fall under the category of mindfulness strategies, exercises which focus on the awareness of bodily sensations and those which focus on decentering from thoughts may have different outcomes.

General Discussion and Future Recommendations

The aim of this systematic review was to evaluate the relative efficacy of interventions designed to reduce food cravings. The included studies (n = 49) used a variety of techniques, the most common of which were imagery- and mindfulness-based strategies. Other less widely used techniques were cognitive techniques and movement techniques. One study combined several of these techniques to form a multi-strategy self-help manual, and others compared the efficacy of different techniques within the same study. Overall, the most consistent craving reduction effects were observed in studies that used imagery-based techniques, predominantly in laboratory-based studies. The evidence for mindfulness-based techniques for reducing food cravings was somewhat mixed, as some studies found that techniques reduced cravings with moderate effect sizes; however, other studies showed no benefit relative to control. Of cognitive and movement techniques, cognitive reappraisal and physical activity showed the most promise for food craving reduction.

Several of the successful food craving reduction techniques reviewed in the present paper lend themselves for use in everyday settings. For example, some of the imagery-based techniques, such as modelling shapes from clay, are relatively simple to use. Others, such as cognitive reappraisal and mindfulness techniques largely rely on internal cognitive resources (e.g., reframing or defusing from thoughts) and may be more challenging to learn, but once learnt, can be applied anywhere at any time. Future research that compares techniques should also consider the ease with which techniques can be adopted by individuals to curb food cravings in everyday life.

Relatedly, successful food craving reduction techniques could be used by clinicians as adjuncts to accompany more structured therapy for problematic cravings and eating behaviours. Thus future research should focus on testing the effectiveness of food craving interventions in individuals who are overweight or obese and experience cravings which lead to overeating (Basdevant, Craplet, & Guy-Grand, 1993; Ng & Davis, 2013; Vander Wal, Johnston, & Dhurandhar, 2007) or binge eating (Gendall, Joyce, Sullivan, & Bulik, 1998; Waters, Hill, & Waller, 2001). Combining several techniques is the next logical step toward developing a battery of techniques for use in clinical settings. The single study that combined several techniques for reducing naturalistic cravings showed large and long-lasting effects at one- and three-month follow-up (Rodríguez-Martín et al., 2013). In such a battery of techniques, different strategies might target different stages of the craving process. In addition, different techniques might be useful for different individuals. Determining the optimal combination of techniques is a future research goal.

The present review highlighted two methodological issues in the existing research. First, few studies included follow-up measures beyond post-test at the end of an intervention. Five laboratory studies took craving measures at 10-20 minutes after intervention, and one field study measured cravings at one- and three-month follow-up. Future studies should include follow-up measures to assess the longevity of effects. Second, only a handful of studies measured individual difference variables (e.g., self-identified craving status, dieting status, emotional eating, hunger), which largely did not affect intervention outcomes. However, the results of the included studies show large variability between individuals. Future research should identify for which groups (e.g., restrictive eaters, emotional eaters), in which states (e.g., when hungry, when satiated), strategies work more effectively, so that interventions can be tailored to the needs of the individual.

It is important to acknowledge some limitations of the current review. First, there was a large degree of variation in the methodology of the included studies, and techniques and methodology were sometimes confounded. For example, most of the imagery-based studies were conducted with university samples and in the laboratory, whereas the mindfulness studies often used selected samples in field settings. Further, results were sometimes difficult to compare because of differences in craving measurement, sample characteristics, number of training sessions, training content, and timing of evaluation. Second, many of the included studies recruited female university students as participants. This limits the generalisation of findings to other demographic groups. However, cravings are more common in women than in men (Weingarten & Elston, 1991), and in younger adults than in older adults (Pelchat, 2002). Finally, intervention studies are vulnerable to publication bias (Scherer, Dickersin, & Langenberg, 1994), a phenomenon that faces many psychological fields where published results tend to show more significant findings than unpublished studies. Although the present study excluded unpublished studies, future studies should seek to include unpublished data from the 'grey' literature.

In summary, the present review sought to evaluate the evidence for strategies used to reduce food cravings. The largest and most consistent evidence base comes from studies using imagery-based techniques, both cognitively demanding tasks requiring the generation of images, as well as less demanding tasks such as watching visual stimuli. There is also good evidence for mindfulness-based interventions, and in particular for those that comprised comprehensive programs taught over several sessions. Techniques such as cognitive reappraisal and physical activity also proved promising. Some of these in-the-moment techniques are relatively simple to use and could be incorporated into everyday and/or clinical contexts. Areas which require further research include evaluating strategies with individuals who suffer from severe or problematic food cravings, examining the role of individual difference variables, comparing the efficacy of several techniques within the same study, and including follow-up measures to determine the longevity of craving reduction effects. It is likely that an optimal intervention would involve several techniques that target different stages of the craving process and could be tailored to meet the needs of different individuals.

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CHAPTER 3: STUDY 2

The food craving experience: Thoughts, images and resistance as predictors of craving intensity and consumption

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Statement of co-authorship: Sophie Schumacher and Eva Kemps formulated the study concept and design. Sophie Schumacher conducted data collection and analysis, as well as the initial first draft of the manuscript. Eva Kemps and Marika Tiggemann edited multiple revised versions of the manuscript.

This manuscript is currently under revisions.

Abstract

The Elaborated-Intrusion Theory of Desire (Kavanagh, Andrade, & May, 2005) suggests that cravings are made up of two distinct stages whereby an initial, seemingly spontaneous craving-related thought is sufficiently intrusive and pleasant for it then to be elaborated with vivid mental imagery. Previous questionnaire studies have investigated the craving experience with a particular focus on the role of imagery. The present study sought to provide a fuller account of the craving process by investigating the role of craving-related thoughts alongside imagery in predicting craving intensity. Further, the present study sought to investigate predictors of craving-related consumption, including spontaneous strategies used to resist cravings. Two-hundred and forty-nine women completed an online questionnaire which asked about their most recent food craving experience. Results showed that around a third of participants reported craving-related thoughts and about half reported craving-related imagery. Craving-related imagery appeared to be a more important predictor of craving intensity than craving-related thoughts; however, neither predicted craving-related consumption. One resistance strategy, ‘recognised it was just a thought’, was successful in decreasing the likelihood of eating in response to craving. Theoretical and practical implications are discussed in the context of the Elaborated-Intrusion Theory.

Introduction

The current food environment has been described as 'obesogenic' (Werthmann, Jansen, & Roefs, 2015). Individuals are constantly bombarded with images of food, through advertising on billboards, television, and print and social media (Mejova, Haddadi, Noulas, & Weber, 2015). Food is also increasingly accessible in Western environments. It is thought that food cues in the environment may trigger food cravings. Food craving is defined as the urge or desire to eat a specific food (Hormes & Rozin, 2010; Weingarten & Elston, 1991). Food cravings are difficult to resist (Hormes & Rozin, 2010), and have been associated with the consumption of energy dense foods (Hill & Heaton-Brown, 1994; Kemps & Tiggemann, 2013). Food cravings have also been associated with binge eating (Curtis & Davis, 2014; Joyner et al., 2015), negative emotions and impulsivity (Meule, Lutz, Vögele, & Kübler, 2014). They prospectively predict unsuccessful dieting, weight gain and increased food consumption (Boswell & Kober, 2016; Meule, Richard, & Platte, 2017). Given these negative outcomes, furthering our knowledge of how food cravings are typically experienced is crucial to informing interventions for reducing food cravings.

One important theory of craving is the Elaborated-Intrusion Theory of Desire (Kavanagh, Andrade, & May, 2005; May, Andrade, Kavanagh, & Hetherington, 2012). This cognitive-motivational theory suggests that the craving process has two stages. In the first stage, initial thoughts appear seemingly automatically in response to cues in the environment, physiological sensations (e.g., stomach rumbling) or mood (Andrade, 2013). These craving-related thoughts may take the form of verbal or image fragments (Kavanagh, Andrade, & May, 2005, pp. 447) and are conscious, but can be either fleeting or intrusive in that they interrupt other trains of thought (Andrade, 2013). In the second stage, if these craving-related thoughts are sufficiently intrusive, they become desires through elaboration with vivid mental imagery. This elaboration process involves multiple sensory modalities, such as visual, gustatory and olfactory imagery, and takes up limited working memory capacity. Although this experience is initially pleasurable, it can become progressively negative, as the absence of the craved target becomes apparent. To alleviate this negative state, a person must either consume the craved food or undertake some other activity (e.g., distraction or redirecting of thoughts) to break the cycle. However, even if the cycle is broken, the same triggers and cues remain and consumption may still occur after a delay.

Previous research has shown support for the presence of both intrusive craving-related thoughts (May, Andrade, Panabokke, & Kavanagh, 2004), and vivid mental imagery during the craving process (Tiggemann & Kemps, 2005). A handful of studies have investigated the typical craving process as experienced by participants. May et al. (2004) found that common triggers for a range of substances (including food) were suddenly thinking about the craved substance, feelings of discomfort, imagining the taste or smell of the target or picturing having it. Tiggemann and Kemps (2005) investigated food cravings specifically and showed that visual, olfactory and gustatory imagery featured in cravings, and that imagery was a key predictor of craving intensity. In addition, May, Andrade, Kavanagh, and Penfound (2008) showed that the combined factors they termed anticipated reward/relief (e.g., 'I'm tired/uncomfortable' and 'I physically need it'), resistance (e.g., 'I try to resist having it') and Elaborated-Intrusion theory factors (e.g., 'I suddenly think about it', 'I imagine the smell/taste of it') accounted for 36% of the variance in craving strength. Finally, a larger, more recent study confirmed intensity, intrusiveness and imagery as separate factors across a range of craved targets including food (May et al., 2014). Together, these findings demonstrate the important role of thoughts and imagery and support the Elaborated-Intrusion theory's account of the craving process.

The present study aimed to provide a more detailed account of the typical food craving experience by examining the relative role of craving-related thoughts and imagery in predicting craving intensity and related consumption. First, we sought to examine the role of craving-related thoughts as well as craving-related imagery in predicting craving intensity. Second, we were interested in whether craving-related thoughts and imagery also predicted craving-related consumption. Although consumption is driven by multiple factors and often occurs in the absence of craving, Kavanagh et al. (2005) suggest that target acquisition (in this case eating the food) is more likely to occur in the presence of craving. Further, not all food cravings lead to consumption. Thus, relatedly we were interested in other factors that might affect craving intensity and consumption, including craving triggers and the typical strategies individuals use to resist their cravings.

Following Tiggemann and Kemps (2005), participants were asked to recount a recent food craving experience. Respondents were also prompted to recall specific thoughts and imagery experienced during the craving episode and, in addition, were asked to identify the strategies they used to resist the craving. Based on previous findings by Tiggemann and Kemps (2005) and May et al. (2008), it was expected that individuals who reported thoughts and/or images would report higher craving intensity than individuals who did not. It was also expected that these, along with craving intensity, would predict consumption. Other analyses were conducted to examine prediction by triggers and resistance strategies.

Method

Participants

Participants were 249 women aged between 17 and 71 years who were recruited for a survey on food craving experiences, which was hosted on the online platform Qualtrics. The sample size was determined based on the range of sample sizes of previous, similar studies (Kemps & Tiggemann, 2005; May et al., 2004; May et al., 2008). A little over half the sample (n = 151, 60.6%) were recruited through Amazon's Mechanical Turk, an online labour market based in the USA whereby workers participate in studies for a small amount of recompense. The rest of the sample (39.4%, *n* = 98) consisted of first-year psychology students at Flinders University in South Australia. The study was granted ethics approval by the Flinders University Social and Behavioural Research Ethics Committee.

Materials and Procedure

All participants first read an information sheet about the study, and indicated their informed consent by proceeding and completing the survey**.** The survey took an average of 26.73 minutes to complete.

Background information. Participants were asked background information, which included their country of residence (sample source), age, height and weight. BMI was later calculated using the formula weight (kg) / height^2 (m). Participants were also asked to rate their current level of hunger from 0 ('not hungry at all') to 100 ('extremely hungry') on a 100 mm visual analogue scale, as hunger can predict craving intensity (Tiggemann & Kemps, 2005). Next, participants were asked a series of questions about their typical food cravings. They were asked how many food cravings they had per week, and to rate the average intensity of their cravings on a 100 mm visual analogue scale from 0 ('not at all intense') to 100 ('extremely intense').

Recent craving experience. Participants were asked to 'think back to the last time you had a food craving', and asked to recall a recent craving experience 'as clearly as you can, as if it were happening right now'. They were explicitly asked to put themselves back in the situation, and write a short paragraph describing that food craving experience in as much detail as they could. Participants were asked to particularly focus on what the craving was like. They were given a free-response text box to describe their experience.

After writing about their experience, participants were asked specific questions regarding their described craving experience. First, participants were asked to rate their craving intensity on a 100 mm visual analogue scale from 0 (‘not at all intense’) to 100 (‘extremely intense’). They were asked which food they craved, and to indicate how many days ago they experienced the craving and at what time of day the craving began. They were also asked how long it had been since they ate prior to the craving beginning.

Triggers. Next, participants were presented with 13 potential craving triggers and asked to identify the extent to which those triggers characterised their craving experience (e.g., ‘I suddenly thought about the food’). These triggers were those used by Tiggemann and Kemps (2005) and May et al. (2008). Participants were also given the opportunity to identify an ‘other’ trigger alongside a free-response text box. The triggers were rated on 6-point Likert scales from 1 (‘not at all’) to 6 (‘definitely’).

Thoughts and images. Participants were then specifically prompted to identify whether they were aware of any thoughts which were present during their craving (e.g., ‘did you notice any specific thoughts as the craving developed?’), with a ‘Yes/No’ response. If respondents selected the ‘Yes’ response, they were asked to describe the thoughts in as much detail as possible with a free-response text box. In addition, respondents were asked to identify whether images were present during the craving (‘did you notice any specific images as the craving developed?’), with a ‘Yes/No’ response. If they responded ‘Yes’, they were asked to describe these images in as much detail as possible in a free-response text box.

Consumption. Following Schumacher et al. (2018), there were two measures of consumption. First, participants were asked whether they ate in response to their craving with a ‘Yes/No’ response. This was used as a categorical variable to measure the likelihood of successfully resisting a craving. Second, if respondents selected ‘Yes’, they were asked to describe what they ate, including the type of food and brand if applicable, in a free-response text box. An example (‘Smith’s original chips’) was given. Then, they were asked to describe the amount of food they ate, and given an example ('55g packet'). This information was later converted into the number of calories consumed using calorie guide databases. When participants did not report sufficient detail, standard serving sizes were used.

Strategies used for resisting cravings. Participants were subsequently asked if they had tried to resist the craving with a 'Yes/No' response. If they selected the 'Yes' response, they were asked to identify the extent to which they used eight specific strategies (e.g., 'avoided thinking about it'). These items were derived from the baseline period of a separate field study (Schumacher, Kemps, & Tiggemann, 2018) in which participants reported the strategies they typically use to resist naturalistic cravings. Participants were also given the opportunity to identify strategies not listed with a free-response option. Each trigger was rated on a 5-point Likert scale from 1 ('not at all') to 5 ('definitely').

Trait food cravings. The 39-item Food Cravings Questionnaire-Trait (FCQ-T; Cepeda-Benito, Gleaves, Williams, & Erath, 2000) was used to measure trait vulnerability to food cravings. It aims to provide a measure of the ways food cravings manifest in particular individuals (Cepeda-Benito et al., 2000). Participants rated items (e.g., 'Whenever I have a food craving, I keep on thinking about eating until I actually eat the food') on a 6-point scale reflecting the extent to which each item applied to them from 'never' to 'always'. Items were then combined to give a total score, with higher scores indicating a higher degree of vulnerability to food cravings. This 39-item questionnaire has good internal consistency (α > .90) across different versions and samples (Cepeda-Benito et al., 2000; Meule, Lutz, Vögele, & Kübler, 2012; Moreno, Rodríguez, Fernandez, Tamez, & Cepeda-Benito, 2008), including the current study (α = .98).

Statistical Analysis

Coding of the qualitative data was conducted by author SS. T-tests were used to assess whether craving intensity differed for individuals who identified thoughts and images and those who did not. Hierarchical multiple regressions were conducted to examine potential predictors of craving intensity and craving-related calories consumed. Logistic regressions were conducted to examine potential predictors of eating in response to cravings (or not), and which craving resistance strategies contributed variance to eating in response to cravings (or not). Finally, simultaneous multiple regressions were conducted to assess whether specific triggers predicted craving intensity and whether craving resistance strategies predicted the number of calories consumed.

