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Chronic stress decreases liking and satisfaction of low-calorie chips

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ABSTRACT

Previous studies have shown that acute stress affects food choice and the amount of consumption. However, relatively little is known about the effect of chronic stress on food perception. This study aimed to determine whether the sensory perception and impression of foods can be different under distinctive levels of chronic stress. Volunteers were asked to fill out a self-administrated questionnaire on psychological stress over the previous month (Perceived Stress Scale; PSS); the PSS score has been found to be related to psychological stress-related biomarkers such as cortisol level. Among the volunteers, those who scored below 10-point on the PSS were labeled "low stress group", while those who scored 25-point or higher were labeled "high stress group." Sensory perception and acceptance in response to low- and high-calorie potato chips were compared between the low and high stress groups. The intensity ratings of overall flavor, saltiness, and crispness did not significantly differ between chronic stress levels. However, hedonic ratings of the appearance and overall flavor of low-calorie chips were significantly lower in the high stress group than in the low stress group. In addition, the high stress group liked low-calorie chips significantly less than did the low stress group. Also, the high stress group was less satisfied with the low-calorie chips after eating when compared to the low stress group. However, for the high-calorie chips, there were no significant differences in the ratings of sensory intensity and liking, overall impression, and satisfaction felt after consumption, between the two chronic stress groups. In conclusion, our findings demonstrate that chronic stress levels can modulate not only acceptability of low calorie-chips, but also satisfaction felt after eating.

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1. Introduction

Over the last few decades the term, "stress eating", meaning the stress-induced changes in food choice and eating habits, has become commonplace (Groesz et al., 2012; Oliver & Wardle, 1999). Popular media have continually drawn the link between stress and obesity, fueled by personal experiences and studies observing stress-related shifts from low-fat foods to high-fat foods (Kandiah, Yake, Jones, & Meyer, 2006; Zellner et al., 2006). With the current obesity epidemic in the United States, the effect of stress on food choice and consumption has been a topic of interest for researchers.

While there is little doubt that obesity is a serious problem in Western nations, the role of stress in this epidemic is slightly more nuanced. For example, the effect of stress on food choice and intake has shown individual variations in earlier studies (Oliver & Wardle, 1999; for a review, Maniam & Morris, 2012; Sominsky & Spencer, 2014). Survey research regarding how people's food intake varies in response to stress found that over-eating (hyperphagia) was equally as common as under-eating (hypophagia) (Oliver & Wardle, 1999; Weinstein, Shide, & Rolls, 1997; Willenbring, Levine, & Morley, 1986). The stress-induced bidirectional trend, i.e., increase or decrease, in the amount of consumption was also observed in studies using real foods (Epel, Lapidus, McEwen, & Brownell, 2001; Gluck, Geliebter, Hung, & Yahav, 2004; Lemmens, Rutters, Born, & Westerterp-Plantenga, 2011; Wardle, Steptoe, Oliver, & Lipsey, 2000; Zellner et al., 2006). Many of the seemingly contradictory results of studies showing a link between stress and food consumption can be somewhat explained by evidence that stress-related eating is highly individualistic in nature (Rutledge & Linden, 1998; Van Strien, Frijters, Bergers, & Defares, 1986). Clinical psychologists have attempted to address how stress influences eating behavior (Carlson, 1916; Herman & Mack, 1975; Kaplan & Kaplan, 1957; Torres & Nowson, 2007). Of these attempts, three main theories have arisen: externality theory (Schachter & Rodin, 1974), psychosomatic theory (Bruch, 1964), and the restraint eating theory (Herman & Polivy, 1975). The theory of externality states that certain people's overeating is due to a personality disposition in which they consume foods based on food-related external triggers, not on their own internal satiety (Schachter & Rodin, 1974). The psychosomatic theory centers on what is commonly known as "emotional eating". It is thought that overeating stems from a confusion of the body's signals, most commonly, internal

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arousal states and the sensation of hunger (Bruch, 1964). The restraint eating theory links overeating to the persistent hunger that may manifest itself in people who are severely dieting. In this state of persistent hunger, it is hypothesized that a breakdown in the restrictive control mechanisms can lead to overeating and other forms of excessive eating (Herman & Polivy, 1975; Van Strien et al., 1986).

Previous studies have demonstrated a link between acute stress and chemosensory perception (Al'absi, Nakajima, Hooker, Wittmers, & Cragin, 2012; Dess & Edelheit, 1998; Ileri-Gurel, Pehlivanoglu, & Dogan, 2013; Nakagawa, Mizuma, & Inui, 1996). For example, Dess and Edelheit (1998) have shown that acute stress increased sensitivity to bitterness of saccharin in young adults. Additionally, Nakagawa et al. (1996) demonstrated that sweetness, sourness, and bitterness intensities were decreased in individuals following stressful mental tasks. Similarly, a recent study showed that acute stress, elicited by public speaking, math, and a cold pressor test, reduced sweet taste perception (Al'absi et al., 2012).

Compared to the effect of acute stress, relatively little attention has been paid to human studies addressing a relationship of chronic stress with food perception or eating behavior. It has been reported that most people suffer from loss of appetite and desire for foods when they are under intense mental stress or when suffering from melancholia (Blundell & Rogers, 1991). By contrast, it has been also observed that chronic stress was shown to increase the amount of consumption (Slochower, Kaplan, & Mann, 1981; Dallman et al., 2003; for a review see Torres & Nowson, 2007). In addition, in randomly selected samples of people, it was found that adults under high levels of chronic stress are more likely to consume a diet high in sugar and fat (Kandiah et al., 2006; Ng & Jeffery, 2003).

