Extending the Boundaries of Sensory Marketing and Examining the Sixth Sensory System: Effects of Vestibular Sensations for Sitting versus Standing Postures on Food Taste Perception

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Prior research has examined the role of the traditional five sensory systems (visual, olfactory, haptic, auditory, and gustatory) and how they influence food evaluations. This research extends the boundaries of sensory marketing by examining the effects of the vestibular system, often referred to as the "sixth sensory system," which is responsible for balance and posture. The results of six experiments show that vestibular sensations related to posture (i.e., sitting vs. standing) influence food taste perceptions. Specifically, standing (vs. sitting) postures induce greater physical stress on the body, which in turn decreases sensory sensitivity. As a result, when eating in a standing (vs. sitting) posture, consumers rate the taste of pleasant-tasting foods and beverages as less favorable, the temperature intense, and they consume smaller amounts. The effects of posture on taste perception are reversed for unpleasant-tasting foods. These findings have conceptual implications for broadening the frontiers of sensory marketing and for the effects of sensory systems on food taste perceptions. Given the increasing trend toward eating while standing, the findings also have practical implications for restaurant, retail, and other food-service environment designs.

Keywords: sensory marketing, vestibular system, posture, food taste, physical stress, cross-modal effects

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Prior research in the domain of sensory marketing has examined how the traditional five sensory systems (visual, auditory, olfactory, haptic, and gustatory) influence our judgments and behaviors (Krishna 2012). In this research, we go beyond the traditional five sensory systems and examine the effects of the vestibular system (responsible for balance and posture), which is often referred to as the sixth sensory system (Angelaki and Cullen 2008). Interestingly, while the vestibular system is under-researched in the behavioral and especially in the marketing literature, it has strong practical implications for human behavior. While the vestibular system can influence several aspects of consumer behavior, in this research we primarily focus on its effects on food taste perception.

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Restaurant, retail, and home environments offer varied options for sitting or standing while eating. In many consumption contexts, such as at cafeterias, many restaurants, and most at-home dining occasions (e.g., at the dining room table or on the couch), individuals eat while maintaining a sitting posture. However, in many other consumption contexts, such as at cocktail parties, grocery store sampling stations, food trucks, conference receptions, and many restaurants, individuals eat in a standing posture. In fact, there is a growing trend toward eating while standing in many countries in Europe and Asia (Muir 2015); this trend is spreading in the US as well. For example, the Japanese steakhouse chain Ikinari does not have chairs available in its restaurants. If patrons choose to dine in, they must stand and eat. Ikinari, which has over 100 locations in Japan, recently opened its first US location, in Manhattan (Settembre 2017). In light of this emerging trend, it is important for restaurant managers and designers to understand the effects of standing versus sitting postures on food evaluations.

This research focuses specifically on standing versus sitting postures and examines whether eating the same food while standing (vs. sitting) might influence taste perception. As mentioned earlier, posture is related to the vestibular sense, the human sensory system responsible for balance, posture, and spatial orientation (Angelaki and Cullen 2008; Fitzpatrick and McCloskey 1994). In essence, this research examines a cross-modal effect—that is, how sensations associated with one sensory system influence sensations and perceptions associated with another sensory system (Biswas and Szocs 2019). Specifically, we examine the cross-modal effect of posture on gustatory evaluations. Given the practical relevance of taste in food consumption, we focus on taste perception. We draw on prior research that demonstrates the effects of physical stress on sensory sensitivity and shows that physical stress associated with maintaining standing postures, even for a brief period, can reduce sensory sensitivity. Additionally, we show that this decreased sensory sensitivity has implications for food and beverage taste evaluation, food temperature perception, and overall consumption volume.

We make several contributions to the literature. First, we add to the literature on physical stress-induced decreases in sensory sensitivity. The majority of studies examining the effects of physical stress on sensory sensitivity have been conducted with animal subjects and have manipulated physical stress through shock or cold swims (van Dijken et al. 1992). Research with human subjects has manipulated physical stress by having individuals immerse a hand in cold water (al'Absi et al. 2012; Porcelli, Lewis, and Delgado 2012) or has examined the effects of physical stress by administering the stress hormone cortisol to participants (Beckwith et al. 1983; Buchanan et al. 2001; Montoya et al. 2014). We draw on research showing that maintaining a standing posture for even a minute is enough to induce physical stress (Chung, Lee, and Kee 2003), and we contribute to the literature related to sensory sensitivity by showing that maintaining a standing posture for a short period of time (e.g., for 15 minutes, as in our studies) decreases sensory sensitivity.

Second, we add to the literature related to ambient factors that influence eating. Research in this stream shows that factors such as ambient lighting (Biswas et al. 2017), scent (Biswas and Szocs 2019), plate size, and tablecloth color (van Ittersum and Wansink 2012) can influence food perceptions and consumption decisions. However, the effects of induced posture, such as through the presence versus absence of chairs in the dining environment, have not been investigated, even though it is important for restaurant managers and designers to understand the effects of different aspects of the ambience to design environments strategically. Moreover, as mentioned earlier, with the increasing prevalence of eating while standing—such as when eating at a food truck, at a fair/carnival, at roadside eateries (which are very common in Asia), and even in many restaurants (especially in Asia and Europe)—it is imperative to understand how this aspect of the service element can influence food evaluations.

Finally, we contribute to the sensory marketing literature. As mentioned earlier, studies in sensory marketing have focused primarily on the traditional five sensory systems (Biswas et al. 2014a; Krishna 2012); we extend the frontiers of sensory marketing by going beyond the five traditional systems. We specifically contribute to the sensory marketing literature on cross-modal effects (Biswas and Szocs 2019; Hoegg and Alba 2007; Knöferle and Spence 2012; Krishna and Morrin 2008) by examining the cross-modal effects of posture-related vestibular sensations on taste perceptions.

Next, we discuss the role of posture as part of the vestibular sense and build a theoretical framework for how posture influences physical stress and taste perception. We test our predictions in six studies. First, in study 1, we show that posture influences taste perception. Studies 2–4 provide evidence that physical stress (i.e., perceived discomfort) associated with standing drives the effects of posture on taste through tests of mediation (study 2), the moderating effects of induced stress (study 3), and induced relaxation (study 4). We demonstrate that the effects of posture on taste perception hold for foods that are pleasant-tasting but reverse for unpleasant-tasting food (study 5). Finally, we show that, in addition to influencing taste perception, posture also influences temperature perception and has downstream effects on consumption amount (study 6).

THEORETICAL BACKGROUND

We develop our conceptual framework by building on work in the physiology literature, which shows that standing (vs. sitting) postures lead to increased physical stress (Abalan et al. 1992; Hennig et al. 2000; O'Sullivan et al. 2002). Physical stress in turn decreases sensory sensitivity (Beckwith et al. 1983; Butler and Finn 2009; Porcelli et al. 2012). In the context of food consumption, a decrease in sensitivity would lead to less favorable taste perceptions for foods and beverages with pleasant tastes. We elaborate on these themes below.

The Vestibular Sense

As mentioned earlier, the vestibular system, referred to as the sixth sense, is responsible for maintaining posture, balance, and overall body orientation (Angelaki and Cullen 2008; Cullen 2012; Fitzpatrick and McCloskey 1994). Unlike some of the other sensory systems (e.g., vision, olfaction, haptics, and audition), vestibular perception is inherently multimodal, which means that it integrates information from multiple sensory inputs (Cullen 2012). In order to maintain posture and balance, the vestibular system works with the proprioceptive system (which relates to the muscles) and the visual system (Horak and MacPherson 1996; Vestibular Disorders Association 2017). To maintain physical balance, the vestibular system combines inputs related to head movements with involuntary muscular tension (i.e., proprioception) and eye movements (i.e., vision) (Angelaki and Cullen 2008; Peters 1969; St George and Fitzpatrick 2011). In this research, we focus on the vestibular sense as it relates to maintaining two specific postures—sitting and standing—and the physical stress these postures impose on the body.

