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Research report

High-calorie food-cues impair working memory performance in high and low food cravers

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ABSTRACT

The experience of food craving can lead to cognitive impairments. Experimentally induced chocolate craving exhausts cognitive resources and, therefore, impacts working memory, particularly in trait chocolate cravers. In the current study, we investigated the effects of exposure to food-cues on working memory task performance in a group with frequent and intense (high cravers, $n = 28$) and less pronounced food cravings (low cravers, $n = 28$). Participants performed an *n*-back task that contained either pictures of high-calorie sweets, high-calorie savory foods, or neutral objects. Current subjective food craving was assessed before and after the task. All participants showed slower reaction times and made more omission errors in response to food-cues, particularly savory foods. There were no differences in task performance between groups. State cravings did not differ between groups before the task, but increased more in high cravers compared to low cravers during the task. Results support findings about food cravings impairing visuo-spatial working memory performance independent of trait cravings. They further show that this influence is not restricted to chocolate, but also applies to high-calorie savory foods. Limiting working memory capacity may be especially crucial in persons who are more prone to high-calorie food-cues and experience such cravings habitually.

Introduction

Craving refers to an urgent desire, longing, or yearning for a particular substance, which includes alcohol, tobacco, addictive drugs, and food (Hormes & Rozin, 2010). Food cravings most often involve an intense desire to eat chocolate (Weingarten & Elston, 1991). It is this intensity and specificity that distinguishes food cravings from ordinary feelings of hunger (Hill, 2007). In both substance use and eating behavior, cravings have been associated with excessive consumption of the craved substance or food, and non-compliance to long-term goals. Drug cravings are associated with relapse in substance abuse (e.g. Allen, Bade, Hatsukami, & Center, 2008) as food cravings are associated with binge eating (Gendall, Sullivan, Joyce, Fear, & Bulik, 1997; Meule, Lutz, Vögele, & Kübler, 2012) or unsuccessful dieting (Meule, Westenhöfer, & Kübler, 2011).

The experience of craving has been found to affect cognitive performance. In simple reaction time tasks, smokers and alcohol-dependent patients displayed a slowing of reactions when craving was induced by either cue-exposure or mental imagery (Baxter & Hinson, 2001; Cepeda-Benito & Tiffany, 1996; Sayette & Hufford, 1994; Sayette et al., 1994). In Tiffany's (1990) cognitive model of drug urges, attempts to inhibit automatic drug use schemata require non-automatic processing during the experience of craving. This limits available cognitive resources, which negatively affects performance in tasks that require non-automatic processing, such as reaction time tasks.

These findings in substance use have been extended to food cravings. Using different types of cognitive tasks, chronic dieters have been found to slow down reactions after exposure to craving inducing mental imagery (Green, Rogers, & Elliman, 2000) or after consuming a preload (Meule, Lukito, Vögele, & Kübler, 2011). Similarly, trait chocolate cravers exhibited increased reaction times (Kemps, Tiggemann, & Grigg, 2008) or a slower detection of neutral targets among food-related distractors after exposure to cues eliciting chocolate craving (Smeets, Roefs, & Jansen, 2009). It has been further argued that the experience of chocolate craving in trait chocolate cravers leads to distraction by, rather than speeded detection of craving-related cues (i.e. chocolate; Smeets et al., 2009).

Craving leads not only to slowed reactions and distraction, it also affects working memory performance. For instance, smokers performed worse in a working memory task when trials were preceded by smoking-cues (Wilson, Sayette, Fiez, & Brough, 2007). Accordingly, inducing food craving lead to impaired working memory performance in trait chocolate cravers (Kemps et al., 2008) or

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in female students without any moderating role of trait chocolate craving (Tiggemann, Kemps, & Parnell, 2010). Vice versa, concurrent visuo-spatial information processing or mental imagery tasks reduced food cravings (see Kemps & Tiggemann, 2010 for a review), which highlights the role of the visual modality in the experience of craving (Tiggemann & Kemps, 2005). Thus, it has been argued that food cravings selectively impact visuo-spatial aspects of working memory (visuo-spatial sketchpad; Baddeley & Hitch, 1974) which could be confirmed recently (Tiggemann et al., 2010).

While existing studies on food cravings and working memory performance have tended to use imagery to induce craving followed by neutral working memory tasks, there is a plethora of cognitive tasks involving food stimuli that impact performance in people with disordered eating behavior (see Brooks, Prince, Stahl, Campbell, & Treasure, 2011 for a review). One of these measures is the *n-back paradigm* where participants are required to monitor a series of stimuli and to respond when a stimulus matches the one presented *n* trials previously (usually 1-, 2-, or 3-back; cf. Owen, McMillan, Laird, & Bullmore, 2005). This task requires monitoring, updating, and manipulation of information within working memory. To date, there is only one study that used an *n*-back task involving food stimuli (Dickson et al., 2008). In this study, pictorial neutral, aversive and food stimuli presented either subliminally or supraliminally preceded letters in a 1-back or 2-back condition. Although they found differential task performance between anorectic patients and controls, food stimuli did not affect task performance.

