Running Head: MULTISENSORY ENHANCEMENT VIA AESTHETIC MATCHING

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Audiovisual aesthetic matching enhances food evaluation by amplifying pleasure and perceived tastiness

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Abstract

Aesthetic experiences can shape the evaluations of consumer's ~~evaluations~~, including in the case of food. While matching multisensory cues can enhance perception, such interventions have not always been shown to promote consumption as effectively as predicted. The present study examined whether and how the multisensory aesthetic match of food plating and background music can enhance consumers' hedonic evaluations and purchase intentions. In both studies, participants viewed or tasted foods with varying plating aesthetics, either with music matched or mismatched in aesthetic value (e.g., ugly vs. beautiful). The participants provided food evaluations before or after tasting. The results revealed that matched audiovisual aesthetics produced enhancement effects on expected evaluations across different aesthetic levels among female participants, whereas men's ratings were enhanced only for the less-aesthetic plating. In contrast, actual evaluations were amplified only for healthy food with less-aesthetic and unhealthy food with relatively high-aesthetic plating. The multisensory enhancement of aesthetic value occurred through distinct pathways, influencing pre- and post-tasting evaluations through pleasure and perceived tastiness. These findings reveal the mechanisms of audiovisual aesthetic matching in enhancing food consumption depend on the type of food and the gender of the participant. Aesthetic cues can be applied to nudge emotional engagement and enrich sensory experiences in daily routines, and to promote health-oriented consumption across different goal orientations (e.g., encouraging or curbing consumption).

Keywords: Multisensory enhancement; Aesthetic value; Plating; Food evaluation; Sensory nudging.

1. Introduction

When consumers evaluate and taste food, the experience is shaped by aesthetic inputs across multiple senses, including sight, hearing, taste, smell, and touch (Auvray & Spence, 2008; Krishna & Elder, 2021). The interplay of visually-appealing plating, contextually appropriate music, and pleasurable taste reflect the integration of aesthetic and gustatory "taste", capturing the essence of the "beauty-is-good" bias in food evaluations (Griffin & Langlois, 2006). As perhaps the first sensory cues before consumers interact with food, the visual plating of food critically shapes consumers' expectations and subsequent product evaluations as can the auditory (musical) ambiance.

Visual aesthetics serve as the primary gateway to food-related sensory experiences, shaping consumers' expectations and emotional responses even before tasting. The visual design of plating directly affects the attractiveness of a dish and consumers' judgments (Schifferstein et al., 2022; Spence, 2022c). When food is presented in a more aesthetically appealing manner, consumers tend to show higher liking (Zellner et al., 2014), greater expected pleasure (Yu & Liu, 2023), and an increased willingness to pay (Michel et al., 2015; Velasco & Veflen, 2021; Zellner et al., 2011). Moreover, food~~s~~ that looks more beautiful, or is arranged more neatly and symmetrically, are often rated as tasting better (Michel et al., 2014; Spence, 2016; Velasco et al., 2016) and can evoke more positive emotion (Petit et al., 2016).

Auditory input, such as music, has received comparatively less attention than visual cues in food-related research, despite its potential role in shaping food-related expectations, emotions, evaluations and consumption (Goldman, 2024; Luo et al., 2025; Spence, 2020a; Wansink & Van Ittersum, 2012). Background noise having little aesthetic value can interfere with taste and flavor perception, as well as overall enjoyment (Budinger et al., 2006; Spence, 2014; Yan & Dando, 2015). In contrast, highly-aesthetic music can enhance flavor (Kantono et al., 2016a; Wang & Spence, 2018) and the pleasure we get from food (Kantono et al., 2018; see Spence et al., 2019a, for a review), thereby influencing how food is perceived. Across the visual or auditory modalities, highly-aesthetic stimuli can affect an individual's emotional state, increase their reward-related brain activity, thus increasing pleasure (Blood & Zatorre, 2001), further improving hedonic experiences (Kantono et al., 2016b, 2018; Zhang et al., 2022).

Individuals typically receive aesthetic information through multiple senses rather than from isolated sensory inputs (Klein et al, 2021; Spence et al., 2014b). For instance, a fresh salad may first be perceived through its vibrant colors (see Spence, 2020c), and this may be accompanied by easy-listening music, the cool touch of the plate, and even a refreshing in-store aroma (Piqueras-Fiszman & Spence, 2014; Zhang & Spence, 2023). More broadly, ambient scent, music, and other servicescape cues can jointly shape consumer evaluations and behavioral responses in retail and hospitality settings (Lin, 2004; Mattila & Wirtz, 2001; Roschk et al., 2017). By providing richer information than any single modality alone (Auvray & Spence, 2008), such external

multisensory cues are not merely decorative but can meaningfully affect actual consumer choice and perception (Sester et al., 2013; Spence, 2017; Spence et al., 2014b; see Zhang & Spence, 2023, for a review). When multiple senses operate simultaneously, crossmodal correspondences can facilitate the association and integration of information across the sens~~ory modaliti~~es. Such correspondences may arise through semantic, affective, or statistical mechanisms (Motoki et al., 2023; Spence, 2011). Semantic correspondence is based on shared conceptual meaning or learned associations across modalities, statistical correspondence reflects regularities of multisensory co-occurrence, and affective correspondence occurs when stimuli are associated through similar emotional or valence responses (Chen & Spence, 2010; Palmer, Schloss, Xu, et al., 2013; Spence, 2011). In contrast, the present study focuses on correspondence in relative perceived aesthetic value at a higher-order evaluative level (cf. Hasenfus, Martindale, & Birnbaum, 1983), although such aesthetic-value matching may overlap with affective correspondence. Compatible multisensory information may also be processed more fluently, and greater processing fluency tends to elicit more positive affective and aesthetic evaluations (Reber et al., 2004; Chen et al., 2025). This alignment of sensory cues in temporal, spatial, or semantic attributes has been linked to increased processing fluency and stronger evaluations (Palmer et al., 2013; Reber et al., 2004). Food and beverages presented with audiovisually matching plating/packaging and music are more popular and can help to enhance taste perception (Cho et al., 2019; Lin et al., 2024; Spence et al., 2011). Such matching promotes multisensory enhancement, whereby harmoniously aligned sensory cues amplify affective and perceptual responses beyond what single modalities can achieve (Ernst & Bülthoff, 2004; Hecht et al., 2008; Li & Deng, 2023; Marucci et al., 2021; Perrault et al., 2005).

