



## The nature of imagery processes underlying food cravings

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**Objective.** The study used a working memory approach to examine the nature of the imagery processes underlying food cravings.

**Design and method.** A sample of 60 dieters and 60 non-dieters were asked to imagine either a food induction or a holiday induction scenario. Participants then performed 18 trials of either a visual imagery task (loading the visuo-spatial sketch pad) or auditory imagery task (loading the phonological loop). Food craving was measured before and after the induction scenario, and then after every 6 trials of the imagery task.

**Results.** Craving intensity increased following instructions to imagine the food (but not holiday) induction scenario, especially for dieters. As predicted, the visual imagery task was superior to the auditory imagery task in reducing the level of food craving.

**Discussion.** The results confirmed the imaginal basis of food cravings. Specifically, they demonstrated that the imagery processes involved in food cravings are predominantly visual in nature. Hence concurrent tasks that load the visuospatial sketch pad of working memory can be used to reduce food cravings. The findings have potential application in the treatment of craving episodes in clinical populations.

The term 'craving' refers to a motivational state characterized by an intense desire or urge for a particular substance, usually drugs or food (Cepeda-Benito, Gleaves, Williams, & Erath, 2000). Such a state can be maladaptive in producing a number of potentially negative consequences. For example, drug cravings both contribute to the maintenance of substance abuse and precipitate relapse following drug abstinence (Shiffman *et al.*, 1997; Tiffany, 1990). Similarly, food cravings have been reported to precede binge eating sessions (Glendall, Joyce, Sullivan, & Bulik, 1998) and bulimia nervosa (Waters, Hill, & Waller, 2001). Binge eating episodes triggered by cravings not only serve to maintain eating disorders (Glendall, Sullivan, Joyce, & Bulik, 1997), but may lead to obesity (Wurtman & Wurtman, 1995) and depression (Glendall *et al.*, 1998). Food cravings have also been implicated in early dropout from weight-loss treatment programmes (Sitton, 1991).

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The physiological origins of food cravings have been well documented. Food cravings have been linked to homeostatic imbalances (Wurtman, 1988), nutrition deficiencies (Wardle, 1987) and hormonal changes (Hill & Heaton-Brown, 1994). However, it is clear that an exclusively physiological basis fails to adequately account for all food craving experiences. A substantial body of data supports a role for affective influences, such as anxiety (Jansen, 1998), depression (Dye, Warner, & Bancroft, 1995) and guilt (Benton, Greenfield, & Morgan, 1998). Food cravings have also been associated with impaired cognitive task performance (Green, 2001). To date, however, the cognitive basis of food craving has received minimal research attention.

Green, Rogers, and Elliman (2000) used a dual-task research paradigm derived from Tiffany's (1990) work on nicotine craving to investigate the cognitive mechanisms involved in food craving. Instructions to imagine a smoking urge script have been shown to induce cigarette cravings (Tiffany & Hakenewerth, 1991) and to disrupt concurrent cognitive activity (Cepeda-Benito & Tiffany, 1996) in cigarette smokers. Similarly, Green *et al.* found that instructions to imagine their favourite food impaired the performance of dieters and highly restrained eaters on a simple reaction time task, but not the performance of non-restrained eaters. Moreover, reaction times were positively correlated with self-reported desire to eat. In contrast, instructions to imagine a favourite holiday did not affect reaction times. Green *et al.* concluded that food cravings are analogous to cigarette cravings, in that both craving states consume limited cognitive processing capacity. In addition, the fact that both craving experiences can be induced experimentally by imagery instructions suggests that mental imagery may be a central feature of naturalistic food cravings, analogous to the desire-related images typical of cigarette craving episodes (Salkovskis & Reynolds, 1994).

The present study aimed to further explore the imaginal basis of food craving. Based on the demonstrated cognitive similarity between cigarette and food craving (Green *et al.*, 2000), the methodology introduced by Panabokke, May, Eade, Andrade, and Kavanagh (submitted) to investigate the nature of the imagery processes underlying cigarette craving was adapted for food craving. Panabokke *et al.* used a working memory approach to conceptualize the phenomenology of imagery in cigarette craving. The working memory model (Baddeley & Hitch, 1974) consists of three components: a supervisory system, the central executive, and two slave systems, the visuospatial sketch pad and the phonological loop. The visuospatial sketch pad maintains visual and spatial material and is involved in visual imagery. The phonological loop maintains verbal material and is involved in auditory imagery. The slave systems have limited storage capacity. Thus, a visual (verbal) task will interfere with the content of the visuospatial sketch pad (phonological loop) by competing for visual (verbal) processing resources. In a series of experiments, Baddeley and Andrade (2000) showed that the vividness of visual imagery was reduced by tasks that selectively loaded on the visuospatial sketch pad, whereas the vividness of auditory imagery was reduced by tasks that specifically utilized the phonological loop.