Standing versus Sitting Postures and Physical Stress

Standing (vs. sitting) requires greater muscular activation in the trunk, legs, and feet, and hence causes greater physical stress in these areas of the body (Grandjean and Hünting 1977; O'Sullivan et al. 2002). When an individual is standing, the feet and legs have to support the entire body mass, whereas when an individual is sitting on a chair with a backrest, a significant portion of the support for the body's mass is shared by the back, pelvis, and buttocks (Grandjean 1988). Additionally, standing postures cause the center of mass (and also the center of gravity) to be farther away from the support base as compared to sitting postures (Kuo and Zajac 1993). Since individuals have to keep the center of mass above the foot and between the toe and heel to maintain balance (Kuo and Zajac 1993), standing versus sitting postures induce greater physical stress on the feet and legs (Grandjean 1988).

Standing postures are also associated with physiological responses that are different from those associated with sitting postures. Standing has been shown to increase heart rate, activate the hypothalamic-pituitary-adrenal (HPA) axis, and lead to increased concentrations of the stress hormone cortisol (Abalan et al. 1992; Hennig et al. 2000). The physiological responses associated with standing postures stem in part from the movement of blood to the lower parts of the body when individuals stand after sitting or lying down. That is, when a person stands, the force of gravity pushes blood to the lower parts of the body; the heart then has to work harder to pump this blood back up to the top of the body, which accelerates heart rate (Callahan 2017). Elevated heart rate and decreased blood pressure are not just momentary reactions to changing posture; rather, these reactions can persist for 40 minutes after one moves from sitting or lying down to standing (Hennig et al. 2000). In sum, prior research shows that standing (vs. sitting) postures induce greater physical stress on the body, as reflected by greater muscular activation, along with increased heart rate and cortisol levels. Next, we discuss how physical stress associated with standing postures could influence food taste perceptions.

Stress and Taste Sensations

Prior research with animal subjects shows that physical stress decreases sensory sensitivity. For instance, rats exposed to physical stress via shocks or a cold swim were less responsive to high temperatures, tail flicks, and paw pinches (Hayes et al. 1978); had decreased auditory and visually cued startle responses; and were slower to respond to heat directed at the tail compared to rats not exposed to such activities (Leitner 1986, 1989). These findings have been attributed to decreased sensory sensitivity following physical stress (Leitner 1986). This proposition is consistent with a widely reported finding that physical stress dulls pain (Bodnar 1986; Butler and Finn 2009), a phenomenon referred to as "stress-induced analgesia."

A limited number of studies with human participants has also shown that physical stress decreases sensory sensitivity. For instance, Porcelli et al. (2012) induced physical stress by having participants immerse a hand in ice-cold water and then examined their neurological responses (via fMRI) to reward and punishment. They found that people exposed to physical stress did not differentiate between reward and punishment but that differences in brain activation between reward and punishment did exist among people in a control group. al'Absi et al. (2012) also induced physical stress by having each participant immerse a hand in cold water and showed that individuals rated sweet, sour, and salty tastes as less intense on days they were exposed to physical stress than on days they were not.

Other studies with human subjects have not manipulated physical stress directly but have examined how administering the stress hormone cortisol, as opposed to a placebo, influences sensory sensitivity. Consistent with the findings of studies that have manipulated physical stress directly, results of hormone studies show that individuals who are

Just a pita chip?

administered cortisol (vs. placebo) are less sensitive to auditory stimuli (Beckwith et al. 1983), show decreased startle reflexes (Buchanan et al. 2001), have longer reaction times (Montoya et al. 2014), and demonstrate decreased reactions to light flashes (Kopell et al. 1970). The decreased sensory sensitivity can occur because the stress hormone slows neuronal conduction (Beckwith et al. 1983). To summarize, prior research with human and animal subjects has consistently demonstrated that physical stress decreases sensory sensitivity.

The key question addressed in the present research is: How would physical stress, which stems from standing (vs. sitting) postures, influence food taste perceptions? As discussed earlier, standing (vs. sitting) leads to increased physical stress; moreover, physical stress decreases sensory sensitivity. Hence, we predict that standing (vs. sitting) postures will lead to less favorable taste perceptions. Since consumers tend to prefer foods with pleasant tastes and avoid foods with unpleasant tastes (Verbeke 2006), we primarily focus on evaluations for foods that taste pleasant. That is, we predict that consumers will evaluate foods as having a less favorable taste when they eat while maintaining a standing (vs. sitting) posture and that this effect is primarily driven by the physical stress associated with standing postures.

H1: Consuming a pleasant-tasting food while maintaining a standing (vs. sitting) posture leads to less favorable taste perception.

H2: Consuming a pleasant-tasting food while maintaining a standing (vs. sitting) posture leads to less favorable taste perception, with physical stress mediating the effect.

STUDY 1: CROSS-MODAL EFFECTS OF VESTIBULAR SENSATIONS ON TASTE

Study 1 tested hypothesis 1 and examined the cross-modal effects of vestibular sensations associated with posture on taste perception. Participants for all our studies were recruited from a subject pool, and the total number of participants for a particular study depended on the number of students who signed up and attended a particular study/session. However, consistent with recommended sample sizes for ANOVAs (vanVoorhis and Morgan 2007), we ensured that each experimental condition had over 30 participants; the actual sample size per cell for our studies ranged from 34 to 175.

Design, Participants, and Procedure

The study used a between-subjects design experiment with two manipulated conditions (posture: sitting vs. standing). Participants arrived at a lab to participate in a study on product evaluations. Each session had a maximum of 20 participants, and the experimental condition was randomly assigned by session. Upon entering the lab, participants were assigned to a numbered station containing a tablet computer and a pita chip. For the sitting conditions, the station also contained an unpadded chair with a backrest. No chairs were provided in the standing conditions. Participants were asked to sample the pita chip and then rate how tasty (1 = not at all tasty, 7 = very tasty) and delicious (1 = not at all delicious, 7 = very delicious) the pita chip was (Biswas et al. 2014b; Elder and Krishna 2010). Since the study was run toward the end of the semester, and participants had been to this lab several times earlier in the semester, we also asked what they thought the purpose of the study was. Of the 358 participants, 15 correctly guessed the purpose of the study. Data from these participants were screened out, leaving a sample size of 343 (45.2% female; M_{age} = 21.66; standing $n = 175$, sitting $n = 168$).

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Results and Discussion

The taste measures were averaged to create a taste perception index ($r = .90$, $p < .01$). Consistent with hypothesis 1, participants who sampled in a standing (vs. sitting) posture rated the taste of the pita chip less favorably ($M_{standing} = 4.11$ vs. $M_{sitting} = 4.53$; $F(1, 341) = 5.19$, $p = .023$, $\eta^2 = .02$). The mean taste perception was significantly greater than the scale midpoint of 4, indicating that the pita chip had a pleasant taste ($M = 4.32$; $t(342) = 3.47$, $p < .01$). The results of study 1 showed that vestibular sensations associated with posture affect taste perception whereby the same food is perceived as better tasting when sampled in a sitting (vs. standing) posture. Next, study 2 examines the process underlying this phenomenon.

STUDY 2: UNDERLYING PROCESS EVIDENCE

Study 2 tested the mediating effects of physical stress (hypothesis 2). In addition, we also address two alternative explanations: (a) negative associations with standing and eating, and (b) participants in the standing condition paying greater attention to bodily sensations. Since individuals in the standing posture may associate standing and eating with time constraints, eating on the go, or having to rush, it is possible that these negative associations may be driving less favorable taste evaluations when individuals sample while standing. To address this alternative explanation, study 2 measured the amount of time participants spent sampling. It is also possible that individuals in the standing condition might pay more attention to the bodily sensations they experience and therefore less attention to sampling, leading to a muted taste experience; hence, we also measured attention to bodily sensations to address this alternative explanation.

Why average these measures when #1 is a negative->positive measure, and the second is a neutral->positive?