Despite theoretical optimism concerning the potential benefits associated with targeted multisensory interventions, empirical findings on their effectiveness in real-world settings remain mixed (Banks et al., 2012; see Spence, 2021, for a review). In fact, several studies have failed to deliver the multisensory boost to experience, or sales (Spence, 2020b). For example, matched pairings between background video and beverage style increased the selection of matching drinks, but did not affect liking or purchase intention (Sester et al., 2013). Only a strong multisensory match across multiple dimensions (i.e., ambient light and scent matched both in perceived temperature and illuminance level) was found to enhance consumer evaluations, whereas a partial match involving just one dimension had no meaningful effect (Doucé, 2022). Such outcomes may perhaps be attributed to sensory redundancy (Banes, 2001), in which additional matched inputs merely repeat information already conveyed by another modality, resulting in pleonastic effects (Spence, 2022a). Alternatively, combining the senses may also give rise to sensory overload (Malhotra, 1984), where excessive sensory input undermines evaluation (Doucé & Adams, 2020; Pikó, 2017).

Most existing research has focused on unisensory aesthetics related to taste perception (e.g., sourness, sweetness) and preference (Kpossa & Lick, 2020; Spence et al.,

2019a). These gaps highlight the need to explore how visual and auditory aesthetic cues jointly shape food evaluation. Aesthetic value refers to the perceived value that a sensory stimulus acquires during aesthetic evaluation, rather than to an objective property inherent in the stimulus (Skov & Nadal, 2020). Visual aesthetic value can arise from features such as color harmony, shape, spatial structure, and composition (Palmer, Schloss, & Sammartino, 2013), whereas musical aesthetic value can arise from formal properties such as melody, rhythm, and harmony (Brattico et al., 2013). Thus, visual and auditory aesthetics need not share identical low-level features but can converge at the higher evaluative level of perceived aesthetic value (Ishizu & Zeki, 2011). Therefore, exploring sensory matching within the aesthetic domain offers a theoretically meaningful perspective. While visual design features directly affect people's taste expectations, music acts more indirectly. Despite differing roles for each sense, crossmodal aesthetic matching may nevertheless still amplify food evaluations by intensifying affective responses.

The aesthetic matching in food evaluation may be expected to enhance consumer evaluations through multisensory interventions (Spence & Youssef, 2019). Against this background, the present research examines the effects of such interventions through two experiments involving both expected and actual food evaluations. Background music whose aesthetic value matches that of the food plating may amplify both the expected and actual sensory perceptions, leading to more polarized evaluation (H1). This polarization is likely driven by intensified emotional responses evoked by matched visual and auditory cues. When aesthetic match occurs across sensory modalities, emotional experience become more heightened and concentrated (Lee et al., 2017; Yilmaz et al., 2025). This enhancement may stem from the additional emotional value conveyed by aligned multisensory aesthetic information. Such emotional responses may also transfer to the food experience itself, leading consumers to perceive food as more pleasurable or appealing (Reinoso-Carvalho et al., 2020a, b). Consumers are thus likely to anticipate the degree of pleasure and make judgments consistent with their feelings (Yu & Liu, 2023). Visual and auditory inputs work together to reinforce evaluations through consistent emotional signaling. However, whether aesthetic alignment alone produce an integrated or emergent multisensory experience in consumer evaluations remains uncertain, as evidence for Gestalt principles in crossmodal contexts is still inconclusive (see Spence & Di Stefano, 2025, for a review). These considerations highlight the need to further examine how multisensory aesthetic match shapes consumer evaluations before and after tasting, as evaluations based on visual and auditory expectations may differ from those formed through direct tasting experience (Spence, 2015, 2022b; Zhou & Li, 2024). Food Type may represent an important boundary condition fo~~f~~r audiovisual aesthetic effects. Previous research suggests that aesthetic presentation can differentially influence evaluations related to food healthiness (Hagen, 2021), while background music can differentially shape preferences for healthy and indulgent foods (Motoki et al., 2022). Accordingly, we ask whether audiovisual aesthetic effects differ between healthy and unhealthy foods (RQ1).

While validating the enhancement effect of aesthetic match on expected and actual food evaluations, it is important to understand how such matching influences purchase intention. Prior research has tied aesthetic food presentation to pleasure (Michel et al., 2014), and consumers often anticipate pleasure from the sensory stimulation that is associated with eating (Deroy et al., 2014; Lee & Yun, 2015; Spence et al., 2014a). Notably, pleasure serves as a mediator in the effect of food aesthetics on purchase intention. For example, artistic or creative plating (vs. conventional, neat plating) tends to evoke stronger pleasure and subsequently promotes purchase intention (Yu & Liu, 2023). Therefore, as noted earlier, aesthetically matched audiovisual stimuli may influence purchase intention through enhanced pleasure (H2).

Beyond emotional pleasure, perceived tastiness plays a key role in shaping people's food-related evaluations. Viewing food images activates the taste cortex in the brain (Simmons, Martin, & Barsalou, 2005; Spence et al., 2016), as these images elicit automatic mental simulations of consumption (Barsalou, 2008; Hung et al., 2017; Motoki et al., 2018). Visual elements heighten consumers' sensory experience and purchase intention through mental simulation and perceived taste (Elder & Krishna, 2012; Jeong & Jang, 2016; Muñoz-Vilches et al., 2019). Moreover, as visually attractive food is often rated as being tastier (Michel et al., 2014; Youssef et al., 2015; Zellner et al., 2010), elevated anticipated pleasure may similarly further contribute to heightened perceived tastiness by facilitating the mental simulation of consumption. Taken together, we propose a serial mediation path: audiovisual aesthetic matching may enhance expected pleasure which, in turn, increases perceived tastiness, ultimately leading to increased purchase intention (H3). However, anticipatory and consummatory food experiences involve separable neural substrates (Small et al., 2008), suggesting that mental simulation and actual consumption are not entirely equivalent. Accordingly, the pathway linking multisensory aesthetic interventions to purchase intention may differ after tasting.