Panabokke *et al.* (submitted) compared the impact of visual and auditory imagery on cigarette cravings. Following a period of abstinence, cigarette smokers imaged a smoking urge script and subsequently rated their craving intensity. Half the participants then completed a visual imagery task, aimed to load the visuospatial sketch pad, while the other half completed an auditory imagery task, aimed to load the phonological loop. All participants again rated their craving intensity. Panabokke *et al.* found that the visual imagery task reduced the level of cigarette craving, whereas the auditory imagery task

did not. They interpreted these results as showing that the imagery processes underlying cigarette cravings are visual, rather than verbal, in nature. In working memory terms, cigarette cravings selectively engage the visuospatial sketch pad and hence can be reduced by loading this component with concurrent cognitive activity.

In view of the proposed analogy between the cognitive mechanisms underlying cigarette and food cravings (Green *et al.*, 2000), the present study similarly tested the hypothesis that the mental imagery involved in food craving is predominantly visual in nature. Specifically, we predicted that requiring participants to perform a visual imagery task (and thereby loading the visuospatial sketch pad) would reduce elicited food cravings, whereas an auditory imagery task (loading the phonological loop) would not. Although cravings are not invariably related to dieting status (Harvey, Wing, & Mullen, 1993; Hill, Weaver, & Bundell, 1991; Rodin, Mancuso, Granger, & Nelbach, 1991), there is some evidence to suggest that dieters experience greater degrees of food craving than non-dieters (Fedoroff, Polivy, & Herman, 1997; Overduin & Jansen, 1996; Pelchat, 1997; Warren & Cooper, 1998). We therefore compared the effects of visual and auditory imagery on food cravings in both dieting and non-dieting samples.

## Method

### *Participants and design*

Participants were 120 female undergraduate students (60 self-identified dieters and 60 non-dieters) at Flinders University in South Australia who took part for course requirements and credit. They were aged between 18 and 35 years ( $M = 20.99$ ,  $SD = 3.94$ ). Following Lowe (1993), current dieting status was determined by participants' response to the question 'Are you currently on a diet to lose weight?' ('Yes'/'No'). There were no pre-existing differences between dieters ( $M = 2.63$ ,  $SD = 0.73$ ) and non-dieters ( $M = 2.77$ ,  $SD = 0.67$ ) on imaging ability,  $t(117) = 1.06$ ,  $p > .25$ , as measured by the Questionnaire Upon Mental Imagery - Brief Version (Sheehan, 1967). Participants were randomly assigned to the conditions of a 2 (induction scenario: food, holiday)  $\times$  2 (imagery task: visual, auditory) factorial design, with equal numbers of dieters and non-dieters in each condition.

## Materials

### *Induction scenario*

Participants were asked to image either a food induction ('Imagine you are eating your favourite food') or holiday induction scenario ('Imagine you are on your favourite holiday'). These scenarios were taken from Green *et al.* (2000) who showed that they were rated equal in vividness. They were selected to be specifically neither visual nor auditory.

### *Imagery task*

The imagery task consisted of 18 visual cues (e.g. 'Imagine the appearance of a rainbow'), or 18 auditory cues (e.g. 'Imagine the sound of a telephone ringing'). These were adapted from Baddeley and Andrade's (2000) lists. All food-related stimuli (e.g. a birthday cake) were removed, and British items (e.g. Trafalgar Square) were replaced with Australian equivalents (e.g. Victoria Square). Each cue was printed on a separate A4 sheet of paper.

### Procedure

Participants initially completed a 100-mm visual analogue scale to give a baseline rating of food craving intensity. The scale ranged from 'no desire or urge to eat' to 'extremely strong desire or urge to eat'. Participants were then asked to imagine the food or holiday induction scenario. They were instructed to close their eyes and to bring the experience to mind as clearly as possible. Participants then rated the vividness of their image on a 100-mm visual analogue scale, ranging from 'no image at all' to 'image perfectly clear - as vivid as the actual experience', and again rated their level of food craving.

Half the participants subsequently completed the visual imagery task and half the auditory imagery task. On each of the 18 trials, participants were asked to read the image cue silently while the experimenter read it aloud. Participants then closed their eyes and maintained the imagined scene or sound for 10 s. A timer signalled participants to open their eyes and rate the vividness of each image on a 100-mm visual analogue scale, ranging from 'no image at all' to 'image perfectly clear - as vivid as normal vision/hearing'. The cues were presented in a fixed order, in three sets of six. Following each set of six cues, participants rated their level of food craving.

