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Research report

Using virtual reality to study food cravings

Tracey Ledoux [a,*], Anthony S. Nguyen [a], Christine Bakos-Block [b], Patrick Bordnick [b]

[a] Department of Health and Human Performance, University of Houston, 3855 Holman Street, Garrison Gym Rm 104, Houston, TX 77204-6015, USA
[b] Graduate College of Social Work, University of Houston, 110HA Social Work Building, Houston, TX 77204-4013, USA

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ABSTRACT

Food cravings (FCs) are associated with overeating and obesity and are triggered by environmental cues. The study of FCs is challenged by difficulty replicating the natural environment in a laboratory. Virtual reality (VR) could be used to deliver naturalistic cues in a laboratory. The purpose of this study was to investigate whether food related cues delivered by VR could induce greater FCs than neutral VR cues, photographic food cues, or real food. Sixty normal weight non-dieting women were recruited; and, to prevent a floor effect, half were primed with a monotonous diet (MD). Experimental procedures involved delivering neutral cues via VR and food related cues via VR, photographs, and real food in counterbalanced order while measuring subjective (self-report) and objective (salivation) FCs. FCs produced by VR were marginally greater than a neutral cue, not significantly different from picture cues, and significantly less than real food. The modest effects may have been due to quality of the VR system and/or measures of FC (i.e., self-report and salivation). FC threshold among non-dieting normal weight women was lowered with the use of a MD condition. Weight loss programs with monotonous diets may inadvertently increase FCs making diet compliance more difficult.

Introduction

Food cravings (FCs) are intense urges to consume specific, usually energy dense foods regardless of physical hunger (Hill, 2007; Liu, von Deneen, Kobeissy, & Gold, 2010; Tiggemann & Kemps, 2005; Weingarten & Elston, 1990). FCs have been positively associated with body mass index (Gilhooly et al., 2007), and overeating (Burton, Smit, & Lightowler, 2007; Fedoroff, Polivy, & Herman, 2003; Hill, Saxton, Webber, Blundell, & Wardle, 2009; Jastreboff et al., 2013; Lenard & Berthoud, 2008; Siwik & Senf, 2006; Tetley, Brunstrom, & Griffiths, 2009; Tetley, Brunstrom, & Griffiths, 2010; White, Whisenhunt, Williamson, Greenway, & Netemeyer, 2002). Some evidence suggests FCs are heightened with weight loss and dietary monotony, and that they interfere with weight loss attempts. (Brunstrom & Witcomb, 2004; Brunstrom, Yates, & Witcomb, 2004; Drobes et al., 2001; Fedoroff, Polivy, & Herman, 1997; Fedoroff et al., 2003; Giesen, Havermans, Nederkoorn, Strafaci, & Jansen, 2009; Gilhooly et al., 2007; Harvey, Wing, & Mullen, 1993; Jansen & van den Hout, 1991; Lim, Norman, Clifton, & Noakes, 2009; Martin, O'Neil, & Pawlow, 2006; Meule, Westenhofer, & Kubler, 2011; Rogers & Hill, 1989; Rogers & Smit, 2000; Sitton, 1991; Tiggemann & Kemps, 2005). Greater understanding of FCs may promote improved weight loss interventions.

Proximal and contextual stimuli become cues for cravings through conditioned learning (Petrovich & Gallagher, 2007; Petrovich, Ross, Gallagher, & Holland, 2007; Petrovich, Ross, Holland, & Gallagher, 2007; Volkow & Li, 2005; Volkow, Wang, Fowler, & Telang, 2008). The barrage of food cues in the current obesogenic environment has been implicated in the obesity epidemic (Lee, McAlexander, & Banda, 2011). Recent research showed binge eating tendency moderated the association between fast food restaurant availability and BMI (Ledoux, Adamus-Leach, O'Connor, Mama, & Lee, submitted for publication) and another study showed impulsivity moderated the relationship between fast food restaurant availability and fast food consumption (Paquet et al., 2010), but little is known about the role of FCs in promoting overeating in response to the obesogenic environment. In addition, the qualities of the obesogenic environment that may trigger FCs are poorly understood. Advancing our knowledge of FCs within the context of the obesogenic environment and in weight loss treatment is limited by current practices for studying FCs (Sobik, Hutchison, & Craighead, 2005).

Investigating the relationship between FCs and complex food and non-food cues found in the obesogenic environment is challenging because FCs induced in the natural environment are difficult to measure and FCs induced in the laboratory setting may have low generalizability to the natural environment. Further study of the relationship between FCs and the obesogenic environment will require delivering environmental food cues within complex naturalistic environments in a secure laboratory environment

* Corresponding author.
E-mail address: TALedoux@uh.edu (T. Ledoux).

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where variables can be precisely measured and conditions manipulated and controlled. Studying FCs in a laboratory setting allows for the use of objective measures of FCs like salivation (Nederkoorn, Smulders, & Jansen, 2000) and brain imaging (Pelchat, Johnson, Chan, Valdez, & Ragland, 2004), but inducing robust FCs in this setting is limited by the need for artificial food cues without accompanying contextual cues. Examples of laboratory stimuli include photo images (Fletcher, Pine, Woodbridge, & Nash, 2007), food words (Pelchat et al., 2004), imagery (Harvey, Kemps, & Tiggemann, 2005; Pelchat et al., 2004), and actual food (Brunstrom et al., 2004). The study of FCs in real world settings is limited by the need to use self-report measures of FCs which are fraught with bias (Gilhooly et al., 2007). The association between environmental food cues, craving, and actual eating behavior would be more clearly demonstrated if people were put in lifelike scenarios, with standardization, and their reactivity measured. This was impossible before the development of virtual reality (VR) methodology.