The present research examines how aesthetic values of visual plating and background music crossmodally influence consumers' expected and actual evaluations of food before and after tasting. By combining visual and auditory aesthetic cues with different perceived aesthetic values, the present study extends prior multisensory congruence research by examining Food Type as a theoretically relevant boundary condition and Gender as an exploratory individual-difference factor, while testing pleasure and perceived tastiness as pathways linking audiovisual aesthetic effects to purchase intention. Two experiments were conducted: Experiment 1 focused on expectation in a digital environment, whereas Experiment 2 examined food evaluations after actual tasting. Together, the two experiments examine both the boundary conditions and the affective and taste-related pathways underlying audiovisual aesthetic effects on food evaluation. Importantly, this research not only underscores the role of aesthetic match as an effective sensory amplification strategy in food-related experiences, but also suggests practical pathways for strengthening connection to aesthetic sensory input and promoting psychological well-being in modern life.

2. Experiment 1

2.1. Methods

Participants

An *a priori* power analysis was conducted using G*Power 3.1 to estimate the sample size. As for the 2 × 2 × 2 mixed-design repeated measures ANOVA being used in this experiment, the projected sample size was a minimum of 112, setting the parameter effect size to 0.20, the probability of Type I error α to 0.05, and a power of 0.95. Because Gender was additionally examined as an exploratory participant-level factor in Experiment 1, we also conducted a power analysis for the 2 × 2 × 2 × 2 mixed design using the same parameters, which indicated a required minimum sample size of 144. A total of 240 Chinese adults were recruited through the online social media platform WeChat (120 females, mean age = 21.90 ± 1.95 years, mean BMI = 21.02 ± 2.54 kg/m^2). With this sample size, a sensitivity analysis with α = 0.05 and power = 0.95 indicated a minimum detectable effect size of Cohen's f = 0.23. In Experiments 1 and 2, participants self-reported being right-handed, non-vegetarian, non-vegan, with normal or corrected-to-normal vision, with normal hearing, without color blindness or weakness, and no current physical or psychological disorders. This study was approved by the Ethics Committee of a university in China, and conducted in accordance with the ethical standards outlined in the Declaration of Helsinki. All participants provided informed consent before experiment. Each participant received 5 Chinese Yuan. The experiment lasted for approximately 15 minutes.

Apparatus and stimuli

All participants completed the task online via the Qualtrics platform (https://www.qualtrics.com). The food images, adapted from Liu et al. (2023), included 10 relatively high-aesthetic and 10 less-aesthetic food plating images (half high-calorie foods categorized as unhealthy and half low-calorie foods categorized as healthy). The food was presented on white plates from the same angle (45°). The resolution of these images was 600×450 pixels (all shown in Fig. 1). The ratings of plating aesthetics for all relatively high-aesthetic food images were significantly higher than those for less-aesthetic images (5.10 vs. 3.07), $t(30) = 12.78$, $p < 0.001$, Cohen's d = 2.30, 95% CI = [1.61, 2.97]. The construction of the plating stimuli was guided by the classical/expressive aesthetics framework (Lavie & Tractinsky, 2004; Liu et al., 2023). Classical aesthetics emphasize order, clarity, and symmetry, whereas expressive aesthetics emphasize creativity, originality, and departures from conventional design. In food presentation, aesthetic principles such as order, symmetry, balance, color, complexity, and composition have been shown to influence visual evaluations of food (Hagen, 2021; Rowley & Spence, 2018; Spence et al., 2014a, 2019b; Velasco et al., 2016; Zellner et al., 2010). We therefore used these aesthetic principles and the classical/expressive framework to guide the construction of the plating stimuli. The relative perceived aesthetic levels of the final stimuli were determined by the independent pretest.

The music materials consisted of two 1-minute piano pieces. The auditory aesthetic manipulation was constructed on the basis of tonality. Western tonal music is characterized by a tonal hierarchy and greater structural predictability, whereas atonal music lacks a stable tonal hierarchy and generally creates greater uncertainty (Mencke et al., 2019, 2022). The tonal excerpt was selected from Fauré's Doll's Suite (Op. 56: Berceuse), representative of 19th-century classical Romantic music, whereas the atonal excerpt was selected from Schoenberg's Three Piano Pieces (Op. 11: I. Bewegt), representative of expressionist music. Tonality and atonality were not treated as inherent indicators of high and low aesthetic value. Rather, tonality provided the structural basis for constructing the auditory conditions, whereas the relative perceived aesthetic value of the two excerpts was determined by the independent pretest. The aesthetic ratings for the relatively high-aesthetic music were significantly higher than the less-aesthetic music (6.13 vs. 3.90), $t(30) = 7.26$, $p < 0.001$, Cohen's $d = 1.30$, 95% CI = [0.82, 1.78]. These aesthetic ratings for images and music were obtained in an independent pretest ($N = 31$). Materials are available at Open Science Framework: https://osf.io/gu5fq/.

