Fear Reduces Perceived Sweetness: Changes in the Perception of Taste due to Emotional State

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Abstract

This study manipulated the emotional state of participants by having them watch movies involving comedy, horror, and beautiful scenery. High state anxiety was triggered among the participants who watched a horror movie, and high juice consumption was confirmed among them. The perception of sweetness of the mixed juice was found to be reduced in the horror movie group compared to the other two groups, while the comedy movie group participants were found to have tasted less bitterness than did the horror movie group participants. Furthermore, the relationship between liking the juice and sweetness was found to differ according to emotional state. This study confirms that our emotional state affects our perception of taste, including that feeling fear and anxiety can reduce the perception of sweetness. These findings suggest that our emotional state may affect our perception of taste.

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Fear Reduces Perceived Sweetness: Changes in the Perception of Taste due to Emotional State.

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Abstract

The taste of food and beverages can depend on emotional state, but this may be due to changes in perception. This study manipulated the emotional state of participants by having them watch movies involving comedy, horror, and beautiful scenery. High state anxiety was triggered among the participants who watched a horror movie, and high juice consumption was confirmed among them. The perception of sweetness of the mixed juice was found to be reduced in the horror movie group compared to the other two groups, while the comedy movie group participants were found to have tasted less bitterness than did the horror movie group participants. Furthermore, the relationship

between liking the juice and sweetness was found to differ according to emotional state. This study confirms that our emotional state affects our perception of taste, including that feeling fear and anxiety can reduce the perception of sweetness. These findings suggest that our emotional state may affect our perception of taste.

Keywords

taste perception, emotional state, emotional state manipulation, sweetness

Introduction

Human beings need to eat and drink to survive, and we always perceive the taste of the things we eat and drink. This function of perceiving taste is important to select necessary nutrients, as well as to identify harmful food or beverages. We memorize the appearance of the food we put in our mouths, along with its smell and perceived taste when we eat it; we then use these food-related memories as assessment criteria for future reference to stay alive and lead a healthy lifestyle.

However, the tastes we perceive are not only influenced by the characteristics of the food and beverages themselves but also by the various contexts in which they are consumed. In fact, several research studies have reported that sound affects taste sensation. For example, Zampini and Spence (2004) verified that amplifying the loudness of the sound heard when biting potato chips or emphasizing high-frequency

sounds increased the perception of freshness and crispness. Wang and Spence (2016) found that the sweetness of mixed fruit juice was enhanced by listening to consonant soundtracks, and its sourness was enhanced by listening to dissonant soundtracks. Another study (Carvalho, Wang, Van Ee, Persoone, & Spence, 2017) found that chocolate was perceived as creamier and sweeter when participants were listening to soft or smooth sounds than when they were listening to hard or rough sounds. Concerning the relation between vision and taste, it has been reported that the flavor of strawberry mousse was perceived as sweeter and more intense when served on a white plate than when the same mousse was served on a black plate (Piqueras-Fiszman, Alcaide, Roura, & Spence, 2012). A study on beetroots determined they were rated as less sweet when their presentation was angular (i.e., three pieces of beetroot were cut into pyramids and displayed so as to form a triangle) on a square plate when compared to a rounded presentation (i.e., three pieces of beetroot were cut in half-spheres and displayed in a circle) of the same beetroots on a round plate resulted in the perception of sweeter flavor (Fairhurst, Pritchard, Ospina, & Deroy, 2015). Taken together, these findings indicate that the perception of taste can change depending on contextual factors.

The consistent finding that our perception of taste changes depending on our emotional state is something we experience in our daily lives. A recent study (Wang & Spence, 2018) showed that seeing pleasant visual stimuli such as a child's smile can

increase the perception of sweetness and seeing unpleasant stimuli such as a crying face can increase the perception of sourness. Another study (Noel & Dando, 2015) focused on fans following hockey games and examined the correlation between their satisfaction regarding the game and their evaluation of the taste of ice cream. The study found that fans tasted more sweetness when they experienced more positive emotions regarding the game and, conversely, tasted more sourness when they experienced more negative emotions regarding the game. Furthermore, the more satisfied they felt with the game, the lower they rated the creamy sensation of the ice cream. The degree of change in the perception of creaminess depending on satisfaction was found to be greater among female participants.