Results

Sample Characteristics

Participants ranged in age from 17 to 71 years (M = 32.44, SD = 13.87). Mean self-reported BMI was 25.89 kg/m^2 (SD = 6.80). In a typical week, participants had approximately five food cravings (M = 4.94, SD = 3.80) of moderate intensity (M = 53.62, SD = 20.05), as rated on a 100 mm visual analogue scale. As the Mechanical Turk sample were significantly older (M_{age} = 41.15, SD = 11.16, heavier (M_{BMI} = 28.09, SD = 7.84) and consisted of US residents, as opposed to the Australian university students (M_{age} = 19.27, SD = 1.82; M_{BMI} = 22.61, SD = 2.81), sample source was entered as a covariate in analyses.

Description of Recent Craving Experience

Only one out of 249 participants was unable to recall a recent food craving. Entries ranged from 4-148 words, and were an average of 46.07 words in length (SD = 22.37). Extending upon themes identified by Tiggemann and Kemps (2005; overwhelming nature of cravings, physical reactions and imagery processes), entries were coded by the first author (SS) for spontaneous reports of thoughts and imagery, as well as hunger, the overwhelming nature of cravings and physiological effects.

Participants most commonly reported cravings for takeaway foods (e.g., burgers and pizza; 47.8%), followed by sweet foods (21.7%) and chocolate (20.5%). Cravings for meals (e.g., fish, lasagne) were the next most common (10.0%). Most participants reported that their craving experience occurred within the last 7 days (78.0%), and began in the afternoon (52.7%) or evening (31.0%). The majority of participants reported that the craving occurred more than 1 hour since last eating (73.9%). Many participants reported eating in response to their craving (67.8%). In addition, just over half of individuals (59.6%) tried to resist their craving.

Approaching half the participants (47.8%, n = 119) spontaneously reported thoughts and/or images as part of their paragraph description of their craving experience. Some respondents commented that their cravings were associated with hunger (10.84%, n = 27), and memories (3.21%, n = 8). Participants often reported about the overwhelming nature of cravings (28.92%, n = 72). For instance, language associated with the urge for the food was often used (e.g., 'felt my body really needed it', 'It feels like a need … a desperate thing'), or the effect of the cravings on their cognitive abilities (e.g., 'It was really hard to concentrate', 'something that I can't stop thinking about'). Participants (17.67%, n = 44) also mentioned physiological effects of craving ('my mouth was watering just thinking about it', 'I usually have a really warm feeling in my stomach and become really fidgety').

Craving-related Thoughts and Images

Next, responses to the specific questions about noticing thoughts or images as part of the craving experience were analysed. Out of 249 participants, 93 (37.3%) reported noticing thoughts and 133 (53.4%) reported noticing images as part of their cravings. All participants who responded 'yes' to noticing thoughts or images in their cravings responded in the free-response text box.

Text responses to the 'thoughts' question were coded for themes. Participants who identified craving-related thoughts often reported that they thought about the taste (24.17%, n

= 22), followed by the look (16.48%, *n* = 15), and smell of the food (4.40%, *n* = 4). Thoughts sometimes also involved actions to obtain the food (23.08%, *n* = 21; e.g., ‘I would immediately think of which specific sushi I was craving and went into depth of which sushi place I would go to and exactly what on the menu I wanted’). Some also involved memories or past experiences of eating the food (14.29%, *n* = 13), such as ‘I thought about the last time I had Indian food which was with my family in a restaurant and … how happy I was at the time’. Interestingly, 15.38% (*n* = 14) of thoughts involved some kind of self-talk or ‘speaking back’ to the craving-related thoughts, or a flight of different thoughts. Often, this self-talk would involve reasons not to indulge the craving (e.g., ‘I shouldn't have an ice cream because I will put on weight’). Some respondents also thought about the benefits or justifications for eating the food (24.18%, *n* = 22; e.g., ‘At first I felt guilty that I was having this food, but then my thoughts began to justify it, pointing out that I was stressed, I need comfort food, I needed a break, it would help my study, it wouldn't really have an effect on me, and that maybe I could do it more often ...’).

Of those participants who identified images as part of their craving (53.4%, *n* = 133), images were primarily visual (81.95%, *n* = 109), gustatory (24.06%, *n* = 32), and olfactory (12.03%, *n* = 16) in nature, although some individuals noted multiple sensory modalities. Images sometimes involved the actions taken to obtain the food (17.29%, *n* = 23; e.g., ‘I saw myself making the taco's [sic] in my kitchen, assembling them and then eating them’). Some participants reported that their imagery was associated with memories (11.27%, *n* = 15; e.g., ‘I imagined my grandmother being in the kitchen and having me help her prepare the meal’) or physical sensations (3.01%, *n* = 4; e.g., ‘the cool feel of it on my tongue’).

Craving Intensity

Independent samples t-tests were conducted to assess potential differences in craving intensity for those who reported craving-related thoughts and images. Results showed that participants who reported craving-related thoughts (M = 74.03, SD = 21.27) had marginally more intense cravings than participants who did not (M = 68.62, SD = 20.90), t(247) = 1.97, p = .051. In addition, participants who reported craving-related images had significantly more intense cravings (M = 73.74, SD = 18.77) than participants who did not (M = 67.08, SD = 23.18), t(247) = 2.51, p = .013.

A hierarchical multiple regression was conducted to examine potential predictors of craving intensity in the recent craving experience. Demographic/background variables of age, sample source, BMI, current level of hunger and trait food craving were entered in Step 1. Next, the number of craving-related thoughts and craving-related images were both entered in Step 2. Overall, these predictors accounted for 14.0% of the variance in craving intensity, R = .374, F (7, 243) = 5.50, $p < .001$. The background variables in Step 1 together explained a significant proportion of the variance (9.9%), R = .315, F(5, 243) = 5.26, $p < .001$. Adding craving-related thoughts and images in Step 2 provided a further unique contribution, R^2_{change} = .042, F_{change} (2, 236) = 5.59, p = .004. The regression coefficients (β) for the final regression equation presented in Table 1, showing that current level of hunger and craving-related images were significant positive predictors in the final model.

Table 1

Standardised regression coefficients (betas) for hierarchical regression analyses to predict craving intensity and craving-related calories consumed, with unstandardized B values from hierarchical logistic regression predicting likelihood of craving-related consumption.

Variable	*Craving intensity*	*Likelihood of consuming*	*Calories consumed*
	β	B	β
Step 1			
Age	.147	.009	.034
Sample source	.115	-.561	-.070
BMI	.093	-.014	.071
Current level of hunger	.120*	-.008	-.060
Trait food craving	.085	.006	.123
Step 2			
Craving-related thoughts	.101	.066	.031
Craving-related images	.172*	-.387	.025
Step 3			
Craving intensity	-	.008	.149*

Craving-related Consumption

Chi-square analyses showed that there was no significant relationship between the likelihood of eating in response to cravings and either reporting thoughts, $\chi^2 = 0.10$, df = 1, $p = .749$, or images, $\chi^2 = 0.84$, df = 1, $p = .361$. There was also no significant difference in the number of craving-related calories consumed between participants who reported thoughts ($M = 311.19$, $SD = 365.08$) and those who did not ($M = 276.61$, $SD = 333.73$), $t(247) = 0.76$, $p = .446$, or between participants who reported images ($M = 309.97$, $SD = 383.06$) and those who did not ($M = 266.09$, $SD = 296.46$), $t(243.66) = 1.02$, $p = .310$.

A logistic regression was conducted to examine potential predictors of eating in response to a craving. The outcome variable (‘did you eat in response to the craving?’) was coded as follows, No = 0, Yes = 1. Background variables of age, sample source, BMI, hunger and trait food craving were entered in Step 1. Craving-related thoughts and images were both entered in Step 2, and finally, craving intensity was entered in Step 3. The final model was not significant, with a Nagelkerke’s pseudo R^2 of .053, $\chi^2 = 9.39$, df = 8, $p = .310$. Further, none of the steps contributed significant variance to the outcome (ps > .05). Table 1 displays the B-values for the final model.

In addition, a hierarchical multiple regression was conducted to assess predictors of number of craving-related calories consumed. Results showed that the final model was not significant, explaining only 5.8% of the variance in calories consumed, $R = .240$, F (8, 243) = 1.79, $p = .079$. Only craving intensity was a significant positive predictor of the number of craving-related calories consumed, $\beta = .149$, $p = .030$. Regression coefficients (β) are given in Table 1.

Craving Triggers

As shown in Table 2, by far the most highly endorsed craving trigger was ‘I suddenly thought about the food’. This was followed by ‘I felt like it’, ‘I pictured myself having it’ and ‘I remembered the time I had it last/once’.

A simultaneous multiple regression was conducted to investigate whether specific triggers significantly predicted craving intensity. All 13 triggers were entered simultaneously, with craving intensity entered as the outcome variable. As shown in Table 2, the triggers ‘I suddenly thought about the food’ and ‘I pictured myself having it’ were associated with higher craving intensity, while ‘I was bored’ was associated with less intense cravings.

Table 2

Mean endorsement of craving triggers, with standardised coefficients (β) shown.

Craving trigger	M (SD)	Craving intensity β
I smelled the food	1.74 (1.47)	-.038
I saw the food (or an image, advertisement of the food)	2.58 (1.97)	-.077
I suddenly thought about the food	4.90 (1.50)	.151*
I felt stressed/anxious/sad	2.39 (1.60)	.064
I was bored	2.52 (1.74)	-.279**
I felt hungry	3.29 (1.71)	.018
I was / someone else was talking about the food	2.02 (1.70)	.078
I usually have it at that time / place	1.87 (1.49)	-.077
I pictured myself having it	3.55 (1.93)	.200*
I felt happy	2.66 (1.68)	-.012
I was really busy	1.90 (1.42)	-.072
I remembered the time I had it last/ once	3.47 (1.89)	.007
I felt like it	3.99 (1.98)	-.062

Strategies Used to Resist Cravings

Over half of participants (59.6%, n = 146) reported trying to resist eating in response to their craving. As can be seen in Table 3, the only moderately endorsed (>3) strategy used to resist cravings was ‘physical barrier’. This was followed by ‘avoided thinking about it’, ‘distracted myself’, and ‘did another task’.

Table 3

Means (and standard deviations), and results of a logistic regression assessing the relationship between craving reduction strategies and likelihood of consumption, and a simultaneous hierarchical regression for craving-related calories consumed.

Item	Mean (SD)	Logistic regression *B*	Odds ratio	Simultaneous hierarchical regression β
Physical barrier (didn't have access, didn't have money, not in the house, not near the shop)	3.23 (1.73)	-.211	.810	.086
Drank water	2.67 (1.51)	.047	1.05	.149
Ate something else instead	2.67 (1.61)	.254	1.29	.064
Told myself something	2.55 (1.49)	.453	1.57**	-.017
Avoided thinking about it	2.99 (1.35)	-.267	.765	-.047
Did another task	2.79 (1.56)	.079	1.08	-.012
Recognised it was just a thought	2.36 (1.41)	-.397	.672*	.074
Distracted myself	2.92 (1.45)	-.394	.674	-.277
Just didn't eat it*	2.57 (1.63)			
Delayed eating*	2.41 (1.49)			
Nagelkerke pseudo r^2	.316			
Chi-square	39.40, $df = 8$, $p < .001$			

* Not included in regression analyses

Two strategies, ‘just didn’t eat it’ and ‘delayed eating’, were excluded from the following analysis because they may be confounded with the outcome (eating/not eating). To test which craving resistance strategies were the most successful (i.e., contributed the most variance to eating in response to cravings), a logistic regression with the remaining eight resistance strategies entered simultaneously was conducted. As shown in Table 3, the overall model was significant, with two strategies contributing significantly to the model. Higher endorsement of ‘recognised it was just a thought’ was associated with a higher likelihood of successfully not eating in response to the craving. In contrast, higher endorsement of ‘told myself something’ was associated with increased likelihood of eating following a craving.

A simultaneous regression was also conducted to assess whether craving resistance strategies predicted calories consumed. In this case, the overall model was not significant, $R = .261$, $F\ (8, 78) = 0.64$, $p = .74$. As can be seen in Table 3, none of the strategies contributed significantly to the model.

Discussion

The present study was designed to extend previous literature which explored the food craving process. The main aim was to provide a fuller account of the craving process by investigating the relative role of craving-related thoughts and images in predicting craving intensity and craving-related consumption. We also explored the typical strategies used to resist cravings. Results showed that craving triggers relevant to the Elaborated-Intrusion Theory (e.g., suddenly thinking about the food, picturing myself having it) were significant positive predictors of craving intensity. Further, in response to the specific prompting questions, participants who identified craving-related thoughts and images had more intense cravings. However, craving-related thoughts and images were not significant predictors of craving-related consumption, neither in the likelihood of consumption following a craving, nor the number of calories consumed. In fact, the only significant predictor of craving-related calories consumed was craving intensity. Only one strategy was significantly associated with successful resistance to a craving, namely, ‘recognised it was just a thought’. Another strategy, ‘told myself something’, significantly increased the likelihood of eating following a craving. None of the resistance strategies significantly predicted the number of calories consumed. As a set, the current findings confirm and extend a number of existing findings.

The content of the ‘recent craving experience’ free response descriptions was comparable with findings from Tiggemann and Kemps (2005). They found that most participants commented on the overwhelming nature of cravings, such that they affected concentration, as was also found in the present study. Participants in Tiggemann and Kemps’ (2005) study also noticed physiological effects of craving, such as salivation, which were similar to participants’ observations in the present study. In addition, just under half of respondents in the present study spontaneously reported thoughts or images as part of their craving experience. The present study also prompted participants to recall specific thoughts and images that were present during their cravings. Results showed that when prompted, more than a third of participants reported thoughts and more than half reported imagery as part of their cravings. Thoughts often involved ‘speaking back’ to cravings, and images were most often visual, then gustatory and olfactory in nature, in line with Tiggemann and Kemps’ (2005) observations. Both thoughts and images sometimes involved actions or plans to obtain the craved food. Interestingly, participants often talked about imagery when answering the specific question about thoughts, and vice versa**.** Indeed, the Elaborated-Intrusion Theory suggests that thoughts may involve verbal or image components. Further, it seems that individuals may not be able to easily distinguish between the two stages of the model (intrusion and elaboration), perhaps because the first intrusion stage of the process is so short-lived.

Both craving triggers and the identification of thoughts and images in cravings were tested as potential predictors of craving intensity. The results showed that triggers relevant to the Elaborated-Intrusion theory, namely suddenly thinking about the food and picturing oneself having the food, were associated with more intense cravings. In addition, participants who identified thoughts and images had more intense food cravings, in line with May et al.'s (2008) finding for substances in general. However, the regression analysis showed that only the presence of craving-related images uniquely predicted craving intensity, suggesting that this may be the more salient of the two processes.

Finally, the present study endeavoured to investigate whether craving-related thoughts and images predicted craving-related consumption. In particular, we examined the likelihood of consumption following a craving and the number of craving-related calories consumed as outcome measures. The present study found that neither craving-related thoughts nor images played a role in predicting the likelihood of successfully or unsuccessfully resisting cravings, nor the number of calories consumed following a craving. This is perhaps not surprising, given that is influenced by a range of other factors, including mood, the level of other cognitive demands and other incentives to consume or resist a craved food (Kavanagh et al., 2005)**.** In addition, the present sample was an unselected non-clinical sample, and the outcomes may have differed in a clinical sample. Nevertheless, of the factors we tested in the present sample, craving intensity was the only predictor of the number of craving-related calories consumed, such that more intense cravings were associated with greater consumption. These findings suggest that although craving-related thoughts and images may contribute to craving intensity, they do not directly contribute to variance in craving-related consumption.

Further, we found limited evidence to show that craving resistance strategies were successful in preventing consumption. In particular, we showed that higher endorsement of 'recognised it was just a thought' was associated with higher likelihood of successfully resisting a craving. 'Recognised it was just a thought' is similar to the technique of cognitive defusion, which teaches the principle of 'de-fusing' or separating the self from thoughts, and has been successfully used to combat food cravings and related consumption (Hooper, Sandoz, Ashton, Clarke, & McHugh, 2012; Jenkins & Tapper, 2014; Schumacher, Kemps & Tiggemann, 2018). In contrast, higher endorsement of 'told myself something' was associated with higher likelihood of eating in response to the craving**.** As individuals did not report exactly what they told themselves, we cannot determine the exact nature of this strategy. Some individuals may have tried to argue against their craving thoughts, whereas others may have rationalised their cravings, as suggested by some of the qualitative responses. Further, our list of potential strategies was derived from previous research investigating spontaneous strategies used to resist cravings (Schumacher, Kemps, & Tiggemann, 2018). Accordingly, there may yet be more formal theory-based strategies that target specific components. For example, mindfulness techniques might be particularly useful for addressing responses to craving-related thoughts, while imagery strategies could be used to combat craving-related imagery.