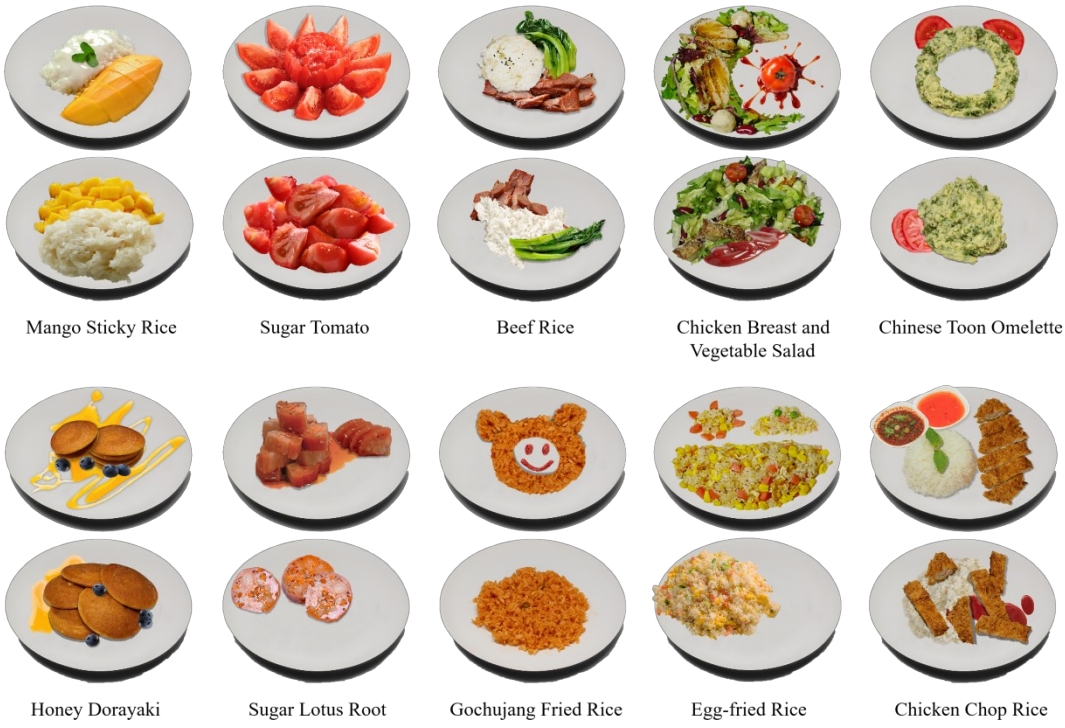


Fig. 1. All food plating used in Experiment 1. The first and third rows show relatively high-aesthetic plating, while the second and fourth rows show less-aesthetic plating.

Design and Procedure

A 2 (Visual Aesthetics: relatively high, low) × 2 (Auditory Aesthetics: relatively high, low) × 2 (Food Type: healthy, unhealthy) mixed design was conducted, with Food Type as the within-participants factor and Visual Aesthetics and Auditory Aesthetics as between-participants factors. The participants were instructed to fast for 2 hours (except water) prior to the experiment to ensure a moderate level of hunger and to

avoid potential interference from substances such as caffeine (Lozano et al., 1999; Panek-Shirley et al., 2018). The participants completed the questionnaire online in a quiet environment, with screen and audio sharing enabled via Tencent Meeting. All auditory stimuli were played through external loudspeakers, with computer volume set to 50, approximately 60 dB, to achieve relatively consistent loudness levels. The experimenter provided verbal instructions and monitored the entire process remotely to help maintain participants' compliance and attentiveness.

After the participants reported their hunger on a 7-point scale ("How hungry do you feel right now?", anchored: 1 = Not at all; 7 = Extremely), they were then randomly assigned to one of four conditions: low visual aesthetic-low auditory aesthetic, low visual aesthetic-high auditory aesthetic, high visual aesthetic-low auditory aesthetic, or high visual aesthetic-high auditory aesthetic, with gender balanced across conditions. The order of images within each condition was randomized. Participants viewed 10 food images, each followed by ratings of visual attractiveness, liking, pleasure, and purchase intention. All four items were measured on 7-point scales anchored from 1 = Not at all to 7 = Extremely. Visual attractiveness was measured with the item, "How appealing do you find this dish?", liking with "How much do you like this dish?", pleasure with "How pleasurable do you find this dish?", and purchase intention with "How likely would you be to purchase this dish?". Participants also rated the aesthetic value of each plating design, "How do you perceive the aesthetic value of this dish's plating?" (anchored: 1 = Extremely ugly; 7 = Extremely beautiful). The participants listened to music while completing the above procedures. The relatively high- and less-aesthetic conditions were identical in terms of ingredients and cooking methods, differing only in terms of how the foods were plated. Finally, participants assessed the aesthetic value of music pieces, "How do you perceive the aesthetic value of this music segment?" (anchored: 1 = Extremely ugly; 7 = Extremely beautiful).

2.2. Results

Before the experiment, participants showed significantly higher levels of hunger than the neutral midpoint of 4, $t(239) = 4.10$, $p < 0.001$, Cohen's $d = 0.26$, 95% CI = [0.14, 0.39], indicating sufficient motivation for food evaluation.

2.2.1. Expected food ratings

Given prior evidence of gender-related differences in sensitivity and neural responses to food-related sensory stimuli (Chao et al., 2017; Michon et al., 2009; Toepel et al., 2012), Gender was examined as an exploratory participant-level factor. Accordingly, we conducted 2 (Visual Aesthetics: relatively high, low) × 2 (Auditory Aesthetics: relatively high, low) × 2 (Food Type: healthy, unhealthy) × 2 (Gender: male, female) mixed-design ANOVAs on participants' ratings of food visual attractiveness, liking, pleasure, and purchase intention for visually presented food images. Across both experiments, all post-hoc analyses were subject to Bonferroni correction for multiple comparisons.

Visual attractiveness

The main effect of Visual Aesthetics was significant, with relatively high- (vs. less-) aesthetic food plating rated as looking more attractive (4.51 vs. 3.90), $F(1, 232) = 24.34$, $p < 0.001$, $\eta_p^2 = 0.09$. The main effect of Auditory Aesthetics was also significant, with relatively high- (vs. less-) aesthetic music leading to higher attractiveness ratings (4.59 vs. 3.82), $F(1, 232) = 40.03$, $p < 0.001$, $\eta_p^2 = 0.15$. The main effect of Food Type was significant, with unhealthy (vs. healthy) foods rated as looking more attractive (4.27 vs. 4.14), $F(1, 232) = 4.29$, $p = 0.040$, $\eta_p^2 = 0.02$. The main effect of Gender was significant, with male participants giving higher attractiveness ratings than female (4.36 vs. 4.05), $F(1, 232) = 6.64$, $p = 0.011$, $\eta_p^2 = 0.03$.