Several issues, therefore, remain unresolved in the literature. Firstly, evidence for the influence of food craving on working memory performance is restricted to chocolate craving. Little is known about other food groups that have also been shown to be craved (Hill, 2007). Secondly, the only study that used food stimuli other than chocolate did not find an effect on working memory performance (Dickson et al., 2008). This could be due to methodological reasons because food-cues only preceded targets. Instead, food-cues may have a stronger influence and, therefore, higher external validity, if they directly require a response. Thirdly, no study has investigated the influence of general food craving on working memory performance as a function of both state and trait cravings.

In the current study, we addressed these issues by using an *n*-back (2-back) task that involved pictorial food stimuli as targets and distractors. In addition and rather than restricting stimuli to chocolate, we presented separated blocks containing either pictures of savory foods, sweet foods, or neutral objects. Moreover, groups of either trait food cravers or low cravers were tested and momentary craving was assessed before and after the task. We expected food stimuli to elicit craving which in turn should lead to a decrement in task performance, i.e. prolonged reaction times and more omission and commission errors. Furthermore, we hypothesized that these effects should be particularly pronounced in trait food cravers. Therefore, the current study extends the existing literature by (1) using a newly developed variant of the *n*-back task that (2) not only involved chocolate cues, but also other sweet and savory foods, and (3) investigating effects in both trait high and low cravers with respect to general food cravings instead of specifically chocolate craving.

Methods

The reported data were part of a study investigating the effectiveness of a biofeedback training to reduce food cravings, the results of which are reported elsewhere (Meule, Freund, Skirde, Vögele, & Kübler, in press). The current data were collected at baseline, i.e. before any intervention.

Participants

An online screening was conducted to recruit high and low food cravers. A link of the screening homepage was distributed via a students' mailing list and an advertisement on a local website. The screening homepage included the subscale *lack of control over eating* of the *Food Cravings Questionnaires – Trait* (FCQ-T-LOC). This subscale represents a major feature of food cravings and was chosen to keep the screening succinct. As an incentive for participation, 3×10,- Euro were raffled among participants who completed the entire set of questions ($N = 603$).

FCQ-T-LOC scores ranged between the minimum and maximum possible values ($M = 16.67$, $SD = 5.90$, Range: 6–36). The majority of respondents had a body mass index (BMI) within the normal range ($M = 22.55$, $SD = 3.83$, Range: 14.15–48.19) and were in young adulthood ($M = 23.99$, $SD = 5.54$, Range: 16–62). Participants who indicated that they were interested in participating in a further study and whose FCQ-T-LOC scores were in the upper and lower third of the distribution from the initial screening were contacted by e-mail. Volunteers were only included if they had a BMI between 20 and 30 kg/m^2, and an age between 18 and 40 years, to ensure a homogenous sample without outlying body mass or age. Of all individuals who were contacted, $n = 56$ (high cravers: $n = 28$, four males; low cravers: $n = 28$, five males) met these criteria and agreed to take part in the study. Participants had a mean age of $M = 24.12$ years ($SD = 3.79$) and a mean BMI of $M = 22.65$ kg/m^2 ($SD = 3.19$). The majority of participants were students ($n = 40$).

Materials

Questionnaires

Habitual food cravings were assessed using the trait version of the Food Cravings Questionnaires (FCQ-T; Cepeda-Benito, Gleaves, Williams, & Erath, 2000; Meule et al., 2012). This 39-item instrument asks participants to indicate on a 6-point Likert scale how frequently they experience food cravings (ranging from *never* to *always*). The FCQ-T consists of nine subscales measuring food cravings in relation to (1) intentions to consume food, (2) anticipation of positive reinforcement, (3) relief from negative states, (4) lack of control over eating, (5) preoccupation with food, (6) hunger, (7) emotions, (8) cues that trigger cravings, and (9) guilt. Subscales are highly inter-correlated and internal consistency of the total FCQ-T is $\alpha > 0.90$ (Cepeda-Benito et al., 2000; Meule et al., 2012). In the current study, we only used total FCQ-T scores in our analyses for the sake of brevity and clarity.

Current food cravings were assessed with the state version of the Food Cravings Questionnaires (FCQ-S; Cepeda-Benito et al., 2000; Meule et al., 2012). This 15-item questionnaire assesses momentary food cravings on the dimensions (1) intense desire to eat, (2) anticipation of positive reinforcement, (3) relief from negative states, (4) lack of control over eating, and (5) hunger. Subscales are highly inter-correlated and internal consistency of the total FCQ-S is $\alpha > 0.90$ (Cepeda-Benito et al., 2000; Meule et al., 2012).

Eating disorder and food addiction symptomatology was assessed with the Eating Disorder Examination – Questionnaire (EDE-Q; Fairburn & Beglin, 1994; Hilbert & Tuschen-Caffier, 2006) and the Yale Food Addiction Scale (YFAS; Gearhardt, Corbin, & Brownell, 2009; Meule, Vögele, & Kübler, in press). The YFAS is a 25-item instrument which contains different scoring options (dichotomous and frequency scoring) to indicate experience of addictive eating behavior. A food addiction symptom count can be calculated which ranges between zero and seven symptoms, according to the diagnostic criteria for substance dependence (Gearhardt et al., 2009). Internal consistency of the YFAS is