VR simulates naturalistic environments by delivering complex multi-sensory cues (proximal and contextual) through an immersive human–computer interaction (de Carvalho, Freire, & Nardi, 2010). A head-mounted display and tracking system respond to user movement by changing the displayed scene in real time as if one were looking around the environment. Evidence of its realistic immersive effect is that exposure to drug-related VR scenarios evokes robust increases in craving among individuals dependent on various drugs of abuse, including alcohol (Bordnick et al., 2008), cocaine (Saladin, Brady, Graap, & Rothbaum, 2006), marijuana (Bordnick et al., 2009), and nicotine (Bordnick, Graap, et al., 2005; Bordnick, Traylor, Graap, Copp, & Brooks, 2005; Bordnick et al., 2004; Ferrer-Garcia, Garcia-Rodriguez, Gutierrez-Maldonado, Pericot-Valverde, & Secades-Villa, 2010; Traylor, Bordnick, & Carter, 2008; Traylor, Bordnick, & Carter, 2009). VR induces craving for alcohol with effect sizes typically ~2 SD in magnitude (Bordnick et al., 2008); three times the effect size found in traditional non-VR cue exposure alcohol craving research (Carter & Tiffany, 1999a; Carter & Tiffany, 1999b). In addition research has shown VR evokes negative body image (Gutierrez-Maldonado, Ferrer-Garcia, Caqueo-Urizar, & Moreno, 2010) and emotions as would be expected in real life scenarios among eating disorder patients (Ferrer-Garcia, Gutierrez-Maldonado, Caqueo-Urizar, & Moreno, 2009; Ferrer-Garcia, Gutierrez-Maldonado, & Pla, 2013; Gorini, Griez, Petrova, & Riva, 2010; Gutierrez-Maldonado, Ferrer-Garcia, Caqueo-Urizar, & Letosa-Porta, 2006). Building upon the success of cue exposure methods currently in use, VR can offer exposure to both proximal and contextual food cues without the limitations of artificial cues, excess measurement error, cost, or logistic challenges.

The purpose of the current study was to investigate whether food cues delivered via a VR environment with realistic proximal and contextual food cues would evoke a stronger craving response than (1) a neutral VR nature environment, (2) photographs of food or (3) plates of real food without the contextual cues to accompany them. A second objective was to test whether the VR effects would be more pronounced among women primed to experience FCs with a monotonous diet (MD) condition than among women who continued to consume their normal diet.

Methods

Participants

A convenience sample of college women were recruited through advertisements on the University of Houston campus. Males were excluded because women report more cravings than men, and men and women report having cravings for different types of foods (Lafay et al., 2001; Pelchat, 1997; Weingarten & Elston, 1991). Recruitment flyers called for females 18 and over to participate in a study to compare reactions to food images delivered in real life, by photo, and by virtual reality. Women were eligible to participate if they were at least 18 years of age, could read and speak English fluently, and had a body mass index (BMI) within normal limits (18–25). Women were excluded if they were currently dieting for weight loss or had any dietary restrictions. Eligibility for participation was determined via telephone screening.

Materials and measures

Demographics

Participants completed a self-report questionnaire of personal age, weight, height, race/ethnicity, household income, and year in school.

Food diary

Compliance with dietary condition was monitored with a food diary, for which participants logged the foods they ate, the amount, and time of day.

Food cravings

Food Craving Questionnaire-State (FCI-S; Cepeda-Benito et al., 2000) is a 15-item valid and reliable measure of state fluctuations in self-reported FC. Responses are scored on a likert scale from 1 to 5 and summed for a total state FC score ranging from 15 to 75. Items are reverse scored, so low scores indicate strong FC experience and high scores indicate low FC experience.

Visual Analog Scale (VAS; (Hill, Weaver, & Blundell, 1991)) requires participants to place a mark on a 100 mm line with one end (100 mm) indicating "extremely" intense craving and the other end (0 mm) representing "not at all." Participants were instructed to make a mark at the point on the line that corresponded with their current craving experience for the three foods used in this study as food cues (chocolate, donuts, and cookies). The sum of the values for each food was determined at each time point. Scores on the total VAS across the three foods could range from 0 to 300.

Salivation magnitude was measured using a valid and accepted method for detecting FCs using salivation (Monti et al., 1987). Pre-weighed absorbent cotton dental rolls were placed in participants' mouths before cue exposure tasks, and after they were removed and re-weighed to determine magnitude of salivation during exposure.

Procedures

Overview

In this 2 (diet condition) × 4 (counterbalanced food cue exposure tasks) mixed within subjects factorial design study, participants were recruited and invited to the University of Houston campus for two appointments at least 2 days apart with a 1.5 day diet condition period between appointments. Diet condition served as the between subjects factor with two levels (monotonous diet or normal diet) and food cue exposure task served as the within subjects factor with four levels (neutral, VR, pictures, and real food cues). In the first appointment, participants provided documentation of informed consent, completed the demographic measure and baseline VAS craving and general preference for target foods (i.e., cookies, donuts, chocolate) measure, were randomly assigned to a monotonous diet (MD) or normal diet (ND) condition, and received instructions and supplies for following their assigned diet for 1.5 days. During the second appointment, participants underwent one neutral baseline cue exposure task followed by