Importantly, the interaction between Visual Aesthetics and Auditory Aesthetics was also significant, $F(1, 232) = 4.25$, $p = 0.040$, $\eta_p^2 = 0.02$, as expected. Notably, this interaction was further qualified by a significant interaction between Visual Aesthetics, Auditory Aesthetics, and Gender, $F(1, 232) = 4.89$, $p = 0.028$, $\eta_p^2 = 0.02$. Simple effect analyses (Fig. 2) revealed that among female participants, less-aesthetic food plating led to lower visual attractiveness for food when paired with less- (vs. relatively high-) aesthetic music (3.27 vs. 4.05), $t(232) = -3.20$, $p = 0.006$, Cohen's $d = -0.42$, 95% CI = [-0.68, -0.16]. Relatively high-aesthetic food plating resulted in higher visual attractiveness when paired with relatively high- (vs. less-) aesthetic music (4.84 vs. 4.02), $t(232) = 3.35$, $p = 0.004$, Cohen's $d = 0.44$, 95% CI = [0.18, 0.70]. In contrast, among male participants, less-aesthetic food plating led to lower visual attractiveness ratings for food when paired with less- (vs. relatively high-) aesthetic music (3.51 vs. 4.78), $t(232) = -5.23$, $p < 0.001$, Cohen's $d = -0.69$, 95% CI = [-0.95, -0.42]. There was no significant difference in visual attractiveness for relatively high-aesthetic food plating paired with relatively high- (vs. less-) aesthetic music (4.69 vs. 4.47), $t(232) = 0.91$, $p = 1.000$, Cohen's $d = 0.12$, 95% CI = [-0.14, 0.38]. The interaction between Visual Aesthetics, Auditory Aesthetics, and Food Type was not significant, $F(1, 232) = 1.35$, $p = 0.246$. Additional interaction effects are reported in the Supplementary Materials, and the same applies to all subsequent analyses.

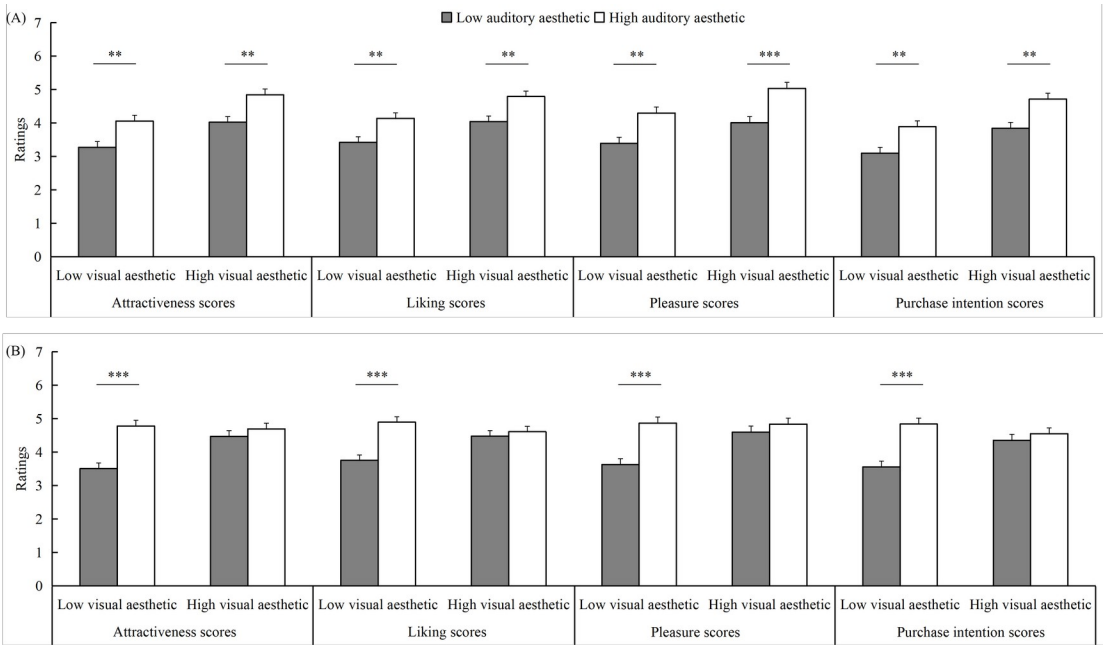


Fig. 2. The mean ratings of Visual Aesthetics × Auditory Aesthetics × Gender in Experiment 1. (A) Mean ratings for female participants. (B) Mean ratings for male participants. Note that the error bars show the standard errors of the means; ** denotes $p < 0.01$, and *** $p < 0.001$.

Liking

The main effect of Visual Aesthetics was significant, with relatively high- (vs. less-) aesthetic food plating receiving higher liking ratings (4.48 vs. 4.05), $F(1, 232) = 13.75$, $p < 0.001$, $\eta_p^2 = 0.06$. The main effect of Auditory Aesthetics was also significant, with foods paired with relatively high- (vs. less-) aesthetic music receiving higher liking ratings (4.61 vs. 3.92), $F(1, 232) = 35.11$, $p < 0.001$, $\eta_p^2 = 0.13$. The main effect of Food Type was significant, with unhealthy (vs. healthy) foods receiving higher liking ratings (4.33 vs. 4.20), $F(1, 232) = 3.90$, $p = 0.050$, $\eta_p^2 = 0.02$. The main effect of Gender was significant, with male participants giving higher liking ratings than female (4.43 vs. 4.10), $F(1, 232) = 8.52$, $p = 0.004$, $\eta_p^2 = 0.04$. There was a significant interaction between Visual Aesthetics and Auditory Aesthetics, $F(1, 232) = 4.48$, $p = 0.035$, $\eta_p^2 = 0.02$.

