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Research report

Stress, cues, and eating behavior. Using drug addiction paradigms to understand motivation for food ☆

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ABSTRACT

Eating patterns that lead to overconsumption of high fat, high sugar (HFHS) foods share similar features with addictive behaviors. Application of addiction paradigms, such as stress inductions, cue reactivity and behavioral economic assessments, to the study of motivation for HFHS food consumption may be a promising means of understanding food consumption. To date, few studies have investigated the interaction of stress and environmental cues on craving, and no study leveraged the state relative reinforcing value of foods (RRV_{food}) under varying conditions of affective states, the foci of the current study. This study used a mixed factorial design (Mood Induction: Neutral, Stress; Cues: Neutral, Food) with repeated measures on time (Baseline, Post-Mood Induction, Post-Cue Exposure). Participants ($N = 133$) were community adults who endorsed liking of HFHS snacks but denied eating pathology. The primary DVs were subjective craving and RRV_{food}. Negative and positive affect (NA, PA), the amount of food consumed, and latency to first bite were also examined. Participants in the Stress condition reported no change in craving or RRV_{food}. Exposure to food cues significantly increased participants' craving and RRV_{food}, but an interaction of stress and cues was not present. Participants did not differ on how many calories they consumed based on exposure to stress or food cues, but participants in the food cues condition had a shorter latency to the first bite of food. This study highlights the importance of environmental cues in food motivation. It also demonstrates the utility of using RRV_{food} to further characterize food motivation.

Introduction

Eating patterns associated with overconsumption of food and drug addiction have many similar features (Davis & Carter, 2009; Volkow & Wise, 2005). HFHS foods and drugs are used to regulate emotional states and cope with stress (Epel, Lapidus, McEwen, & Brownell, 2001; Sinha, 2007). Individuals with substance use disorders and those who overconsume HFHS foods report increased craving in response to relevant cues (Volkow & Wise, 2005) and display hyperactivity of the limbic system in response to environmental cues and consumption of both HFHS foods and drugs (Gearhardt et al., 2011; Volkow & Wise, 2005). Therefore, applying paradigms used in drug addiction research to the study of HFHS food consumption has the potential to inform our understanding of the motivational processes that influence consumption.

The link between exposure to negative emotional states and drug use is abundantly documented (e.g., Ludwig, Wikler, & Stark, 1974; Sinha, 2001a). The basis for this has been addressed by several theoretical accounts, including Baumeister's self-control theory (Baumeister & Heatherton, 1996; Muraven & Baumeister, 2000), Loewenstein's (1996) visceral theory that coping with acute and chronic stress increases the salience of a preferred substance, and Metcalfe and Mischel's (1999) model of cool and hot processing of stimuli that influences decision-making. The most common methods for eliciting psychosocial stress in the laboratory involve either performance of various challenging tasks (non-personalized), such as the Trier Social Stress Test (TSST; Kirschbaum, Pirke, & Hellhammer, 1993), or exposure to personally salient stressful material via imagery (Sinha, 2001b). Studies on drug addiction have used the personalized guided imagery (GI) paradigm extensively and found that it elicits not only the expected negative mood states but also craving for a preferred substance both in substance dependent individuals (Fox, Bergquist, Hong, & Sinha, 2007; Sinha, Catapano, & O'Malley, 1999) and recreational users (Chaplin, Hong, Bergquist, & Sinha, 2008; Rousseau, Irons, & Correia, 2011). Therefore, the GI paradigm appears to be a robust method for eliciting craving for a preferred substance in the addiction studies.

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Experimental studies on stress and eating have produced inconsistent results. Several suggest that self-reported distress is related to increased caloric intake (e.g., Chua, Touyz, & Hill, 2004; Epel et al., 2001), self-reported preference for HFHS foods (Oliver, Wardle, & Gibson, 2000), and increased craving for food (Udo et al., 2013). However, there are a number of studies that did not find a relationship between distress and eating behavior or urges to eat (e.g., Bongers, Jansen, Havermans, Roefs, & Nederkoorn, 2013; Loxton, Dawe, & Cahill, 2011; Telch & Agras, 1996). Those studies that measured craving or subjective hunger (as a proxy for craving), found that stress either did not influence the urge to eat (Chua et al., 2004) or affected it inversely (Loxton et al., 2011). However, the one study that used the GI paradigm, found that indeed it increased food craving (Udo et al., 2013). Therefore, the use of this paradigm appears to be promising even with food.

Craving has been extensively examined in relation to drug addiction, and the experience of cravings has been added as a symptom of addictive disorders in DSM-5 (American Psychiatric Association, 2013). Craving episodes are typically situation-specific, in that cues paired with a preferred substance elicit cravings (Ludwig et al., 1974; Tiffany & Conklin, 2000). Thus, a cue-reactivity laboratory paradigm in which individuals are exposed to visual cues of their preferred substance has been widely used to investigate drug craving (e.g., Carter & Tiffany, 1999; Perkins, 2009). Recent reviews support the importance of cue-elicited craving in motivation for consumption of alcohol and tobacco (MacKillop & Monti, 2007; Robbins, Ersche, & Everitt, 2008).

