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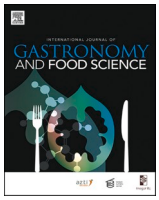

Emotions shape taste perception in a real restaurant environment

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ABSTRACT

Can emotions make your drink taste sweeter, bitterer, or more sour? Previous laboratory studies show that incidental emotions – emotions that are unrelated to the situation at hand – can influence taste perception. For example, people who recall a happy memory before tasting food may find it sweeter than after recalling a sad memory. However, outside of the confines of the laboratory, little research has examined how integral emotions – emotions that are directly tied to the situation at hand – can be used to shape consumers' experiences. We recruited 231 participants for a drink-tasting session at Copenhagen's Alchemist restaurant, where dining is accompanied by a 360-degree immersive visual experience projected into a dome ceiling. Unbeknownst to the participants, there were only two different drinks (one kombucha and one water kefir) that participants tasted each twice, while immersive scenes designed to elicit positive or negative feelings were projected. Results showed that the same beverage tasted less sweet and more bitter and sour when accompanied by an unpleasant emotional scene. These findings demonstrate that emotions, when elicited as part of a real-world multisensory gastronomic experience, can shape our taste perceptions.

1. Introduction

Imagine sitting in the sophisticated ambiance of Copenhagen's Alchemist restaurant, an enchanting beverage cradled in your hand. Suddenly, the domed ceiling above transforms into a 360-degree video projection of the ethereal Northern Lights. The spectacular dance of colors across the 'sky' ignites pleasant emotions that appear to deepen the flavors of your drink. Now, picture a stark shift in the scene. The serene Northern Lights are replaced with a graphic video from a chicken slaughter factory, immediately eliciting unpleasant emotions. How might this abrupt change in emotional state alter the perceived sweetness, sourness, bitterness, saltiness, and acidity quality of your drink? These scenarios set the stage for an intriguing scientific question: How does our emotional state shape taste perception, especially when manipulated by immersive experiences?

Decades of research demonstrated the intimate connection between taste and emotions. These links are so deeply ingrained in our experiences that most people routinely use taste descriptors like "sweet," "bitter," or "spicy" to depict our emotional states (Chan et al., 2013; Vainik, 2018). This linguistic bond is not just metaphorical. As vividly exemplified by Proust's Madeleine, food can trigger powerful emotions (e.g., Mielmann and Brunner, 2022). Taste is indeed a complex experience, activating a range of neural activities that can evoke pleasure or displeasure, such as the sweet enjoyment of a dessert or the fiery burn of a hot pepper (see Mastinu et al., 2023 for review). Remarkably, this taste-emotion connection extends beyond mere affective valence to influence even our moral emotions. For example, research shows that individuals who consume a bitter beverage tend to rate moral transgressions as more morally repugnant than those who drink a sweet beverage or water (Eskine et al., 2011).

While it is clear that taste can trigger emotions, initial—and relatively small scale—research suggests that emotions can also influence our taste perception. For instance, participants exposed to an anxiety-provoking horror movie ($N = 29$) before tasting a mix of fruit juices found the beverage less sweet than participants exposed to a comedy movie or a neutral documentary (Zushi et al., 2021). Similarly, after exposure to acute stressors ($N = 38$), participants rate umami and sweet solutions as less intense (Al'absi et al., 2012). Conversely, people's ability to detect and respond to bitterness, a taste associated with harmful and toxic substances (Schienle et al., 2015), increases among participants exposed to a stressful noise ($N = 14$) compared to control participants (Dess and Edelheit, 1998).

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Going beyond stress, other studies have examined the broader effects of positive and negative affect on taste perceptions. For example, in a lab experiment that involved repeated tasting of different water solutions after watching sad, happy, and neutral movie clips, researchers found that both positive and negative moods increased the perception of citric acid compared to the neutral condition (Platte et al., 2013). However, the authors did not observe differences in sucrose, glutamate, quinine, and fat perceptions. In a more naturalistic study, hockey fans celebrating wins or licking wounds after losses were asked to rate different ice cream flavors (Noel and Dando, 2015). Fans' positive emotions correlated with enhanced sweet taste and lessened sour flavors, whereas negative emotions, on the other hand, correlated with lessened sweet taste and enhanced sour flavors.