Design, Participants, and Procedure

Study 2 was a between-subjects experiment with two manipulated conditions (posture: sitting vs. standing). Each study session had up to 15 participants. In the lab, participants were asked to go to one of 15 stations that were set up around a conference table. Each station contained a tablet computer and a bite-sized sample of a brownie. In the sitting sessions, each station also contained a cushioned chair with a backrest. In the standing sessions, there were no chairs around the table. Thus, posture was varied by experimental session through the presence or absence of chairs. Since the participants had never been to this lab, they were unlikely to guess the study purpose from the presence or absence of chairs.

Participants were told they would complete a number of unrelated tasks. The first task involved evaluating a brownie. A full-sized brownie was displayed on a plate in the center of the table. Participants were told that a sample of the displayed brownie was in the cup at their station. The survey instructed participants to eat the brownie sample provided and then click on the tablet to go to the next page. To measure the time participants spent eating the brownie, we recorded the amount of time between when they were instructed to sample the brownie and when they clicked to go to the next page. After the sampling, we measured perceived taste by asking participants to rate the taste (1 = very bad, 7 = very good) and deliciousness (1 = not at all delicious, 7 = very delicious) of the brownie (Biswas et al. 2014b; Elder and Krishna 2010). Then, participants completed a second, purportedly unrelated, task that instructed them to notice the sensations they were experiencing in their bodies and then answer questions about those sensations. Participants rated the physical discomfort they were experiencing in their (a) legs, (b) feet, and (c) back (1 = not at all, 7 = to a great extent) for all three items. These measures, which served as the key process measures, are consistent with prior work that operationalized postural stress in terms of physical discomfort (Chung et al. 2003; Genaidy, Barkawi, and Christensen 1995). It should be noted that perceived physical discomfort has been shown to be correlated with objective measures of physical stress, such as maximal holding time and compressive force (Kee and Lee 2012). Finally, participants were asked to indicate how much attention they paid to the sensations they experienced in their bodies when they were sampling the brownie (1 = very little attention, 7 = a lot of attention).

One hundred fifteen undergraduate students from a US university participated in this study in exchange for course credit. Four individuals indicated that they hated brownies and/or did not sample the brownie. Data from these four participants were removed, leaving a final sample of 111 (52.3% females; $M_{age} = 22.75$; $n_{standing} = 52$, $n_{sitting} = 59$).

Results

Main Effects. The two taste perception measures were averaged to create an index ($r = .92$, $p < .01$). In support of hypothesis 1, a one-way ANOVA revealed that participants perceived the brownie as less favorable tasting when they sampled it in a standing (vs. sitting) posture ($M_{standing} = 4.85$ vs. $M_{sitting} = 5.36$; $F(1, 109) = 3.96$, $p = .049$, $\eta^2 = .04$).

Process Evidence. The three physical discomfort measures were averaged to create an index ($\alpha = .83$). A one-way ANOVA revealed that participants experienced greater physical discomfort when they maintained a standing posture ($M_{standing} = 2.26$ vs. $M_{sitting} = 1.62$; $F(1, 109) = 8.12$, $p < .01$, $\eta^2 = .07$). While perceived physical discomfort was below the scale midpoint for both of the experimental conditions, it was relatively higher in the standing condition. We tested for mediation using Preacher and Hayes's PROCESS model 4 with 5,000 bootstrapped samples (Preacher and Hayes 2008). There was an indirect effect, with the effect mediated by physical discomfort (ß = –.1319, SE = .0772, CI_{95}: –.3274, –.0135) since the confidence interval excludes zero. Hence, these findings support hypothesis 2.

Ruling Out Alternative Explanations. There was no difference in the amount of time participants spent sampling ($M_{standing} = 8.49$ seconds vs. $M_{sitting} = 8.79$ seconds; $F(1, 109) = .11$, $p = .75$, $\eta^2 = .001$) or attention to bodily sensations based on posture ($M_{standing} = 4.67$ vs. $M_{sitting} = 4.59$; $F(1, 109) = .07$, $p = .79$, $\eta^2 = .001$).

Discussion

The results of study 2 show that, consistent with hypothesis 2, physical stress mediated the effects of posture on taste perception. Additionally, the results suggest that greater attention to bodily sensations and associations between standing and eating on the go are not influential processes driving this effect. Next, study 3 provides additional evidence for the role of physical stress in driving the effects of posture on taste, and it addresses alternative explanations related to psychological stress and comforting properties of the food.

STUDY 3: MODERATING EFFECTS OF INDUCED PHYSICAL AND PSYCHOLOGICAL STRESS

Study 3 provides further insight into the underlying process by examining the moderating effects of induced physical stress through a secondary task. If, as we are conceptualizing and as shown in study 2, the effects of posture on taste are driven by physical stress, then inducing physical stress through a secondary task (e.g., having participants hold heavy shopping bags) should attenuate the effects of posture. The attenuation of effects should result in a decrease in taste perceptions when participants are seated and physical stress is induced. Moreover, taste perceptions of individuals who are seated and physically stressed should be similar to those of individuals who are standing and do not have any additional stress induced. Formally stated:

> **H3:** The effect on taste perception of consuming a pleasant-tasting food while maintaining a standing (vs. sitting) posture is attenuated by secondary physical stress. Secondary physical stress decreases taste perception in the sitting condition.

A secondary purpose of study 3 was to examine the role of psychological stress as a possible alternative underlying factor. It is possible that standing postures might be more psychologically stressful than sitting postures. This is because tasks that are physically stressful (e.g., holding a heavy shopping bag) can also lead to psychological stress, and psychological stress (induced through a priming task) can lead to physiological stress responses (Zhang and Li 2012). It should be noted that while Zhang and Li (2012) found that physical and psychological stress have reciprocal effects, other streams of research suggest that physical and psychological stress have unique effects on behavioral outcomes (Pijlman et al. 2003; Pijlman and van Ree 2002; Pijlman, Wolterink, and van Ree 2002, 2003). For instance, physically stressed (vs. psychologically stressed or unstressed) rats engage in less locomotor activity and exploration, while psychologically stressed rats engage in more locomotor activity than unstressed rats (Pijlman et al. 2002; Pijlman et al. 2003; Pijlman and van Ree 2002). Furthermore, neuroscience research shows that different areas of the brain are activated by physical and psychological stressors (Dayas et al. 2001). Given the lack of consistency in prior work, we do not make a formal prediction about how psychological stress will influence taste perceptions.

Finally, a tertiary objective of study 3 was to show robustness of our effects across different stimuli and to address a possible alternative explanation related to comforting properties of the sampled foods reducing stress and influencing taste perception. Specifically, the stimuli used in studies 1 and 2 (a pita chip and a brownie) might be considered vice products or comfort foods. Comfort foods—specifically high-calorie, fat-laden foods—have been shown to decrease stress (Osdoba et al. 2015). It is possible that comforting aspects of the stimuli in studies 1 and 2 reduced stress, which can influence taste perception. We address this potential alternative explanation in study 3 by having participants sample a healthy fruit snack.

Taste Pretest

We conducted a pretest to ensure that the fruit snack used in study 3 was not perceived as having an unpleasant taste and to ensure that participants did not perceive it as indulgent or as a comfort food. Thirty-nine university students (M_{age} = 22.2 years; 51.3% females) participated in the pretest. The pretest took place in a classroom setting, and all participants were seated. Participants were told that we were interested in their evaluation of a fruit snack that contained only dried fruits. Participants were given a fruit snack and a paper survey. They were asked to eat the fruit snack and rate the taste (1 = very bad, 7 = very good) and deliciousness (1 = not at all delicious, 7 = very delicious) (Biswas et al. 2014b; Elder and Krishna 2010). The responses to the two taste items were averaged (r = .93, p < .01). Perceived taste was not lower than the scale midpoint of 4 (M = 4.09; t(38) = .35, p = .73) and hence not unpleasant.

