

Symposium on ‘Molecular mechanisms and psychology of food intake’

The psychology of food craving*

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Cravings are hedonic responses to food, characterised by their intensity and their specificity. Food cravings are extremely common, reported by the majority of young adults. They are closely associated with liking but not synonymous with increased intake. Structured interviews and prospective incident accounts of food cravings have succeeded in revealing a richness of information about their character, their antecedents and their consequences. In addition, laboratory investigations are adding to what is being learned from field and clinical studies. Taking dieting as an example of an assumed influence on food craving, the outcomes of cross-sectional studies are mixed and unconvincing. Prospective and experimental research shows a clearer relationship. Dieting or restrained eating generally increase the likelihood of food craving while fasting makes craving, like hunger, diminish. Attempted restriction or deprivation of a particular food is associated with an increase in craving for the unavailable food. This relationship suggests a variety of underlying cognitive, conditioning and emotional processes, of which ironic cognitive processes, conditioned cue reactivity and dysphoric mood are prominent. Food cravings may also be self-attributions, accounting for why a highly-palatable but self-restricted food is (over-)consumed. Overall, the popularised account of cravings as elicited by specific nutritional need is having to give way to a more subtle and complex appreciation of human eating behaviour.

Food craving: Dieting: Dietary restraint: Hunger: Mood

A commonly-held view is that food cravings are expressions of bodily wisdom, elicited by need and serving to stimulate consumption of the required nutrient. This position is becoming increasingly contentious as new research evidence accumulates. However, the demand for a mechanical and unifying explanation of food craving means that non-confirming evidence is often marginalised or overlooked. The purpose of the present paper is to provide an update on these quintessentially psychological phenomena, to look again at the evidence on dieting and food cravings and consider the alternative underlying mechanisms.

The phenomenology of food craving

Most surveys find food cravings are extremely common events, and are reported by the great majority of young

adult samples. Food craving is closely associated with liking, since the most-commonly-craved foods, such as chocolate, are highly palatable (Pelchat, 2002). However, craving is not synonymous with increased eating. Foods are frequently eaten without being craved for and craved foods are not always eaten. Similarly, hunger is not a pre-condition for craving. Instead, there are stronger links between mood and craving. Cravings that lead to episodes of binge eating, for example, are more likely to happen against a backdrop of reduced hunger but increased negative affect.

So, what is a food craving? How is it defined? Craving is a problematic term for the addictions literature. It is a hypothetical construct, inferred from reports of subjective experience, changes in physiological state and overt behaviour. Craving is even more problematic in the context of food as it has weak links with consumption and food is not

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one substance but comprises many different macro- and micronutrients. Furthermore, food is not addictive in the true sense; rather, components of food are necessary to sustain life. It follows that models of food craving relate poorly to those applied to substances such as alcohol and nicotine (Weingarten & Elston, 1990).

Given these circumstances it is not surprising that most researchers define food craving pragmatically and based just on the subjective experience of craving. Strength and specificity are the core components. So, a craving needs to be both an intense desire and directed at a particular food, drink or taste. It follows that estimates of food-craving prevalence vary depending on the elements required for defining a craving. Gendall *et al.* (1997) have found that 58% of a random sample of adult women report having experienced a food craving, which reduces to 52% when limited to non-pregnancy cravings. This percentage further reduces to 42 when moderate to strong intensity is a requirement and to 21% when it is limited to strong intensity.

There are similarities with fear. Approximately 20–30% of the population have mild fears about things like spiders, dogs, thunder or blood. The experience of mild fear is sometimes seen in altered behaviour towards these objects or events. However, only 1% has a severe phobia, a state of extreme fear typified by absolute avoidance of the feared object or event. Similarly, a great majority of the population can identify a time when they have experienced a distinct urge to eat a particular food. However, for a much smaller proportion these urges are irresistible and their behavioural or emotional consequences are serious. Food craving, therefore, should be seen on a continuum of experience that ranges from mild to extreme.

Descriptive research

Numerous attempts have been made to fully characterise food cravings by scaling their subjective features, the attendant emotions and consequent behaviours, and describing the circumstances in which they occur. A selection of these studies will be outlined that in turn reveal the variety of approaches and methodologies used.