These findings attest to the profound interplay between our emotional and gustatory—taste—systems. However, the current body of research, largely conducted with small samples in controlled laboratory settings, raises questions about its applicability to real-world situations, such as in the context of a meal at a restaurant.

First, existing studies have primarily induced emotions in *incidental* ways, such as by showing participants films, having them write about memories, or exposing them to unpleasant noise before tasting (Zhou and Tse, 2022; Zushi et al., 2021). This contrasts with the induction of emotions in an *integral* manner, where emotions are directly tied to the situation participants are in, such as the consumption experience itself. This distinction is crucial for two main reasons. Incidental emotion effects on judgment are often weak and inconsistent, while integral emotion effects are typically more robust (Ferrer and Ellis, 2021). The use of incidental methods might explain the mixed and sometimes inconclusive results on how positive and negative emotions affect taste perception (Platte et al., 2013; Zhou and Tse, 2022). Additionally, even if incidental emotions do influence taste, these methods are unlikely to be relevant to the food and hospitality industries. For instance, it would be impractical for restaurants to have diners recall autobiographical memories or serve food based on sports team victories.

Second, many studies employ highly controlled but unconventional taste stimuli, such as water solutions with varying sweetness or acidity levels. This doesn't translate well to understanding how emotions affect the taste of real food and drinks people consume daily.

Finally, past research has been limited in scope, often focusing solely on specific taste dimensions like sweetness or bitterness. This neglects the potential influence of emotional states on other essential aspects of taste, such as acidity or saltiness. Expanding the research to encompass these dimensions would provide a more comprehensive understanding of the complex interaction between emotion and taste.

Establishing robust and naturalistic evidence for the notion that people's emotional states shape how sweet, sour, bitter, salty, and savory they experience the same food or drinks is not only important to our understanding of human taste judgment but also has significant implications for theories of emotion. According to the appraisal-tendency framework (Lerner and Keltner, 2000, 2001), different emotions carry specific appraisal tendencies that guide cognitive processing in a way congruent with the emotion (Lerner et al., 2015). For instance, fear, associated with uncertain threats, leads to risk-averse choices, while anger, associated with certain threats and clear attribution, leads to risk-seeking choices (Lerner and Keltner, 2000). Similarly, pride fosters attributing favorable events to one's own efforts, whereas surprise fosters attributing favorable events as unpredictable and outside one's own control. As a result, pride increases perceptions of one's own responsibility, and surprise increases perceptions of others' responsibility, even when the judgment is unrelated to the source of the pride or surprise (Lerner et al., 2015). However, demonstrating that people's emotional states influence sensory perception would show that emotions don't just shape how we think and make decisions, but also how we perceive basic sensory information from the world around us. Providing initial evidence for this idea, Rauwolf et al. (2021) aimed to induce uncertainty by telling participants their compensation would be determined by die roll at the end of the study before asking them to taste different sucrose solutions. Participants in the uncertainty condition with an initial preference for sweet tastes showed a heightened perception of sweetness than participants in the control condition. Examining the broader dimension of positive vs. negative affect would represent a significant advancement in our understanding of the scope of emotion's impact on human experience. With this aim, our study seeks to examine how emotional states, induced in a real-world restaurant environment, influence taste perception.

2. Method

2.1. Participants

As part of a larger study on dining and emotion, we recruited a convenience sample of 231 participants (M_{age} = 28.19; SD_{age} = 9.11; 51% men, 44% women, 5% other/prefer not to say) from different universities and culinary institutions in Copenhagen for a free non-alcoholic drink-tasting experience at 2-Michelin stars restaurant *Alchemist*—one of the best restaurants in the world at the time of the study (OAD, 2022). Alchemist, with its focus on holistic cuisine, provides a unique setting where dining is accompanied by a 360-degree immersive visual experience projected into the restaurant's 18-m-wide planetarium dome ceiling. Participants were told that Chef Rasmus Munk and Alchemist's R&D team are developing new drinks and invited volunteers to taste them. Participants were randomly assigned to the control (N = 97) or the experimental condition (N = 134) in small groups (M = 15.5 people; SD = 6.6; min = 7; max = 30) across three days, during which the dome was exclusively used for the tastings. Although recruitment was opportunistic, simulation-based power analysis for our mixed model indicated that our sample size was adequate to detect small to moderate effects (r = .20).