The results of the study (Ileri-Gurel, Pehlivanoglu, & Dogan, 2012) that measured participants' taste perception after eliciting stress using the Stroop color-word interference test and the cold pressor test indicated that the taste thresholds for sweetness and saltiness significantly decreased during stressful conditions. Meanwhile, in another study (Heath, Melichar, Nutt, & Donaldson, 2006), a 5-HT-specific reuptake inhibitor (SSRI), an agonist of serotonin receptors within the central nervous system, was administered to patients to reduce their anxiety levels. In this emotional state, there was a significant reduction in their threshold for tasting sweetness and bitterness. The findings of these two studies are conflicting in terms of the effect of stress and anxiety on the ability to detect sweetness. The reason for the difference in change of taste may

be that different neurotransmitters are involved depending on the degree of anxiety and stress experienced. However, the fact that both studies reported changes in the perception of sweetness suggests that there is some form of correlation between the emotional state and perception of sweetness.

In the current body of research, there is insufficient information regarding how a person's emotional state can affect the perception of taste. As the effects of stress and anxiety on the perception of sweetness differed in previous studies, the focus of this study was aimed specifically at the perception of taste while experiencing a feeling of anxiety (fear) and comparing this perceptual experience to taste perception while experiencing positive emotions. We included sex as a factor of analysis, as sex differences were predicted to correlate with the extent to which emotions would be aroused and impact taste sensitivity. The degree of change in the perception of taste due to emotional state was predicted to be greater in female participants

Materials and methods

Participants

The participants included 87 Japanese university and graduate school students in Japan (39 male and 48 female; aged 18 to 26 years). Of them, 29 (13 male, 16 female) were assigned to the comedy movie group, 29 (13 male, 16 female) to the scenery movie group, and 29 (13 male, 16 female) to the horror movie group. Participants were

randomly assigned to the three groups, but four female participants who declared their dislike for viewing horror movies were assigned to groups other than the horror movie group.

Prior to conducting this study, approval was obtained from the Human Research Ethics Committee of the University of Tsukuba. All participants were informed regarding what the task entailed and provided written informed consent to participate.

Taste stimulus

A juice mixture was used as a taste stimulus. The blend ratio was 1:2:2 (Dole grapefruit juice: Dole peach mix juice: KIRIN Salty lychee juice). Each sample consisted of 250 ml of juice and was served at room temperature in a 320 ml transparent plastic cup. The taste stimulus was prepared to be sweet, salty, sour, bitter, and not unpleasant, and was specifically designed to provide an unfamiliar stimulus.

Movie stimuli

Three movies were used: Delinquent Hamsters (Piso Studio) for the comedy movie group, See the World by Train (Asahi Simbun Publications Inc.) for the scenery movie group, and Honogurai Mizu No Soko Kara (KADOKAWA) for the horror movie group. Fifteen-minute excerpts were taken from each movie. These movies were chosen

to avoid extremely harsh content and in an effort to provide movies that were unlikely to be very familiar to participants (i.e., students in their 20s).

Procedure

Each participant sat in front of a computer screen with headphones and watched the movie that he or she had been assigned to watch. After doing so, participants were asked to drink the juice and evaluate the intensity of sweetness, saltiness, sourness, bitterness, and umami using a visual analog scale (VAS) ranging from 0 (no taste) to 100 (strong taste). The visual analog scale is a commonly used psychophysical measure of taste intensity perceptions (e.g., Noel & Dando, 2015; Wang & Spence, 2016). Participants also evaluated their liking of the juice using a VAS ranging from 0 (do not like) to 100 (like). After providing evaluations of the juice, each participant answered the STAI-JYZ (Hidano, Hukuhara, Iwawaki, Soga, & Spielberger, 2000), the Japanese version of the State-Trait Anxiety Inventory (STAI; Spielberger et al., 1983) used to investigate the state of anxiety caused by watching the movies. Participants could consume the juice freely while evaluating its taste and answering the STAI. While the participants were watching the movie (15 minutes) and answering the STAI (8 minutes), the experimenter waited in another room.

