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Research report

The time-varying association between perceived stress and hunger within and between days ☆

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ABSTRACT

Objective: Examine the association between perceived stress and hunger continuously over a week in free-living individuals. *Methods:* Forty five young adults (70% women, 30% overweight/obese) ages 18 to 24 years (Mean = 20.7, SD = 1.5), with BMI between 17.4 and 36.3 kg/m^2 (Mean = 23.6, SD = 4.0) provided between 513 and 577 concurrent ratings of perceived stress and hunger for 7 days via hourly, text messaging assessments and real-time eating records. Time-varying effect modeling was used to explore whether the within-day fluctuations in stress are related to perceived hunger assessed on a momentary basis. *Results:* A generally positive stress–hunger relationship was confirmed, but we found that the strength of the relationship was not linear. Rather, the magnitude of the association between perceived stress and hunger changed throughout the day such that only during specific time intervals were stress and hunger significantly related. Specifically, the strength of the positive association peaked during late afternoon hours on weekdays ($\beta = 0.31$, $p < .05$) and it peaked during evening hours on weekend days ($\beta = 0.56$, $p < .05$). *Conclusion:* This is the first empirical study to demonstrate potentially maladaptive, nonlinear stress–hunger associations that peak in the afternoon or evening hours. While we are unable to infer causality from these analyses, our findings provide empirical evidence for a potentially high-risk time of day for stress-induced eating. Replication of these findings in larger, more diverse samples will aid with the design and implementation of real-time intervention studies aimed at reducing stress-eating.

Introduction

Nearly 70% of adults in the United States are overweight or obese (Ogden, Carroll, Kit, & Flegal, 2014). Although the causes of obesity are complex (McAllister et al., 2009), one potential contributor is psychosocial stress. A recent report by the American Psychological Association indicated that nearly all Americans have felt "moderately stressed" in the past month and 22% felt extremely stressed, with nearly 70% reporting altering their eating behavior in response to stress (American Psychological Association, 2012). The report revealed that 39% have a tendency to overeat when under high stress, and another 29% skip meals. These findings were consistent with other research showing changes in eating behavior and food choice in response to stress (Greeno & Wing, 1994). Furthermore, when examining the impact of psychosocial stress on weight change, Block, He, Zaslavsky, Ding, and Ayanian (2009) demonstrated that perceived stress was positively related to weight gain among U.S. adults, and among those classified as obese, in particular. While the biological mechanisms of this relationship are not completely understood, evidence suggests that psychosocial stress can trigger an overactive stress response leading to the increased production of cortisol and insulin, and to subsequent food intake, particularly among high cortisol reactors (Adam & Epel, 2007; Epel, Lapidus, McEwen, & Brownell, 2001). Thus, there is initial evidence that supports the adverse effects of stress on food intake and the growing rates of obesity in the U.S.

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The stress-induced eating hypothesis has been supported by various laboratory studies in humans that demonstrate subjective feelings of hunger increase in intensity as perceived stress increases (Raspopow, Abizaid, Matheson, & Anisman, 2014; Sarker, Franks, & Caffrey, 2013). While of great value, it is unclear how generalizable these studies are to real-life conditions in which both perceived stress and hunger change in response to daily events. Preliminary studies support the notion of changing levels of stress throughout a day (Nelson, 2005). Research using momentary assessment techniques has shown that minor stressful daily events are associated with within-day changes in mood and perceived stress (Smyth & Stone, 2003). Similarly, levels of perceived hunger fluctuate considerably throughout a day as a function of a variety of homeostatic, hedonic, and conditioned or psychological factors that underlie a natural circadian rhythm. Peaks in hunger tend to occur around "mealtimes"; however, they may vary between individuals or days (weekdays vs. weekend days) and even within individuals (e.g., across time-sensitive contexts such as high- and low-stress valence). Collectively, these findings suggest that the relationship between perceived stress and hunger is likely better described as a non-constant, nonlinear association, and that it may vary in its magnitude and strength throughout the day in real life; however, this has yet to be tested empirically.