2.2. Drink preparation and tasting

The tasting featured four non-alcoholic fermented beverages, namely kombucha and water kefir. We opted for these drinks instead of more familiar options like wine, beer, or treats like ice cream and chocolate, for which people might already have established taste preferences and emotional associations.

For the kombucha base, we mixed organic cane sugar and hot water (90 °C) and stirred in milky oolong tea leaves for 5 min. After cooling the mixture to 35 °C, we added the kombucha SCOBY and fermented it at 24 °C for four days. To create the second infusion, we added dried hibiscus and dried blueberries to the strained milky oolong kombucha base and infused it for 24 h at 2 °C. Afterward, the kombucha was strained and stored in sterilized 1-L glass bottles at 2 °C.

For the water kefir base, we mixed sucrose, dried figs, raisins, lemons, water kefir grains, and water and fermented it at 24 °C for 48 h. After fermentation, we added dried hibiscus and dried blueberries to the strained water kefir base and infused it for 24 h at 2 °C. Finally, the water kefir was strained and stored in sterilized 1-L glass bottles at 2 °C.

Participants tasted and rated each drink on four dimensions: sweet, sour, salty, and bitter, using a 7-point scale ranging from 1 (not at all) to 7 (a great deal), with whole numbers for intermediate ratings. We chose to focus on these four primary taste dimensions and excluded the fifth taste, "umami," as research indicates that "umami" is not universally understood, with many individuals in Western contexts struggling to identify or label this taste (e.g., Hartley et al., 2019; Yamaguchi and Ninomiya, 2000).

The samples were served in 20 ml tasting glasses. Unbeknownst to the participants, there were only two different drinks: one kombucha and one water kefir. That is, participants tasted the same drinks twice, allowing us to tease apart the emotional influence on taste perception from the actual differences in drinks. Consistent instructions were provided across the conditions. The entire experiment, including

instructions, seating, and debriefing, took around 30 min.

2.3. Emotion induction

As shown in Fig. 1, emotions were induced by projecting different scenes (i.e., 360-degree audiovisual content) onto the dome for each drink. In the *control* condition, the dome displayed in random order four pleasant scenes depicting corals, butterflies, cherry blossoms, and a theatre stage, respectively. In the *experimental* condition, the dome displayed three pleasant scenes above and one unpleasant scene depicting either caged chickens or eyeballs, all at random. The unpleasant scene was displayed during the second or third tasting, also randomized. Each scene lasted approximately 2 min, during which participants tasted the drink and simultaneously rated it.

Our choice to use a pleasant environment instead of a neutral control condition was driven by practical considerations. Given the notoriety of Alchemist and its dome ceiling in Denmark, a neutral environment might have led to unmet expectations, inadvertently inducing negative emotions among participants. We reasoned that a positive environment (vs. a potentially awkward, plain white dome) would provide a more realistic baseline for our experiment.

All the scenes were designed by Alchemist's design studio and are used, as part of a larger set, in the restaurant's regular dining experience. We chose these specific scenes based on a pretest (see the candidate scenes in appendix, Figs. A1–A9). In short, we asked an independent sample of participants ($N = 144$) to watch recordings of nine candidate scenes and report, among other variables, how the videos made them feel on a 101-point affect valence slider ranging from unpleasant to pleasant (adapted from Betella and Verschure, 2016; see Figure A12). Scenes depicting caged chickens ($M_{valence} = 10.77$, $SD_{valence} = 13.28$) and eyeballs ($M_{valence} = 18.09$, $SD_{valence} = 19.84$) were rated as the most unpleasant, all below the scale midpoint. In contrast, scenes depicting corals ($M_{valence} = 78.81$, $SD_{valence} = 19.95$), butterflies ($M_{valence} = 76.72$, $SD_{valence} = 20.68$), cherry blossoms ($M_{valence} = 76.17$, $SD_{valence} = 17.95$), and the theatre stage ($M_{valence} = 64.30$, $SD_{valence} = 24.85$) were rated as the most pleasant, all above the scale midpoint.

2.4. Analytical strategy

Due to the nested structure of the dataset, with repeated measures for each participant, we used linear mixed-effects models in R using the *lme4* package to analyze the impact of emotion on taste perception. Our models included both fixed effects for emotion (pleasant or unpleasant dome content) and drink type (kombucha or water kefir), and random intercepts accounting for individual variations among participants. Separate models were computed for each of our four taste dimensions: sweet, sour, salty, bitter, and acidic, to independently assess the effects on each aspect of taste perception.