Results

Emotional state

STAI. Each subscale score of the STAI was compared for each group using a two-way factorial analysis of variance (ANOVA) with sex (male, female) and group (comedy, scenery, and horror movies) as factors. Regarding the mean trait anxiety score, we found no main effects of group or sex (comedy: male $M = 52.69$, $SD = 9.58$, female $M = 47.94$, $SD = 9.16$; scenery: male $M = 50.08$, $SD = 9.80$, female $M = 45.62$, $SD = 13.07$; horror: male $M = 46.54$, $SD = 11.01$, female $M = 43.94$, $SD = 11.00$). However, for state anxiety, a main effect of group was found ($F[2, 81] = 57.87$, $p < .0001$, $\eta_p^2 = .59$; Figure 1). The average state anxiety score for the horror movie group was higher than that for the other two groups(comedy: male $M = 35.07$, $SD = 4.30$, female $M = 32.12$, $SD = 6.15$; scenery: male $M = 36.46$, $SD = 7.57$, female $M = 36.5$, $SD = 8.32$; horror: male $M = 50.07$, $SD = 7.06$, female $M = 55.5$, $SD = 7.8$).

[Insert Figure 1 here.]

Consumption

Regarding consumption, a two-way factorial ANOVA with sex (male, female) and group (comedy, scenery, and horror movies) as factors showed two main effects. The horror movie group exhibited significantly higher consumption than did the other two groups ($F[2, 81] = 7.78$, $p = .0008$, $\eta_p^2 = .16$), and male participants showed higher consumption than did the female participants ($F[1, 81] = 6.18$, $p = .0149$, $\eta_p^2 = .07$; Figure 2). No interaction was found ($F[2, 81] = 2.36$, $p = .1010$, $\eta_p^2 = .06$).

[Insert Figure 2 here.]

Taste perception

Intensity and liking. Regarding the intensity of sweetness, a two-way factorial ANOVA with sex (male, female) and group (comedy, scenery, and horror movies) as factors showed a main effect of group (F[2,81] = 8.10, p = .0006, η_p^2 = .17; Figure 3). We found no effect of sex (F[1, 81] = 0.92, p = .3391, η_p^2 = .01) and no interaction (F[2, 81] = 0.44, p = .6454, η_p^2 = .01)..

[Insert Figure 3 here.]

Regarding the intensity of bitterness, two main effects were found. The horror movie group's score was significantly higher than that of the comedy movie group's score (F[2, 81] = 3.40, p = .0379, η_p^2= .08), and the male participants' mean score was higher than that of the female participants (F[1, 81] = 6.77, p = .0110, η_p^2 = .07; Figure 4). No interaction was found (F[2, 81] = 1.75, p = .1806, η_p^2= .04). There were no significant group or sex differences in the intensity of saltiness, sourness, or umami, or in the level of liking the juice.

[Insert Figure 4 here.]

Relationship between liking and sweetness. The results of the examination of the correlation between taste intensity and pleasantness using a Pearson's correlation analysis revealed that sweetness intensity was positively correlated with the pleasantness of the juice for the scenery movie group (r = .60, p = .0006). However, there were no significant correlations for the comedy (r = .14, p = .4406) or horror movie group (r = .36, p = .0529). The scores for sweetness and liking are shown in Figure 5. There was also no correlation between the level of liking the juice and consumption level for any group (comedy: $r = .01$, $p = .9499$; scenery: $r = .02$, $p = .9124$; horror; $r = .00$, $p = .9840$).

[Insert Figure 5 here.]

Discussion

The aim of this study was to examine differences in the perception of taste depending on emotional state. The emotional state of the study's participants was manipulated by the type of movie they were assigned to watch. The state anxiety score of the STAI confirmed that watching a horror movie aroused state anxiety among the participants. Meanwhile, no main effect of movie group was observed in the trait anxiety score, so there was no difference overall between the groups in terms of a tendency toward anxiety as a personal characteristic. We also observed that the juice

consumption of the horror movie group was significantly higher than that of the other two groups. This could be attributed to the participants' bodies being in a state of tension, causing their parasympathetic nervous systems to function weakly, which, in turn, caused them to be thirsty.