An incident approach to food craving has been developed by the author's research group. This approach differs from the continuous sampling methodology often used to measure hunger motivation, in that participants are asked to note every occurrence of a food craving and to complete a detailed account of the experience once it has passed. The information is noted on a food-craving record, a list of eighteen or more questions and ratings of the event contained on a single sheet of paper. The craving record builds on an earlier study (Hill *et al.* 1991) and was first used to describe food cravings in a group of twenty-five healthy women (Hill & Heaton-Brown, 1994). These women recorded their food cravings for five consecutive days in 1 week over a 5-week period, enabling any influence of their menstrual cycle to be detected. While this approach has been described as prospective, in truth it is probably better seen as quasi-prospective. The monitoring for food craving incidents is prospective but their detailed account

is retrospective, only being documented once the experience has passed.

The monitoring period was found to yield 219 craving episodes, averaging at 2.2 cravings per 5 d period or approximately two per week. Craving for chocolate or chocolate-containing foods was found to be the most common, accounting for 49% of episodes, with craving 'something sweet' the next most frequent at 16%, followed by craving for cereals (biscuits, cakes, puddings) and cravings for savoury foods in a minority at 12%. The great majority of cravings were found to occur at home or at work. Cravings were found to be equally likely alone or in company, to happen at all times of day and to be most frequently preceded by thinking about the craved food. Cravings for chocolate were found to be stronger and to disappear much more slowly than those for other sweet or savoury foods, even though they were equally likely to result in eating. Small but positive changes in mood were found across the craving experience and hunger decreased. In addition, a 66% increase in the number of cravings (but no difference in the types of food craved for) was observed during the premenstrual phase. This study describes the normality of craving for this group of women. It characterises cravings as hunger-reducing mood-improving experiences, directed at wanting to consume highly-pleasant-tasting food and most commonly triggered by thinking about that food.

Another prospective approach to cravings is reported by Schlundt *et al.* (1993). They included a question about whether participants were craving sweets within a detailed food-intake diary, and alongside a variety of other information to be completed at each eating occasion. Also recorded were the situational aspects of eating and current emotional state. Participants were eighty moderately-obese women monitored over a 2-week pre-intervention period, selected from a larger cohort on the basis of craving frequency. No difference was found in high- and low-frequency sweet cravers on most demographic, physiological and food-intake measures. Craving for sweets was shown to be closely associated with snacking and boredom but quite different from the experience of hunger. The novelty of the paper lies in the application of sequential analysis techniques to see how well eating behaviour can be predicted from events occurring at the previous meal. Certainly, no evidence was found that missing an eating episode results in a greater likelihood of later craving sweets. Interestingly, these cravings were shown to be associated with subsequent impulsive eating and overeating, argued as evidence of violations of dietary abstinence rules.

In a very different approach, Pelchat (1997) has used structured interviews to compare the food-craving experiences of old and younger adults. Elderly participants reported fewer cravings and for a more limited number of foods, and some evidence was found that craving for sweets, which is greater in women, also declines with age. Interviews have been used to investigate cultural differences in craving. For example, when young and older Egyptian adults were interviewed (Parker *et al.* 2003) it was noted that savoury rather than sweet foods are much more likely to be identified as those craved. This finding

contrasts with the predominant craving for chocolate and other sweet foods by Europeans and North Americans. Of particular interest is the observation that in Egyptian Arabic there is no single word that describes food cravings for anyone other than pregnant women.

Finally, in the study of Tiggemann & Kemps (2005) a sample of undergraduates were asked to recall their last experience of a food craving, remembering it as if it was happening right now, writing a short paragraph about the experience as well as completing ratings of its intensity and character. Here, the focus was directed firmly at the experience rather than at features such as frequency. It was found that only two of 130 participants were unable to recall a craving experience, perhaps unsurprising given that they had volunteered for a food-craving survey. The intensity of the experience is apparent from both the ratings and written account. Chocolate and other sweet foods were found to make up >40% of the foods named, but were overtaken by the proportion of cravings for takeaway foods, meal foods and savoury treats. More women than men were reported to crave chocolate and more men than women to crave a meal. Given the nature of the task it is not surprising that capacity to visualise the food and imagine its taste were both found to be strongly correlated with craving strength.