3. Results

As depicted in Fig. 2, results from our linear mixed models revealed that the emotional valence of the dome content had meaningful effects on our four taste dimensions.

For sweetness, the model revealed significant main effects of dome valence and drink type. Participants rated drinks as significantly less sweet when tasted under the unpleasant emotion condition ($b = -.370$, $t(750.65) = -3.346$, $p < .001$). Participants also rated kombucha as significantly sweeter than water kefir ($b = .881$, $t(690.21) = 11.845$, $p < .001$).

For sourness, there was a significant main effect of dome valence, with drinks tasted during an unpleasant emotional scene being rated as sourer ($b = .275$, $t(745.25) = 2.586$, $p = .01$). The effect of drink type on sourness was not significant ($b = .106$, $t(689.80) = 1.492$, $p = .136$).

The analysis of saltiness showed a significant main effect of drink type, with kombucha being rated as saltier than water kefir ($b = .246$, $t(688.77) = 3.913$, $p < .001$). However, dome valence did not significantly affect the perception of saltiness ($b = .052$, $t(736.50) = .558$, $p = .577$).

Regarding bitterness, significant main effects were observed for both dome valence and drink type. Drinks tasted under the unpleasant emotion condition were rated as more bitter ($b = .636$, $t(736.99) = 5.978$, $p < .001$), and kombucha were rated as less bitter than water kefir

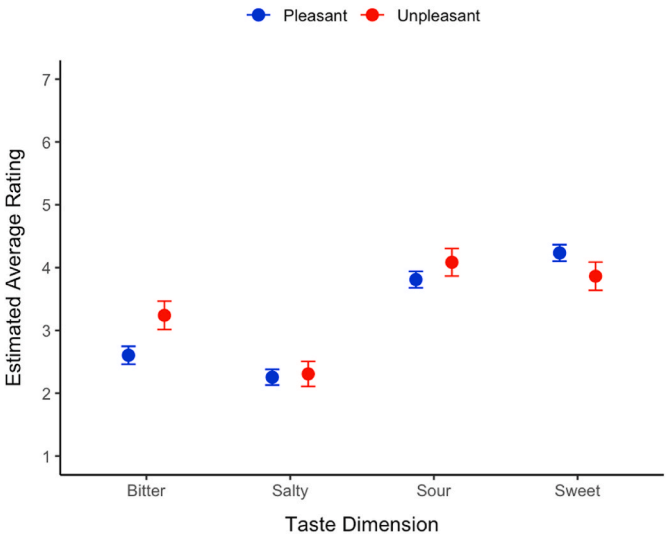

Fig. 2. Drinks average taste profile under pleasant and unpleasant emotion induction.
Note. Error bars depict 95% Confidence Intervals.

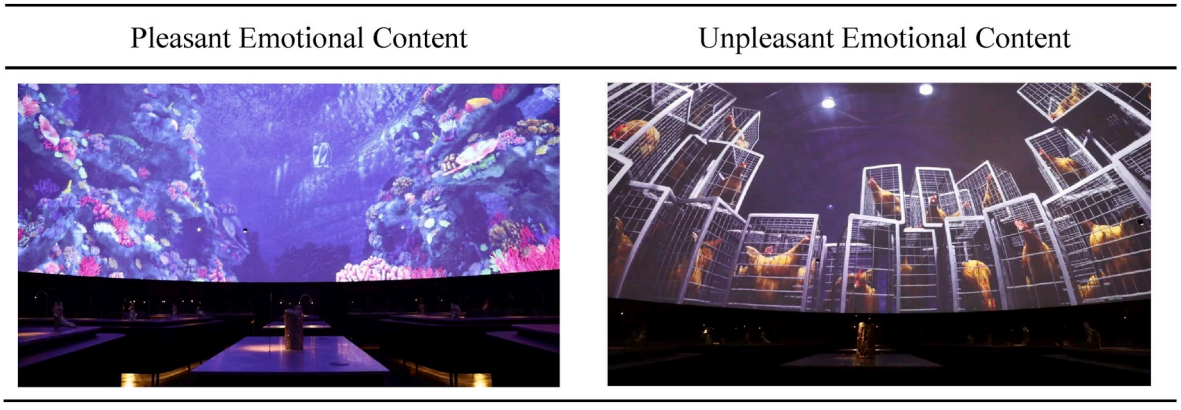

Fig. 1. Examples of pleasant (corals) and unpleasant (caged chickens) emotional scenes projected into the dome ceiling during the tasting.