The interaction between Visual Aesthetics, Auditory Aesthetics, and Gender was also significant, $F(1, 232) = 5.18$, $p = 0.024$, $\eta_p^2 = 0.02$. Simple effect analyses revealed (Fig. 2) that among female participants, less-aesthetic food plating received lower liking ratings when paired with less-aesthetic (vs. relatively high-aesthetic) music (3.42 vs. 4.14), $t(232) = -3.10$, $p = 0.009$, Cohen's $d = -0.41$, 95% CI = [-0.67, -0.15]. Relatively high-aesthetic food plating received higher liking ratings when paired with relatively high-aesthetic (vs. less-aesthetic) music (4.79 vs. 4.04), $t(232) = 3.26$, $p = 0.005$, Cohen's $d = 0.43$, 95% CI = [0.17, 0.69]. In contrast, among male participants, less-aesthetic food plating received lower liking ratings when paired with less-

aesthetic (vs. relatively high-aesthetic) music (3.75 vs. 4.89), $t(232) = -4.98$, $p < 0.001$, Cohen's $d = -0.65$, 95% CI = [-0.92, -0.39], whereas no significant difference was observed for relatively high-aesthetic food plating paired with less- and relatively high-aesthetic music (4.48 vs. 4.61), $t(232) = -0.55$, $p = 1.000$, Cohen's $d = -0.07$, 95% CI = [-0.33, 0.19]. The interaction between Visual Aesthetics, Auditory Aesthetics and Food Type was not significant, $F(1, 232) = 1.10$, $p = 0.294$.

Expected pleasure

The main effect of Visual Aesthetics was significant, with relatively high- (vs. less-) aesthetic food plating rated as looking significantly more pleasant (4.62 vs. 4.04), $F(1, 232) = 20.00$, $p < 0.001$, $\eta_p^2 = 0.08$. The main effect of Auditory Aesthetics was significant, with relatively high- (vs. less-) aesthetic music leading to higher pleasure ratings (4.76 vs. 3.90), $F(1, 232) = 44.38$, $p < 0.001$, $\eta_p^2 = 0.16$. The main effect of Gender was significant, with male participants giving higher pleasure ratings than female participants (4.48 vs. 4.18), $F(1, 232) = 5.49$, $p = 0.020$, $\eta_p^2 = 0.02$. The main effect of Food Type was not significant, $F(1, 232) = 2.38$, $p = 0.124$.

The Visual Aesthetics × Auditory Aesthetics interaction was not significant, $F(1, 232) = 3.01$, $p = 0.084$. However, the interaction between Visual Aesthetics, Auditory Aesthetics and Gender was significant, $F(1, 232) = 4.80$, $p = 0.029$, $\eta_p^2 = 0.02$. Simple effect analyses (Fig. 2) revealed that among female participants, when food was presented with less-aesthetic plating, the expected pleasure gained from food accompanied by less- (vs. relatively high-) aesthetic music was lower (3.39 vs. 4.30), $t(232) = -3.55$, $p = 0.002$, Cohen's $d = -0.47$, 95% CI = [-0.73, -0.20]. When food plating was rated as relatively highly-aesthetic, the expected pleasure gained from food accompanied by relatively high- (vs. less-) aesthetic music was higher (5.03 vs. 4.01), $t(232) = 4.00$, $p < 0.001$, Cohen's $d = 0.53$, 95% CI = [0.26, 0.79]. In contrast, among male participants, less-aesthetic food plating led to lower expected pleasure for food when paired with less- (vs. relatively high-) aesthetic music (3.63 vs. 4.87), $t(232) = -4.89$, $p < 0.001$, Cohen's $d = -0.64$, 95% CI = [-0.90, -0.38]. There was no significant difference in the expected pleasure for relatively high-aesthetic food plating paired with relatively high- (vs. less-) aesthetic music (4.83 vs. 4.60), $t(232) = 0.92$, $p = 1.000$, Cohen's $d = 0.12$, 95% CI = [-0.14, 0.38]. The interaction between Visual Aesthetics, Auditory Aesthetics, and Food Type was not significant, $F(1, 232) = 2.26$, $p = 0.134$.

Purchase intention

The main effect of Visual Aesthetics was significant, with relatively high- (vs. less-) aesthetic food plating giving rise to a higher purchase intention (4.36 vs. 3.84), $F(1, 232) = 17.56$, $p < 0.001$, $\eta_p^2 = 0.07$. The main effect of Auditory Aesthetics was significant, with relatively high- (vs. less-) aesthetic music giving rise to a higher purchase intention (4.50 vs. 3.71), $F(1, 232) = 40.10$, $p < 0.001$, $\eta_p^2 = 0.15$. The main effect of Gender was significant, with male participants ~~giving rise to~~expressing a

higher purchase intention than female participants (4.32 vs. 3.88), $F(1, 232) = 12.52$, $p < 0.001$, $\eta_p^2 = 0.05$. The main effect of Food Type was not significant, $F(1, 232) = 1.75$, $p = 0.187$.

The interaction between Visual Aesthetics and Auditory Aesthetics was significant, $F(1, 232) = 4.06$, $p = 0.045$, $\eta_p^2 = 0.02$. Notably, the interaction between Visual Aesthetics, Auditory Aesthetics and Gender was also significant, $F(1, 232) = 5.53$, $p = 0.020$, $\eta_p^2 = 0.02$. Simple effect analyses (Fig. 2) revealed that among female participants, less-aesthetic food plating led to lower purchase intention for food images that were accompanied by less- (vs. relatively high-) aesthetic music (3.10 vs. 3.89), $t(232) = -3.18$, $p = 0.007$, Cohen's $d = -0.42$, 95% CI = [-0.68, -0.16]. When food was presented with relatively high-aesthetic plating, female participants' purchase intention for food accompanied by relatively high- (vs. less-) aesthetic music was higher (4.71 vs. 3.84), $t(232) = 3.52$, $p = 0.002$, Cohen's $d = 0.46$, 95% CI = [0.20, 0.72]. In contrast, among male participants, less-aesthetic food plating led to lower purchase intention for food images that were accompanied by less- (vs. relatively high-) aesthetic music (3.55 vs. 4.84), $t(232) = -5.21$, $p < 0.001$, Cohen's $d = -0.68$, 95% CI = [-0.95, -0.42]. There was no significant difference in purchase intention for relatively high-aesthetic food plating paired with relatively high- (vs. less-) aesthetic music (4.55 vs. 4.35), $t(232) = 0.79$, $p = 1.000$, Cohen's $d = 0.10$, 95% CI = [-0.15, 0.36]. The interaction between Visual Aesthetics, Auditory Aesthetics and Food Type was not significant, $F(1, 232) = 2.17$, $p = 0.142$.