## Results

### Induction scenario

An independent samples *t*-test on the image vividness ratings of the induction scenarios confirmed that there was no difference in vividness between the food ( $M = 76.95$ ,  $SD = 14.54$ ) and holiday induction scenarios ( $M = 74.00$ ,  $SD = 17.03$ ),  $t(118) = -1.02$ ,  $p > .30$ .

To assess the success of the craving induction, pre- and post-induction craving scores were analysed by a 2 (dieting status: dieter, non-dieter)  $\times$  2 (induction scenario: food, holiday)  $\times$  2 (time: baseline, post-induction scenario) mixed-design ANOVA, with repeated measures on the last variable. Mean craving ratings are presented in Table 1.

**Table 1.** Mean baseline and post-induction food craving ratings as a function of dieting status and induction scenario (standard deviations in parentheses)

Dieting status	Induction scenario	Time	
		Baseline	Post-induction
Dieter	Food	33.73 (30.04)	60.67 (32.10)
	Holiday	43.17 (31.60)	38.02 (24.80)
Non-dieter	Food	24.33 (26.45)	37.03 (28.80)
	Holiday	29.00 (29.13)	27.03 (23.31)

The analysis revealed a main effect of dieting status,  $F(1, 116) = 8.65$ ,  $p < .01$ . As expected, dieters ( $M = 49.34$ ,  $SD = 30.65$ ) reported significantly higher levels of craving than non-dieters ( $M = 32.25$ ,  $SD = 26.42$ ). There was also a main effect of time,  $F(1, 116) = 23.82$ ,  $p < .001$ , whereby craving ratings were higher following the induction scenarios ( $M = 40.80$ ,  $SD = 29.75$ ) compared to baseline ( $M = 32.56$ ,  $SD = 29.82$ ). Importantly, this effect was modified by a significant induction scenario  $\times$  time interaction,  $F(1, 116) = 47.07$ ,  $p < .001$ . As can be clearly seen in Table 1, relative to baseline, craving intensity increased following instructions to image the food induction scenario. In contrast, imaging the holiday induction scenario did not affect craving ratings.

There was also a significant three-way interaction between dieting status, induction scenario and time,  $F(1, 116) = 6.99, p < .01$ . *Post hoc* contrasts conducted on craving change scores (post-induction minus baseline ratings) indicated that there was a significantly greater increase in craving following the food induction scenario for dieters than for non-dieters ( $p < .05$ ). None of the other effects was statistically significant.

Finally, there was a significant positive correlation between vividness ratings of the food induction scenario and craving,  $r = .31, p < .02$ . This was not the case for the holiday induction scenario,  $r = -.23, p > .05$ .

### **Effects of visual versus auditory imagery**

The vividness ratings across the 18 trials of the imagery task were averaged to produce a single index. An independent samples *t*-test showed that visual ( $M = 70.63, SD = 15.35$ ) and auditory ( $M = 66.29, SD = 14.73$ ) images were rated as equally vivid,  $t(118) = -1.58, p > .10$ .

As the craving ratings for each of the three sets of six trials did not differ from one another ( $F < 1$ ), the mean rating across the three sets was used in the analysis. These craving scores were analysed by a 2 (dieting status: dieter, non-dieter)  $\times$  2 (induction scenario: food, holiday)  $\times$  2 (imagery task: visual, auditory)  $\times$  2 (time: pre-, post-imagery task) mixed-design ANOVA. Because there were no significant interactions with dieting status, Table 2 displays only the mean craving ratings for the induction scenario  $\times$  imagery task  $\times$  time conditions.

**Table 2.** Mean pre- and post-imagery task food craving scores as a function of induction scenario and imagery task (standard deviations in parentheses)

Induction scenario	Imagery task	Time	
		Pre-imagery-task	Post-imagery task
Food	Visual	58.53 (29.99)	34.06 (25.69)
	Auditory	39.17 (32.48)	28.53 (30.15)
Holiday	Visual	33.43 (23.73)	30.40 (25.98)
	Auditory	32.05 (25.54)	34.96 (26.20)

The analysis yielded a significant main effect of dieting status,  $F(1, 112) = 9.51, p < .01$ . Dieters ( $M = 37.76, SD = 28.24$ ) reported greater cravings than non-dieters ( $M = 26.21, SD = 24.27$ ). There was also a significant main effect of time,  $F(1, 112) = 31.97, p < .001$ , whereby craving ratings were lower after the imagery task ( $M = 31.99, SD = 26.86$ ) than before ( $M = 40.80, SD = 29.76$ ).