($b = -.280$, t (690.33) $= -3.941$, $p < .001$).

Finally, we examined whether the emotion manipulation had distinct effects for kombucha and kefir. There was no significant interaction between drink type and emotional manipulation on any taste perception dimension (all $ps > .10$), suggesting that the emotional manipulation influenced taste perceptions similarly across both drinks.

4. Discussion

Taken together, our data suggest that an unpleasant emotional state can enhance the perception of sourness, bitterness, and acidity, while diminishing the perceived sweetness of beverages. Remarkably, these effects were observed within the same individual tasting the same beverage twice under differing emotional contexts. Only three participants suspected they were tasting the same drink twice. This suggests that not only does our emotional state modulate our sensory experience, but it can also do so to a degree that the same stimulus can be perceived as fundamentally different. These findings have both theoretical and practical implications.

Our findings align with recent top-down, prediction-based models of perception and affect, which propose that the brain actively constructs our sensory experiences using prior knowledge and context rather than passively receiving information from the environment (Barrett and Simmons, 2015; Joffily and Coricelli, 2013; Seth, 2013). Continuously processing all sensory inputs is inefficient for our brains because neural signaling is metabolically expensive. Instead, the brain optimizes perception by predicting which incoming sensations are most likely in a given context (Clark, 2013; Friston, 2010; Hohwy, 2013). To make these predictions, the brain runs an internal model of the body in the world, built from statistical regularities in sensory data from both outside and inside the body. Our affective states essentially represent summary information reflecting the integration of incoming sensory information from the external world with the somatovisceral, kinesthetic, proprioceptive, and neurochemical homeostatic fluctuations that occur within the body. These affective states help us navigate the world by predicting reward and threat (Barrett and Bliss-Moreau, 2009; Barrett, 2017). Due to its connection with precise interoceptive signals, affect is a strong driver of perceptual predictions, regardless of the properties of the external stimuli. Our study supports this interpretation, showing that affect induced through the visual system influenced affect-congruent perceptions of external stimuli (i.e., drinks) through the gustatory system. This finding underscores the powerful influence of affect on sensory perception and highlights the brain's ability to alter sensory experiences based on emotional context.

While our study provides valuable insights into the interplay between emotional states and taste perception, several limitations should be considered. First, the study was conducted in a world-renowned restaurant featuring a planetarium-like dome that creates a highly immersive environment. Less technologically advanced forms of emotion induction or more typical dining settings may not produce effects of similar magnitude, potentially limiting the generalizability of our findings. Additionally, although we ensured during recruitment that participants who had previously dined at Alchemist were not included in the study, it is possible that the volunteers we recruited were more interested in or familiar with high-end dining than the general population. Future research should explore how varying levels of exposure to unusual or immersive dining environments moderates the influence of emotions on taste perception.

Second, our choice of a pleasant environment instead of a neutral control condition, driven by practical considerations, introduces challenges in interpreting whether positive affect diminishes or negative affect amplifies certain taste perceptions. While positive affect and negative affect often exhibit opposing effects across various domains (e.g., decision-making, motivation, and attention; Watson et al., 1988), research suggests that these are unipolar, distinguishable dimensions rather than endpoints of a single continuum (Russell and Carroll, 1999). Future research could benefit from incorporating a neutral control condition to provide a clearer reference point and further disentangle the unique contributions of positive and negative affect to taste perception. Additionally, our experimental design did not fully disentangle the effects of emotional valence from arousal, as these dimensions often interact. Research indicates a V-shaped relationship between arousal and valence, with higher arousal linked to extreme positive or negative emotions (Kuppens et al., 2013). Future studies should sample across the four affective space quadrants to disentangle their respective influences on taste perception.

Third, while our findings showed that taste perceptions were congruent with the induced affective states—positive affect enhancing perceptions of sweetness and reducing sourness, and negative affect doing the opposite—the underlying mechanisms remain unclear. Future research is needed to test whether these associations are rooted in universal, fundamental biological processes or are learned and thus culturally dependent. For instance, in East Asian cultures, positivity is not always considered the ideal emotional state (Tsai, 2017), as these cultures emphasize balance and harmony, including the acceptance of negative emotions (Miyamoto et al., 2010). This cultural perspective could lead to different affect-taste associations, where positive affect might not enhance certain tastes in the same way as in Western contexts.