The present findings generally support the Elaborated-Intrusion Theory's account of food cravings by showing that a number of participants identify thoughts and/or images as part of their cravings. Further, we showed that when prompted, around a third of participants reported thoughts and around half of participants reported imagery. It seems, however, that individuals did not necessarily differentiate between thoughts and images during the craving experience. Perhaps the nature of seemingly automatic, intrusive thoughts is such that they are difficult to detect, even when prompted. Further, vivid images are likely more salient and easily remembered than initial, spontaneous craving-related thoughts which are so short-lived. Although the present study focused more on the theoretical underpinnings of the craving process, the findings also have practical implications. For individuals, increasing their own awareness of their typical craving experience may have been a useful exercise in itself, in identifying typical patterns or triggers which induce cravings. For researchers, knowledge about the different stages of the craving experience, from triggers to thoughts to images and strategies to resist cravings, could potentially be used to inform points at which to intervene to reduce food cravings.

In conclusion, the current study provided further insight into the role of craving triggers, thoughts, images and resistance strategies in predicting both craving intensity and craving-related consumption. In particular, the current study highlighted the importance of craving-related imagery in predicting craving intensity, which in turn predicted number of craving-related calories consumed. Findings of the current study could be used to identify targets for interventions to reduce cravings, and ultimately the unwanted consumption of craved foods.

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CHAPTER 4: STUDIES 3 AND 4

Acceptance- and imagery-based strategies can reduce chocolate cravings: A test of the Elaborated-Intrusion Theory of Desire

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Statement of co-authorship: Sophie Schumacher and Eva Kemps formulated the study concept and design. Sophie Schumacher conducted data collection and analysis, as well as the initial first draft of the manuscript. Eva Kemps and Marika Tiggemann edited multiple revised versions of the manuscript.

Acknowledgements: We thank David Hall and Paul Douglas for technical assistance with audio-recording the intervention scripts. This research was supported by funding from Flinders University.

This manuscript has been published as:

Schumacher, S., Kemps, E., & Tiggemann, M. (2017). Acceptance-and imagery-based strategies can reduce chocolate cravings: A test of the elaborated-intrusion theory of desire. *Appetite, 113,* 63-70. doi: 10.1016/j.appet.2017.02.012

Abstract

The Elaborated-Intrusion Theory of Desire proposes that craving is a two-stage process whereby initial intrusions about a desired target are subsequently elaborated with mental imagery. The present study tested whether the craving reduction strategies of cognitive defusion and guided imagery could differentially target the intrusion and elaboration stages, respectively, and thus differentially impact the craving process. Participants were randomly assigned to a cognitive defusion, a guided imagery or a mind-wandering control condition. Pre- and post-intervention chocolate-related thoughts, intrusiveness of thoughts, vividness of imagery, craving intensity, and chocolate consumption were compared. Experiment 1 recruited a general sample of young women (*n* = 94), whereas Experiment 2 recruited a sample of chocolate cravers who wanted to reduce their chocolate consumption (*n* = 97). Across both experiments, cognitive defusion lowered intrusiveness of thoughts, vividness of imagery and craving intensity. Guided imagery reduced chocolate-related thoughts, intrusiveness, vividness and craving intensity for chocolate cravers (Experiment 2), but not for the general sample (Experiment 1). There were no group differences in chocolate consumption in either experiment. Results add to existing evidence supporting the Elaborated-Intrusion Theory of Desire in the food domain, and suggest that acceptance- and imagery-based techniques have potential for use in combatting problematic cravings.

Introduction

Food cravings are thought to play a key role in the over-consumption of high caloric foods (May, Andrade, Kavanagh, & Hetherington, 2012). Cravings refer to an intense urge to ingest a particular food and are difficult to resist (Weingarten & Elston, 1990). Cravings are distinct from hunger, in that hunger can be satisfied by ingesting food in general, whereas craving is usually for a specific food (Pelchat, 2002). The most commonly craved foods are those high in fat, salt and sugar, with chocolate being the most highly craved food in Western society (Hill & Heaton-Brown, 1994; Weingarten & Elston, 1990; Weingarten & Elston, 1991). Cravings are thought to be cognitive in nature, and have been described as a subjective motivational state (Shiffman, 2000; White, Wisenhunt, Williamson, Greenway, & Netemeyer, 2002). Although food cravings are not necessarily pathological, they can be maladaptive for some people. In particular, food cravings have been linked to negative mood and depression (Davis et al., 2011), disordered eating, especially binge eating episodes (Gendall, Joyce, Sullivan, & Bulik, 1998; Mitchell, Hatsukami, Eckert, & Pyle, 1985; Waters, Hill, & Waller, 2001), as well as health problems associated with weight gain and obesity (von Deneen & Liu, 2011; Wurtman & Wurtman, 1986). In light of these negative consequences, there is a clear need to develop interventions to combat food cravings.

A number of theories have been proposed to explain the inception and maintenance of cravings. The Elaborated-Intrusion Theory of Desire proposes that a craving is a cognitive motivational process that consists of two distinct stages (Kavanagh, Andrade, & May, 2005; May et al., 2012). First, thoughts or intrusions are generated in response to craving-related cues (e.g., pictures of food) in the environment. These cues can be cognitive, emotional or physiological in nature, and can be tied to positive memories and associations, which contribute to an initially pleasant experience. Second, craving-related thoughts subsequently motivate the individual to mentally elaborate the intrusion with vivid imagery using several senses, which creates a realistic representation of the craved target. Of the five sensory modalities, visual, olfactory and gustatory components feature prominently in food craving-related imagery elaboration (May, Andrade, Pannabokke, & Kavanagh, 2004; Tiggemann & Kemps, 2005). Mental elaboration, while initially pleasurable, can grow to become unpleasant if the desire cannot be satisfied. Desire thinking theory (Caselli & Spada, 2010; 2015) likewise emphasises multi-sensory imaginal elaboration of a desired target. Desire thinking theory also adds another process, verbal perseveration, which involves continual self-talk about reasons for engaging with the desired target (Caselli, Soliani, & Spada, 2013). Accordingly, Caselli and Spada (2010) suggest that metacognitions play a role in desire thinking and contribute to the cyclic continuation of desire thoughts and stronger cravings (Spada, Caselli, Nikčević, & Wells, 2015). Normally cravings can be alleviated by either ingesting the target, or through diversion with an alternative task. However, as food and craving cues in the environment are abundant, the process may be triggered repeatedly, and consumption of the target may still occur after a delay.

As the Elaborated-Intrusion Theory suggests that cravings can be reduced through a reduction of intrusions and elaboration, techniques could logically target either of these mechanisms. To date, food craving research has primarily focused on targeting the later elaboration stage, rather than the initial intrusions. Most strategies have used alternative imagery to replace craving-related imagery in limited capacity visuospatial working memory. Laboratory studies have demonstrated that forming alternative images of objects (e.g., imagining the appearance of a rainbow), smells (e.g., imagining the smell of freshly mown grass; Hamilton, Fawson, May, Andrade, & Kavanagh, 2013; Harvey, Kemps, & Tiggemann, 2005; Kemps & Tiggemann, 2007) or enjoyed activities (e.g., walking on the beach;

Knäuper, Pillay, Lacaille, McCollam, & Kelso, 2011) can interrupt craving-related imagery in the laboratory. Other techniques include forming mental representations of shapes while modelling clay into pyramid and cube shapes with hands hidden from direct view (Andrade, Pears, May & Kavanagh, 2012), watching dynamic visual noise (a flickering, random pattern of black and white dots; Kemps, Tiggemann, & Christianson, 2008; Kemps, Tiggemann, & Hart, 2005; Kemps, Tiggemann, Woods, & Soekov, 2004; McClelland, Kemps, & Tiggemann, 2006), and even playing the computer game 'Tetris' (Skorka-Brown, Andrade, & May, 2014). Kemps and Tiggemann (2013) and Hsu et al. (2014) further showed that imagery-based techniques can reduce craving-related consumption in the field.

More recently, May et al. (2012) have suggested that mindfulness-based interventions may be beneficial for targeting the initial intrusion stage, a suggestion consistent with targeting metacognitions in desire thinking (Spada et al., 2015). Specifically, changing individuals' reactions to their intrusions before elaboration can take place may be an effective way to halt the craving process in this early stage. More generally, mindfulness-based interventions have been applied to the eating domain (Alberts, Mulkens, Smeets, & Thewissen, 2010; Alberts, Thewissen, & Raes, 2012; Baer, Fischer, & Huss, 2005; Kristeller & Hallett, 1999; Papies, Barsalou, & Custers, 2012) and one particular skill, cognitive defusion, has shown promise for use with chocolate cravings (Forman et al., 2007; Hooper et al., 2011; Jenkins & Tapper, 2014; Lacaille et al., 2014; Moffitt, Brinkworth, Noakes, & Mohr, 2012). A number of studies have compared cognitive defusion to other mindfulness techniques (e.g., acceptance, awareness), alternative cognitive techniques (e.g., cognitive restructuring) or control (e.g., distraction or no instructions) and found that cognitive defusion increased the likelihood of abstaining from chocolate (Moffitt et al., 2012; Jenkins & Tapper, 2014; Hooper et al., 2011; Forman et al., 2007). However, there has been mixed evidence as to whether cognitive defusion can reduce cravings (Moffitt et al., 2012; Lacaille et al., 2014; Forman et al., 2007). In addition, previous studies did not examine the mechanisms postulated by the Elaborated-Intrusion Theory.

To date, only a handful of studies have compared mindfulness-based and imagery-based craving reduction techniques within the context of the Elaborated-Intrusion Theory. The first study by May, Andrade, Batey, Berry and Kavanagh (2010) compared mindfulness-based strategies (i.e., breath focus and body scan, techniques promoting acceptance of physiological sensations in the body) with imagery-based strategies (i.e., guided imagery). They found that body scan reduced thoughts but not craving intensity; breath focus and guided imagery had no effect on either. In the second study, Hamilton et al. (2013) found that body scan and guided imagery reduced craving intensity relative to a mind wandering control; however, there was no effect of either technique on intrusiveness of thoughts and vividness of imagery.

In the present study, we were particularly interested in targeting the individual components of craving, namely, intrusions (targeted by a cognitive defusion technique) and elaboration (targeted by a guided imagery technique), to determine effects on craving intensity and consumption. Cognitive defusion was chosen to target the initial intrusion process instead of body scan (as used by May et al., 2010 and Hamilton et al., 2013) because it is less likely to draw attention to physiological cues linked with hunger. Cognitive defusion focuses specifically on acceptance of thoughts rather than physical states. We used chocolate as the desired target because it is the most commonly craved food in Western environments (Hill & Heaton-Brown, 1994; Weingarten & Elston, 1990; Weingarten & Elston, 1991) and is more likely to induce cravings than breakfast food items (as used by Hamilton et al., 2013). Experiment 1 examined the impact of cognitive defusion and guided imagery in a general sample of young undergraduate women. Experiment 2 replicated and extended this investigation to a sample of self-identified chocolate cravers.

Based on the Elaborated-Intrusion Theory framework, and consistent with the predictions of desire thinking theory**,** we expected that craving intensity and consumption would be reduced through a decrease in the individual craving mechanisms of intrusiveness of thoughts and vividness of imagery. We predicted that cognitive defusion would halt the craving process by reducing the intrusiveness of thoughts, and subsequently the vividness of imagery, craving intensity and consumption. We further predicted that guided imagery would reduce the vividness of imagery, and subsequently reduce craving intensity and consumption.

Experiment 1

Method

Participants

Participants were 94 women aged 17-26 years (*M* = 20.68, *SD* = 2.45), who were recruited from the Flinders University student population, and from the wider Adelaide community. Young women were specifically recruited because cravings are more common in women than in men (Weingarten & Elston, 1991), and cravings are reported less often as people age (Pelchat, 2002). A further inclusion criterion was that participants should like chocolate. This criterion was confirmed at testing where all participants responded affirmatively to the question ‘Do you like chocolate?’. Participants were asked to refrain from eating or drinking for 2 hours prior to attending the session, to ensure they were equated on hunger and satiety. Participants were also asked to abstain from eating chocolate for 24 hours prior to attending the testing session.

Design

The study used a mixed 3 (condition: cognitive defusion, guided imagery, control) x 2 (time: pre-intervention, post-intervention) experimental design. Condition was a between-subjects factor and time was a within-subjects factor. Participants were alternately allocated to the cognitive defusion (n = 32), guided imagery (n = 30) or control conditions (n = 32). Sample sizes were based upon previous studies (Hamilton et al., 2013; Kemps & Tiggemann, 2013). The dependent variables were number of chocolate-related thoughts, intrusiveness of craving-related thoughts, vividness of craving-related imagery, craving intensity and chocolate consumption. Ethics approval was granted by the Flinders University Social and Behavioural Research Ethics Committee.

Materials

Craving Induction. Following Kemps and Tiggemann (2007), chocolate cravings were induced through a combination of deprivation and exposure. First, as noted above, participants were asked to refrain from eating chocolate for the 24 hours prior to the experiment. Second, upon arrival at the laboratory, participants were presented with a bowl of individually wrapped Lindor milk, dark and white chocolate balls and asked to select their favourite and then to unwrap, touch and smell the chocolate and imagine what it would taste like. The selected chocolate and the bowl with other chocolates were then removed.

Intervention. Interventions were delivered in a manner similar to that used by Hamilton et al. (2013) and May et al. (2010; Experiment 2), where participants heard 30 audio-recorded instructional statements through headphones. Each statement was separated by a ten second period of silence, in which participants could practise the previous instruction. The duration of each recording was approximately ten minutes.

Cognitive defusion. The cognitive defusion script was created based on the general cognitive defusion principles used in other interventions by Hooper et al. (2012) and Jenkins and Tapper (2013). Cognitive defusion is a metacognitive skill that asks individuals to observe and distance themselves from their thoughts, and to think of them as thoughts and not as truths that must be behaviourally enacted. Statements included psychoeducation about thoughts (e.g., ‘We can become fused to our thoughts, when we believe our thoughts to be true without questioning them') as well as instructions to defuse from thoughts (e.g., 'Consider your thoughts as merely thoughts, and do not judge them'). The script did not contain the words 'food', 'craving' or 'chocolate'; nor did it contain imagery of any kind.

Guided imagery. The guided imagery script was that used by May et al. (2010) with minor adaptations for the Australian context (e.g., 'forest' instead of 'wood'). Participants were instructed to imagine a walk through a forest. This guided imaginal experience cued participants with visual, auditory and olfactory sensory information (e.g., 'All around you are flowers, bobbing their heads in the breeze. The scent of the flowers wafts around you.').

Control. The control script was taken from May et al. (2010). Statements comprised instructions to allow the mind to wander, and to think of whatever the participant wished (e.g., 'Let your mind wander wherever it will go, thinking about anything or nothing at all').

Number of chocolate-related thoughts. Chocolate-related thoughts were sampled with thought probes, using a similar method to that used by May et al. (2010; Experiment 1). Specifically, 20 bell tones were pseudo-randomly timed to occur at intervals between 15 and 45 seconds. No other sound occurred between bell tones. Participants were asked to listen for the sound of a bell chiming and to report out loud what they were thinking in one or two words. They were told that they could report 'nothing' if they were not thinking about anything specific at that time. The experimenter recorded participants' thoughts as they were reported. At the end of the experiment, participants self-classified their recorded thoughts as being related to chocolate, food, or 'other'. Percentage of chocolate-related thoughts was then calculated. Retrospective self-classification of thoughts (originally developed by Teasdale, Lloyd, Proctor and Baddeley, 1993) was used to reduce disruptions at the point of sampling and to allow participants to clarify their thoughts without giving excess details (May et al., 2010; Smallwood & Schooler, 2006).

Intrusiveness of craving thoughts and vividness of craving imagery. Intrusiveness of craving-related thoughts and vividness of craving-related imagery were assessed with the corresponding subscales of the Craving Experience Questionnaire-Strength (May et al., 2014). Participants completed these specifically with regard to cravings for chocolate during the previous ten-minute period. Participants rated three questions about the intrusiveness of their thoughts (e.g., ‘How hard were you trying not to think about it?’) and four questions about the vividness of their imagery (e.g., ‘How vividly did you imagine its taste?’) on 11-point Likert scales ranging from 0 (not at all) to 10 (extremely). The mean score for each subscale was calculated.

Chocolate craving intensity. Following the protocol of Kemps and Tiggemann (2007; 2013), chocolate craving intensity was measured with a 100mm visual analogue scale ranging from ‘no desire or urge to eat chocolate’ to ‘extremely strong desire or urge to eat chocolate’. Such a visual analogue scale is quick and easy to administer, and useful for measurement across repeated time points.

Chocolate consumption. Chocolate consumption was assessed in a taste test. Participants were presented with three bowls containing 100g each of white, dark and milk chocolate buttons, approximately 6mm in diameter. The order in which the bowls were presented was counterbalanced. Participants were given ten minutes to taste and rate each type of chocolate on sensory characteristics (e.g., ‘How sweet is this chocolate?’), using 100mm visual analogue scales ranging from ‘not at all’ to ‘extremely’. They were instructed that they could eat as much of the chocolate as they liked, as the remainder would be thrown away. Participants were left alone in the room while tasting. Total chocolate consumption in grams was surreptitiously measured by weighing the bowls before and after the tasting period.