In general, these studies have captured some of the intensity and variety of the craving experience, showing how naturally-occurring variations such as menstrual cycle, age and culture affect food craving. Above all, they describe individuals' familiarity with food cravings in a manner that neither sensationalises them nor makes them bizarre. Their findings serve as a template against which to understand circumstances associated with food craving. One such is dieting, a topic that also permits insight into some of the cognitive and emotional processes that drive food craving.

Dieting and food craving

If food cravings are psychological registrations of the body's energy depletion then there should be a straightforward association between dieting and food-craving frequency or strength. The journal *Appetite* published a mini-symposium on food craving in 1991. Three of the papers (Hill *et al.* 1991; Rodin *et al.* 1991; Weingarten & Elston, 1991) have reported outcomes that fail to find this expected relationship. In a survey of a large sample of Canadian undergraduate women (Weingarten & Elston, 1991), the 15% who said they were currently on a diet were found to be no more likely to report food cravings than the non-dieters. When a group of young American women were interviewed (Rodin *et al.* 1991) about their craving experiences over the preceding 2 weeks on four occasions in a 2-year period, those women who reported food cravings were found to score no higher on dietary restraint than non-cravers. In contrast, an association between dietary restraint and craving strength, albeit weak, was found (Hill *et al.* 1991) in a cross-sectional study of UK women. However, both craving strength and frequency were found to be much more strongly related to emotional

and external eating, scales that describe conditions that provoke unplanned eating or overeating. When this study was extended through the short-term monitoring of small groups of cravers and non-cravers, higher daily levels of boredom and anxiety were confirmed in the cravers but no differences were found in dietary restraint or evidence of dieting from diary records.

A somewhat different approach was used by Delahanty *et al.* (2002). Looking at baseline data from a cohort of participants on the Diabetes Prevention Program, they report that food craving along with binge-eating severity and poor dietary restraint are independently and positively related to BMI. The question used to measure food cravings was unusual: the extent to which participants 'fantasised a lot about favourite foods while dieting'. It is the relationship between food fantasising, diet breakdown and higher BMI that is a most striking outcome of this study. Overall, this evidence that dieting is associated with an increase in food cravings is not strong.

Fasting and very-low-energy diets

One area in which food cravings appear responsive to dietary reductions is fasting. The direction of change is unexpected. There is evidence that fasting, in both the short-term (Lappalainen *et al.* 1990) and the long-term (Harvey *et al.* 1993), is associated with fewer food-craving experiences. This decrease in craving is generalised across all food groups and does not rebound during re-feeding (Harvey *et al.* 1993; Martin *et al.* 2006). While such interventions are effective at bringing about weight loss, there is no relationship between the amount of weight lost and reduction in food craving.

This suppression of food craving is consistent with other observations of reduced appetite during weight loss on very-low-energy diets. The paradox 'less food, less hunger' is the headline of a study by Wadden *et al.* (1987). Groups of obese patients following a 2092 kJ (500 kcal)/d or 5020 kJ (1200 kcal)/d diet were monitored over a 3-month period. In fact, the suppression of hunger in the very-low-energy-diet group was found to be significant ($P < 0.05$) only on the second month and was overshadowed by a marked increase in physical symptoms such as constipation, dizziness and fatigue. Hunger suppression during low energy intake is not without precedent. Reduced hunger has been reported in patients with eating disorders who have similarly low levels of daily energy intake (Halmi & Sunday, 1991).

Ketosis has been suggested as a mechanism for this decrease in hunger and food craving, although there is very little evidence of an association. However, short-term manipulations of blood glucose levels do affect craving experiences. For example, using a set of questions on craving taken from Hill & Heaton-Brown (1994), it was found (Strachan *et al.* 2004) that two-thirds of a small sample of subjects with type 1 diabetes report food cravings during insulin-induced acute hypoglycaemia, which contrasts with only 15% craving during euglycaemia. Hypoglycaemia was also found to be associated with increases in craving strength, difficulty ignoring cravings,

rated hunger and the desirability of many foods, especially those high in carbohydrate.