Additionally, individual differences in both taste preferences and emotional processing could have influenced participants' responses. Personality traits, such as extraversion and neuroticism, which shape how people experience positive and negative affect, may have moderated their taste perceptions. Baseline taste preferences and prior conceptual associations with specific tastes might also interact with emotional context, further shaping the way participants perceived flavors.

Fourth, we relied on pre-test data instead of real-time emotion monitoring to avoid inadvertently regulating participants' emotional responses, as naming emotions can diminish their intensity and influence (Lieberman et al., 2007). However, this approach limits our understanding of how emotions unfolded during the experiment. Non-intrusive real-time monitoring (e.g., skin conductance) could offer deeper insights into the intensity, individual differences, and dynamics of emotional responses, shedding light on the temporal interplay between emotions and taste perception.

Finally, our emotional experiences are typically complex and multifaceted (Trampe et al., 2015). More work is needed to fully understand how specific emotions and their blends (e.g., curiosity mixed with bittersweet nostalgia) might compound to shape our taste perceptions. The complexity of human emotions means that the simple positive-negative dichotomy used in our study may not capture the full range of emotional influences on taste perception.

5. Conclusions

This study explored the influence of emotional states, induced through immersive visual experiences, on taste perception in a real-world restaurant environment. Our findings demonstrate that affect significantly impacts various dimensions of taste perception, including sweetness, sourness, bitterness, and acidity. These results extend the current understanding of the emotion-taste relationship, which has predominantly been examined in controlled laboratory settings, by providing evidence from a naturalistic dining context.

Moving forward, our research calls for further studies exploring a broader spectrum of emotions across a wider range of hospitality settings and cultural contexts. By demonstrating that emotions not only shape decision-making but also influence our sensory experiences, this study highlights the potential for leveraging emotional cues to enhance customers' culinary experiences. Chefs, restaurateurs, and food marketers can use these insights to develop innovative strategies that cater to the emotional aspects of gustatory exploration.

CRediT authorship contribution statement

Sandra Sinem Kaya: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Rasmus Munk:** Supervision, Resources. **Diego Prado:** Project administration, Conceptualization. **Jordi Quoidbach:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Formal analysis, Conceptualization.

6. Implications for gastronomy

This study could have significant implications for the food and hospitality industry. With a growing interest in experiential dining (Rodríguez et al., 2022; Spence, 2022; Spence and Youssef, 2022), manipulating emotions through ambient factors like audiovisual content could be a powerful tool for enhancing customers' gustatory experiences (Spence et al., 2019; Kantono et al., 2019). Chefs and restaurateurs can create dining experiences that consider the emotional impact of the environment, pairing menu items with ambiance and visual elements that enhance certain taste perceptions.

Our research also emphasizes the importance of considering emotional context in taste tests and product development. Traditional product development often occurs in neutral lab settings, which may not reflect the emotional states in which consumers experience the products. This mismatch can result in suboptimal formulations. For instance, determining the ideal sugar level for a new champagne in a lab might suggest higher sugar content for desired sweetness. However, since champagne is typically consumed during joyful celebrations, where elevated emotional states enhance sweetness perception, the champagne might taste overly sweet in real-world contexts. To address these discrepancies, product developers should simulate the emotional contexts in which products will be consumed during taste tests. This approach ensures that products align more closely with consumers' affectively-laden taste preferences, leading to formulations that better match real-world experiences. Lastly, leveraging emotional contexts can be an effective strategy for promoting healthier eating habits or enhance the sensory experience of lower-carb food.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijgfs.2024.101080.

Data availability

The data and R-code for this study are available at https://researchbox.org/3055&PEER_REVIEW_passcode=VKIQOQ.

References

Al'Absi, M., Nakajima, M., Hooker, S., Wittmers, L., Cragin, T., 2012. Exposure to acute stress is associated with attenuated sweet taste. Psychophysiology 49 (1), 96–103. https://doi.org/10.1111/j.1469-8986.2011.01289.x.

Barrett, L.F., 2017. The theory of constructed emotion: an active inference account of interoception and categorization. Soc. Cognit. Affect Neurosci. 12 (1), 1–23. https://doi.org/10.1093/scan/nsw154.