Procedure

Participants were tested individually in the Applied Cognitive Psychology laboratory.

Experimental sessions were approximately one hour in duration. All sessions took place after midday, as cravings are most commonly reported to occur in the afternoon (Hill, Weaver, & Blundell, 1991). Sessions were divided into pre-intervention, intervention and post-intervention phases. In the pre-intervention phase, participants underwent the craving induction procedure, the initial ten-minute thought probe and rated the intrusiveness of their thoughts and the vividness of their images, followed by their first chocolate craving intensity rating. In the intervention phase, participants listened to the instructional scripts for their allocated condition (cognitive defusion, guided imagery, or control). The post-intervention phase consisted of another set of thought intrusiveness and imagery vividness ratings and a second craving intensity rating, followed by a ten-minute post-intervention thought probe, and a third craving intensity rating, and finally the chocolate taste test.

Results

Statistical Considerations

An alpha level of .050 was used to determine significance. Partial eta-squared was used as the measure of effect size for Analysis of Variance (ANOVA), with .010 representing a small effect, .060 a medium effect and .140 a large effect. Cohen's *d* was the effect size measure for t-tests, with benchmarks at 0.20 for small, 0.50 for medium and 0.80 for large effects. A series of 3 (condition: cognitive defusion, guided imagery, control) x 2 (time: pre-intervention, post-intervention) mixed factorial ANOVAs was conducted to assess the effect of the interventions on chocolate-related thoughts, intrusiveness of thoughts and vividness of imagery. Planned comparisons were used to assess predicted change within conditions when examining the intervention effects across time. One-way ANOVAs and *t*-tests showed no significant differences between conditions at pre-intervention on percentage of chocolate-related thoughts, intrusiveness, vividness and craving intensity (all ps $\geq .05$).

Percentage of Chocolate-related Thoughts

Analyses showed a main effect of condition, $F(1, 91) = 3.75$, $p = .027$, $\eta_p^2 = .076$, but no main effect of time $F(1, 91) = .07$, $p = .797$, $\eta_p^2 = .001$. There was also a significant condition by time interaction, $F(2, 91) = 3.56$, $p = .033$, $\eta_p^2 = .073$. Pairwise comparisons showed that only the control condition had an increase in chocolate-related thoughts after the intervention period ($M = 25.63$, $SD = 16.84$) compared with before ($M = 20.16$, $SD = 16.19$, $p = .050$, $d = 0.33$). By contrast, participants in the cognitive defusion and guided imagery conditions reported no significant change in chocolate-related thoughts after the intervention (cognitive defusion: before $M = 15.78$, $SD = 13.80$, after $M = 11.41$, $SD = 10.87$, $p = .115$, $d = 0.35$; guided imagery: before $M = 20.50$, $SD = 18.35$, after $M = 18.17$, $SD = 17.49$, $p = .413$, $d = 0.13$).

Intrusiveness of Craving-related Thoughts

Analyses revealed a main effect of time, $F(1, 90) = 7.71$, $p = .007$, $\eta_p^2 = .079$, but no main effect of condition, $F(2, 90) = 1.34$, $p = .268$, $\eta_p^2 = .029$, or condition by time interaction $F(2, 90) = 2.23$, $p = .114$, $\eta_p^2 = .047$. Nevertheless, as predicted, planned pairwise comparison analyses showed that participants in the cognitive defusion condition experienced a significant reduction in thought intrusiveness from pre- ($M = 4.19$, $SD = 2.86$) to post-intervention ($M = 2.56$, $SD = 2.28$, $p = .002$, $d = 0.63$). However, mean scores did not change for participants in the guided imagery or control conditions (guided imagery before: $M = 3.93$, $SD = 2.06$, after: 3.86, $SD = 2.89$, $p = .883$, $d = 0.03$; control before: $M = 4.73$, $SD = 3.22$, after $M = 3.95$, $SD = 2.95$, $p = .129$, $d = 0.25$).

Vividness of Craving-related Imagery

Analyses showed a main effect of time, $F(1, 91) = 9.73$, $p = .002$, $\eta_p^2 = .097$, but no main effect of condition, $F(2, 91) = 1.13$, $p = .327$, $\eta_p^2 = .024$, or condition by time interaction, $F(2, 91) = 2.26$, $p = .110$, $\eta_p^2 = .047$. As predicted, planned comparisons showed that participants in the cognitive defusion condition experienced significant reductions in imagery vividness (before: *M* = 4.67, *SD* = 3.08, after: *M* = 2.54, *SD* = 2.78, $p = .001$, d = 0.73). However, participants in the guided imagery and control conditions did not (guided imagery: before *M* = 4.08, *SD* = 2.81, after *M* = 3.55, *SD* = 2.83, $p = .390$, d = 0.19; control: before *M* = 4.78, *SD* = 3.02, after *M* = 4.18, *SD* = 3.19, $p = .317$, d = 0.19).

Craving Intensity

A 3 (condition: cognitive defusion, guided imagery, control) x 3 (time: pre-intervention, post-intervention, 10-min post-intervention) mixed factorial ANOVA was used to analyse the effect of the intervention on craving intensity. Analyses revealed main effects of condition, $F(2, 91) = 6.57$, $p = .002$, $\eta_p^2 = .126$, time, $F(1.72, 156.88) = 3.56$, $p = .037$, $\eta_p^2 = .038$, and a significant condition by time interaction, $F(3.45, 156.88) = 4.41$, $p = .003$, $\eta_p^2 = .088$. As shown in Figure 1, planned pairwise comparisons revealed significant reductions in craving for the cognitive defusion condition from pre- (*M* = 56.34, *SD* = 29.87) to post-intervention (*M* = 39.72, *SD* = 28.07, $p = .002$, d = 0.57). This reduction in craving was maintained at 10-minute post-intervention (*M* = 37.06, *SD* = 26.42). In contrast, cravings did not decrease for the guided imagery or control conditions over the three assessment points (within condition, between each assessment point, all *p*s > .05).

Chocolate Consumption

A one-way ANOVA was used to assess the effect of condition on chocolate consumption (in grams). Contrary to prediction, there was no group difference in the total amount of chocolate eaten between the cognitive defusion (*M* = 31.34, *SD* = 20.81), guided imagery (*M* = 41.73, *SD* = 21.33), or control (*M* = 33.35, *SD* = 21.91) conditions, $F(2, 92) = 2.00$, $p = .142$. Follow-up t-tests showed that there were no significant differences between any pair of conditions (all *p*s ≥ .05).

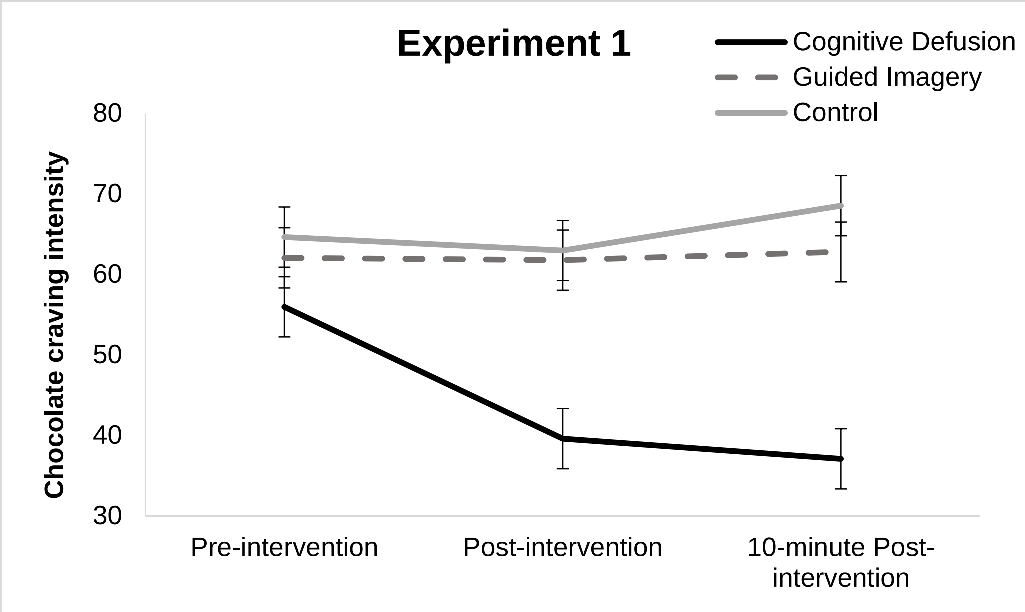

Figure 1. Chocolate craving intensity across three time-points, for cognitive defusion, guided imagery and control conditions. Within-subjects 95% confidence intervals (+/- 3.73) shown (Masson & Loftus, 2003).

Discussion

As predicted, cognitive defusion reduced the intrusiveness of craving-related thoughts, which in turn reduced the vividness of craving-related imagery, ultimately reducing craving intensity. Contrary to prediction, guided imagery did not reduce the vividness of imagery or chocolate craving intensity. When the results are examined in the context of the Elaborated-Intrusion Theory, it appears that cognitive defusion effectively targeted initial thoughts, which reduced the intrusiveness, vividness and overall craving experience. In contrast to predictions drawn from the Elaborated-Intrusion Theory, reductions in imagery vividness and craving intensity were not found for the guided imagery condition. This finding is somewhat surprising in that it differs from results of many other studies that have shown reduced cravings following alternative imagery tasks (Hamilton et al., 2013; Harvey, Kemps, & Tiggemann, 2005; Kemps & Tiggemann, 2007). The present pattern of results may indicate that once cravings have progressed to the imagery elaboration stage, they are more difficult to reduce. As such, perhaps targeting the initial intrusion or pre-elaboration stage is more effective for diminishing cravings than targeting the later elaboration stage.

Although the results for cognitive defusion support the assumptions of the Elaborated-Intrusion Theory (and desire thinking theory), neither of the experimental techniques had the predicted effect on chocolate consumption. There was no difference in consumption between conditions. This lack of difference may have occurred because chocolate, the desired target, may not have been sufficiently motivationally relevant for this sample of young women. Although participants liked chocolate, they may not necessarily have craved it. This factor may have also affected the intrusiveness and vividness findings for participants who received the guided imagery intervention. If participants were not necessarily cravers, their chocolate imagery may not have been particularly vivid. It is likely that the experimental techniques would have a stronger effect in women who regularly crave chocolate. Further, participants may not have been motivated to reduce their chocolate consumption. We therefore replicated Experiment 1 in a targeted sample of young women who craved chocolate at least once per day and wanted to reduce their chocolate consumption.

Experiment 2

Method

Participants

Participants were 97 women aged 17-25 years (M = 20.15, SD = 2.00), who were Flinders University undergraduate students. Recruitment materials specified that the study was seeking women who craved chocolate at least once a day and wanted to reduce their chocolate consumption. Participants confirmed that they met these two inclusion criteria upon arrival at the laboratory by responding affirmatively to two corresponding ‘yes/no’ questions.

Design, Materials and Procedure

Design, materials and procedure were identical to those of Experiment 1.

Results

Percentage of Chocolate-related Thoughts

Analyses showed a significant interaction between condition and time, $F(2, 93) = 3.48$, $p = .035$, $\eta_p^2 = .070$, but no main effects of condition, $F(2, 93) = 1.50$, $p = .228$, $\eta_p^2 = .031$, or time, $F(1, 93) = 1.60$, $p = .209$, $\eta_p^2 = .017$. Planned pairwise comparisons showed that participants in the cognitive defusion condition did not experience a reduction in percentage of chocolate-related thoughts from pre-intervention (*M* = 24.31, *SD* = 19.25) to post-intervention (*M* = 23.16, *SD* = 19.37, *p* = .812, *d* = 0.06), whereas participants in the guided imagery condition did (before *M* = 32.91, *SD* = 41.12, after *M* = 19.39, *SD* = 21.79, *p* = .006, *d* = 0.41). As in Experiment 1, participants in the control condition experienced an increase in chocolate-related thoughts from pre-intervention (*M* = 15.48, *SD* = 15.62) to post-intervention (*M* = 19.52, *SD* = 21.26, *d* = 0.21); however, this was not statistically significant (*p* = .416). It should be noted, however, that in contrast to Experiment 1, the guided imagery and control conditions differed on initial percentage of chocolate-related thoughts (*p* = .03).

Intrusiveness of Craving-related Thoughts

Analyses revealed a main effect of time $F(1, 92) = 35.56$, $p < .001$, $\eta_p^2 = .279$, but no main effect of condition, $F(2, 92) = .03$, $p = .968$, $\eta_p^2 = .001$, or condition by time interaction, $F(2, 92) = 1.51$, $p = .227$, $\eta_p^2 = .032$. Planned pairwise comparisons showed that participants in the cognitive defusion and guided imagery conditions had significantly less intrusive thoughts after using the technique than before (cognitive defusion before: *M* = 5.51, *SD* =

2.36, after: M = 3.89, SD = 2.52, p < .001, d = 0.66; guided imagery before: M = 5.51, SD = 2.44, after: M = 3.85, SD = 2.82, p < .001, d = 0.63, to a greater extent than controls (before M = 4.96, SD = 2.56, after M = 4.16, SD = 2.68, p = .048, d = 0.31).

Vividness of Craving-related Imagery

Analyses showed a main effect of time, $F(1, 93) = 54.81$, $p < .001$, $\eta_p^2 = .371$, but no main effect of condition, $F(2, 93) = .23$, $p = .796$, $\eta_p^2 = .005$, or condition by time interaction, $F(2, 93) = .99$, $p = .375$, $\eta_p^2 = .021$. Planned comparisons showed that all groups experienced a statistically significant reduction in craving-related imagery after completing the technique. As predicted, scores in the cognitive defusion and guided imagery conditions decreased significantly after the intervention (cognitive defusion: before M = 5.92, SD = 2.25, after M = 4.07, SD = 2.50, p < .001, d = 0.78; guided imagery: before M = 5.70, SD = 2.29, after M = 3.52, SD = 2.84, p < .001, d = 0.85). However, scores in the control condition also decreased significantly, albeit with a smaller effect size, from pre-technique (M = 5.43, SD = 2.36) to post-technique (M = 4.08, SD = 3.16, p = .002, d = 0.48).

Craving Intensity

Analyses revealed no main effect of condition, $F(2, 93) = .13$, $p = .879$, $\eta_p^2 = .003$, but did show a significant main effect of time, $F(1.75, 162.97) = 22.78$, $p < .001$, $\eta_p^2 = .197$ and a significant condition x time interaction, $F(3.51, 162.97) = 2.77$, $p = .036$, $\eta_p^2 = .056$. As predicted (see Figure 2), planned pairwise comparisons revealed significant reductions in craving intensity for the cognitive defusion and guided imagery conditions from pre- (cognitive defusion: M = 71.44, SD = 20.49, guided imagery: M = 74.82, SD = 19.42) to post-intervention (cognitive defusion: M = 55.59, SD = 26.09, p < .001, d = 0.68; guided imagery: M = 56.45, SD = 26.67, p < .001, d = 0.79). Craving reductions for both conditions were maintained at ten-minute post-intervention. In contrast, craving intensity remained stable over the three assessment points for the control condition (within condition, between each assessment point, all *p*s > .05).

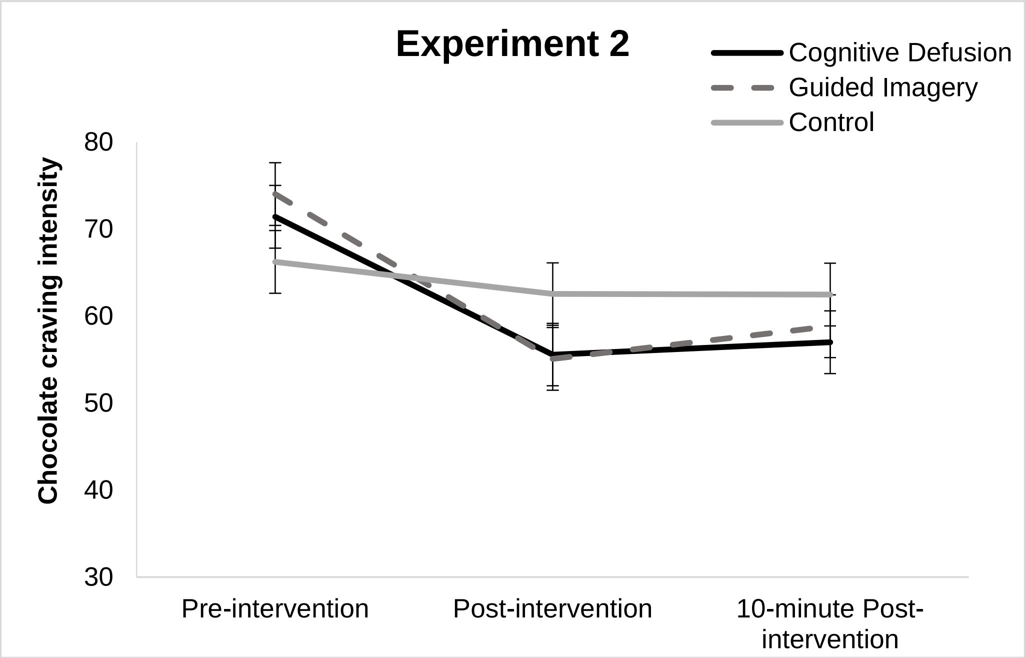

Figure 2. Chocolate craving intensity across three time-points, for cognitive defusion, guided imagery and control conditions. Within-subjects 95% confidence intervals (+/- 3.77) shown (Masson & Loftus, 2003).