Prospective studies

True prospective studies of the relationship between dieting and food craving generally fall into two groups. The focus of attention is on either the diet or the craving experiences themselves. As an example of the former, a small group of normal-weight women and men were asked to follow an energy-restricted diet for a period of 2 weeks (5020 kJ (1200 kcal)/d and 6276 kJ (1500 kcal)/d respectively) and to eat normally for 2 weeks (Warren & Cooper, 1988). It was found that all participants lost weight over the course of the diet, indicating compliance. An increase was found in ratings of being preoccupied with thoughts about food or eating and feeling a strong urge to eat during the dieting period but there was no change in mood. Although increased, these changes were not dramatic, at means of approximately 30 on a 100 mm visual analogue scale. They suggest either a shared moderate increase in craving-related sensations or substantial variability in response, with some participants experiencing large increases and others none at all.

With a focus on food-craving experiences, a group of female undergraduates were asked to keep daily records of mood and food craving over a period of 5 weeks (Cohen *et al.* 1987). Only cravings for high-carbohydrate (and high-fat) foods during the 10 d before and 10 d after the onset of menses were analysed. Craving intensity was found to be higher in the late luteal menstrual-cycle phase than in the early follicular phase. Dividing participants into groups according to their median dietary restraint score reveals no effect of dieting status on craving intensity. However, comparing the ten women with the highest restraint scores with the ten lowest scorers shows that highly-restrained women have lower craving intensity over both menstrual-cycle phases. Although it was observed that mood becomes increasingly negative across the luteal phase, the association between mood and food cravings was not found to be significant. In other words, cravings are less likely in highly-restrained eaters and no more likely to occur in the context of negative mood.

A very different outcome is apparent in the author's research. It was found (A Massey and AJ Hill, unpublished results) that dieters do report more food-craving experiences, and that these experiences are more likely in the context of mildly negative mood and low hunger. There are important differences between the studies that may account for some of the differences in outcome. The author's study (A Massey and AJ Hill, unpublished results) recruited a community sample of women, two-thirds of whom were members of a commercial slimming group. In all, 127 women with a mean age of 41 years took part in the study. They completed daily mood assessments, a food-intake diary and craving records over a 7 d period, using the quasi-prospective methodology of Hill & Heaton-Brown (1994) described earlier. The women were divided into three groups according to whether they self-categorised as currently dieting to lose weight, currently dieting or watching what they ate so as not to gain

weight or currently not dieting. This distinction between dieting and watching has not been made before in the context of food craving but follows an observation made of teenage dieting (Nichter *et al.* 1995). Watching to avoid weight gain is more common than dieting for weight loss, but both involve restraint over eating. It is possible that in previous research some watchers may have been misclassified as dieters when in fact they were not motivated, or changing their eating, to lose weight.

In many respects watchers fall between dieters and non-dieters. In the sample used by A Massey and AJ Hill (unpublished results) they were of normal weight (dieters were overweight), had a higher maximum past weight than non-dieters and were intermediate in their dietary restraint score. They were also found to be intermediate in the number of cravings experienced in the week of recording, with dieters reporting significantly more cravings than non-dieters (3.81 (SE 0.42) *v.* 2.27 (SE 0.33)), and watchers showing no difference from either group (2.83 (SE 0.42)). The craving experiences recorded by dieters were found to be stronger, more difficult to resist and slower to disappear than those of non-dieters. Craving onset was shown to be associated with less positive mood and lower hunger than in non-dieters. However, no differences were found in the situations where cravings started, the time of day of onset, the foods that were craved or even whether cravings led to eating.

The nature of deprivation

Dieters do not only potentially deprive themselves of food energy, they deprive themselves of foods they enjoy eating. They may also lose variety in their daily menu. Both monotony and self-restriction are associated with increased food-craving experiences. Feeding a nutritionally-adequate sweet monotonous liquid diet (Sustacal; Mead Johnson Nutritionals, Evansville, IN, USA) plus water for 5 d results in an increase in food cravings compared with baseline, but in young adults rather than elderly adults (Pelchat & Schaefer, 2000). Interestingly, the increase was observed for meal foods and not sweets, those foods that differed in sensory quality to the liquid diet and that participants were denied the opportunity to eat.