2.2.2 The mediating role of pleasure of foods

To clarify the mediating role of pleasure (derived from visually presented food images, the same below), we conducted moderated mediation analysis using mixed-effects regression models. Participant was included as a random intercept. Auditory Aesthetics was entered as the independent variable, pleasure as the mediator, and purchase intention as the dependent variable. Visual Aesthetics and Gender were included as moderators, whereas hunger and Food Type were included as covariates. Thus, conditional effects of Auditory Aesthetics on purchase intention through the pleasure were estimated at each combination of Visual Aesthetics and Gender.

To obtain statistical inference for the indirect effects while accounting for within-participant dependence due to repeated measurements, we used a cluster bootstrap procedure with participants as the resampling unit (5000 bootstrap samples). An indirect effect was considered significant if its 95% bootstrap confidence interval did not include zero. All resulting p values for the conditional effects were adjusted using a Bonferroni correction.

As shown in Fig. 3, Auditory Aesthetics predicted the pleasure associated with visually presented food, moderated by Visual Aesthetics and Gender ($X \rightarrow M$). When food was presented with less-aesthetic plating, less- (vs. relatively high-) aesthetic music reduced pleasure among female participants, $b = -0.91$, $p = 0.003$, 95% CI = [-1.43, -0.40], and male participants, $b = -1.24$, $p = 0.002$, 95% CI = [-1.78, -0.70].

When food was presented with relatively high-aesthetic plating, relatively high- (vs. less-) aesthetic music significantly increased pleasure among female participants, b = 1.02, p = 0.002, 95% CI = [0.58, 1.50], but not among male participants, b = 0.24, p = 1.000, 95% CI = [-0.19, 0.69]. Pleasure significantly influenced food purchase intention (M → Y), b = 0.87, p < 0.001, 95% CI = [0.82, 0.93]. The total effect of Auditory Aesthetics on purchase intention showed a similar pattern (X → Y) to the effect of Auditory Aesthetics on pleasure, with details shown in Fig. 3.

Most importantly, the indirect effect of Auditory Aesthetics on food purchase intention via pleasure was significant when food was presented with less-aesthetic plating. When food was presented with relatively high-aesthetic plating, this indirect effect remained significant amongst the female participants, but not amongst the male participants, with details shown in Fig. 3. The index of moderated ~~moderated~~ mediation was -0.98, 95% bootstrap CI = [-1.85, -0.11], indicating that the moderating effect of Visual Aesthetics on the indirect effect differed by Gender. None of the conditional direct effects of Auditory Aesthetics on food purchase intention was significant, ps > 0.299. Therefore, Auditory Aesthetics influenced pre-tasting purchase intention through food pleasure, with the indirect effect moderated by Visual Aesthetics and Gender. It was significant for both genders under less-aesthetic plating, but only for female participants under relatively high-aesthetic plating.

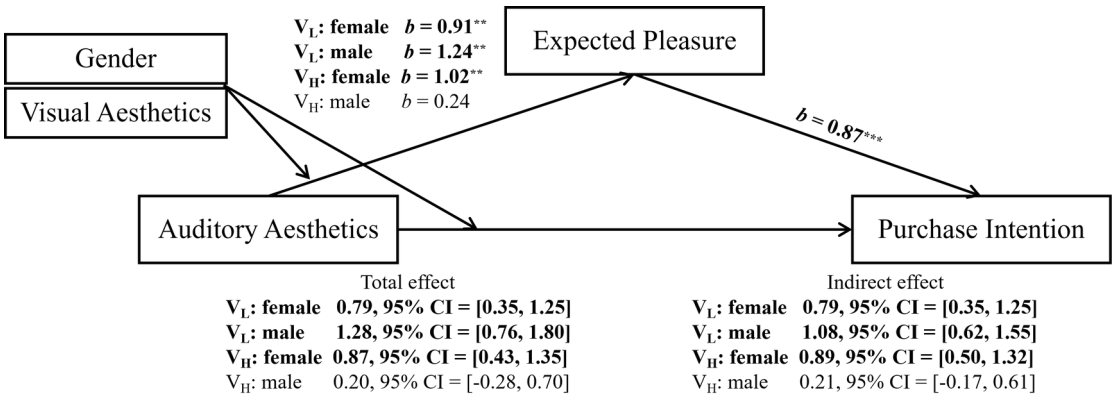


Fig. 3. Mediation analysis in Experiment 1 showing the effect of Auditory Aesthetics on pre-tasting food purchase intention through the pleasure, moderated by Visual Aesthetics and Gender. V_L represents less-aesthetic plating and V_H represents relatively high-aesthetic plating. Bold rows represent statistically significant paths in the model estimation under the relevant conditions. * denotes p < 0.05, ** p < 0.01, and *** p < 0.001.

2.3. Summary

The results of Experiment 1 revealed two main findings: First, exploratory analyses indicated that female consumers perceived food with aesthetically plated images of food accompanied by relatively high-aesthetic music as more attractive, with higher liking, expected pleasure, and purchase intention, while less-aesthetic music led to lower ratings. This suggests that audiovisual aesthetic matching amplifies consumer evaluation by conveying the combined value of sensory attributes and guiding

subsequent decisions (Zhu & Wang, 2015). Notably, among male participants, less-aesthetic music reduced evaluations for less-aesthetic plating, whereas relatively high-aesthetic music did not further enhance evaluations for relatively high-aesthetic plating. This gender difference may reflect different sensitivities to audiovisual aesthetic matching and is addressed in more detail in the Discussion.