Chocolate Consumption

Contrary to prediction, there was no significant difference in chocolate consumption between participants in the cognitive defusion (M = 42.73, SD = 34.78), guided imagery (M = 49.15, SD = 30.39) and control conditions (M = 42.41, SD = 21.67), $F(2, 94) = 0.53$, p = .592. Follow-up t-tests showed no differences between any conditions (all ps ≥ .05), as in Experiment 1.

Discussion

Experiment 2 examined the effects of cognitive defusion and guided imagery on chocolate cravings and consumption in a targeted sample of chocolate cravers. Both techniques reduced the intrusiveness of craving-related thoughts, the vividness of craving-related imagery, and craving intensity. Guided imagery also reduced the number of chocolate-related thoughts. Further, for both cognitive defusion and guided imagery, reductions in cravings were maintained ten minutes after completing the intervention. However, contrary to prediction, but like in Experiment 1, participants from all three conditions ate approximately the same amount of chocolate in the taste test.

General Discussion

The aim of the present study was to compare two craving reduction techniques within the context of the Elaborated-Intrusion Theory of Desire. Further, we aimed to investigate the techniques' effect on the frequency of chocolate-related thoughts, the intrusiveness of chocolate-related thoughts and vividness of chocolate-related imagery (the proposed mechanisms of the craving experience), craving intensity and consumption. Experiment 1 provided preliminary evidence for the use of cognitive defusion as a technique for targeting intrusions and craving intensity in a general sample of young women. Experiment 2 added to and extended upon this evidence, demonstrating that both cognitive defusion and guided imagery reduced intrusiveness of thoughts, vividness of imagery and craving intensity for women who craved chocolate and wished to reduce their chocolate consumption.

Cognitive defusion reduced the intrusiveness of craving-related thoughts, vividness of imagery and craving intensity in both the general sample (Experiment 1) and in the chocolate cravers (Experiment 2). This pattern of results is consistent with predictions of the Elaborated-Intrusion Theory, and suggests that cognitive defusion can beneficially target intrusions, and may be able to halt the craving process before intrusions are mentally elaborated. It also fits with predictions of desire thinking theory (Caselli & Spada, 2010;

2015) that metacognitive techniques can be used to reduce cravings. This evidence adds to previous studies that have shown mindfulness-based strategies (Alberts, Thewissen, & Raes, 2012; Hamilton et al., 2013), and specifically cognitive defusion (Lacaille et al., 2014; Moffitt et al., 2012), to be useful for combatting food cravings.

Results for guided imagery were mixed across the two experiments. It was predicted that guided imagery, which targets the imagery elaboration stage, would reduce imagery vividness and craving intensity. Guided imagery did not produce the predicted reductions in vividness of imagery or craving intensity in the general sample in Experiment 1. However, reductions in imagery vividness and craving intensity were observed in the sample of chocolate cravers in Experiment 2. The discrepancy between Experiments 1 and 2 is likely a function of the difference in samples, in that the desired target (chocolate) would have been more salient for chocolate cravers than for participants who like but do not necessarily crave chocolate. Further, craving-related imagery vividness was likely weaker for the general sample in Experiment 1 than that of the chocolate cravers in Experiment 2, and as such, more difficult to reduce. Indeed, the scores for vividness of imagery at pre-intervention in Experiment 2 (M = 5.68) were considerably higher than in Experiment 1 (M = 4.52). Our finding that the effects of guided imagery were generally stronger for chocolate cravers than for a general sample also echoes that of previous research (Kemps et al., 2005). The results of Experiment 2 more generally add to existing support for the use of imagery tasks to intervene with food cravings (Andrade et al., 2012; Harvey et al., 2005; Kemps & Tiggemann, 2007).

Our findings contrast with the only other study in the food domain to specifically examine the craving mechanisms of intrusiveness and imagery vividness (Hamilton et al., 2013), which found that body scan and guided imagery techniques affected craving intensity but not intrusiveness or imagery vividness. However, there are several methodological differences between this and the present study. First, the present study used cognitive defusion instead of a body scan technique. Cognitive defusion may have been more successful in reducing intrusiveness (and imagery vividness) because it explicitly targets thoughts, whereas body scan focuses upon physical sensations, which could in turn draw attention to physiological hunger cues. Further, in contrast to the present study, Hamilton et al. (2013) deprived participants of food for at least nine hours prior to testing, and thus may have captured hunger rather than craving. Finally, while we used chocolate as the desired target in the present study, Hamilton et al. (2013) used breakfast items, which tend to be eaten more for their nutritional benefits or to satisfy hunger rather than being an object of desire.

A novel finding in this study was that reductions in craving following guided imagery in Experiment 2, and following cognitive defusion in both experiments, were sustained from immediately post-intervention to ten minutes post-intervention. This indicates that the effects of the techniques on craving intensity can be maintained, at least over the short term. To our knowledge, this is the first study to demonstrate this maintenance of craving intensity reduction beyond immediate post-intervention. Hamilton et al. (2013) did not assess craving intensity post-intervention, and May et al. (2010) found that craving intensity rose in the ten-minute period after completing the intervention. Further research is required to assess whether craving reduction lasts over longer time periods.

Despite preliminary evidence supporting cognitive defusion and guided imagery as techniques for lowering intrusiveness, imagery vividness and craving intensity, they did not have the predicted impact on subsequent chocolate consumption. There was no difference in chocolate consumption between the experimental and control conditions, neither for the general sample (Experiment 1) nor for the chocolate cravers (Experiment 2). Although the latter were motivated to reduce their chocolate consumption, the observed reduction in chocolate cravings for the experimental conditions did not lead to a reduction in chocolate consumption. Our findings are similar to those of Knäuper et al. (2011) and Skorka-Brown, Andrade, Whalley and May (2015) who found that alternative imagery techniques reduced craving, but not consumption. There are several possible explanations for this finding. First, it is possible that presenting participants with chocolate in the taste test may have re-activated their chocolate cravings. Further, participants here were explicitly asked to taste the chocolates rather than actively try to resist them, perhaps overriding their motivation to resist the chocolates. Second, the brief duration of the experimental interventions may not have been sufficiently potent to affect chocolate consumption, despite the finding that craving reduction was sustained at ten-minute post-intervention. Future research could investigate whether more intensive interventions over a longer time period could successfully influence consumption behaviour. Finally, the taste test paradigm in which participants sampled and rated three types of chocolate in the laboratory may not be a realistic reflection of real-world consumption behaviour. Indeed, the studies that found that imagery-based techniques reduced craving-related consumption were conducted with naturally occurring cravings and consumption opportunities (Hsu et al., 2014; Kemps & Tiggemann, 2013). Therefore, future research could usefully examine the effect of cognitive defusion and guided imagery on consumption in a real-world setting.

Results of both experiments have theoretical implications for the Elaborated-Intrusion model (Kavanagh et al., 2005) of the craving process, and desire thinking theory (Caselli & Spada, 2010; 2015). Results of Experiment 1 support the idea that targeting the intrusion stage may be more beneficial than waiting until initial thoughts are elaborated in the second stage. However, this finding may be specific to the general sample, who may not necessarily crave chocolate, but do nonetheless have chocolate thoughts that can be targeted. Results from Experiment 2 are consistent with the Elaborated-Intrusion model, in that for chocolate cravers, both cognitive defusion and guided imagery reduced imagery vividness and craving intensity. However, both techniques also reduced intrusiveness, which was not expected for guided imagery. As participants in the guided imagery condition had significantly less chocolate-related thoughts post-intervention, their chocolate-related thoughts may have been seen as less intrusive. Although results from Experiment 2 are consistent with predictions of both the Elaborated-Intrusion model and desire thinking theory for elaborated intrusions contributing to craving, questions do remain regarding the impact of craving reduction on resulting consumption behaviour. Further research could also explore the role of metacognitions in prolonging and conversely reducing cravings.

Beyond theoretical implications, the present findings also have practical applications. The current study provides support for the use of cognitive defusion and guided imagery for reducing chocolate cravings in a laboratory setting. However, it is not known whether these techniques have applicability to other craved foods, and can impact consumption in settings outside the laboratory. Future studies could usefully investigate these ideas. Nevertheless, techniques tested in the present study have potential real-world applicability. As the techniques are brief, inexpensive and easy to learn, they could potentially be incorporated into therapy or eHealth interventions (such as mobile applications) for combatting unwanted food cravings.

In conclusion, the present experiments have demonstrated that cognitive defusion and guided imagery are effective craving reduction techniques for chocolate cravings, particularly for women who crave chocolate. Both techniques are easy to understand and use, are unobtrusive, brief, and therefore have potential real-world applicability. The impact of these techniques on consumption in more ecologically valid environments could usefully be explored in future research.

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CHAPTER 5: STUDY 5

Cognitive defusion and guided imagery tasks reduce naturalistic food cravings and consumption: A field study

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Acknowledgements: We thank Ben Maddock and David Hall for their help and advice with recording the audio clips and adapting the diaries for online platforms. This research was supported by funding from Flinders University.

This manuscript has been published as:

Schumacher, S., Kemps, E., & Tiggemann, M. (2018). Cognitive defusion and guided imagery tasks reduce naturalistic food cravings and consumption: A field study. *Appetite*, *127*, 393-399. doi: 10.1016/j.appet.2018.05.018

Abstract

The present study investigated the effect of two craving reduction techniques, namely, cognitive defusion and guided imagery, on naturalistic food cravings. These techniques targeted the intrusion and elaboration stages of the craving process, respectively (Kavanagh, Andrade, & May, 2005). Participants underwent a seven-day baseline period followed by a seven-day intervention period, during which they recorded their food cravings as they occurred using online diaries accessed via smartphone. In the intervention period, participants were randomly assigned to one of cognitive defusion, guided imagery or control conditions. Participants in the cognitive defusion and guided imagery conditions listened to three-minute audio clips containing their respective instructions every time they experienced a food craving, and rated their craving intensity before and after the intervention, while the control participants recorded their cravings as they did in the baseline week. Results showed that both cognitive defusion and guided imagery techniques reduced craving frequency, intensity, the likelihood of consumption following cravings, and craving-related calorie intake, consistent with predictions. These findings show that cognitive defusion and guided imagery are useful for dealing with naturally occurring cravings across a range of foods, and can reduce craving-related consumption in everyday life.

Introduction

Food craving is defined as the intense urge or desire to consume a specific food that is difficult to resist (Weingarten & Elston, 1990). Whereas hunger can be satisfied by consuming food in general, cravings are usually for a specific food (Pelchat, 2002). Food cravings have been associated with negative mood and depression (Davis et al., 2011), binge eating (Gendall, Joyce, Sullivan, & Bulik, 1998; Waters, Hill, & Waller, 2001) and feelings of guilt. Certain sub-groups such as people who are overweight or obese, or people with binge-eating disorder, can be particularly vulnerable to food cravings (Davis et al., 2011; von Deneen & Liu, 2011; Wurtman & Wurtman, 1986). However, food cravings are a general phenomenon experienced not only by overweight and obese individuals, but also by individuals of healthy weight (Hofmann, Baumeister, Förster, & Vohs, 2012). In such individuals, calorie intake following cravings could have a cumulative effect and thus lead to weight gain over time. In support, Boswell and Kober (2016) demonstrated that cravings significantly predicted eating and weight gain in people who are lean, as well as in overweight and obese individuals. Therefore, it is important to develop and test strategies which can reduce cravings and associated consumption.

The Elaborated-Intrusion Theory of Desire suggests that cravings develop in two distinct stages (Kavanagh, Andrade, & May, 2005; May, Andrade, Kavanagh, & Hetherington, 2012). First, initial craving-related thoughts or intrusions may be triggered by food cues in the environment, or other thoughts or memories. Second, these intrusions are then elaborated with vivid mental imagery, which may include visual, olfactory and gustatory features. For example, an individual may experience a seemingly automatic thought about a craved food such as chocolate, and then begin to mentally picture how that chocolate looks, smells or tastes. The craving may continue to grow in intensity and the individual may also develop negative emotions as they become aware of the absence of the craved food. This may spur more intrusions about the desired target and contribute to a developing cycle of intrusions and elaborations, which can become a progressively more negative affective experience. Usually, cravings are alleviated by giving in to the craving and eating the craved food. Based on the Elaborated-Intrusion Theory, May et al. (2012) suggest that craving reduction techniques could target either the intrusion or elaboration stage of the craving process.

A growing body of literature has used mindfulness-based techniques to target food cravings (Alberts, Mulkens, Smeets, & Thewissen, 2010; Forman et al., 2007; see Tapper, 2018 for a review). May et al. (2012) have suggested that mindfulness techniques may change individuals' responses to intrusions, prevent craving-related elaborations and therefore reduce craving frequency. Cognitive defusion, or decentering, is a specific mindfulness-based strategy which teaches individuals to accept their thoughts without trying to banish or challenge them, or automatically act upon them (Blackledge, 2007; Masuda, Hayes, Sackett, & Twohig, 2004). When applied to food cravings, cognitive defusion could target intrusions in the first stage of craving to change individuals' interpretations of their craving-related thoughts and promote more conscious, thoughtful behaviour which better aligns with long-term health goals (Forman et al., 2007). Experimental studies have shown that cognitive defusion tasks can reduce cravings for a range of unhealthy foods (Alberts et al., 2010; Papies, Pronk, Keesman, & Barsalou, 2015). In addition, several field studies showed that cognitive defusion can reduce state and trait chocolate cravings (Lacaille, Zacchia, Bourkas, Glaser, & Knäuper, 2014), and craving-related chocolate consumption (Hooper, Sandoz, Ashton, Clarke, & McHugh, 2012; Jenkins & Tapper, 2014; Moffitt, Brinkworth, Noakes, & Mohr, 2012). However, it is not known whether cognitive defusion can also be used for naturalistic cravings for foods other than chocolate.

Techniques have also been developed to target the second mental imagery stage of craving (May et al., 2012). Imagery-based techniques are designed on the premise that working memory capacity is limited, so that craving-related imagery can be replaced by alternative imagery (Harvey, Kemps, & Tiggeman, 2005; Kemps & Tiggemann, 2007; Versland & Rosenberg, 2007). Guided imagery is one technique in which individuals are instructed to generate an alternative imagery-based scenario such as a walk through a forest or on a beach. This technique incorporates multi-sensory imagery cues to mirror the range of sensory features in craving-related imagery. Guided imagery has been used to combat experimentally-induced cravings for breakfast and snack foods in a series of laboratory-based studies (Hamilton, Fawson, May, Andrade, & Kavanagh, 2013; May, Andrade, Batey, Berry, & Kavanagh, 2010). Other imagery-based tasks (e.g., imagining alternative imagery, playing Tetris or watching dynamic visual noise) have been shown to reduce naturally occurring cravings for a range of substances, including food in the field (Kemps & Tiggemann, 2013; Knäuper, Pillay, Lacaille, McCollam, & Kelso, 2011; Skorka-Brown, Andrade, & May, 2014; Skorka-Brown, Andrade, Whalley, & May, 2015). While Kemps and Tiggemann (2013) found that dynamic visual noise reduced consumption, Skorka-Brown et al. (2015) and Knäuper et al. (2011) did not find effects of other imagery-based techniques on consumption. Skorka-Brown et al. (2015) argued that the participants in their unselected sample may not have been motivated to resist their desires, but Knäuper et al.'s (2011) sample consisted of individuals who wished to reduce their craving-related consumption. In light of these mixed results, we sought to further explore whether reductions in craving intensity result in reductions in related consumption. Our overarching aim was to compare the efficacy of cognitive defusion and guided imagery as craving reduction techniques in the field.

One laboratory-based paper (Schumacher, Kemps, & Tiggemann, 2017) has specifically tested whether cognitive defusion and guided imagery techniques alter the two theoretical stages of the craving process they are thought to target (May et al., 2012) in a general sample (Experiment 1) and in regular chocolate cravers (Experiment 2). A combination of chocolate deprivation and exposure was used to induce chocolate cravings. As predicted, cognitive defusion reduced the intrusiveness of thoughts, guided imagery reduced the vividness of imagery, and both techniques reduced overall intensity of chocolate cravings. However, contrary to prediction, neither technique affected the consumption of chocolate in a laboratory-based taste test. This adds to the uncertainty in the literature about whether reducing cravings leads to reductions in craving-related consumption.