Attempted restriction over eating was found to be one of the best discriminators between dieters, watchers and non-dieters in the study described earlier (A Massey and AJ Hill, unpublished results); no difference was found between the groups in terms of the types of food craved. Chocolate was found to be the most common target, craved on 35% of occasions. The difference was that dieters rated their cravings as being for foods they had recently tried to restrict eating. It was found that watchers score intermediate on this scale and non-dieters very low. Paradoxically, dieters' attempts at resisting eating certain foods appear to have led to cravings for the same foods, and their consumption on 70% of craving occasions.

This association between restriction or deprivation and food craving has also been studied in the laboratory. Polivy *et al.* (2005) have looked at cravings and consumption of chocolate or vanilla-containing foods following 1 week when participants were required to refrain from eating

foods containing either chocolate or vanilla. It was found that chocolate-deprived participants eat more chocolate in the taste test situation than either vanilla-deprived participants or non-flavour-deprived participants. Restraint status qualifies this outcome, with only the high restraint group showing this increased chocolate intake. Vanilla deprivation was found to have no comparable effect. Highly-restrained eaters also reported a stronger desire to eat chocolate at the start of the session and abandoned a psychological test earlier believing they could access chocolate sooner. Importantly, restrained eaters reported more food cravings generally, although deprivation was not found to specifically increase craving for either chocolate or vanilla.

Using a similar methodology Coelho *et al.* (2006) have shown a selective effect of short-term (3 d) carbohydrate or protein restriction on craving for these food types. Abstaining from foods high in complex carbohydrates was found to be associated with an increase in craving them, and higher intakes in the taste test situation. Abstaining from foods high in animal protein was found to have a similar effect on craving for high-protein foods but no increase in intake. Overall, participant's restraint level was found to have no effect on outcome either for craving or for intake. So, either restriction-induced craving is a general phenomenon that dieters have more life experience of, or there is something special about chocolate to dieters that is not shared by bread or chicken.

Cognitive, conditioning and emotional processes

Cognitive psychology has experienced a reinvigoration in empirical research and theory development over the last decade. Unsurprisingly, this work has included studies of craving, much of it driven by a need to understand and manage appetites for psycho-active and addictive substances. The more ambitious conceptualisations such as that by Kavanagh *et al.* (2005) have attempted to integrate thoughts, imagery, memory processes, affect and physiology into models that account for research evidence across a range of substances and a continuum of intensity of desire. A relative minority of evidence has been taken from the literature on food craving. However, there is value in identifying the main themes, some of which relate to the previous discussion of food cravings and dieting.

The ironies of thought suppression

One perspective is the theory of ironic processes of cognitive control, an approach previously applied to dieting (Herman & Polivy, 1993). Once more this is paradox territory. Briefly, the theory describes how, under certain conditions, efforts to avoid thinking about a situation or stimulus actually lead to an increase in their salience. Wegner (1997) describes mental self-control as the product of two processes: a conscious effortful search for mental content that will produce a desired state of mind; an unconscious automatic search for content that signals a failure to produce this outcome. This latter process is the necessary check for failure to create the intended mental

state. It is ironic since in searching for evidence of failure it increases the accessibility of the undesirable evidence. Most of the time the search for failure is overshadowed by the search for consistency. It is when the cognitive system is under pressure that ironic processes are most observable. So, intended thought suppression under mental load makes the suppressed thought more accessible. In the context of food and eating, there are circumstances in which trying to distract oneself from thinking about a particular desired food makes evidence of the existence and appeal of that food more prominent.

Applying this reasoning to food craving, small groups of chocolate cravers and non-cravers were recruited to complete a computer task that yielded chocolate rewards Johnston *et al.* (1999). Participants were given the task of planning a dessert menu for a large dinner party and asked to verbalise the thoughts that came to mind. Half the participants were instructed to try not to think about chocolate and half were given no thought-suppression instructions and acted as controls. Shortly after the menu-planning task participants played a computer game for which they were shown how their performance could be translated into different types and sizes of chocolate bar. It was found that those asked to suppress thoughts about chocolate do significantly better at the task and so win more chocolate, regardless of whether they are chocolate cravers or not. So, while the thought-suppression task reduces the number of verbalised thoughts about chocolate, the opportunity to access chocolate immediately afterwards shows an ironic spill-over (or rebound) into performance and chocolate-reward driven behaviour.