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Additionally, participants were asked to rate how indulgent the fruit snack was and the extent to which they considered the fruit snack a comfort food (1 = not at all, 7 = very much so) for both items. The mean indulgence rating (M = 2.79; t(38) = 5.70, p < .01) and the mean comfort rating (M = 3.0; t(38) = 3.51, p < .01) were significantly below the scale midpoint of 4, indicating that the fruit snack was not perceived as indulgent or a comfort food.

Design, Procedure, and Participants

Study 3 had a 2 (posture: sitting vs. standing) × 3 (induced stress: physical vs. psychological vs. control condition of no additional stress) between-subjects design. Each study session had up to 15 participants, and the experimental condition for each session was randomly determined. Participants were assigned a number as they entered the lab. The number corresponded to a station around the perimeter of the lab (indicated by numbers posted on the wall). In the sitting conditions, an unpadded chair with a backrest was placed at each numbered station, and participants were instructed to go to the assigned number and sit on the chair, facing the wall. In the standing conditions, there was no chair at the station, and participants were instructed to stand, facing the wall.

We manipulated physical stress by having participants hold additional weight. Participants in the physical stress conditions were told that because consumers often carry shopping bags while sampling foods at grocery stores, they would be asked to hold a shopping bag while they completed a sampling task. A reusable shopping bag that contained one unopened gallon of water weighing 8.3 pounds was placed at each station in the lab. Participants were instructed to pick up the bag and hold it by placing their arm through the straps. After picking up the bag, participants undertook the sampling task and then completed the survey on a tablet. Participants were instructed to put the bag down after responding to the key dependent measures.

We manipulated psychological stress through a priming task. Specifically, participants in the psychological stress conditions were asked to think about a time they had to carry something heavy and were stressed by it. Then, they were asked to write about the event they thought of. After writing about the event, participants completed the sampling task. We employed these manipulations of physical stress and psychological stress as similar manipulations have been used in prior research (Zhang and Li 2012), and we wanted the physical and psychological tasks to be as similar as possible. In the control conditions, participants completed only the sampling task without undertaking any of the additional stress-inducing activities.

Two hundred thirty-two students (M_{age} = 21.8 years; 50.4% females) from a major US university participated in this study in exchange for course credit. One participant expressed problems with using the tablet and could not record the responses properly; this participant was excluded from the study, leaving a final sample of 231 ($n_{sitting–physical\ stress} = 36$, $n_{standing–physical\ stress} = 37$, $n_{sitting–psychological\ stress} = 34$, $n_{standing–psychological\ stress} = 45$, $n_{sitting-control} = 34$, $n_{standing-control} = 45$). The sampling task involved eating and evaluating the same healthy fruit snack we had used in the pretest. Participants were instructed to sample the fruit snack and then rate the taste, using the same two items as used in study 1 ($r = .88$; $p < .01$).

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Results

There was a marginally significant 2 (posture) × 3 (induced stress) interaction effect on perceived taste ($F(2, 225) = 2.45$, $p = .09$, $\eta^2 = .02$). There was also a marginally significant main effect of posture whereby consumers in a standing (vs. sitting) posture evaluated the fruit snack as having a less favorable taste ($M_{sitting} = 4.0$ vs. $M_{standing} = 3.59$; $F(1, 225) = 3.54$, $p = .06$, $\eta^2 = .02$). We also examined the 2 (posture) × 2 (physical stress vs. control) interaction. Examining this two-way interaction makes sense given our focus on the role of physical stress. For the 2 × 2 design, there was a significant interaction effect between posture and stress on taste perception ($F(1, 148) = 5.32$, $p = .02$, $\eta^2 = .04$). For this design, neither the overall effect of posture ($F(1, 148) = 2.08$, $p = .15$, $\eta^2 = .01$) nor the overall effect of stress was significant ($F(1, 148) = .34$, $p = .56$, $\eta^2 = .002$).

Follow-up tests showed that, consistent with hypothesis 1 and the results of our previous studies, in the control condition (of no additional stress), participants evaluated the fruit snack as having a less favorable taste when they sampled it in a standing (vs. sitting) posture ($M_{standing} = 3.40$ vs. $M_{sitting} = 4.32$; $F(1, 225) = 6.59$, $p = .01$, $\eta^2 = .03$). This effect was attenuated when physical stress was induced. That is, when participants held a physical weight while sampling, there was no difference in taste perception based on posture ($M_{sitting–physical\ stress} = 3.61$ vs. $M_{standing–physical\ stress} = 3.82$; $F(1, 225) = .33$, $p = .57$). It should be noted that when the physical weight was added, taste perceptions among individuals in a seated posture decreased and were lower than taste evaluations of individuals who sampled in a seated posture in the "no additional weight–control" condition ($M_{sitting–physical\ stress} = 3.61$ vs. $M_{sitting-control} = 4.32$; $F(1, 225) = 3.54$, $p = .06$) but were not significantly different from taste evaluations of individuals in the "standing-control" condition ($M_{sitting–physical\ stress} = 3.61$ vs. $M_{standing-control} = 3.40$; $F(1, 225) = .36$, $p = .55$). Also, the "standing–physical stress" condition did not differ from the "standing-control" condition ($M_{standing–physical\ stress} = 3.82$ vs. $M_{standing-control} = 3.40$; $F(1, 225) = 1.46$, $p = .23$); see figure 1 . These results support hypothesis 3.

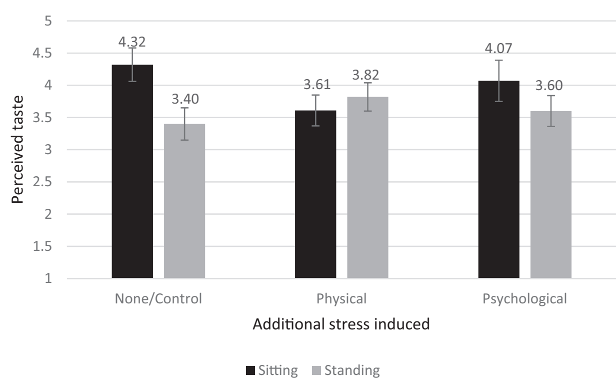
The pattern of results was different in the case of induced psychological stress. Perceived taste in the "sitting–psychological stress" condition was not significantly different from that in the "sitting-control" condition ($M_{sitting–psychological\ stress} = 4.07$ vs. $M_{sitting-control} = 4.32$; $F(1, 225) = .42$, $p = .52$) but was marginally more favorable than in the "standing-control" condition ($M_{sitting–psychological\ stress} = 4.07$ vs. $M_{standing-control} = 3.40$; $F(1, 225) = 3.50$, $p = .06$). When participants were primed with psychological stress, there was no difference in taste based on posture ($M_{sitting} = 4.07$ vs. $M_{standing} = 3.60$; $F(1, 225) = 1.73$, $p = .19$). Also, while the mean for the "sitting–physical stress" condition was directionally lower than that for the "sitting–psychological stress" condition, it was not statistically significant ($F(1, 225) = 1.49$, $p = .22$). Figure 1 presents the findings of study 3, with the error bars representing one standard error above and below the mean.

Stress Post-Test

We conducted a post-test ($n = 162$, $M_{age} = 21.34$; 42.2% females) to ensure that the manipulations of physical and psychological stress were perceived as intended. Lab

FIGURE 1

STUDY 3—MODERATING EFFECTS OF INDUCED PHYSICAL VERSUS PSYCHOLOGICAL, VERSUS NO STRESS



participants were assigned to one of three between-subjects conditions (physical stress vs. psychological stress vs. control/no stress). Participants in the physical stress conditions were instructed to pick up a reusable shopping bag containing a gallon of water and to hold the bag by placing the handles over their shoulder. Participants in the psychological stress condition were asked to think about a time they had to carry something heavy and were stressed by it. Then, they were asked to write about that event. In the control condition, participants were simply instructed to notice how they were feeling. All participants then completed measures of physical and psychological stress; they were asked to indicate the extent to which they disagreed or agreed with the statements: "I feel physical discomfort" and "I feel mental discomfort" (1 = strongly disagree, 7 = strongly agree).