The current field study was designed to extend the previous literature by testing the relative effect of cognitive defusion and guided imagery on naturalistic food cravings and resultant consumption outside the laboratory. First, we aimed to test the effectiveness of the techniques for cravings for a range of foods, not just chocolate. Second, we wished to test the techniques in the field, where individuals experience naturally occurring cravings, along with ample consumption opportunities. An online diary was used so that participants could record their cravings as they occurred in real-time, with diaries available on mobile platforms. We collected baseline data in Week 1 with which to compare the effects of the interventions implemented in Week 2. We also incorporated a control condition. We predicted that participants who used cognitive defusion or guided imagery would report fewer cravings of lower intensity. We further predicted that participants in the cognitive defusion and guided imagery conditions would be less likely to eat in response to their cravings, and consequently would consume fewer craving-related calories than those in the control condition.

Method

Participants

Participants were 127 women who were recruited from the Flinders University student population, and from the wider Adelaide community. Following the protocol of Kemps and Tiggemann (2013), we specifically recruited participants who reported experiencing at least one food craving per day**.** Recruitment targeted women because they tend to experience more frequent cravings than men (Weingarten & Elston, 1991). To participate, women had to have access to a smartphone, and could not be pregnant. During the baseline week (Week 1), 9 participants declined to continue in the study, which left 118 women aged 17-53 years (*M* = 21.96, *SD* = 7.45) who completed the full two weeks of the study. Data are reported for the 118 completers. According to Cohen's (1992) guidelines, this sample size is sufficient to detect a moderate to large effect at 0.80 power, with an alpha of 0.05 (Cohen, 1992). Prior to Week 1, participants reported a mean of 1.32 food cravings per day (*SD* = 1.14). Approximately half of the participants (47.4%) reported that they were on a diet to lose weight or were watching what they ate in order to not put on weight. Mean BMI of the sample was 23.36 kg/m^2 (*SD* = 5.25), which is considered to be in the healthy weight range (WHO, 2017). Using BMI weight categories for classification, 11.9% of participants were classified as underweight (BMI of <18.5), 60.2% were in the healthy weight range (BMI of 18.5-24.9), 12.7% were overweight (BMI of 25-29.9) and 15.3% were obese (BMI >30).

Design

The study used a 3 (condition: cognitive defusion, guided imagery, control) x 2 (time: Week 1 (baseline), Week 2 (intervention)) mixed factorial design where condition was the between-subjects factor and time was the within-subjects factor. Outcome variables were craving frequency, intensity, percentage of cravings followed by consumption and craving-related calories consumed. Participants were allocated to the three conditions: cognitive defusion (*n* = 42), guided imagery (*n* = 39) or control (*n* = 37), at the beginning of Week 2 according to a pre-determined counterbalanced appointment schedule.

Materials and Procedure

The first week (Week 1) of the study served as a baseline, during which participants recorded their food cravings and craving-related consumption. The intervention took place in the second week. During Week 2, participants in the control condition continued to report their cravings and consumption as in Week 1. Participants in the cognitive defusion and guided imagery conditions were asked to listen to and use techniques delivered as three-minute audio guides every time they experienced a food craving.

Throughout the two-week study period, participants recorded their food cravings and consumption using an online self-report diary. The online diary was designed using Qualtrics, and adapted for use on mobile platforms. Participants were able to access their online diaries wherever they were, using their personal smartphones, laptops, desktop computers or tablets. Participants accessed the diaries using a hyperlink, which was sent along with a reminder each day. Reminders were sent via text message or email (according to preference) at 11:00am each day. Participants were instructed to make a record whenever they experienced a craving, rather than at specific times throughout the day. This meant that multiple entries were made if a participant had multiple cravings. If a participant did not have a craving, they did not make an entry.

Diary content was adapted from the paper diaries used by Kemps and Tiggemann (2013). Participants were first asked to report the food they craved. Next, they were asked to rate the intensity of the craving on a 100mm visual analogue scale ranging from ‘not at all intense’ to ‘extremely intense’. Participants then reported whether or not they ate in response to the craving with a 'Yes/No' response. These responses were used to calculate the percentage of cravings followed by consumption. If participants selected the 'Yes' response, they were asked to report what and how much they ate. Participants were instructed to specify the brand of food and portion size (e.g., small bowl or grams/millilitres) where possible. Responses were converted to calories using the calorie guide websites, My Fitness Pal and Calorie King (My Fitness Pal, 2018; Calorie King, 2018). If participants did not report the serving size, standard serving sizes were used. The number of calories consumed per craving (including episodes where cravings were resisted) and per consumption episode (only cravings which were indulged) were calculated, as well as the total number of craving-related calories consumed for the week.

At the beginning of the baseline week (Week 1), participants attended a brief information session, which took place in the Applied Cognitive Psychology Laboratory. During this session, participants were given information about the study procedure. They also completed an example of the food craving diary. Once the session had ended, participants were instructed to complete their online diaries for one week, recording their cravings as often as they occurred with the help of their daily reminders.

After participants had completed Week 1 of the online diaries, they attended a second information session where they were given instructions about how to complete the diaries in the second week (intervention). Participants in the control condition were instructed to continue reporting their cravings and consumption as they had done in the first week. Participants in the cognitive defusion and guided imagery conditions were instructed to complete intervention diaries which involved using a brief technique. To create the technique audio guides, the experimenter voice-recorded instructional statements in three-minute clips, and then embedded these in the diaries (statements were adapted from those used in Schumacher et al., 2017, with guided imagery script originally from May et al., 2010; see

Appendix A for experimental scripts).

Participants using the cognitive defusion technique were asked to listen to and follow instructions which asked them to pay attention to and create distance between themselves and their thoughts (e.g., ‘Notice the thoughts you are having now. Take a moment to step back from them, viewing them as merely thoughts’). Content also covered distinguishing thoughts from facts, and increasing awareness of the automaticity of thought and behaviour patterns. Participants in the guided imagery condition were told to listen to instructional statements which led them through an imaginary walk through a forest. Participants were asked to create mental imagery depicting sights, sounds, smells and sensations associated with being in a forest (e.g., ‘You can smell the damp earth and can see a haze of blue in the distance. You feel the twigs breaking under your feet’). A range of multi-sensory cues were deliberately used in the instructions to encourage the generation of alternate forest-related imagery that had similar sensory features to craving-related imagery. No reference to food or cravings was made in either technique clip. Participants were not able to skip through the audio clip, and were instructed to listen to and carefully follow the instructions throughout the clip. Participants reported whether they had followed instructions with a ‘Yes/No’ question immediately following the audio clip (participants responded ‘Yes’ on 80.7% of occasions). Participants in the cognitive defusion and guided imagery conditions rated their craving intensity immediately before and after using the technique. Aside from these changes, the diaries were the same as in Week 1.

Results

Statistical Analysis

To determine significance, an alpha level of 0.05 was used. For measuring effect size in Analysis of Variance (ANOVA), partial eta-squared was used, with 0.01 representing a small effect, 0.06 a moderate effect and 0.14 a large effect. For *t*-tests, Cohen's *d* was used, with benchmarks at 0.20 for small, 0.50 for moderate and 0.80 for large effects. A series of 3 (condition: cognitive defusion, guided imagery, control) x 2 (time: Week 1, Week 2) mixed factorial ANOVAs was conducted to assess the effect of the interventions on craving frequency, percentage of cravings followed by consumption, craving-related calorie intake and total craving-related calorie intake. Within-condition change for the intervention conditions was assessed using EMMEANS. Finally, orthogonal planned comparisons were conducted to compare the change scores in the cognitive defusion and guided imagery combined and the control condition, and against each other.

Table 1

Means (and standard deviations) for baseline (Week 1) characteristics of sample

	Cognitive Defusion	Guided Imagery	Control
Age	22.51 (9.17)	21.08 (4.59)	22.29 (7.81)
BMI (kg/m^2)	22.28 (4.53)	23.26 (4.62)	24.75 (6.39)
Number of cravings	7.76 (4.90)	8.92 (5.77)	6.76 (3.25)
Craving intensity	62.56 (14.81)	58.21 (13.47)	61.22 (16.39)
% cravings followed by intake	58.84	59.52	60.50
Calories consumed (satisfied cravings only)	309.19 (227.61)	298.08 (256.05)	327.73 (250.90)

Sample Characteristics

Table 1 shows the baseline characteristics of the sample. During Week 1, cravings were most common for chocolate (25.3%; e.g., chocolate, chocolate cake), followed by savoury meals (17.2%; e.g., cheese, roast dinner, seafood), sweet foods (16.5%; e.g., cakes, doughnuts, ice-cream), and takeaway foods (13.9%; e.g., pizza, burgers, fries). All participants reported at least one craving per week. The number of cravings reported ranged from 1 to 34 in Week 1 (M = 7.83, SD = 4.82) and 1 to 17 in Week 2 (M = 3.99, SD = 2.77).

Effect of Interventions on Cravings

Craving frequency. Analyses showed no main effect of condition, $F(2, 115) = 1.46$, p = .237, η_p^2 =.025 (small effect). There was, however, a significant main effect of time, $F(1, 115) = 106.93$, p < .001, $\eta_p^2 = 0.482$ (large effect), and a condition x time interaction, $F(2, 115) = 4.19$, p = .018, $\eta_p^2 = 0.068$ (moderate effect). As shown in Figure 1, craving frequency reduced from Week 1 to Week 2 following both cognitive defusion ($|M_{difference}| = 4.57$, $p < .001$, $d = 1.12$) and guided imagery ($|M_{difference}| = 4.54$, $p <.001$, $d = 1.04$), both with large effect sizes. Orthogonal planned comparisons confirmed that although craving frequency also declined in the control condition from Week 1 to Week 2 ($|M_{difference}| = 2.27$, $p = .001$, $d = 0.74$; moderate effect), this was to a significantly lesser extent than in the experimental conditions combined, $t(115) = 2.89$, $p = .005$, $d = 0.58$, showing a moderate sized difference. Each of cognitive defusion and guided imagery were individually different from the control condition (cognitive defusion $t(77) = 3.44$, $p = .001$, $d = 0.78$; guided imagery $t(74) = 2.30$, $p = .024$, $d = 0.53$), with no difference between them, $t(115) = 0.04$, $p = .970$, $d = 0.01$.

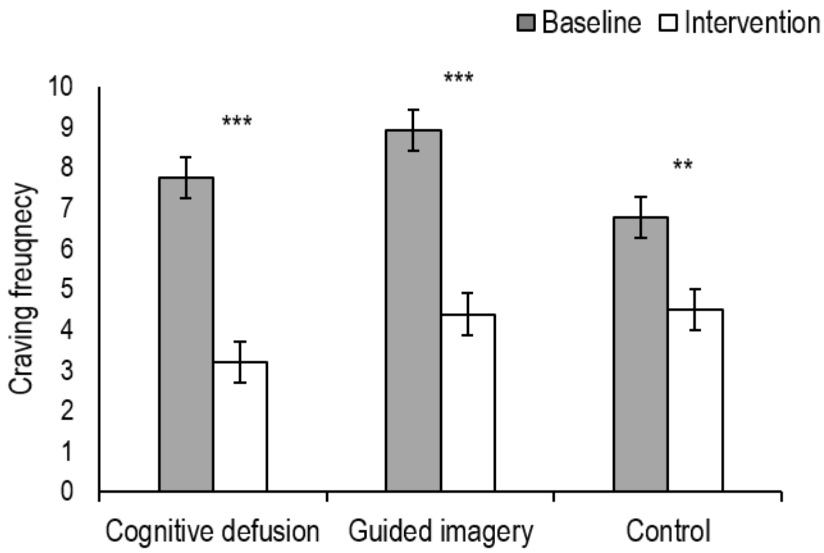

Figure 1. Craving frequency for baseline (Week 1) and intervention (Week 2) by condition. Within-subjects 95% confidence intervals (± 0.51) shown (Masson & Loftus, 2003). NB. * $p < .05$, ** $p < .01$, *** $p < .001$.

Craving intensity. During the intervention period (Week 2), participants in the cognitive defusion and guided imagery conditions rated their craving intensity on each occasion immediately before and after using the respective technique. The control condition continued to rate their craving intensity once per occasion, as they had done in Week 1. Craving intensity means were calculated for each participant across the week. Paired samples *t*-tests showed that there was a significant reduction in craving intensity after completing the cognitive defusion task (M = 42.49, SD = 19.94) compared to before (M = 62.37, SD = 17.71), $t(39) = 6.59$, $p < .001$, $d = 1.05$ (large effect). There was a similar reduction in craving intensity for participants in the guided imagery condition (before: M = 60.94, SD = 14.05, after: M = 46.76, SD = 17.41), $t(38) = 6.51$, $p < .001$, $d = 0.90$ (large effect).

Two one-way ANOVAs were used to test whether both the pre- and post-intervention craving intensity ratings of the experimental conditions differed from the single-item craving intensity measure of the control condition. Results showed that the pre-intervention ratings in the cognitive defusion (*M* = 63.40, *SD* = 18.19) and guided imagery conditions (*M* = 60.94, *SD* = 14.05) did not differ from the control condition rating (*M* = 67.97, *SD* = 16.60), $F(2, 117) = 1.79$, $p = .172$, $\eta^2 = .030$ (small effect). In contrast, the post-intervention ratings significantly differed from the control condition rating, $F(2, 113) = 21.59$, $p < .001$, $\eta^2 = .276$ (large effect). Post-intervention ratings in the cognitive defusion (*M* = 42.49, *SD* = 16.60) and guided imagery (*M* = 46.76, *SD* = 17.41) conditions were not significantly different, $t(77) = 1.01$, $p = .314$, $d = 0.25$ (small effect).

Effect of Interventions on Craving-related Consumption

Percentage of cravings followed by consumption. Results showed significant main effects of condition, $F(2, 115) = 3.63$, $p = .029$, $\eta_p^2 = 0.059$ (moderate effect), and time, $F(1, 115) = 35.18$, $p < .001$, $\eta_p^2 = 0.234$ (large effect). The condition x time interaction fell just short of significance, $F(2, 115) = 2.83$, $p = .063$, $\eta_p^2 = 0.047$ (small effect). As can be seen in Figure 2 and following predictions, participants in the cognitive defusion condition ate significantly less often in response to their cravings in Week 2 than in Week 1 ($|M_{difference}|$ = 29.72%, $p < .001$, $d = 1.03$; large effect). Similarly, participants in the guided imagery condition were less likely to eat in response to their cravings in Week 2 than in Week 1 ($|M_{difference}|$ = 18.35%, $p = .002$, $d = 0.73$; moderate to large effect). In contrast, for control participants, the difference between the percentage of cravings followed by consumption in Week 1 and Week 2 was not statistically significant ($|M_{difference}|$ = 10.72%, $p = .072$, $d = 0.32$; small effect). Orthogonal planned comparisons showed a near significant difference between change scores of the two experimental conditions combined and the control condition, $t(115) = 1.87$, $p = .064$, $d = 0.38$ (small effect), and no significant difference between the two experimental conditions, $t(115) = 1.43$, $p = .156$, $d = 0.32$ (small effect).

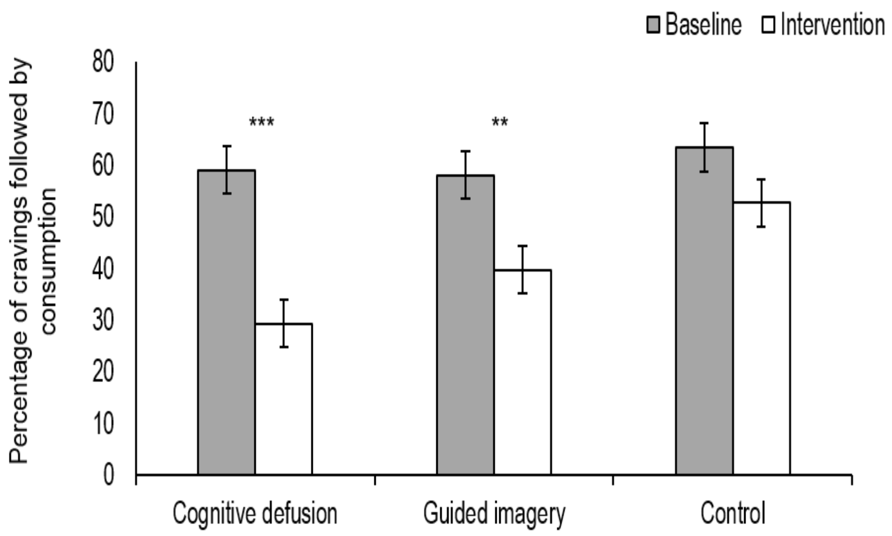

Figure 2. Percentage of cravings followed by consumption for baseline (Week 1) and intervention (Week 2) by condition. Within-subjects 95% confidence intervals (± 4.62) shown (Masson & Loftus, 2003). NB. * $p < .05$, ** $p < .01$, *** $p < .001$.