Of course, participants did not have to eat the chocolate they won, not immediately at least. Also, it is generally hard to show food-related ironic processes changing eating behaviour, which is not itself a problem for food cravings since not all cravings lead to eating, and even when they do the consequences can be emotionally benign (Hill & Heaton-Brown, 1994). Accordingly, the outcomes of two other studies (Mann & Ward, 2001; Soetens & Braet, 2006) are relevant here. Instructed to refrain from eating either a neutrally-liked or highly-liked food for 5 d, undergraduates' thinking about the food, desire to eat it and consumption were monitored in their home environment and in the laboratory (Mann & Ward, 2001). It was found that avoidance results in a relative increase in thoughts about the forbidden food and in some instances a relative increase in the desire to eat it. Both of these processes are components of craving, albeit weakly expressed, and the outcome is consistent with the laboratory-based research of Polivy *et al.* (2005).

Applying this approach to a clinical sample in controlled conditions, obese adolescents and a comparison normal-weight group were asked to button press each time a thought about food and eating came to mind (Soetens & Braet, 2006). When asked to suppress these thoughts (while concurrently monitoring and indicating their presence) it was found that all participants were successful. However, in the period immediately afterwards, when they were told to think about anything they liked, it was found that highly-restrained obese adolescents show the characteristic ironic rebound. That is, they indicate an increase

in food and eating thoughts, above baseline and suppression levels, and greater than the levels reported by other participant groups. Restriction-associated cravings described earlier therefore have some semblance in ironic cognitive processes.

Visual imagery

Imagery is a key part of the Kavanagh and co-workers' (Kavanagh *et al.* 2005) cognitive–emotional theory of desire. It is seen as central to the experience of nearly all intense craving episodes, and while visual content is paramount there may be attendant sensory experiences such as smell, taste, texture, feel or sound.

Asking participants to imagine their favourite food is a relatively simple way of exploring the contribution of imagery to the experience of food craving. In addition to asking undergraduate participants to recall the last time they experienced a food craving, Tiggemann & Kemps (2005) also asked them to think about their favourite food and to imagine eating it. Participants were asked to bring to mind the experience as vividly as possible and as if happening at that moment. It was found that the most commonly visualised are meal foods followed by take-away foods. Sweet foods are even less commonly identified than in the craving recall task. Experiences of the taste, smell and texture of the food are also rated relatively high. Rated craving, inferred from the concurrent rating of participant's desire or urge to eat the food, is high and at a similar level to rated vividness. Image vividness and craving intensity are again inter-correlated. Moreover, craving intensity is also correlated with seeing oneself eating the food, tasting the food and current level of hunger. In terms of predictors of craving intensity, it was found that image vividness and current hunger are the most important statistically. However, neither participant's current dieting status nor dietary restraint were shown to be related to any of these measures of current craving and only weakly to some of the imagery experience measures.

The capacity to create a strong visual image of food appears to reflect visual imagery skills in general. It follows that techniques that reduce the vividness of imagery may also reduce the perceived intensity of food craving. Accordingly, staring at a flickering matrix of black and white squares (dynamic visual noise) on a computer screen reduces craving more than staring at a blank screen, as does a simple forehead finger tapping task (for example, see McClelland *et al.* 2006). The longevity of their interference and effects on cravings deemed intense and disruptive are yet to be determined. Nevertheless, this series of studies is rare in moving beyond the descriptive to exploring ways of managing craving.