Importantly, there was a significant interaction between time and imagery task,  $F(1, 112) = 10.08, p < .01$ . As predicted, craving ratings decreased much more following the visual imagery task than the auditory imagery task. There was also a significant interaction between time and induction scenario,  $F(1, 112) = 31.50, p < .001$ , whereby craving ratings decreased for those participants who had earlier received the food induction scenario, but not the holiday induction scenario. None of the other effects was statistically significant.

## Discussion

The aim of this study was to more fully investigate the cognitive mechanisms underlying food cravings. Craving intensity increased following instructions to imagine a food induction scenario, but not a holiday induction scenario, thereby supporting an imaginal basis for food craving. Here the food and holiday induction scenarios were imagined equally vividly. Hence the differential effect on craving ratings was not attributable to differences in image vividness. Nevertheless, there was a positive correlation between the image vividness and craving ratings for the food induction scenario, indicating that stronger cravings are associated with more vivid food images. This mirrors the positive association between vividness and craving ratings following smoking urge scripts observed in cigarette smokers (Drobes & Tiffany, 1997; Maude-Griffin & Tiffany, 1996), and thus reinforces the commonality between cigarette and food cravings (Green *et al.*, 2000).

As expected, dieters consistently reported higher levels of food craving than non-dieters, confirming the previously observed association between dieting and food craving (Fedoroff *et al.*, 1997; Overduin & Jansen, 1996; Pelchat, 1997; Warren & Cooper, 1998). Although this is consistent with restraint theory's argument that craving is a direct result of dieting (e.g. Polivy & Herman, 1985), an alternative explanation could be that those individuals who experience food cravings might diet to prevent overeating. Further research will be required to tease apart these two possibilities. Nevertheless, dieters in the present study demonstrated a greater increase than non-dieters in cravings following instructions to imagine eating their favourite food. This result parallels Green *et al.*'s (2000) finding of a slower reaction time for dieters than non-dieters following this same instruction and supports their analogy between dieters and abstinent drug users.

However, the main objective of the present experiment was to examine the nature of the imagery processes involved in food craving in a different way with a different methodology, using the working memory model as a theoretical framework. As predicted, craving intensity was reduced much more significantly following the visual imagery task than the auditory imagery task. Thus, in terms of the working memory model, loading the visuospatial sketch pad interferes with food craving in a way that loading the phonological loop does not. This leads to the conclusion that the imaginal component in food cravings is predominantly visual rather than verbal in nature. It should be noted that the visual and auditory stimulus cues were rated as equally vivid and thus the differential effect of the two modalities cannot be explained in terms of image vividness.

Nevertheless, we need to acknowledge that imagery can occur in other sensory modalities besides sight and hearing (Betts, 1909). In the case of food cravings, it is possible that images involving smell or taste may be more powerful than auditory images. In fact, data from a recent questionnaire study exploring the subjective experience of cravings for a range of desired substances, including food, suggest that both visual and olfactory images are key elements of craving episodes (May, Andrade, Panabokke, & Kavanagh, 2004). Further research might usefully investigate whether an olfactory imagery task could also reduce food cravings.

The present set of results has both theoretical and practical implications. Theoretically, the visual imagery basis of cravings associated with smoking urges (Panabokke *et al.*, submitted) has been extended to food cravings, thus offering strong support to the proposed analogy between the cognitive mechanisms underlying cigarette

and food cravings. Not only have we confirmed that cigarette and food cravings can be elicited in parallel ways, but we have also empirically shown that they can be reduced in parallel ways. These data further demonstrate the utility of the working memory model as a theoretical basis for investigating the cognitive underpinnings of food craving.

The present findings also have potential application in the treatment of food craving episodes in clinical and non-clinical populations. For example, food cravings can give rise to binge eating episodes in bulimia nervosa which, in turn, remind the sufferer of the desirable characteristics of craved foods, leaving her/him more susceptible to future cravings (Glendall *et al.*, 1997). Visual imagery techniques may provide an effective intervention tool for reducing acute cravings and break the vicious crave–binge cycle in bulimia. Visual imagery could similarly be potentially used to reduce food cravings and subsequent food intake in obese individuals. Finally, techniques based on visual imagery may prove beneficial in preventing the development of binge eating in individuals who frequently experience intense food cravings, such as dieters and restrained eaters.

In conclusion, the present study has confirmed that mental imagery is a central feature of food craving. The nature of these imagery processes underlying food cravings was shown to be essentially visual. Consequently visual imagery techniques may prove useful therapeutic aids for reducing food cravings in clinical and non-clinical populations.

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