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Research report

State craving, food availability, and reactivity to preferred snack foods

W. Jack Rejeski [a,*], Terry D. Blumenthal [b], Gary D. Miller [a], Morgan Lobe [a], Caroline Davis [a], Lauren Brown [a]

[a] Department of Health and Exercise Science, Wake Forest University, Winston-Salem, NC 27109, United States
[b] Department of Psychology, Wake Forest University, United States

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ABSTRACT

The startle response has been shown to be useful in studying reactivity to food cues. Following 6 h of food deprivation and exposure to neutral and food cues, we examined the role of state craving combined with both a short and long delay of consumption on affect and startle reflex. Participants completed the PANAS, consumed a controlled early morning meal, and experienced 6 h of food deprivation. They then reported back to the laboratory, completed a second baseline PANAS, and had their baseline eyeblink EMG startle responses to 100 dB(A) startle probe assessed. Prior to and following the presentation of cues, startle probes were presented and responses were recorded. The PANAS and state craving were also assessed after each cue. Food cues provoked higher levels of state craving than neutral cues and startle responses failed to habituate as quickly to food cues as they did to neutral cues. In addition, cue exposure created the highest NA among high state cravers in the long delay of consumption group. Startle responses differed from NA in that with long delay startle was high irrespective of state craving scores; in the short delay of consumption condition, startle increased linearly with state craving. These results illustrate that state craving and expectations of food availability are important variables in understanding food-related cue reactivity.

Due to the risk and health consequences of obesity, overeating has been recognized as a significant health threat both in Europe and in the United States (Abelson & Kennedy, 2004). Because food has effects on the brain that are similar to addictive behaviors such as smoking and drug abuse (Pelchat, Johnson, Chan, Valdez, & Ragland, 2004), recidivism in the treatment of obesity is common and results of weight lost in behavioral interventions are characterized by substantial within treatment variability (Wadden & Osei, 2002). Indeed, it is known that dopamine increases with the consumption of food (Berridge, 1996) and, over time, this increase becomes conditioned to the anticipation of food consumption (Phillips, Atkinson, Blackburn, & Blaha, 1993). The objective of the current research is to begin to understand how individual differences in state craving for preferred foods and food deprivation influence affect and a physiological marker of appetitive vs. aversive states, the startle response. The defensive startle reflex is potentiated by unpleasant and frustrating experience (Bradley, Cuthbert, & Lang, 1990; Cook, Hawk, Davis, & Stevenson, 1991) and it is well recognized that affect is a core component of desire for substances such as food. Specifically, the elaborated intrusion theory of desire (Kavanagh, Andrade, & May, 2005) "...holds that emotive imagery and associated sensations are especially important in craving because somatosensory links contribute a particular piquancy and motivational power to the experience" (p. 446). The fact that startle is an automatic and pre-attentive marker of affect suggests that it may be a useful additional index of desire, craving, and frustration. Startle may also be a more useful measure than either cardiovascular reactivity or skin conductance, both of which are good metrics of arousal, since startle can serve as a signal for both the direction of affect as well as arousal.

In attempting to understand the etiology of overeating, there has been increased interest in the concept of food craving (Gendall, Joyce, Sullivan, & Bulik, 1998; Gibson & Desmond, 1999; Rogers & Smit, 2000; White, Whisenhunt, Williamson, Greenway, & Netemeyer, 2002). Although individual differences in food craving are not entirely dependent upon differential levels of satiety (Cornell, Rodin, & Weingarten, 1989), it is well recognized that the reinforcing value of food increases with food deprivation (Epstein, Truesdale, Wojcik, Paluch, & Raynor, 2003). This is an important relationship given the central role that caloric restriction plays in weight loss. Hawk, Baschnagel, Ashare, and Epstein (2004) recently examined startle response during exposure to slides of preferred food cues following 12-h of food deprivation. They reported an

* Corresponding author at: Department of Health and Exercise Science, Wake Forest University, P.O. Box 7868, Winston-Salem, NC 27109, United States.
E-mail address: rejeski@wfu.edu (W.J. Rejeski).

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inhibition of the startle reflex, but only among high and not low state cravers. This pattern suggests that participants were experiencing positive hedonic tone due to anticipated consumption, as would be expected given that participants were allowed to consume food during the course of the experiment.

Study 1 of an earlier paper by Drobes et al. (2001) examined how the duration of food deprivation—0, 6, or 24 h—influenced startle responses in the presence of pictures of food. While they point out that food deprivation can increase the appetitive value of food cues as seen by Hawk et al., resulting in an inhibition of the startle reflex, food cues could facilitate startle if there is not an explicit opportunity for consumption, since this creates a state of frustration (Amsel, 1958). In the Drobes et al. study, participants were not allowed to consume food until the entire experimental protocol had been completed. They found that either 6 or 24 h of food deprivation increased startle magnitude as compared to the no deprivation condition. In addition, in study 2, they found that the presentation of food cues in food deprived participants and binge eaters led to increases in startle magnitude as compared to participants who had not been food deprived or scored high on a restraint scale, however, this effect was only observed among those who scored high on a measure of state craving.