Cue reactivity

The way that individuals react physiologically and behaviourally to food-related cues has been investigated in relation to food craving (Rogers & Hill, 1989; Overduin *et al.* 1997; Jansen, 1998; Nederkoorn *et al.* 2000; Federoff *et al.* 2003). Again, the approach has been extensively developed within the area of addiction. At its core is the

idea that the intensity of psychophysiological reactions to substance-related cues is an index of the responses underlying craving. So, cue-induced heart rate acceleration or increased skin conductance are non-subjective measures of craving (and dependence). They are also thought to describe risk for post-treatment relapse and are potential indices of treatment effectiveness.

Various attempts have been made to differentiate restrained and unrestrained eaters in terms of cue reactivity. Their success depends on what is measured. Food intake outcomes tend to show a difference. So, smelling and thinking about highly-liked foods leads restrained participants to eat more of these foods but not other well-liked foods (Federoff *et al.* 2003). Research looking at physiological outcomes has been far less successful (for example, see Rogers & Hill, 1989; Overduin *et al.* 1997) but has prompted further investigation of their relationship with food craving. For example, Nederkoorn *et al.* (2000) have looked at a range of physiological measures (including heart rate, blood pressure, gastric activity, salivation) on exposure to favourite foods, and during and after eating them. Exposure to food was found to have pronounced effects on these measures, a finding consistent with their characterisation as cephalic-phase responses. Concurrent ratings of craving were shown to be correlated only with blood pressure, supporting the idea that at least some physiological responses are part of the craving experience. Looking at chocolate craving, high cravers exposed to images of chocolate show a reduction in heart rate but exaggerated startle reflex compared with low cravers (Rodríguez *et al.* 2005). The authors discuss this apparently contradictory outcome in terms of the simultaneous activation of both appetitive and aversive motivational states.

The clearest rationale for an interest in cue reactivity and food cravings is for a better understanding of the processes involved in binge eating. It is usual to place their operation within a classical conditioning framework. Jansen (1998), for example, argues as follows. In normal circumstances food intake is an unconditioned stimulus and its physiological and metabolic consequences are unconditioned responses. Cues that reliably signal food intake (sight, smell, taste or food) act as conditioned stimuli that trigger reactivity or conditioned responses. These conditioned responses can be physiological changes such as those cephalic-phase responses described earlier. The alternating binge and fasting behaviours of individuals with binge-eating problems facilitate the conditioning process, as the behaviours are extreme (strong unconditioned responses) and the range of cues (conditioned stimuli) limited and specific. Over time the physiological responses that define cue reactivity are subjectively experienced as cravings and lead to binge eating.

Research into cue reactivity in eating disorders such as bulimia nervosa is relatively extensive (for example, see Carter *et al.* 2006) but tends to overlook food craving in favour of urge to eat or urge to binge, if these subjective data are collected at all. Also, food cravings are not the only triggers to binge episodes. Using information from craving records it has been shown (Waters *et al.* 2000) that to account for binge behaviour outside a clinical setting

the combination of internal states, such as craving or previous consumption of the craved food, and external factors, such as time of day or social circumstance, need to be recognised.

Emotional state

As is apparent from the earlier account of the phenomenology of food cravings, mood plays an important role in food craving. For example, cravers are more likely to be bored or anxious during the day and to experience dysphoric mood immediately before cravings (Hill *et al.* 1991). Cravings in women without psychopathology are associated with a mild and positive change in mood across the craving experience (Hill & Heaton-Brown, 1994), although this change in affective tone can differ according to whether cravings are resisted or given in to, and the gender of the craver (Lafay *et al.* 2001).

The idea that some individuals choose and eat foods to intentionally regulate mood has a long history. Several biological pathways have been proposed, most prominent being brain serotonin and endogenous opioids. Indeed, there may be several mechanisms that account for the relationship between mood and food and they need not be mutually exclusive (Rogers & Smit, 2000). Some reflect the fact that frequently-craved foods such as chocolate are very pleasurable to eat and so inherently rewarding. The idea of emotionally-instrumental eating has been examined by Macht & Simons (2000). They have found that motivation to eat is higher during negative emotion and in this state participants tend to eat to provide distraction, to relax and to feel better.