Barrett, L.F., Bliss-Moreau, E., 2009. Affect as a psychological primitive. Adv. Exp. Soc. Psychol. 41, 167–218. https://doi.org/10.1016/S0065-2601(08)00404-8.

Barrett, L.F., Simmons, W.K., 2015. Interoceptive predictions in the brain. Nat. Rev. Neurosci. 16 (7), 419–429. https://doi.org/10.1038/nrn3950.

Betella, A., Verschure, P.F., 2016. The affective slider: a digital self-assessment scale for the measurement of human emotions. PLoS One 11 (2), e0148037.

Chan, K.Q., Tong, E.M.W., Tan, D.H., Koh, A.H.Q., 2013. What do love and jealousy taste like? Emotion 13 (6), 1142–1149. https://doi.org/10.1037/a0033758.

Clark, A., 2013. Whatever next? Predictive brains, situated agents, and the future of cognitive science. Behav. Brain Sci. 36 (3), 181–204. https://doi.org/10.1017/S0140525X12000477.

Dess, N.K., Edelheit, D., 1998. The bitter with the sweet: the taste/stress/temperament nexus. Biol. Psychol. 48 (2), 103–119. https://doi.org/10.1016/S0301-0511(98)00014-3.

Eskine, K.J., Kacinik, N.A., Prinz, J.J., 2011. A bad taste in the mouth: gustatory disgust influences moral judgment. Psychol. Sci. 22 (3), 295–299. https://doi.org/10.1177/0956797611398497.

Ferrer, R.A., Ellis, E.M., 2021. Preliminary evidence for differential effects of integral and incidental emotions on risk perception and behavioral intentions: a meta-analysis of eight experiments. J. Behav. Decis. Making 34 (2), 275–289. https://doi.org/10.1002/bdm.2209.

Friston, K., 2010. The free-energy principle: a unified brain theory? Nat. Rev. Neurosci. 11 (2), 127–138. https://doi.org/10.1038/nrn2787.

Hartley, I.E., Liem, D.G., Keast, R., 2019. Umami as an 'alimentary' taste. A new perspective on taste classification. Nutrients 11, 182. https://doi.org/10.3390/nu11010182.

Hohwy, J., 2013. The Predictive Mind. OUP, Oxford.

Joffily, M., Coricelli, G., 2013. Emotional valence and the free-energy principle. PLoS Comput. Biol. 9 (6), e1003094. https://doi.org/10.1371/journal.pcbi.1003094.

Kantono, K., Hamid, N., Shepherd, D., Lin, Y.H.T., Skiredj, S., Carr, B.T., 2019. Emotional and electrophysiological measures correlate to flavour perception in the presence of music. Physiol. Behav. 199, 154–164. https://doi.org/10.1016/j.physbeh.2018.11.012.

Kuppens, P., Tuerlinckx, F., Russell, J.A., Barrett, L.F., 2013. The relation between valence and arousal in subjective experience. Psychol. Bull. 139, 917–940. https://doi.org/10.1037/a0030811.

Lerner, J.S., Li, Y., Valdesolo, P., Kassam, K.S., 2015. Emotion and decision making. Annu. Rev. Psychol. 66, 799–823. https://doi.org/10.1146/annurev-psych-010213-115043.

Lerner, J.S., Keltner, D., 2001. Fear, anger, and risk. J. Pers. Soc. Psychol. 81 (1), 146–159. https://doi.org/10.1037/0022-3514.81.1.146.

Lerner, J.S., Keltner, D., 2000. Beyond valence: toward a model of emotion-specific influences on judgement and choice. Cognit. Emot. 14, 473–493. https://doi.org/10.1080/026999300402763.

Lieberman, M.D., Eisenberger, N.I., Crockett, M.J., Tom, S.M., Pfeifer, J.H., Way, B.M., 2007. Putting feelings into words. Psychol. Sci. 18 (5), 421–428. https://doi.org/10.1111/j.1467-9280.2007.01916.x.

Mastinu, M., Melis, M., Yousaf, N.Y., Barbarossa, I.T., Tepper, B.J., 2023. Emotional responses to taste and smell stimuli: self-reports, physiological measures, and a potential role for individual and genetic factors. J. Food Sci. 88 (S1), A65–A90. https://doi.org/10.1111/1750-3841.16300.