Craving-related calorie intake. Analyses of the effect of the interventions on calories consumed per craving occasion (including episodes where participants resisted their cravings) showed significant main effects of condition, $F(2, 115) = 3.73$, $p = .027$, $\eta_p^2 = 0.061$ (moderate effect), and time, $F(1, 115) = 13.09$, $p < .001$, $\eta_p^2 = 0.102$ (moderate effect). The condition x time interaction effect fell just short of significance, $F(2, 115) = 2.92$, $p = .058$, $\eta_p^2 = 0.048$ (small effect). As shown in Figure 3, there was a significant reduction in craving-related calorie consumption per occasion for cognitive defusion from Week 1 to Week 2 ($|M_{difference}| = 77.25$, $p = .003$, $d = 0.65$; moderate effect). Calorie consumption per craving occasion also significantly decreased in the guided imagery condition from Week 1 to Week 2 ($|M_{difference}| = 83.74$, $p = .002$, $d = 0.66$; moderate effect). In contrast, craving-related consumption per occasion did not significantly differ between Week 1 and Week 2 for the control condition (|$M_{difference}$| = 2.38, *p* = .930, *d* = 0.02). Orthogonal planned comparisons showed a significant difference between change scores in the experimental conditions and the control condition, *t*(115) = 2.41, *p* = .017, *d* = 0.48 (moderate effect), with no difference between cognitive defusion and guided imagery, *t*(115) = 0.18, *p* = .858, *d* = 0.05.

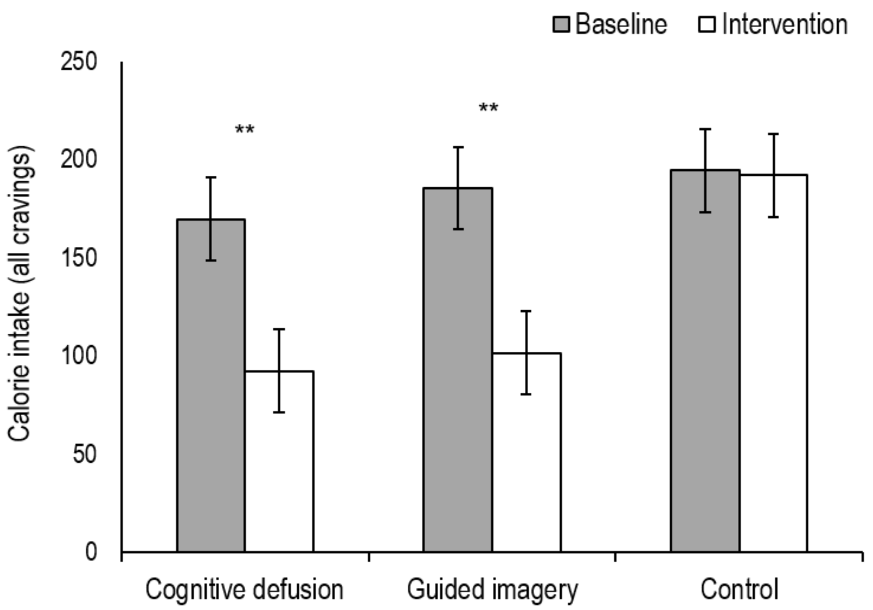

Figure 3. Mean calories consumed (all craving episodes), for baseline (Week 1) and intervention (Week 2) by condition. Within-subjects 95% confidence intervals (± 21.05) shown (Masson & Loftus, 2003). NB. * *p* < .05, ** *p* < .01, *** *p* < .001.

A second ANOVA was conducted to assess the effect of the intervention techniques on calorie intake for the subsample of cravings which were followed by consumption. This analysis excluded 37 participants who successfully resisted their cravings in either Week 1 or 2. The analysis showed no main effect of condition, *F*(2, 78) = 1.62, *p* = .204, η_p^2 = 0.040 (small effect), time, *F*(1, 78) = 0.28, *p* = .601, η_p^2 = 0.004, or a condition x time interaction, *F*(2, 78) = 1.99, *p* = .144, η_p^2 = 0.048 (small effect). There were no significant within-condition changes from Week 1 to Week 2 in any condition; cognitive defusion ($|M_{difference}|$ = 12.16, p = .745, d = 0.08), guided imagery ($|M_{difference}|$ = 38.32, p = .247, d = 0.26; small effect), or control ($|M_{difference}|$ = 58.36, p = .108, d = 0.41; small effect). Orthogonal planned comparisons confirmed that there was no significant difference between the two experimental conditions combined and the control condition, $t(78) = 1.64$, p = .106, d = 0.23 (small effect), or between cognitive defusion and guided imagery, $t(78) = 1.02$, p = .313, d = 0.14.

Total craving-related calorie intake. Finally, analyses on the total number of craving-related calories consumed for the week revealed no main effect of condition, $F(2, 115) = 0.91$, p = .405, η_p^2 = 0.016 (small effect), but a main effect of time, $F(1, 115) = 43.57$, $p < .001$, η_p^2 = 0.275 (large effect). Importantly, there was a significant condition x time interaction, $F(2, 115) = 3.92$, p = .023, η_p^2 = 0.064 (moderate effect). As can be seen in Figure 4, participants consumed significantly fewer craving-related calories in Week 2 than in Week 1 in both the cognitive defusion ($|M_{difference}|$ = 1048.76, $p < .001$, d = 0.78 (moderate to large effect) and guided imagery conditions ($|M_{difference}|$ = 1090.23, $p < .001$, d = 1.15; large effect). However, there was no significant difference between the number of calories consumed in Week 1 and Week 2 for the control condition ($|M_{difference}|$ = 321.30, p = .150, d = 0.31; small effect). Orthogonal planned comparisons confirmed a significant difference between change scores in the control condition and the two intervention conditions, $t(115)$ = 2.80, p = .006, d = 0.56 (moderate effect), and no difference between the interventions, $t(115) = 0.14$, p = .890, d = 0.03.

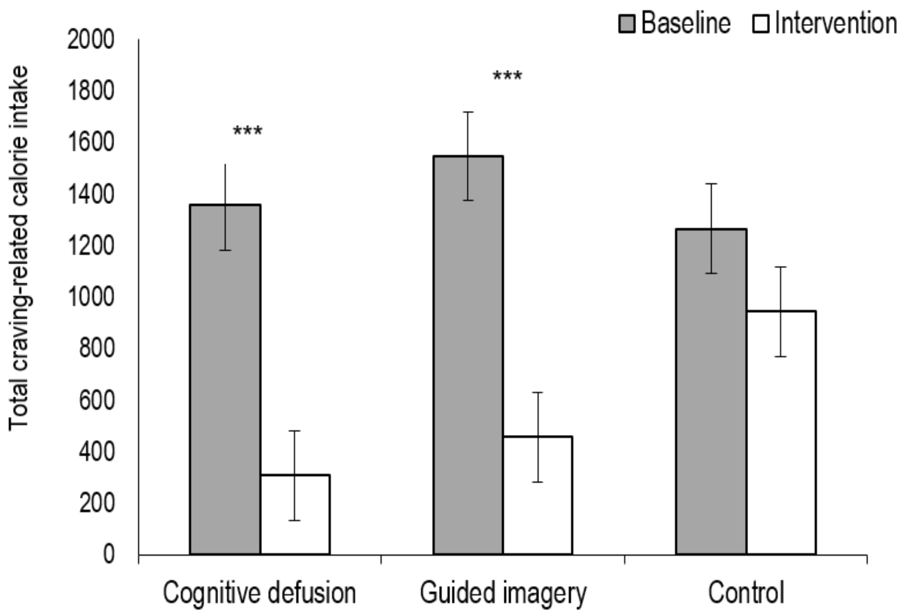

Figure 4. Total craving-related calorie intake for baseline (Week 1) and intervention (Week 2) by condition. Within-subjects 95% confidence intervals (± 173.78) shown (Masson & Loftus, 2003). NB. * $p < .05$, ** $p < .01$, *** $p < .001$.

Discussion

The main aim of the present study was to test the field application of two craving reduction strategies informed by the Elaborated-Intrusion Theory of Desire (Kavanagh et al., 2005). Specifically, the study compared the efficacy of cognitive defusion and guided imagery as intervention techniques for reducing naturally occurring cravings for food of any kind. The real-world setting also allowed for an ecologically valid measure of consumption. Thus, at any time when a craving arose, individuals could apply their respective technique, with access to the consumption opportunities they would normally face. In line with our predictions, we found that participants who used cognitive defusion or guided imagery experienced reductions in craving frequency and intensity. Importantly, we showed that cognitive defusion and guided imagery reduced the percentage of cravings followed by consumption, as well as the total number of craving-related calories consumed during the week relative to both baseline consumption and to the control condition.

The results showed that both cognitive defusion and guided imagery equally reduced craving frequency from Week 1 to Week 2, and craving intensity within the intervention week, with a large effect size. The observed craving reduction following cognitive defusion fits with previous research which has shown that it is a useful strategy for targeting unwanted chocolate cravings (Jenkins & Tapper, 2014; Lacaille et al., 2014; Moffitt et al., 2012), and extends this to food in general. It provides further confirmation of the conclusion of a recent review that cognitive defusion is a promising technique in the broader food craving and consumption field (Tapper, 2017).

The observed craving reduction following guided imagery is in line with studies that have used other imagery-based techniques for reducing naturalistic cravings (Kemps & Tiggemann, 2013; Knäuper et al., 2011; Skorka-Brown et al., 2014; Skorka-Brown et al., 2015). In comparing the relative efficacy of cognitive defusion and guided imagery, the present study found that there was no difference between the techniques in their ability to reduce craving frequency, nor intensity. This suggests that they are equally effective for reducing naturally occurring food cravings in everyday settings.

Not only did cognitive defusion and guided imagery reduce craving frequency and intensity, but importantly, the interventions also reduced craving-related consumption. First, orthogonal planned comparisons showed that the craving-related consumption per craving episode was significantly lower in the experimental conditions than the control condition, with a moderately sized effect. Second, although the number of craving-related calories consumed per episode did not differ by condition among those who gave in to their cravings, overall, because participants in the experimental conditions gave in to their cravings less often, they consumed significantly fewer craving-related calories in Week 2 compared with the control condition and Week 1. Together, these results suggest that the cognitive defusion and guided imagery interventions increased participants' ability to resist their cravings.

These novel consumption findings contrast with previous research examining cognitive defusion and guided imagery in a laboratory context (Schumacher et al., 2017), which did not find any effect on consumption. Laboratory studies testing craving reduction strategies often rely on experimentally-induced cravings for a specific food, whereas the present study tested naturally occurring cravings for a range of foods. Moreover, laboratory-based studies typically measure consumption with a single 'taste test', where participants are required to consume at least some of the food presented (which they may not necessarily like), and may restrict their consumption due to the implicit or explicit presence of the researcher. The current pattern of results suggests that a one-off consumption measure (such as a laboratory taste test) may not afford participants the opportunity to resist their cravings, and thus does not fully represent the effect of the techniques on ongoing naturalistic consumption.

Our results contrast with other field studies that found no effects of other imagery-based techniques on consumption (Knäuper et al., 2011; Skorka-Brown et al., 2015). It is possible that guided imagery may be more effective for reducing craving-related consumption than tasks such as Tetris (Skorka-Brown et al., 2015) or imagining a pleasurable activity (Knäuper et al., 2011) because it is more absorbing, cognitively demanding and structured. Guided imagery requires participants to form mental images that are constantly changing, with continuous prompting which guides individuals from one mental scene to another. Likewise, cognitive defusion is a cognitively demanding and structured task that requires participants to mentally distance themselves from their thoughts in response to prompts. Future research will need to confirm this suggestion by comparing the efficacy of cognitive defusion, guided imagery and other imagery-based techniques. Nonetheless, the current results support the notion that in-the-moment interventions such as cognitive defusion and guided imagery can effectively curb cravings to reduce the likelihood that they will be satisfied, which accumulates to fewer craving-related calories consumed over time.

The present study has several theoretical and practical implications. Theoretically, the results provide additional support for craving reduction techniques developed within the context of the Elaborated-Intrusion Theory of Desire (Kavanagh et al., 2005). Cognitive defusion is a technique thought to target the intrusion stage of the craving process. Guided imagery is a technique designed to target the elaboration stage. Here we showed that both techniques were successful in reducing naturalistic craving frequency, intensity and consumption, suggesting that targeting either the intrusion stage or the elaboration stage disrupts the craving process, as the theory would predict.

Practically, the major contribution of the present study is that the techniques not only reduced craving frequency and intensity, but also consumption. While the reduction in calorie intake per occasion did not differ by condition, both cognitive defusion and guided imagery more than halved the total number of additional craving-related calories consumed, amounting to over 1000 fewer calories per week. This reduction in craving-related consumption has potential implications for substantial cumulative reductions in calorie intake over weeks, months and years, and is consistent with Boswell and Kober’s (2016) findings that food cravings predict weight gain. Further, the versions of the techniques we developed are easy to use and readily accessible via mobile phone or tablet. Such forms of intervention carry the advantage that they can be used discreetly in-the-moment, and can provide support anytime and anywhere.

Despite its methodological strengths, the current study also has a number of limitations. First, we used a passive control condition with which to compare the experimental techniques. An active control task should be used in future research to discriminate the effect of the experimental techniques from outcomes due to other factors. Second, our control condition only rated craving intensity at a single time point, whereas the experimental conditions had pre- and post-intervention craving intensity measures. Third, although participants were instructed to report their craving-related consumption with as much detail as possible, sometimes they did not do so, in which case responses had to be coded according to standard serving sizes. In addition, future research should measure overall diet and calorie consumption in order to ensure that reduction in consumption in response to cravings is not compensated for by increased consumption at other times. Finally, although participants in the experimental conditions reported that they had used the technique most of the time (80.7%), there was no way in which to assess the extent to which they had followed the instructions and attended to the content of the audio clip on each occasion.

In conclusion, the present study has shown that cognitive defusion and guided imagery can reduce food craving frequency and intensity, and importantly, craving-related consumption. We extended previous evidence to show that these techniques can be used successfully for naturalistic food cravings in the participant's own environment. The interventions were brief and easily accessible for in-the-moment use. Future research should test their effectiveness for individuals who suffer from problematic cravings and unwanted over-consumption of food.

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CHAPTER 6: GENERAL DISCUSSION

Chapter Overview

The overarching aim of the present thesis was to investigate interventions for reducing food cravings, using the theoretical underpinning of the Elaborated-Intrusion Theory of Desire (Kavanagh, Andrade, & May, 2005; May, Andrade, Kavanagh, & Hetherington, 2012). Each individual chapter in the thesis had its own sub-aims. The first sub-aim was to evaluate the comparative efficacy of existing food craving reduction techniques (Study 1 in Chapter 2). The second sub-aim was to extend our knowledge of the food craving process by examining the role of craving-related intrusions, strategies used by individuals to resist their cravings, and factors which predict craving intensity and craving-related consumption (Study 2 in Chapter 3). The final sub-aim was to test two techniques, cognitive defusion and guided imagery, in their ability to reduce cravings and related consumption. This particular sub-aim was addressed in three studies, which were presented in two chapters (Studies 3 and 4 in Chapter 4, and Study 5 in Chapter 5). These studies tested cognitive defusion and guided imagery both in laboratory and field settings, on experimentally induced and naturally occurring cravings for chocolate and other craved foods. This final general discussion chapter aims to summarise the findings of the present thesis and discuss them in the context of the overarching aim of the thesis and the existing literature. Further, the implications of the findings for both theory and practice will be discussed. Strengths, limitations and recommendations for future research will also be discussed, and conclusions will be drawn from the overall findings.

Summary of Findings

Chapter 2 presented the results of Study 1, which was a systematic literature review designed to address the first sub-aim of the thesis. Specifically, it aimed to compare the relative efficacy of existing food craving reduction techniques, in order to establish the level of evidence for each type of technique. Study 1 found that imagery-based techniques reduced cravings with the most consistent effects. Mindfulness-based techniques also had good evidence for reducing cravings, particularly in studies where individuals were trained across several sessions. Cognitive techniques and movement strategies produced mixed evidence, with strategies such as cognitive reappraisal and physical activity showing promise for craving reduction. Other strategies such as cognitive bias modification training and breathing exercises did not reduce cravings. Studies which combined or compared multiple craving reduction strategies showed mixed effects. However, combining several strategies to form a battery of techniques to target different stages of the craving process or to suit different individuals could be a useful target for future research.

Study 2, which was presented in Chapter 3, investigated the role and content of food craving-related thoughts, the spontaneous strategies used to resist cravings, and the factors predicting craving intensity and related consumption in an online questionnaire. This study found that the presence of craving-related imagery was a more important factor in predicting craving intensity than craving-related thoughts. However, neither of these factors were significant predictors of craving-related consumption. Commonly endorsed strategies for resisting cravings included physical barriers (e.g., not having the food in the house) and avoiding thinking about the food. Furthermore, these strategies increased the likelihood of not consuming the food following a craving. Hunger also significantly predicted craving intensity, and craving intensity significantly predicted craving-related consumption.