Research on within-person variations in the effects of psychosocial stress on perceived hunger in natural settings is generally limited (Newman, O'Connor, & Conner, 2007; O'Connor, Jones, Conner, McMillan, & Ferguson, 2008; Stone & Brownell, 1994). Using traditional assessment (daily diaries) and (linear) statistical methods, two studies conducted by O'Connor and colleagues (Newman et al., 2007; O'Connor et al., 2008) showed that daily stressors were significantly associated with high fat/high sugar snacking during the same day with the strongest effects among women with high cortisol reactivity (Newman et al., 2007). Though these studies have significantly contributed to our understanding of the association between stress and daily food intake, the use of modern assessment and non-linear statistical methods could enhance our understanding of the stress–hunger relationship. Using momentary assessment methods and an advanced statistical approach for intensive longitudinal data, one can determine whether the magnitude and direction of stress–hunger relationship is constant, independent of the contextual factors such as circadian rhythms (e.g., time of the day) or days of the week (e.g., week days, weekends). Contextual dynamics combined with biological fluctuations in hormonal cycles and circadian rhythms may manifest in novel, time-varying relationship patterns that can contribute to a deeper understanding of the effects stress has on eating behaviors.

Therefore, the overarching goal of the current study was to examine the association between perceived stress and hunger based on measures taken in situ several times a day over the course of a week (Shiffman, 2009). We compared this hunger–stress association between weekdays and weekends and tested the association using more traditional (i.e., constantly linear) and novel, nonlinear statistical approaches. We hypothesized (1) that a generally positive association between perceived stress and hunger would be detected via the traditional, general linear mixed and, via nonlinear time-varying effect modeling, (2) that the strength of the association would vary within a typical day, and (3) that the dynamics would manifest differently between weekdays vs. weekends.

Methods

Project TwEATs

Project TwEATs (Text with Ease Appetite Tracking System) was launched with an objective to test the use of Ecological Momentary Assessment (EMA) methodologies to collect hourly records of appetitive states and eating events. Results from Project TwEATs I demonstrated that automated text-messaging is an acceptable method to monitor perceived hunger ratings in a sample of adults over a consecutive week (Schembre & Yuen, 2011) representing an improvement over previously validated methodologies (Almiron-Roig et al., 2009; Mattes, Hollis, Hayes, & Stunkard, 2005; Stratton et al., 1998; Stubbs et al., 2000; Yeomans, Gray, Mitchell, & True, 1997). For Project TwEATs II we recruited a new sample of participants to explore the relationships between perceived psychological and physiological states, and eating behavior.

Participants

A convenience sample of 51 college students 18 to 24 years of age was recruited during the two weeks prior to the start of a spring semester. Eligibility requirements included being free from chronic diseases that could affect eating patterns (e.g. diabetes, Celiac disease), no history of a diagnosed eating disorder, no current pregnancy or lactation, and access to an unlimited text messaging plan with a personal mobile telephone service carrier. As part of Project TwEATs II, pre-prandial blood glucose data were collected via commercially available glucometers. Students who reported being unwilling to monitor their blood glucose levels prior to meals were additionally excluded.[1] Two students, who initially met the screening requirements, were later deemed ineligible to participate in the study due to the impaired fasting blood glucose concentrations (>99 mg/dl). Of the 49 enrolled participants, four (8%) failed to provide momentary eating records. The final analytical sample included 45 participants. All participants provided informed consent, and study protocols were approved by the Institutional Review Board at the University of Hawaii Cancer Center, Honolulu, Hawaii.

Design

This was a seven-day observational study. Upon study enrollment, participants completed a number of online questionnaires and provided demographic data. Additionally, measures of weight, height, waist circumference, and fasting blood glucose concentrations were obtained in person. All participants were enrolled within 3 weeks of the start of the semester. To control for possible variations in mean stress levels from the beginning to the end of the college semester, participants were randomized to one of two cohorts beginning on the seven-day monitoring period either 1 week or 8 weeks after study enrollment. Notably, neither perceived stress ($p = 0.37$) nor perceived hunger ($p = 0.99$) varied significantly between the two cohorts. Randomization was stratified by sex and weight status.

EMA data sampling scheme

Interval- and event-contingent sampling methods were used to collect self-reported perceived stress and hunger data during the monitoring period. Interval-contingent data were collected using automated, reminder text messages delivered to the participant's

[1] Students enrolled in the study were encouraged to test their blood glucose concentrations within 5 minutes of every eating event; however, they were not required to do so. They were instructed to record all eating events, but could refrain from measuring their blood glucose levels if, for any reason, they were uncomfortable or unable to complete the test. These instructions were provided to minimize missing eating event data as these data were most integral to the study's main objective. Furthermore, the research staff did not disclose the purpose of collecting these data and, beyond explaining what the test measured, no other potentially leading information (e.g., possible associations between high/low blood glucose concentrations and hunger) was shared with the study participants. The adequate mitigation of any detrimental influence of collecting pre-prandial blood glucose data on our findings is evidenced by consistent associations between PS and PH when including or excluding data collected at these event-contingent assessment points.