Anxiety was found to impact the perception of sweetness, as the sweetness evaluation score of the horror movie group was significantly lower than that of the other two groups. This finding complements a previous study (Heath et al., 2006) that found that reducing anxiety increases sensitivity to sweetness. Herman and Polivy (1975) found that people who lacked self-control (those who were unrestrained) consumed larger quantities of ice cream when in a state of high than low anxiety. This may imply that high anxiety reduces the perceived intensity of ice cream's sweetness, leading the participants in the aforementioned study to consume large quantities of ice cream in pursuit of satisfaction in terms of sweetness.

A significant difference was observed in the intensity of bitterness tasted by the comedy and horror movie groups; correspondingly, the perception of bitterness was found to change depending on the participants' emotional state. However, as neither group was significantly different from the scenery movie group, it is impossible to draw conclusions about the following two possibilities: (i) the emotional state aroused by watching a comedy movie suppressed the taste of bitterness; (ii) the emotional state aroused by watching a horror movie increased the taste of bitterness. Additionally, male

participants rated the intensity of bitterness significantly higher than did female participants. This finding contradicted that of a previous study (Fischer et al., 2013) that found that female participants rated bitterness higher than did male participants. Given that the morphology of bitter-taste receptors is inherent, there may indeed be a sex difference. However, no sex difference was observed in sweetness and umami perceptions even though their respective receptors are similar to those of bitterness. This potential sex-based difference needs to be considered in future relevant studies. In this study, the degree of change in perception of taste due to emotional state was predicted to be greater in female participants. However, that hypothesis could not be confirmed.

No main effects according to group or sex were observed for the intensity of saltiness, sourness, or umami. However, previous studies (Ileri-Gurel et al., 2012) have shown that stress can cause the threshold for saltiness to decline, and the taste of sourness can increase after being exposed to dissatisfying or unpleasant stimuli (Noel & Dando, 2015; Wang & Spence, 2016, 2018).

In terms of juice consumption, female participants consumed less juice than did male participants, which was attributed to the different perceptions of men and women surrounding the consumption of large quantities of food and drink in front of others. This suggests that social desirability effects caused female participants to suppress their intake to only a low consumption level. As no correlation was observed between

consumption and liking the juice for any group, it is also unlikely that the liking of the juice variable affected consumption.

No difference was observed between groups in terms of liking the juice. This indicates that emotional state affects the perception of each flavor without changing the level of liking of the taste stimuli themselves. Furthermore, a positive correlation was observed between sweetness and liking the juice for only the scenery movie group, and no significant correlation was found for the other two groups. Since sweetness releases narcotic-like substances such as β-endorphin in the brain, it is considered a desirable taste. According to direct reports, 90% and 69% of the participants who had watched the comedy and scenery movies, respectively, reported that the movie was interesting. Therefore, participants who had watched the comedy movie were considered to have been in a relatively positive emotional state and suggests that a change in emotional state weakens the correlation between sweetness and level of liking regardless of whether the emotional state is positive or negative.

Conclusions

This study confirmed that emotional state affects the perception of taste, including that the emotion of fear can suppress the taste of sweetness. Furthermore, the correlation between the perception of taste and the liking of the stimuli was found to vary depending on emotional state. Future studies should investigate what kinds of

psychological and physical changes serve as mechanisms by which emotional state affects the perception of taste. Similarly, we need to consider the possibility that the perception of taste differs according to the specific type of stress or anxiety endured. Furthermore, our findings are only applicable to the specific taste stimuli used in this study; thus, the changes observed in this experiment cannot be generalized to other taste stimuli. Even when restricted to the characteristics of food and beverages themselves, our perception of the taste of food and beverages is formed by various elements that were not measured in this study, including sharpness, astringency, texture, and temperature. In future research, we need to consider the effects of emotional state with a more realistic tasting experience that includes these various elements.

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