Studies 3-5, which were presented in Chapters 4 and 5, tested two specific strategies for reducing cravings for chocolate and other craved foods. Across three studies, cognitive defusion and guided imagery were used to target craving-related thoughts and imagery, respectively, and reduce craving intensity and related consumption. Specifically, Studies 3 and 4 (Chapter 4) tested whether cognitive defusion could reduce the intrusiveness of thoughts, and whether guided imagery could reduce the vividness of imagery. Further, these studies tested whether the techniques could reduce craving intensity and chocolate consumption, first in a general sample of young women (Study 3), and then in a sample of women who experienced regular chocolate cravings and wished to reduce their chocolate consumption (Study 4). In both studies, cognitive defusion reduced the intrusiveness of thoughts and the vividness of imagery. Guided imagery reduced the vividness of imagery, but only for the regular cravers of Study 4. In addition, cognitive defusion and guided imagery reduced craving intensity in both studies. However, neither intervention reduced chocolate consumption. In the General Discussion of Chapter 4, we argued that there could be several reasons why the techniques did not reduce consumption. First, the cravings were experimentally induced rather than naturally occurring. Second, the laboratory-based taste test is not an ecologically valid measure of consumption. Therefore, Study 5 (Chapter 5) aimed to address these issues and extend the findings of Studies 3 and 4 by comparing the efficacy of cognitive defusion and guided imagery for reducing naturally occurring food cravings and consumption in the field. This study first measured baseline levels of craving frequency, intensity and craving-related consumption using an online diary accessed via mobile phone in Week 1, and changes in these outcomes as a result of brief interventions delivered with audio clips in Week 2. Study 5 found that craving frequency, intensity and craving-related consumption decreased in response to both cognitive defusion and guided imagery.

Together, Studies 3-5 as a set contribute to the understanding of how cognitive defusion and guided imagery may reduce cravings, by targeting the theoretical mechanisms of craving-related thoughts and imagery, respectively (Studies 3 and 4). These studies found that cognitive defusion reduced the intrusiveness of thoughts and vividness of imagery, and guided imagery reduced the intrusiveness of thoughts and vividness of images, but only in chocolate cravers. Across the three studies, results showed that cognitive defusion and guided imagery reduced laboratory-induced chocolate craving intensity (Studies 3-4) and naturalistic food cravings in the field (Study 5). Results also furthered our understanding of the relationship between the reduction of craving intensity and resultant craving-related consumption (Studies 3-5), by demonstrating that cognitive defusion and guided imagery could reduce both cravings and resultant consumption in a field setting (Study 5), but not in laboratory taste tests (Studies 3-4).

Theoretical Implications

The present thesis has several important theoretical implications. Each study presented in this thesis explored facets of the Elaborated-Intrusion Theory (Kavanagh et al., 2005; May et al., 2012), and overall, the studies as a group provided evidence to support the predictions of the theory. For example, Chapter 3 (Study 2) supported the idea that both craving-related thoughts and images were involved in food cravings. However, findings also suggested that thoughts and images are not easily distinguished as separate stages by participants. Further, not all participants were explicitly aware of the presence of thoughts and images. The results presented in Chapter 3 suggested that craving-related imagery played a more crucial role in predicting craving intensity than craving-related thoughts. Previous studies also showed that craving-related thoughts (May, Andrade, Kavanagh, & Penfound, 2008) and imagery (May et al., 2008; Tiggemann & Kemps, 2005) predicted craving intensity; however, Study 2 (Chapter 3) was the first to examine craving-related thoughts and images as separate, unique predictors. In Chapter 2 (Study 1), the systematic literature review concluded that imagery-based strategies, many of which were theoretically grounded in the Elaborated-Intrusion Theory, were the most effective for reducing cravings. Interventions which target the mental imagery component of cravings were likely to successfully reduce cravings. These findings support the Elaborated-Intrusion Theory's suggestion that mental imagery plays a key role in cravings, and can be effectively targeted to interrupt the craving process, thereby reducing craving intensity. The review concluded that of all techniques, imagery techniques most consistently reduced food cravings (Kemps & Tiggemann, 2013; Kemps, Tiggemann, & Hart, 2005; Knäuper, Pillay, Lacaille, McCollam, & Kelso, 2011; Skorka-Brown, Andrade, & May, 2014; Skorka-Brown, Andrade, Whalley, & May, 2015). Further, mindfulness techniques, which may target craving-related thoughts, also showed promise in reducing cravings (Alberts, Mulkens, Smeets, & Thewissen, 2010; Alberts, Thewissen, & Raes, 2012; Lacaille et al., 2014). However, as methodology across studies varied in content, number of sessions and homework input, further research is needed to test individual mindfulness skills and better determine the mechanisms of change (Tapper, 2017).

As a set, the findings presented in Chapters 4 and 5 (Studies 3-5) showed that cognitive defusion and guided imagery were able to reduce craving intensity. These results support the Elaborated-Intrusion Theory by suggesting that targeting one of the two stages of the craving process is an effective means for reducing craving intensity. Studies 3 and 4 investigated whether cognitive defusion and guided imagery reduced the individual craving processes they were thought to target, namely, craving-related thoughts and images. In Study 3 (Chapter 4), cognitive defusion reduced the intrusiveness of thoughts and the vividness of imagery, whereas guided imagery reduced neither of these variables. For the regular chocolate cravers assessed in Study 4 (Chapter 4), the same result was found for cognitive defusion, but in this sample, guided imagery also reduced the vividness of imagery, as expected based on the predictions of the Elaborated-Intrusion Theory. It is possible that craving imagery may have been more vivid and salient for individuals who frequently experienced cravings, and this may have accounted for the difference in results between Studies 3 and 4. Together, these results supported the idea that cravings involve a progression from intrusions to elaborations. The findings suggested that cognitive defusion targeted intrusions in the initial stage, thereby potentially preventing elaboration from occurring. Aside from the theoretical mechanisms such as intrusiveness of thoughts and vividness of imagery, results from Study 4 (Chapter 4) and Study 5 (Chapter 5) showed that cognitive defusion and guided imagery were equally effective at reducing craving intensity.

Several studies (Study 2 in Chapter 3, Studies 3 and 4 in Chapter 4 and Study 5 in Chapter 5) examined the relationship between cravings and resultant consumption. Study 2 (Chapter 3) showed that while craving-related thoughts and images contributed uniquely to craving intensity, they did not directly predict craving-related consumption. Craving intensity was the only significant predictor of craving-related consumption. The two studies described in Chapter 4 (Studies 3 and 4) showed that cognitive defusion and guided imagery could reduce craving intensity, but not craving-related consumption. Finally, the field study (Study 5) described in Chapter 5 found that cognitive defusion and guided imagery reduced both craving intensity and craving-related consumption. Altogether, it seems that the relationship between craving intensity and consumption is not straightforward. Cravings do not always lead to consumption, and conversely, consumption is not always driven by cravings.

In addition, measurement issues may also affect the relationship between cravings and consumption. For example, the measurement of craving-related consumption in the laboratory is limited to the foods selected by researchers, rather than foods individuals regularly eat outside the laboratory. Further, participants may also (sub)consciously alter their eating behaviour due to the implicit presence of the researcher. In contrast, craving-related consumption may be better measured with more ecological validity in field environments that are more similar to daily life, and allow participants to select and consume their own choice of food. Future research should consider that the way in which consumption is measured (e.g., food diary vs. laboratory taste test) may affect outcomes.

Practical Implications

In addition to theoretical implications, the findings of the present thesis also have practical implications. Broadly, the thesis has contributed to knowledge of craving mechanisms, and how these can be successfully targeted to reduce cravings and related consumption. First, the literature review in Chapter 2 (Study 1) showed that imagery-based interventions had the most evidence for reducing food cravings, when compared to other psychological interventions. Second, Study 2 (Chapter 3) showed that craving-related imagery appeared to be a more important predictor of craving intensity than craving-related thoughts; however, neither predicted craving-related consumption. Third, Studies 3-5 (Chapters 4 and 5) provided good evidence to show that cognitive defusion and guided imagery consistently reduced craving intensity, and this may have occurred through the reduction of the intrusiveness of thoughts and vividness of imagery. Further, Study 5 (Chapter 5) extended upon the findings of Studies 3 and 4 (Chapter 4) and showed that cognitive defusion and guided imagery can also reduce consumption following naturalistic cravings.

Reducing cravings is an important step toward the goal of reducing the unwanted over-consumption of unhealthy (craved) foods. The field study presented in Chapter 5 (Study 5) demonstrated that cognitive defusion and guided imagery reduced the total number of craving-related calories consumed across a week. In fact, the results showed that the fewer indulged cravings accumulated to over 1000 fewer calories consumed over seven days. This finding has potential implications for individuals who struggle with the over-consumption of high caloric foods. If individuals were able to employ these strategies over longer periods of time, cognitive defusion and guided imagery may be able to meaningfully reduce the number of craving-related calories consumed across weeks or even months. As food cravings are commonly reported by individuals who are overweight or obese (Ng & Davis, 2013), and those who suffer binges and other disordered eating (Waters, Hill, & Waller, 2001), the present findings have potential broader implications for these populations. Future testing is needed to determine whether the reductions in cumulative craving-related consumption found in Study 5 (Chapter 5) could be achieved with people who experience regular over-consumption and binge eating driven by cravings. Longitudinal studies could assess whether craving reduction strategies contribute to meaningful weight loss over time.

Further, the results of the present thesis suggest that cognitive defusion and guided imagery can be useful in dealing with both naturalistic cravings and resultant consumption. Study 5 (Chapter 5) showed that the techniques were easily used in the field, across a 7-day period. Because the techniques are brief and easy to use, they could potentially be translated into clinical contexts. Practically, there may be opportunity to incorporate the techniques as adjunct tools into therapies for craving and eating problems, such as treatments for weight loss or binge eating, particularly if behaviours are driven by food craving (Ng & Davis, 2013, Waters, Hill, & Waller, 2001).

Limitations and Future Directions

The present thesis had several strengths in addressing the key overarching aim, which was to investigate food craving reduction interventions within the context of the Elaborated-

Intrusion Theory of Desire (Kavanagh, Andrade, & May, 2005; May et al., 2012). First, the studies in the present thesis explored not only food cravings, but also craving-related consumption, an important outcome for the practical application of results. Second, the studies explored food cravings across both controlled laboratory environments, in which mechanisms of food cravings could be explored, and in a field setting, in which naturalistic food cravings could be assessed in real time. Third, the studies in the present thesis used samples of participants recruited from a range of settings, including a university campus, the wider community of metropolitan Adelaide, and an online community in the United States. These samples contained participants from a range of ages and weight categories, which enables the findings to be generalised across a range of women.

Despite the strengths of the present thesis, it also has some limitations which give rise to areas in which further research is warranted. First, individuals who experienced regular cravings were recruited, but these individuals did not necessarily have problematic cravings, such as those that drive binge eating episodes (Gendall, Joyce, Sullivan, & Bulik, 1998; Waters, Hill, & Waller, 2001). This means that the findings in the thesis cannot necessarily be generalised to individuals who have problematic cravings. Food cravings are commonly reported by overweight and obese individuals (Basdevant, Craplet, & Guy-Grand, 1993; Vander Wal, Johnston, & Dhurandhar, 2007), and individuals who suffer binge eating episodes (Gendall, Joyce, Sullivan, & Bulik, 1998; Waters, Hill, & Waller, 2001). Therefore, a logical next step would be to test cognitive defusion and guided imagery strategies with samples of individuals who experience problematic cravings that lead to unwanted overconsumption.

Second, the present thesis tested craving reduction strategies in relatively controlled environments, but they have not been tested in clinical settings. Techniques also were not tested as adjuncts to other therapies. A logical next step for this research program would be to test cognitive defusion and guided imagery as adjunct, ‘in-the-moment’ techniques to use alongside existing weight loss treatments such as cognitive-behavioural therapy. Cravings have been linked to early drop-out from weight loss treatment programs (Sitton, 1991). It may be important to test whether cognitive defusion and guided imagery could mitigate early drop-out by increasing individuals’ control over their food cravings. Strategies could also potentially be used at home by individuals in between therapy sessions, and support other therapeutic techniques guided by health professionals.

Further, anecdotal evidence suggests that participants found the techniques to be simple and easy to use. These features potentially increase the practicality of the techniques in daily life. However, before applying the techniques to clinical contexts, it would be useful to obtain participant feedback on their acceptability and usability (Moffitt, Brinkworth, Noakes, & Mohr, 2012). It would also be useful to test whether techniques can be internalised over time and used effectively without the audio guides used in Studies 3-5 (Chapters 4 and 5) of the present thesis. Ideally, with practice over time, individuals could remember and effectively apply the principles of cognitive defusion and guided imagery for themselves during times of craving.

Conclusion

The present thesis addressed the overarching aim of testing craving reduction techniques within the context of the Elaborated-Intrusion Theory (Kavanagh et al., 2005; May et al., 2012) by first demonstrating the role for craving-related thoughts and images in cravings, and then testing two strategies to reduce cravings. The thesis demonstrated that both craving-related thoughts and images are important components of the craving process, and are appropriate targets for interventions aiming to reduce both cravings and craving-related consumption. Results provide support for the predictions of the Elaborated-Intrusion Theory of Desire. Further, they suggest that cognitive defusion and guided imagery could be easily applied to everyday cravings, and could potentially be utilised as adjunct, in-the-moment techniques alongside structured therapy. Future research should focus on testing the efficacy of cognitive defusion and guided imagery strategies with clinical samples of individuals who experience problematic cravings.

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APPENDIX A

Cognitive Defusion Script

Now that your headphones have been fitted comfortably, please close your eyes. Sitting on your chair, feet flat on the floor and hands resting in your lap. Focus on your breath, feeling how the air moves in and out of your body. You may feel sensations in your body, notice them but allow them to pass. Notice any thoughts that come to your mind, staying within the present moment. Try to focus all of your attention on any thought you have in mind. Sometimes, we are able to see thoughts more clearly if we take a step back from them. We can become fused to our thoughts, when we believe our thoughts to be true without questioning them. But this is not always the case. Sometimes it is useful to take a step back from your thoughts, to consider whether they align with your goals, values and beliefs. It can be helpful to think of yourself as different or separate to your thoughts. They are creations of your mind, and can sometimes be different to your intentions. Sometimes we believe that thoughts are causal to actions, that because our thoughts are true, we must act on them. But this is not always the case. Notice the thoughts you are having now. Take a moment to step back from them, viewing them as merely thoughts. When you become more aware that you are having a thought, you will notice that it will soon fade, similar to the way leaves might float away on a stream. Whatever thoughts you are having at this moment, stay present with them. Do not try to change or challenge them, just let them exist. Consider your thoughts as merely thoughts, and do not judge them. If you sit with your thoughts, you will be able to ride them like a wave, even if they become stronger and more powerful, eventually they will fade. You are in control of your actions, and you do not need to act on your thoughts. You are in charge of your own thoughts, just like you are separate from them. You can decide whether you will act on them or not. Notice any thoughts you are having at this moment. Step back from them and view them for what they are, just thoughts. Focus your attention again on your breathing. Notice the way your breath moves in and out of your lungs. And when you feel ready, open your eyes and once again take in the room.

Guided Imagery Script (adapted from May et al., 2010)

Now that your headphones have been fitted comfortably, please close your eyes. Sitting on your chair, feet flat on the floor and hands resting in your lap. I want you to imagine that you are walking along the edge of a field towards a small forest just ahead of you. The sun is out and the air is bright and fresh. You walk into the forest along a narrow path between the trees. The forest is composed of many kinds of trees. The trees extend their leafy branches down to the earth. The branches of the trees wave towards you. Brightly coloured birds call from the forest, their voices rising and fading. Thousands of shades of green moss carpet the ground beneath the trees. Sunlight plays with the leaves and casts shadows on the path. You can smell the damp earth and can see a haze of blue in the distance. You feel the twigs breaking under your feet. Look up to see bits of the blue sky through the tops of the trees. Catch glimpses of birds as they fly from one tree to the next. In front of you a winding path leads uphill through the trees. Feel the path beneath your feet as you travel through the forest. The trees become denser and the air becomes cooler. It becomes darker as the trees grow closer together. You can see blue sky through the trees. All around you are flowers, bobbing their heads in the breeze. The scent of the flowers wafts around you. Ahead of you is a large log that has fallen and settled in the middle of the forest. You sit on the log and look around you at the forest, run your hand along the branch, feeling the contours of the rough, old bark. Small forest animals are going about their daily business, unaware of your presence. A brightly coloured bird comes close and you can see the green feathers of his chest. Further away you see beetles and ants scurrying along. The branches of the trees make strange shapes against the sky. There are sounds of bird song and the breeze in the tree branches. You can hear a stream running past somewhere nearby. The sounds of the forest are all around you. When you feel ready, open your eyes and once again take in the room.