The concept of availability and craving has been a focal point of study in the smoking and drug addiction literature for a number of years (Carter & Tiffany, 2001) with a meta-analysis of over 40 cue reactivity studies with cigarette smokers, alcoholics, and cocaine addicts supporting the position that addicts have significant cue-specific reactions to drug related stimuli (Carter & Tiffany, 1999). Using a novel study design, Carter and Tiffany (2001) found that smokers had stronger negative affect during the presentation of smoking cues, but only on trials when access to the stimuli was not permitted. In other words, the cues were appetitive when smoking was allowed upon exposure to the cues, but were aversive when participants had to wait until the experiment had ended—a short delay between exposure and availability of a cigarette. This finding parallels the differential effects observed with food cues by Hawk et al. (2004) and Drobes et al. (2001) as discussed previously. Carter and Tiffany also concluded that negative affect, not positive affect, is most clearly related to craving, and that there is little evidence for concordance between self-report and physiological measures of craving.

In the current study, we were interested in examining how the independent and combined effects of food availability and state craving would influence both affect and the startle response when participants were exposed to either neutral or food cues. Availability was manipulated as either a short (after an experimental session that lasted ~30 min had been completed) or long (the expectation of an additional 6 h fast) delay for consumption. Expectations of availability are conceptually important in caloric restriction particularly when cravings may occur in conjunction with preferred food cues. For example, in their elaborated intrusion theory of desire, Kavanagh et al. (2005) argue that desire or craving is initiated as an automatic process involving intrusive thoughts about an appetitive target that are subsequently subjected to cognitive elaboration. The hypotheses investigated here were that negative affect and startle responses would be higher in the long than short delay food availability condition when participants were exposed to food as opposed to neutral cues. We also expected state craving to be directly related to negative affect and startle responses following exposure to the food cues. Because expectations of availability—a form of cognitive elaboration (Kavanagh et al., 2005)—likely fuel the aversive nature of food cues under conditions of deprivation, we hypothesized that the most negative affect and highest startle reflex would occur in response to food cues among high state craving participants in the long delay availability condition.

Methods

Participants

Participants for this study were recruited from freshman and sophomore classes at Wake Forest University ($n = 46$) and were paid $25 as compensation for the time commitment. There were an equal number of men and women in the study and all participants were neither actively dieting nor self-reported an eating disorder. The mean (SD) age and BMI were 19.02 (1.03) and 24.39 (3.31), respectively. The research protocol for this study was approved by the university review board for human research in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

Materials and measures

Eyeblink EMG

Eyeblink EMG responses were measured from the orbicularis oculi muscle with In Vivo Metric surface recording electrodes (Ag/AgCl, 11 mm outer diameter, 4 mm inner diameter contact surface) placed below the left eye. EMG activity of this muscle was amplified with a Biopac EMG amplifier and sampled (1000 Hz) by a Biopac MP150 workstation which stored four versions of the EMG input: raw unfiltered EMG, filtered EMG in a passband of 28–500 Hz, a rectification of the filtered EMG signal, and a rectified and smoothed (five sample boxcar filter) derivation of the filtered signal. The data reported in this paper are based on the smoothed EMG signal (Franklin, Moretti, & Blumenthal, 2007), with raw blink magnitudes in microvolts and proportional blink magnitudes in ratios (mean for the cue condition divided by the baseline mean).

Startle stimuli

Startle stimuli were 100 dB(A) broadband noises (20 Hz to 20 kHz), with a 50 ms duration and a rise/fall time of <1 ms, presented to the participants through Bose Triport headphones. Stimulus intensities were calibrated with steady-state signals presented through the headphones and measured with a Quest sound level meter with a fitted earpiece. The startle stimuli were presented to participants using SuperLab software integrated with the Biopac MP150 workstation. Within each assessment block, stimuli were presented to the participant every 10–20 s (15 s average ITI).

Positive and negative affect schedule (PANAS)

To measure state changes in affect, we used the short form of the PANAS, which consists of 10 items, 5 that measure positive affect and 5 that measure negative affect (Mackinnon et al., 1999). In a large probability sample ($n = 2651$), the measure was found to have acceptable factor structure with all factor loadings on both subscales in excess of 0.50. In the current study, the Cronbach's alpha was 0.78 for positive affect and 0.87 for negative affect.

Food craving inventory (FCI)

The FCI was used to measure food cravings (White et al., 2002). The FCI was originally designed as a trait measure and consists of 28 items. Although there are 4 subscales—high fats, sweets, carbohydrates/starches, and fast-food fats—these are highly correlated, producing one higher order factor called food craving. Both the total score and the subscale scores have good internal consistency reliability (>0.75) and test–retest reliability coefficients (>0.86). White et al. (2002) have provided evidence for both the concurrent and discriminant validity of the measure. Recently, this research group has also developed a state food craving inventory. This measure consists of 15 items that target craving for a specific food using a 5-point Likert format (scored 1–5) from "strongly disagree" to "strongly agree" with the mid-point being