Extending this idea to food craving it has been hypothesised that some individuals eat a specific food, and crave it, for reasons of negative reinforcement; i.e. consumption reduces aversive mood states such as boredom and depression. To explore this idea in self-defined chocolate 'addicts' and a group of women who like chocolate but are not addicted, an inspection has been made of 7 d diary records of chocolate intake and mood ratings (Macdiarmid & Hetherington, 1995). Before eating chocolate the addicts were found to have higher ratings of craving intensity, guilt and depression, and to be less content and relaxed. Chocolate consumption was observed to decrease craving and hunger, with the only change in mood being a small increase in guilt that was greater for the addicts. It may be that any relief from negative mood occurs only during eating or is too transient to be detected.

It is also possible that mood improvement is dependent on the intensity of negative mood in the first place and the behaviour that follows the food craving. Food cravings and their relationship to binge eating in women with bulimia nervosa has been investigated (Waters *et al.* 2001). It was found that food cravings that lead to a binge are associated with higher tension and lower mood than cravings that do not lead to a binge. In addition, when a craving is followed by a binge there is a further substantial deterioration of post-craving mood. In contrast, mood improves when there is no subsequent binge. Interestingly, hunger is lower when craving leads to a binge and reduces regardless of whether

or not a binge occurs. In an eating disorder context, craving and the subsequent behaviour appear much more affect-driven than hunger-oriented. Also, this account is consistent with the widely-accepted view of binge eating as an emotionally-regulating behaviour that occurs more often in a context of negative affect and has a stress-reduction function.

Conclusions

There is increasing confidence in taking seriously and researching the subjective experience of individuals in relation to food and eating. This confidence is apparent in the increasing attention that has been focused on issues such as food craving. Research is revealing a richness of information about the character, antecedents and consequences of cravings. Food cravings are moving away from being cast as personal peccadilloes to that of shared common experience that is often benign but on occasion is emotionally costly. Increased understanding of these phenomena should also help the subject move further away from an over-simplistic cause-and-effect model of nutrients on behaviour.

The increasing confidence can be seen in the way that food craving is being taken into laboratory situations and subject to the rigour of tight experimental methodology. It is true synergy between laboratory and field investigation that is likely to best develop understanding. The challenge will be to ensure that work in these two situations investigates the same phenomenon. Conceptualising craving along a continuum of experience may help integrate research directed at students' favourite foods with the powerful cravings that drive binge behaviour in clinical samples.

The present paper has taken the opportunity to reveal the complexity of food craving through reviewing the evidence linking these experiences with dieting. Although the outcomes of cross-sectional studies are mixed and unconvincing, those from prospective and experimental investigations show a clearer relationship. Dieting or restrained eating increase the likelihood of food craving while fasting makes craving, like hunger, diminish.

This association directs attention to two further issues. First, although desire to eat is a defining component of food craving, craving strength is not a metric or analogue of hunger. Several circumstances have been described in which food cravings are more likely when hunger is reduced. However, they are not independent of hunger. Again, it is likely that the more extreme or intense cravings deviate most from a normal hunger experience. Second, this analysis has provided an insight into possible underlying mechanisms. The observation that attempted restriction over eating or deprivation leads to an increase in craving for the restricted food suggests a variety of cognitive, conditioning and emotional processes. Ironic cognitive processes, conditioned cue reactivity and dysphoric mood are prominent in this regard.

Perhaps the feature that most distinguishes food craving from hunger is the ambivalence shown towards the object of craving. In their excellent review Rogers & Smit

(2000) show how the tension between the pleasure and reward value of foods such as chocolate and the guilt following (over-)consumption accounts for some of the anomalous outcomes that have been reported. Understanding the real dilemma faced by individuals attempting to restrain their eating in a circumstance of available highly-palatable foods also helps in the appreciation of why craving is such a commonly-used term in daily life. A craving is frequently an attribution to account for why a food was eaten. It is a personally- and socially-acceptable reason for eating that resonates with reasoning about why individuals smoke cigarettes and drink alcohol (Rogers & Smit, 2000). However, food is not addictive. Food cravings are another example of a bias in self-attributions, the ways individuals make sense of their own behaviour. For events with negative outcomes the cause is more often seen as external or situational (the food) rather than caused by internal psychological features (Malle, 2006). It is the complexity of the individual that is the key to food cravings not simply a magical property of the food being craved.

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