Mielmann, A., Brunner, T.A., 2022. Linking the sensory taste properties of chocolate-based biscuits to consumers' emotions: a cross-cultural study. Appl. Sci. 12 (16), 8038. https://doi.org/10.3390/app12168038.

Miyamoto, Y., Uchida, Y., Ellsworth, P.C., 2010. Culture and mixed emotions: Co-occurrence of positive and negative emotions in Japan and the United States. Emotion 10 (3), 404–415. https://doi.org/10.1037/a0018430.

Noel, C., Dando, R., 2015. The effect of emotional state on taste perception. Appetite 95, 89–95. https://doi.org/10.1016/j.appet.2015.06.003.

OAD, 2022. Europe top restaurants. https://www.oadguides.com/lists/europe/top-restaurants/2022.

Platte, P., Herbert, C., Pauli, P., Breslin, P.A., 2013. Oral perceptions of fat and taste stimuli are modulated by affect and mood induction. PLoS One 8 (6), e65006. https://doi.org/10.1371/journal.pone.0065006.

Rauwolf, P., Millard, S.K., Wong, N., Witt, A., Davies, T.J., Cahill, A.M., Madden, G.J., Parkinson, J.A., Rogers, R.D., 2021. "Just not knowing" can make life sweeter (and saltier): reward uncertainty alters the sensory experience and consumption of palatable food and drinks. J. Exp. Psychol. Gen. 150 (10), 2015–2035. https://doi.org/10.1037/xge0001029.

Rodríguez, G.E., Arboleya, J.C., Prado, D., Munk, R., Valerón, N.R., 2022. Bioluminescence experience in the holistic cuisine: making contact through living light and sound. Int. J. Gastron. Food Sci. 31, 100641. https://doi.org/10.1016/j.ijgfs.2022.100641.

Russell, J.A., Carroll, J.M., 1999. On the bipolarity of positive and negative affect. Psychol. Bull. 125 (1), 3.

Schienle, A., Arendasy, M., Schwab, D., 2015. Disgust responses to bitter compounds: the role of disgust sensitivity. Chemosensory perception 8, 167–173.

Seth, A.K., 2013. Interoceptive inference, emotion, and the embodied self. Trends Cognit. Sci. 17 (11), 565–573. https://doi.org/10.1016/j.tics.2013.09.007.
Spence, C., 2022. On the use of ambient odours to influence the multisensory experience of dining. Int. J. Gastron. Food Sci. 27, 100444. https://doi.org/10.1016/j.ijgfs.2021.100444.
Spence, C., Reinoso-Carvalho, F., Velasco, C., Wang, Q.J., 2019. Extrinsic auditory contributions to food perception & consumer behaviour: an interdisciplinary review. Multisensory Res. 32 (4–5), 275–318.
Spence, C., Youssef, J., 2022. On the rise of shocking food. Int. J. Gastron. Food Sci. 30, 100615. https://doi.org/10.1016/j.ijgfs.2022.100615.
Trampe, D., Quoidbach, J., Taquet, M., 2015. Emotions in everyday life. PLoS One 10 (12), e0145450. https://doi.org/10.1371/journal.pone.0145450.
Tsai, J.L., 2017. Ideal affect in daily life: implications for affective experience, health, and social behavior. Current Opinion in Psychology 17, 118–128.
Vainik, E., 2018. Emotion meets taste: taste-motivated emotion terms in Estonian. Folklore: Electronic Journal of Folklore (71), 129–154.
Watson, D., Clark, L.A., Tellegen, A., 1988. Development and validation of brief measures of positive and negative affect: the PANAS scales. J. Pers. Soc. Psychol. 54 (6), 1063.
Yamaguchi, S., Ninomiya, K., 2000. Umami and food palatability. J. Nutr. 130 (4), 921S–926S. https://doi.org/10.1093/jn/130.4.921S.
Zhou, Y., Tse, C.S., 2022. Sweet taste brings happiness, but happiness does not taste sweet: the unidirectionality of taste-emotion metaphoric association. J. Cognit. Psychol. 34 (3), 339–361. https://doi.org/10.1080/20445911.2021.2020797.
Zushi, N., Ogawa, M., Ayabe-Kanamura, S., 2021. Fear reduces perceived sweetness: changes in the perception of taste due to emotional state. Sage Open 11 (1). https://doi.org/10.1177/2158244021989318.