For physical discomfort, there was an overall main effect ($F(2, 159) = 5.23$, $p < .01$, $\eta^2 = .06$), and it was higher in the physical stress condition than in the control condition ($M_{\text{physical-stress}} = 2.53$ vs. $M_{\text{control}} = 1.69$; $F(1, 159) = 9.25$, $p = .003$). For psychological discomfort, there was an overall main effect ($F(2, 159) = 8.13$, $p < .01$, $\eta^2 = .09$), and it was higher for individuals in the psychological stress condition than in the control condition ($M_{\text{psychological-stress}} = 2.73$ vs. $M_{\text{control}} = 1.63$; $F(1, 159) = 16.24$, $p < .01$).

Discussion

The results of study 3 provide additional evidence in support of our theorizing about the effects of posture on taste being driven by physical stress associated with standing, which leads to less favorable taste perceptions. Specifically, study 3 demonstrates that inducing physical stress, by having participants hold a heavy shopping bag, decreased taste evaluations for consumers who were seated to levels similar to consumers in the "standing-control" condition. These findings again highlight the underlying mechanism related to physical stress driving the effects of posture on taste perceptions. It should be noted that additional physical stress did not further reduce taste perceptions among individuals who were standing. One possible reason for this relates to the manipulation of added physical stress. Specifically, holding a heavy shopping bag while sampling may have made the physical stress that participants were experiencing salient. Prior research shows that making an extraneous sensory cue salient can decrease the influence of the cue on judgments (Biswas et al. 2014b). Thus, it is possible that the salience of the added physical stress attenuated further decreases in taste perceptions.

Interestingly, priming psychological stress led to a different pattern of effects than inducing physical stress. The results suggest that psychological stress is not the dominant underlying process for our observed effects. In other words, this pattern of results supports our theorizing related to the effects of posture on taste evaluations being driven by physical stress, rather than psychological stress, associated with standing postures. Next, study 4 provides additional process evidence.

STUDY 4: MODERATING EFFECTS OF INDUCED RELAXATION

Study 3 examined the moderating effects of induced physical stress. Study 4 looks at the other side of this process and examines the moderating effects of induced relaxation. We theorized that a standing (vs. sitting) posture would decrease taste evaluations due to stress induced by the posture. If our theorizing holds, then inducing physical relaxation should attenuate these effects since the induced relaxation should neutralize the stress induced by posture. In terms of directions of cell means, in the absence of any induced relaxation, standing (vs. sitting) postures would lead to less favorable taste perceptions; when physical relaxation is induced, taste perceptions for both the sitting and standing conditions should be at the same level as the "relaxation absent–sitting" condition. Formally stated:

> **H4:** The effect on taste perception of consuming a pleasant-tasting food while maintaining a standing (vs. sitting) posture is attenuated by induced physical relaxation. Induced physical relaxation increases taste perception in the standing condition.

Design, Procedure, and Participants

Study 4 was a 2 (posture: sitting vs. standing) × 2 (induced physical relaxation: absent vs. present) between-subjects experiment. Participants entered the lab and were assigned a number that corresponded to a station around the perimeter of the lab. Posture was manipulated through the presence (vs. absence) of a chair at the numbered station. Participants were told that they would complete several unrelated tasks. The first task involved evaluating a beverage. All participants were given a white cup containing 1.5 ounces of a flavored sports drink. To induce physical relaxation, we used placebo effects (Irmak, Block, and Fitzsimons 2005; Shiv, Carmon, and Ariely 2005). Participants in the "induced physical relaxation present" (i.e., placebo effects) conditions were told that this new beverage was clinically proven to induce physical relaxation. In the control conditions, participants were just told the beverage was a new product. Participants were instructed to sample the beverage and indicate how likely they would be to purchase it (1 = very unlikely, 7 = very likely) (Andrade 2005). As a recall check, participants were asked: "Based on the information provided earlier, what is this beverage clinically proven to do?" They could select one of four responses: "reduce dehydration," "provide physical relaxation," "I wasn't given any specific information," and "I can't remember." After this, participants completed the focal task, which involved sampling and evaluating the taste of a ginger snap cookie (1 = very bad, 7 = very good).

In exchange for course credit, 224 undergraduate students participated in this study. Five students did not sample the cookie and the beverage. Data from these participants was excluded from the analysis, leaving a final sample of 219 (49.3% females; M_{age} = 20.79; $n_{sitting\text{-}control}$ = 52, $n_{sitting\text{-}relaxation}$ = 54, $n_{standing\text{-}control}$ = 56, $n_{standing\text{-}relaxation}$ = 57).

Results

Recall Check. Consistent with the intended manipulation, a greater proportion of participants in the induced physical relaxation present (vs. absent) conditions said that the beverage induced physical relaxation ($P_{present}$ = 95.50% vs. P_{absent} = 1.85%; $\chi^2 = 193.71$, $p < .01$).

Taste Perception. A 2 (posture) × 2 (induced physical relaxation) ANOVA on perceived taste revealed a significant interaction effect ($F(1, 215) = 3.97$, $p = .048$, $\eta^2 = .02$). There was also a main effect of posture, whereby perceived taste was less favorable when participants sampled the cookie while standing than while sitting ($M_{standing} = 4.11$ vs. $M_{sitting} = 4.75$; $F(1, 215) = 8.64$, $p = .004$, $\eta^2 = .04$). The overall main effect of induced physical relaxation was not significant ($F(1, 215) = .56$ $p = .46$, $\eta^2 = .003$). Follow-up tests showed that in the absence of induced physical relaxation, participants in the standing (vs. sitting) condition rated the taste of the cookie less favorably ($M_{standing} = 3.80$ vs. $M_{sitting} = 4.88$; $F(1, 215) = 12.00$, $p < .01$, $\eta^2 = .05$). However, when physical relaxation was induced via placebo effects, taste evaluations among individuals who sampled while standing increased, leading to the effects of posture getting attenuated ($M_{standing} = 4.40$ vs. $M_{sitting} = 4.61$; $F(1, 215) = .46$, $p = .50$, $\eta^2 = .002$). Both the means for the induced physical relaxation conditions (4.61 and 4.40) were similar to the non-induced relaxation sitting condition (4.88; all p's >.10) and were higher than the standing condition (3.80; all p's = .05 or less). These results support hypothesis 4 and are graphically presented in figure 2.

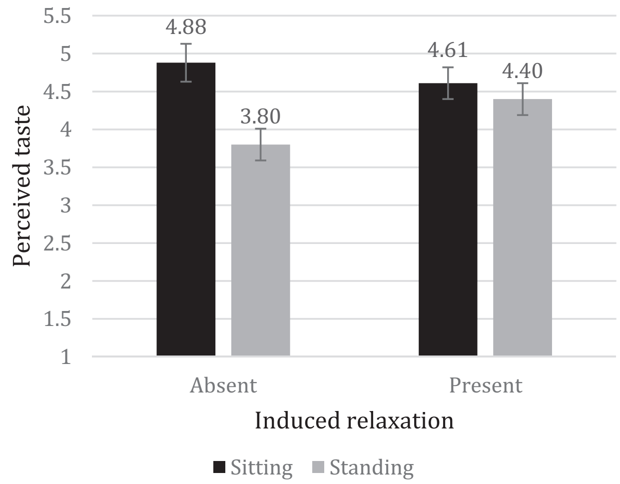
There was no difference in likelihood of purchasing the sports drink based on posture ($F(1, 215) = .65$, $p = .42$, $\eta^2 = .003$), relaxation inducement ($F(1, 215) = .08$, $p = .78$, $\eta^2 = .000$), or their interaction ($F(1, 215) = .58$, $p = .45$, $\eta^2 = .003$).

Discussion

The results of this study show that the effects of posture on taste perception hold in the absence of induced relaxation, with the effects getting attenuated when individuals believe that they have sampled a beverage that induces physical relaxation. This pattern of results provides further evidence for our proposed theorizing. Next, study 5 provides additional process evidence by showing that the effects of posture on taste perceptions reverse for unpleasant-tasting foods. Study 5 also addresses a potential alternative explanation related to negative affect.