There are a limited number of studies showing a relationship between chronic stress and chemosensory perception. Data obtained in animal studies suggest that the relationship to chronic stress may involve changes in taste receptors (Okamoto, Miyoshi, Imoto, Ryoke, & Watanabe, 2010). In that study, the researchers found chronic stress to decrease sweet and umami taste perception in rats. When further examined, Okamoto et al. (2010) found that the mRNA transcription for the taste receptor, T1R3, was reduced in the high stress rats. In a recent human study, Al'absi et al. (2012) showed a relationship between perceived stress and distress on intensities of sweet and umami tastes. In other words, reduced intensities of sweet and umami tastes in response to stress were more pronounced in the participants who reported being under higher chronic stress.

As shown above, relatively less attention has been paid to the chronic stress-induced changes in chemosensory perception. However, many North Americans still report high levels of chronic stress. Notably, according to the 2013 Stress in America survey, 78% of adults in the United States reported that mental stress level increased or remained the same over the past 5 months in everyday life (American Psychological Association, 2014). Additionally, because chronic stress has been linked to other physiological changes such as poor immune function (Dhabhar & Mcewen, 1997), cardiovascular disease (Vitaliano et al., 2002) and metabolic syndrome (Aschbacher et al., 2014; Chandola, Brunner, & Marmot, 2006; Vitaliano et al., 2002), it is valuable to note a possible link between chronic stress and chemosensory perception. Building on previous research, this study aimed to determine whether chronic stress alters sensory perception and overall impression of foods, in particular with potato-chips.

2. Materials and methods

This study was conducted according to the Declaration of Helsinki for studies on human subjects. The protocol was approved by the University Institutional Review Board of the University of Arkansas (Fayetteville, AR, U.S.A.). The experimental procedure was thoroughly explained to all participants and a written informed consent was obtained from each prior to their participation. In the online survey (see below), if volunteers chose to continue the online survey, their consent was implied.

2.1. Participants

Using an online survey program (http://www.surveymonkey.com), a survey containing the 10-item Perceived Stress Scale (PSS), a self-administrated questionnaire on stress over the previous month (Cohen, Kamarck, & Mermelstein, 1983; Cohen & Williamson, 1988), was sent out potential volunteers registered through the consumer profile database of the University of Arkansas Sensory Service Center (Fayetteville, AR). The consumer database contains over 5000 area residents (Northwest Arkansas), with the majority of the consumers between 18 and 55 years old. Potential participants were asked to rate the degree to which situations in life are perceived as stressful on a 5-point scale ranging from 0 (never) to 4 (very often). Among the 10 items, 4 items were worded in an opposite (i.e., positive) direction; they were then reverse-scored. Next, the individual responses to the 10 items were summed (Cohen & Janicki-Deverts, 2012). The summed score can be ranged from 0 to 40-point, with higher scores representing greater psychological stress in the last month. Previous clinical studies have demonstrated positive relationships between the scores of PSS and psychological stress-related biomarkers such as cortisol level (Kalra, Einarson, Karaskov, Van Uum, & Koren, 2007; Pruessner, Hellhammer, & Kirschbaum, 1999).

The participants who scored below 10-point on the PSS were labeled "low stress group", while the participants who scored 25-point or higher were labeled as "high stress group." Sixty-eight participants (34 males and 34 females) whose scores were within one of the two ranges were invited to participate in the study. The low stress group (mean age $\pm$ standard $= 37 \pm 13$ years) and high stress group (40 ± 11 years) were not significantly different in terms of mean age [$t = -1.03$, $P = 0.31$]. In addition, the two groups were not significantly different in the gender ratio (for both groups: 17 males and 17 females).

2.2. Samples and preparation

Four different potato chips were used: Lay's Original® (Frito-Lay, Plano, TX, U.S.A.), Great Value Original Potato Chips (Great Value, Bentonville, AR, U.S.A.), Lay's Oven Baked Original® (Frito-Lay, Plano, TX, U.S.A.), and Popchips Sea Salt Potato® (Popchips Inc., San Francisco, CA, U.S.A.).

According to the amount of calorie per serving-size, the four chips were classified into two groups: "high-calorie chips" and "low-calorie chips". That is, the Lay's Original® (160 cal per serving; 90 cal from fat) and the Great Value Original Potato Chips (160 cal per serving; 90 cal from fat) were grouped together as "high-calorie chips", while the Lay's Oven Baked Original® (120 cal per serving; 20 cal from fat) and Popchips Sea Salt Potato® (120 cal per serving; 35 cal from fat) made up the "low-calorie chips".

All food samples were purchased from the local supermarket one day before the sensory test and stored at room temperature until served.

2.3. Procedure

Participants were asked not to eat and drink for 2 h before the experiment. The participants sat in individual sensory testing booths maintained at approximately 20 °C. Compusense® five software (Compusense Inc., Guelph, ON, Canada) was used for instruction, scales and data collection. During the experiment, each participant was presented with 3 potato chips of each sample served in a sequential monadic fashion, in which the presentation order was based on the William Latin Square design (Williams, 1949). Each sample was served in a 4-oz soufflé cup identified by a 3-digit randomized code in order to minimize any stimulus error (Meilgaard, Civille, & Carr, 2007). After consuming the served food sample, participants were asked to rate overall liking of the food itself on a 9-point hedonic scale ranging from