Craving is also associated with consumption of HFHS foods (Lafay et al., 2001; Martin, O'Neil, Tollefson, Greenway, & White, 2008). Presentation of food cues in a laboratory elicits food craving compared to neutral cues (Sobik, Hutchison, & Craighead, 2005) and cravings for some foods are associated with increased consumption (Martin et al., 2008). Some studies indicated positive associations between the physiological changes associated with preparation for consumption (i.e., cephalic phase response) and craving, and between craving and food intake (Jansen, 1998; Martin et al., 2008; Nederkoorn, Smulders, & Jansen, 2000). Thus, food cues generally elicit cravings, which in turn may be associated with increased consumption.

Despite the fact that there are theoretical accounts of the influence of "visceral factors," such as emotional states and exposure to environmental cues, on decreased ability to control cravings (Loewenstein, 1996; Metcalfe & Mischel, 1999), little research has been conducted in actually examining the multiplicative effects of these two factors on food motivation. In the addiction literature, this potentiation has been found in several (Fox et al., 2007; Sinha, Fuse, Aubin, & O'Malley, 2000; Sinha et al., 2003) but not all studies (Ray, 2011). The one study that examined these effects on motivation to eat in college women failed to find multiplicative effects of stress and environmental cues on craving unless the women endorsed disinhibited eating style (Loxton et al., 2011). That study used a non-personalized mood induction procedure (i.e., a film clip from the movie *Color Purple*) and an all female sample. Thus, no study to date examined multiplicative effects of negative affect and food cues on food cravings using the personally salient mood induction.

Behavioral economics (BE), a hybrid of microeconomics and behavioral learning theory (Hursh, 2000), has been widely used in addiction research and is relevant to understanding eating behavior. Several BE indices can be used to describe the value of a commodity, broadly defined as the relative reinforcing value (RRV) of that outcome to the individual. Relative reinforcing value is typically measured by pitting a fixed amount of a preferred substance (e.g., alcohol) against escalating amounts of an alternative reward, typically money (e.g., Benson, Little, Henslee, & Correia, 2009; Goldfield, Epstein, Davidson, & Saad, 2005; Griffiths, Rush, & Puhala, 1996; Griffiths, Troisi, Silverman, & Mumford, 1993). Individuals typically prefer the drug reward at lower monetary amounts and, as the monetary rewards escalate, tend to switch their preference to money. Relative reinforcing value has been quantified via the cross-over point, or the point at which an individual starts preferring the alternative reinforcer (i.e., money) over the preferred one (i.e., drug) as the latter becomes harder to get (Goldfield et al., 2005). Relative reinforcing value can be studied using laboratory tasks or self-report questionnaires (e.g., Amlung & MacKillop, 2014; MacKillop et al., 2008, 2010; Rousseau et al., 2011). Relative reinforcing value of food has mainly been studied using laboratory tasks where participants are placed on a concurrent reinforcement schedule and work for access to food vs. a non-food related activity (e.g., Epstein et al., 2007; Temple, Legierski, Giacomelli, Salvy, & Epstein, 2008).

Consistent with behavioral economic theory, experiential craving (e.g., in response to cues) increases RRV of a preferred drug (Amlung, Acker, Stojek, Murphy, & Mackillop, 2011; MacKillop et al., 2008, 2010). There is also preliminary evidence that negative mood states increase RRV of different drugs (Amlung & MacKillop, 2014; Owens, Ray, & MacKillop, 2015; Rousseau et al., 2011). However, there has been little empirical research examining changes in RRV_{food} based on mood states or exposure to food cues. In fact, with the exception of one considerably older study that found that participants were willing to work harder for food when they were presented with a visual cue versus no cue (Johnson, 1974), there are no rigorous experimental studies to examine the influence of cue exposure on RRV_{food}. In addiction studies, BE indicators correlate with experiential craving but have enough unique variance to be an informative measure of motivation above and beyond self-reported craving (e.g., Amlung et al., 2011; MacKillop et al., 2010). In fact, they are particularly useful in elucidating the shift in preference from neutral conditions (preference for sobriety) to the conditions of high affective states or presence of environmental cues (preference for a drug). Thus, using state RRV_{food} to measure motivation for food may provide additional information regarding decision-making processes underlying consumption beyond subjective craving.

Current study

Given the promise of applying addiction research paradigms to the study of eating behavior, the goal of this study was to use a novel stress induction paradigm and a cue reactivity paradigm to understand motivation for HFHS foods measured by both experiential craving and a behavioral economic index of RRV_{food} in a non-pathological sample of community adults. This is a proof-of-concept study examining these processes using novel paradigms. In the addiction literature, the GI procedure has been shown to elicit negative mood and craving for preferred substance, thus it is a promising means to study the influence of negative mood on food motivation. Additionally, this is the first study to use the BE index of RRV_{food} as a state measure of food motivation in addition to self-reported experiential craving under varying environmental conditions in order to elucidate decision-making processes for food. Finally, this is only the second study to examine the multiplicative effects of stress and exposure to cues on motivation for food in a rigorous experimental design. Thus, stress and cues were examined separately in order to determine the main effect of the GI procedure on craving and RRV_{food}, and the effect of cue exposure on RRV_{food}, while the interaction of stress and cues was examined to determine their multiplicative effects on craving and RRV_{food}. The study used a $2 \times 2 \times 3$ mixed factorial design to examine the effects of mood (Neutral Mood, Stress Induction) and environmental cues (Neutral Cues, Food Cues) on motivation for food, with time being a repeated measures factor (Baseline, Post-mood Induction, Post-cue Exposure). The primary dependent variables (DVs) were subjective craving and RRV_{food}. Negative and positive affect were examined as a manipulation check for the effectiveness of the stress