FIGURE 2

STUDY 4—MODERATING EFFECT OF INDUCED RELAXATION



STUDY 5: REVERSAL OF EFFECTS WITH UNPLEASANT-TASTING FOODS

The purpose of study 5 is to provide additional evidence that reduced sensitivity from physical stress is driving the effects of posture on taste evaluations, as well as to rule out a potential alternative explanation related to negative affect. Specifically, it is possible that negative affect induced by the standing posture is being used as information (i.e., affect-as-information theory; Greifeneder, Bless, and Pham 2011; Pham 1998; Pham et al. 2001) and is leading to less favorable taste evaluations when individuals sample in a standing (vs. sitting) posture. If negative affect associated with standing is driving the effects of posture on taste, then taste perceptions should be less favorable when individuals sample in a standing (vs. sitting) posture irrespective of whether the sampled food has a pleasant or unpleasant taste. This is because negative affect associated with standing would negatively influence taste evaluations for both types of foods. In contrast, if our theorizing is correct, and the effects are driven by decreased sensory sensitivity associated with physical stress, then consumers should rate pleasant-tasting foods less favorably when they sample in a standing (vs. sitting) posture. However, consumers should rate unpleasant-tasting foods relatively more favorably (due to a less intense unpleasant experience) when they sample in a standing (vs. sitting) posture. Thus, the effects of posture on taste evaluations observed in studies 1–4 should hold for pleasant-tasting foods but should reverse for unpleasant-tasting foods. Formally stated:

> **H5:** For pleasant-tasting foods, consuming the food while maintaining a standing (vs. sitting) posture leads to less favorable taste perception.
>
> For unpleasant-tasting foods, consuming the food while maintaining a standing (vs. sitting) posture leads to relatively more favorable taste perception.

Pretest

Prior to conducting the main study, we needed to identify pleasant- and unpleasant-tasting versions of the same food to use as stimuli in the main study. We collaborated with a local restaurant to prepare two versions of brownies. One version was a classic brownie recipe that is predicted to have a pleasant taste. The other version contained all ingredients included in the classic recipe plus an additional 1/4 cup of salt. The purpose of the added salt was to make the brownie taste unpleasant. It should be noted that prior research (Lee, Frederick, and Ariely 2006) has altered food and beverage taste through the addition of ingredients, and we followed a similar procedure.

To confirm that the classic recipe was perceived as pleasant-tasting, and the recipe with added salt was perceived as unpleasant-tasting, we conducted a pretest. Fifty-two university students were given a bite-sized sample of either the classic recipe brownie or the brownie with added salt. One participant did not eat the brownie, which left us with a final sample of 51 (53% female; $M_{age} = 22$ years). Participants were asked to eat the brownie sample and rate the taste using the following two measures ("How would you rate the brownie overall?" and "How would you rate the flavor of the brownie?" [1 = very bad, 7 = very good]). The two taste items were averaged to create an index ($r = .88$, $p < .001$). Participants were also asked to rate the visual appearance of the brownie (1 = very bad, 7 = very good). As predicted, the taste of the classic brownie recipe was rated more favorably than the recipe with the added salt ($M_{classic} = 5.41$ vs. $M_{added\text{-}salt} = 2.78$; $F(1, 49) = 46.74$, $p < .001$). Moreover, the classic recipe brownie taste rating was higher than the scale midpoint of 4 ($t(27) = 6.70$, $p < .01$) and the added-salt brownie's taste evaluation was significantly lower than the scale midpoint ($t(22) = 3.60$, $p < .01$). There was no difference in appearance between the two recipes ($M_{classic} = 5.29$ vs. $M_{added\text{-}salt} = 4.74$; $F(1, 49) = 1.34$, $p = .25$). These two versions of the brownies were used in the main study.

Main Study

Design, Procedure, and Participants. The main study was a 2 (posture: sitting vs. standing) × 2 (type of food: pleasant-tasting vs. unpleasant-tasting) between-subjects experiment. The lab had 15 stations around a conference table. All stations contained a tablet computer and a bite-sized brownie sample. The brownie samples were randomly distributed by research assistants, and both pleasant- and unpleasant-tasting brownies were present in all sessions. Posture was varied by experimental session. In the "sitting posture" sessions, each station contained a padded chair with a backrest. In the "standing posture" sessions, the chairs were removed.

Participants were told that they would complete a series of unrelated tasks. The first task involved evaluating a brownie. They were instructed to eat the bite-sized brownie sample. After eating the brownie, they evaluated the taste with two measures ("How would you rate the brownie overall?" and "How would you rate the flavor of the brownie?" [1 = very bad, 7 = very good]).

Two hundred thirteen undergraduates participated in this study; six individuals did not follow directions regarding the study procedures (e.g., did not eat the brownie). Data from these six individuals were removed, leaving a final sample of 207 (46.9% female; $M_{age} = 21.04$; $n_{sitting\text{-}pleasant} = 45$, $n_{sitting\text{-}unpleasant} = 42$, $n_{standing\text{-}pleasant} = 64$, $n_{standing\text{-}unpleasant} = 56$).

Results. We created a taste perception index by averaging participants' responses to the two taste measures ($r = .92$, $p < .001$). A 2 (posture) × 2 (food type) ANOVA revealed a significant interaction effect ($F(1, 203) = 6.01$, $p = .01$, $\eta^2 = .03$) and a significant main effect of brownie type ($F(1, 203) = 70.67$, $p < .001$, $\eta^2 = .26$). Due to the moderating effects of food type, the main effect of posture was not significant $F(1, 203) = .000$, $p = .998$, $\eta^2 = .00$). Follow-up tests showed that when participants sampled the pleasant-tasting brownie, those who sampled in the standing (vs. sitting) posture rated the taste marginally less favorably ($M_{standing} = 5.02$ vs. $M_{sitting} = 5.56$; $F(1, 203) = 3.16$, $p = .077$, $\eta^2 = .02$). However, among individuals who sampled the unpleasant-tasting brownie, those who sampled in the standing (vs. sitting) posture rated the taste marginally more favorably ($M_{standing} = 3.71$ vs. $M_{sitting} = 3.17$; $F(1, 203) = 2.86$, $p = .092$, $\eta^2 = .01$). These results are consistent with hypothesis 5.

Discussion. The results of study 5 provide additional support for our prediction that physical stress associated with standing leads to decreased sensory sensitivity. The results show that when participants sample a pleasant-tasting food, decreased sensitivity associated with physical stress leads to less favorable taste evaluations when individuals sample while standing (vs. sitting). However, when they sample an unpleasant-tasting food, decreased sensory sensitivity that results from physical stress leads to relatively more favorable taste evaluations when individuals sample while standing (vs. sitting). This pattern of results suggests that negative affect associated with standing postures is not driving the effects of posture on taste since an affect-as-information–based account would have predicted less favorable taste evaluations when individuals sample in a standing posture, irrespective of the food being pleasant or unpleasant. Next, in study 6, we examine the robustness of our effect to other sensory evaluations and also the downstream effects of posture on consumption volume.

STUDY 6: EFFECTS OF POSTURE ON OTHER SENSORY EVALUATIONS AND CONSUMPTION VOLUME

The purpose of study 6 was to provide converging evidence that physical stress associated with standing leads to an overall decrease in sensory sensitivity. If, as we are predicting, physical stress associated with standing (vs. sitting) posture leads to an overall decrease in sensory sensitivity, then this decrease should lead to less intense evaluations for other sensory aspects of the sampled item, such as temperature. We focus on temperature evaluations since temperature is an important aspect of foods and beverages (Cardello and Maller 1982). If our theorizing is correct, and standing postures decrease sensory sensitivity, then sampling a hot beverage in a standing (vs. sitting) posture should lead consumers to perceive the temperature of the beverage as less intense (i.e., relatively less hot).

A secondary objective of study 6 was to examine the downstream effects of posture on consumption. Prior studies have documented both increases (Epel et al. 2001) and decreases in consumption with stress (Stone and Brownell 1994). On one hand, perceived taste and consumption amount tend to be correlated (Glanz et al. 1998). Moreover, stress has been shown to suppress the appetite such that physically stressed (vs. unstressed) rats consume lower volumes of saccharin solutions (van Dijken et al. 1992). In a similar vein, exposure to mild but unpredictable physical stress leads to decreased responsiveness to sweet and nonsweet conditioned rewards (Papp, Willner, and Muscat 1991). On the other hand, for some individuals, stress can lead to increased consumption (Epel et al. 2001). Given the complicated relationship between stress and consumption (Torres and Nowson 2007), we do not offer a formal hypothesis about how stress and diminished sensitivity associated with standing postures will influence consumption amount.

Design, Participants, and Procedure

Study 6 was a between-subjects experiment with two manipulated conditions (posture: sitting vs. standing). Participants were invited to the lab to participate in a coffee taste test. One hundred sixty-five university students (55.8% females; $M_{age} = 25.11$; $n_{sitting} = 84$, $n_{standing} = 81$) participated in this study for course credit. The experimental condition was randomly varied by session so that all participants in a given session were in the same condition. Each session had up to 15 participants. Upon entering the lab, participants were assigned a number that corresponded to a station in the lab. In the sitting conditions, each station contained a chair, a table, and a tablet computer. In the standing conditions, the chairs were removed, and the numbered stations contained only a tablet computer placed on a table. Participants were told they would be asked to evaluate a new coffee blend.

Coffee was brewed in a 40-cup coffee urn every hour. The coffee urn was temperature-controlled to keep the coffee at a constant temperature. Coffee was poured into Styrofoam cups 5 minutes before each session. Each participant was given a Styrofoam cup of black coffee weighing 160 grams. Participants were asked to sample the coffee and complete the taste measures ("How would you rate the flavor of the coffee?" [1 = very bad, 7 = very good] and "How delicious was the coffee?" [1 = not at all delicious, 7 = very delicious]). They were also asked to rate the temperature ("How cold or hot was the coffee?" [1 = very cold, 7 = very hot]). Participants were then allowed to add cream and sweetener to the coffee and told they could continue to drink the coffee as they completed the rest of the extra credit activity. Participants were asked to indicate their overall liking for coffee (1 = hate it, 7 = love it), to state how much coffee they think they drank (1 = very little, 7 = a lot), and to provide demographic information. After participants left the session, the cups were weighed to measure actual consumption. A research assistant inadvertently missed out on measuring the cup weight for one of the participants, leaving us with a sample size of 164 for this dependent variable.

Results

Taste. The two taste measures were averaged to create a taste perception index ($r = .82$, $p < .01$). An ANCOVA with posture as the independent variable, perceived taste as the dependent variable, and overall liking for coffee as the covariate revealed that participants who sampled while standing (vs. sitting) perceived the coffee as having a less favorable taste ($M_{standing} = 3.67$ vs. $M_{sitting} = 4.06$; $F(1, 162) = 3.94$, $p = .049$, $\eta^2 = .02$). Not surprisingly, overall liking for coffee was a significant covariate ($F(1, 162) = 14.97$, $p < .01$, $\eta^2 = .08$).

Temperature. Consistent with our prediction about standing (vs. sitting) postures leading to an overall decrease in sensory sensitivity, participants who sampled while standing (vs. sitting) rated the hot coffee as lower in temperature—that is, as being less hot (ANCOVA results:

$M_{standing} = 5.43$ vs. $M_{sitting} = 5.89$; $F(1, 162) = 5.18$, $p = .02$, $\eta^2 = .03$).

Perceived and Actual Consumption. There was no difference in perceived consumption amount based on posture (ANCOVA results: $M_{sitting} = 3.62$ vs. $M_{standing} = 3.40$; $F(1, 162) = .77$, $p = .38$, $\eta^2 = .005$). We subtracted the weight of the remaining coffee (after participants left the lab) from 160 grams to determine the number of grams consumed. There was a significant difference in actual consumption, with participants in the standing (vs. sitting) posture consuming a lower volume of coffee (ANCOVA results: $M_{standing} = 62.88$ vs. $M_{sitting} = 81.14$; $F(1, 161) = 7.95$, $p < .01$, $\eta^2 = .05$). Since perceived taste was less favorable for the standing (vs. sitting) condition, it seems that consumption volume followed a similar pattern.

Discussion

The results of study 6 provide converging evidence in support of our theorizing that physical stress associated with standing (vs. sitting) posture leads to decreased sensory sensitivity by demonstrating that consumers evaluated hot coffee as being less hot when they sampled in a standing (vs. sitting) posture. In addition, the results of this study reveal an important downstream behavioral outcome of posture in terms of consumption volume. Specifically, participants consumed a lower volume of the coffee in a standing (vs. sitting) posture. Interestingly, there was no difference in perceived consumption. This suggests that individuals may not be aware of the effects of posture on consumption.

GENERAL DISCUSSION

The results of six experiments demonstrate the cross-modal effects of vestibular sensations associated with standing versus sitting postures on taste perceptions. For pleasant-tasting foods, consuming in a standing (vs. sitting) posture leads to less favorable perceived taste (studies 1–4 and 6), with the effects reversing for unpleasant-tasting foods (study 5). The underlying process seems to be greater physical stress induced by standing (vs. sitting) posture, which decreases sensory sensitivity (study 2). The findings of our studies also suggest that negative associations between standing and eating (study 2), attention to bodily sensations (study 2), comforting aspects of the food (study 3), and negative affect (study 5) are not the dominant processes driving our effects. Moderating effects of induced physical stress (study 3) and induced relaxation (study 4) provide further support for our theorizing. Finally, we show that decreased sensory sensitivity that stems from physical stress associated with standing (vs. sitting) posture leads to less intense temperature perceptions and decreased consumption volume (study 6).

We conducted a single-paper meta-analysis (SPM) to test the reliability of the effects of posture on food taste perception (McShane and Böckenholt 2017). We included the main effects conditions of studies 1–6 and web appendix study 1 for the conditions where the food taste was favorable; hence, web appendix study 2 was not included. The SPM estimates the effects of posture at .5609 (SE = .0973). The appendix provides the plots for the contrasts across the studies. As can be seen from the SPM plots in the appendix, the effects of study 6 are relatively weak; this is not surprising given the significant covariate effect of liking for coffee. In essence, for our studies, the results of the SPM suggest that standing (vs. sitting) posture reduces food taste perception by an overall amount of .5609 (on a 1–7 scale).

Theoretical Contributions

While there is interesting emerging research in the domain of sensory marketing, most of these research studies have focused on topics related to the five traditional sensory systems. The current research extends the boundaries of sensory marketing and takes the novel approach of focusing on the posture-related vestibular system, which is often referred to as the sixth sensory system (Angelaki and Cullen 2008), and its effects on food taste perceptions. This in turn contributes to the literature on taste formation and evaluation (Elder and Krishna 2010; Lee, Frederick, and Ariely 2006).

We also demonstrate how physical stress associated with standing postures decreases sensory sensitivity, which subsequently influences taste perception. While prior research has examined the effects of stress and sensory sensitivity across a wide range of variables, the focus on taste perception is unique. Beyond taste perception, we also show effects for temperature perception and consumption volume. Further, we show the moderating effects of pleasantness/unpleasantness of the food taste, whereby the effects are in opposite directions for pleasant- versus unpleasant-tasting foods.

While there is emerging research on the effects of servicescapes, such as lighting (Biswas et al. 2017) or scent (Biswas and Szocs 2019), and how they influence consumer behavior, the present research examines an underexplored atmospheric element—that related to seating options. Given the lack of research on this element of servicescape, there is scope for additional work in this domain.

Our study also adds to the research on the unconscious drivers of consumption amount. Factors such as size labels (Aydinoğlu and Krishna 2011), packaging cues (Madzharov and Block 2010), and food texture (Biswas et al. 2014b) influence the amount consumed. We add to this stream by showing that the posture maintained while eating can also influence consumption volume.

Finally, this research adds to the literature related to the effects of stress on eating. Prior research in this domain has examined how a number of different situational and chronic stressors influence consumption. Findings in this stream are mixed and suggest that in some cases stress can lead to increased consumption, and in other cases stress can lead to decreased consumption (Greeno and Wing 1994; Torres and Nowson 2007). We add to this body of literature by showing that the nature of the stress (physical vs. psychological) and the pleasantness of the food and beverage consumed play important roles in how stress influences taste perceptions and consumption. This is important since prior studies on stress have largely focused on consumption rather than on taste. Because the results of study 3 suggest that physical and psychological stress have different effects on taste evaluations, it is also possible that drawing a distinction between physical and psychological stress can help in resolving the inconsistent findings in prior literature. Clearly, additional research is needed to reconcile this inconsistency.

Practical Implications

No!!!!

Our research offers important insights for managers. Eating while standing is becoming more common, not only in restaurants in Europe and Asia, but also in the US. For instance, standing-only restaurants, which have been a Japanese tradition (Muir 2015), have started opening in the United States (Dai 2016; Fujita 2013). Existing restaurants have also started to experiment with standing-only dining areas and alternative retail formats, such as pop-up restaurants and food carts (Vishal 2016), where individuals have the option of standing while eating. In addition, several restaurants in European countries and roadside eateries in India and Thailand offer only the option to stand. The results of this research identify an unintended consequence of standing while eating in terms of influencing taste perceptions and overall consumption volume. The results of our studies suggest that managers at restaurants might find it an optimal strategy to encourage diners to sit down while eating. At the other end of the spectrum, restaurants with buffet or all-you-can-eat options might find it optimal to have standing sections since standing can reduce consumption volume.

We also ran a study (not reported in the main article text) that examined the effects of sitting on a chair versus sitting on a stool versus standing (see web appendix study 2). The findings of this study show that for taste perception, sitting on a "stool without a backrest" is in between sitting on a "chair with backrest" and being in a standing posture. Many restaurants in the US use stools in the bar area; the findings of this study would suggest that providing chairs, instead of stools, might be more beneficial in terms of favorably influencing taste perceptions; see web appendix study 2 for details.

When individuals receive food samples at grocery stores, trade shows, and food courts, they are often in a standing posture. Our findings suggest that it might be a better idea for companies to walk around to areas where individuals are seated and offer food samples in those locations. Similarly, our findings have implications for product testing. Many food manufacturers conduct product taste tests in laboratory environments or simulated dining environments, while others allow consumers to test items in the comfort of their homes. If manufacturers need a conservative taste test, our findings suggest that they would be wise to consider the effects of posture on taste evaluations and to encourage participants to sample in a standing posture.

Our research also offers insights for consumers. First, the results of study 5 show that consumers evaluate unpleasant-tasting foods relatively more favorably when they sample in a standing (vs. sitting) posture. This finding suggests that parents might be able to make unpleasant-tasting, healthy foods seem more palatable to reluctant children by having them eat standing up (vs. sitting down). In a similar vein, it might also be beneficial to maintain a standing posture when consuming pharmaceutical products that have unpleasant tastes. Second, medical articles continue to emphasize the health benefits of standing over sitting, as standing leads to better blood circulation and reduces the likelihood of several serious illnesses, including cancer (Shmerling 2016). Our research contributes to this line of thinking and highlights how standing (vs. sitting) while eating leads to lower consumption volume.

Limitations and Future Research Avenues

To ensure stronger experimental controls, our studies were conducted in laboratory settings. Future research should examine the effects of posture on taste evaluations in field settings. Additionally, we had participants maintain the same posture throughout the sampling experience. At some cocktail parties, consumers might switch between sitting and standing postures. Can switching postures influence taste perceptions or consumption amount?

In this research we had consumers evaluate different types of foods and beverages that varied in terms of pleasantness of taste as well as healthiness level (e.g., pita chips, brownies, coffee, healthy fruit snacks). However, foods can vary along other dimensions, such as texture, transportability, or shape. Additionally, we preselected all stimuli in our studies, while in many situations, consumers select foods for themselves. Would posture influence the types of foods consumers might choose to eat? Also, attention paid to different types of foods can vary across different postures; we did not examine this in our research. Further research is needed to examine these different topic areas.

This research did not examine how individual physiological factors might moderate the effects of posture on taste perceptions and consumption. Future research should examine how individual differences (such as chronic back pain, age, or body structures) might moderate the effects of posture on food taste perceptions.

The level of significance for some of our results is marginal, and the effect sizes across all studies are small. This, by itself, is not surprising since the effects of posture are subtle and subliminal; hence, very large effect sizes would not be expected. Also, all our study sessions lasted 15 minutes or less. Longer study sessions might lead to different outcomes.

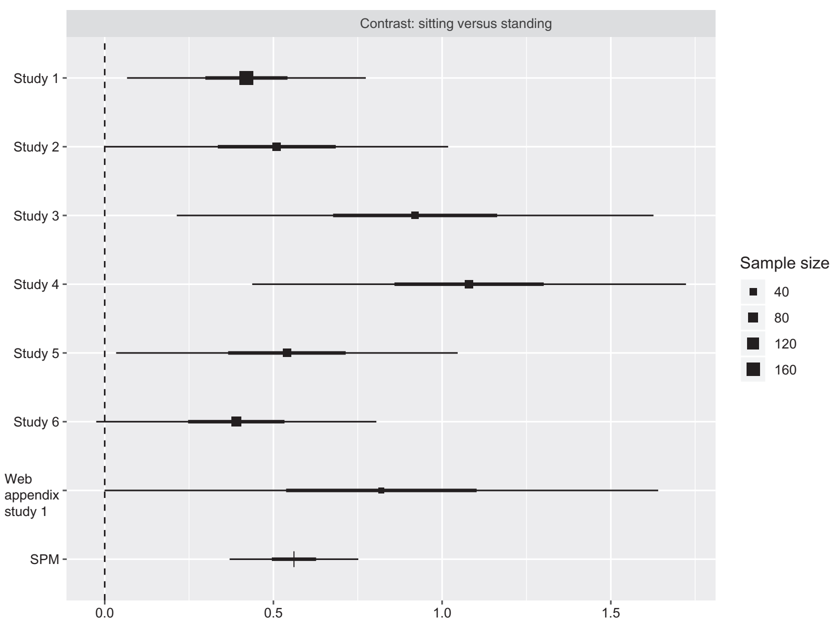
Sensory marketing is becoming a very popular area of research. However, prior research in this domain has primarily been limited to examining the main effects, interaction effects, or cross-modal effects for the five traditional sensory systems. Examining effects of the vestibular system, referred to as the sixth sensory system, would be novel and timely. Moreover, we focused on the effects of posture on food-related outcomes only; hence, there are significant opportunities to extend this to nonfood contexts. Overall, given the extremely limited amount of research on the effects of the vestibular system, there is scope for significant future work in this domain. We hope our research will spur further work in this area.

DATA COLLECTION INFORMATION

The first and third authors supervised the data collection for study 1 (in fall 2018), study 4 (in spring 2018), and web appendix study 2 (in fall 2017), at the University of South Florida, Tampa (USF). All three authors supervised the data collection for study 2 (in spring 2018), study 3 (in fall 2017), and study 5 (in spring 2018) at USF. The second author supervised the data collection for study 6 (in spring 2018) and web appendix study 1 (in fall 2016) at Portland State University. The first author analyzed the data for all the studies.

APPENDIX: SINGLE-PAPER META-ANALYSIS FOR EFFECTS OF POSTURE ON FOOD TASTE PERCEPTION

99% Impossible: A Valid, or Falsifiable, Internal Meta-Analysis



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