Second, the effect of aesthetic value across modalities aligns with the "beauty is good, ugly is risk" impression often observed in the context of eating (Castagna et al., 2021). It has been suggested that from an evolutionary perspective the preference for high aesthetics is rooted in survival instincts (Griffin & Langlois, 2006), extending naturally to food consumption. In the present study, audiovisual aesthetic cues appeared to shape purchase intention primarily through expected pleasure. Even in an online context, the match of auditory aesthetics with visual plating mediated the effect on purchase intention for female consumers, whereas for male consumers, the mediation was partial under low visual aesthetics but absent under high visual aesthetics. This suggests that pleasure serves as the affective pathway translating audiovisual aesthetic information into purchase intention, with gender moderating the strength of this effect.

Experiment 1 provides evidence for the role of crossmodal aesthetic matching in shaping anticipatory food evaluations. However, given the relatively limited control over auditory presentation conditions in the online setting, as well as the differences between expectation-based evaluations and those formed through direct tasting experience, Experiment 2 was conducted in a more controlled laboratory setting to examine whether audiovisual aesthetic matching would continue to influence food evaluations after tasting.

3. Experiment 2

3.1. Methods

Participants

As for the 2 × 2 × 2 mixed design used in this experiment, the projected sample size was a minimum of 112, setting the same parameter as Experiment 1. Therefore, 131 Chinese adults were recruited from a university in China. After excluding two participants whose ratings exceeded three standard deviations from the mean, 129 participants were included in the final analysis (68 females, mean age = 21.08 ± 2.38 years, mean BMI = 21.60 ± 2.93). With the final sample size, a sensitivity analysis with $\alpha = 0.05$ and power = 0.95 indicated a minimum detectable effect size of Cohen's $f = 0.32$. All participants provided informed consent prior to taking part in the study. Each participant received 10 Chinese Yuan. The experiment lasted for approximately 20 minutes.

Apparatus and stimuli

The music materials were the same as in Experiment 1. The food materials, adapted from Liu et al. (2023), consisted of four foods (half high- and low-calorie foods), two

of which were the same as in Experiment 1. The specific food items were sugar tomato and honey dorayaki (both used in Experiment 1), along with pineapple and toast covered in chocolate spread. The image sizes matched those in Experiment 1. The plating designs used in Experiment 2 are shown in Figure 4B. In the same independent pretest, the aesthetic ratings for the relatively high-aesthetic food plating were significantly higher than the less-aesthetic ones (4.97 vs. 3.44), $t(30) = 7.42$, $p < 0.001$, Cohen's $d = 1.33$, 95% CI = [0.84, 1.81], confirming the validity of the aesthetic manipulations.

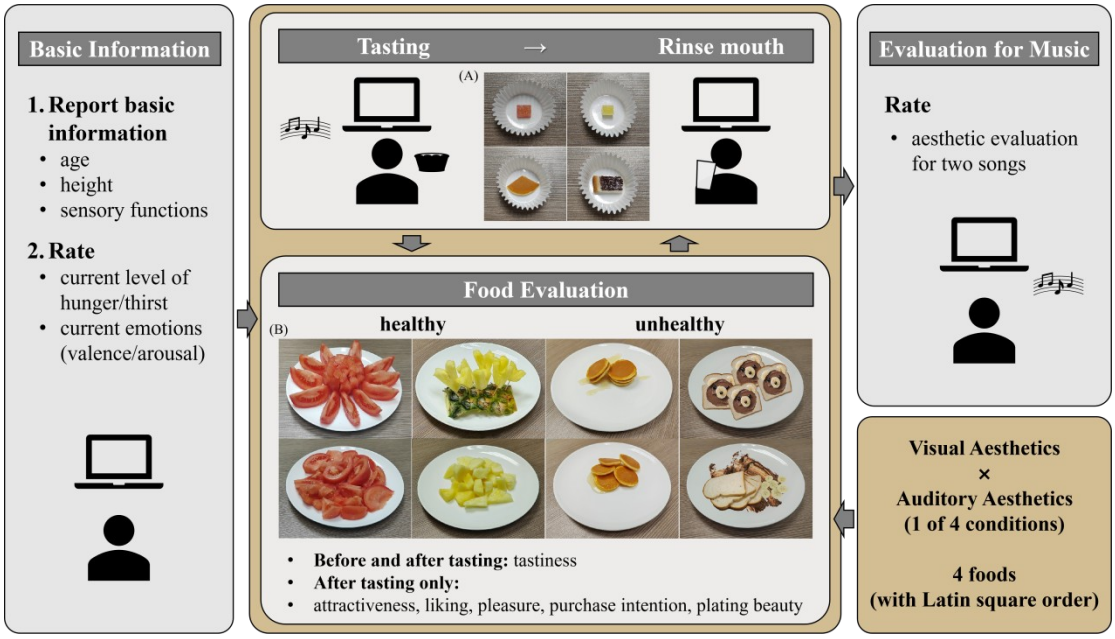


Fig. 4. The procedure used in Experiment 2 is shown. (A) The corresponding food presented to participants for each tasting. (B) The first row shows relatively high-aesthetic plating, and the second row shows the corresponding less-aesthetic plating of the same foods.

Design and Procedure

A 2 (Visual Aesthetics: relatively high, low) × 2 (Auditory Aesthetics: relatively high, low) × 2 (Food Type: healthy, unhealthy) mixed design was conducted, with Food Type as the within-participants factor and Visual Aesthetics and Auditory Aesthetics as between-participants factors. The participants completed the questionnaire on the computer screen (1920×1080, 144Hz), positioned 60 cm away. During the experiment, music was played through loudspeakers at 60 dB (Lin et al., 2024). The participants were instructed to fast for 2 hours (except water) prior to taking part in the experiment.

The participants sat alone at a table with a glass of water. As shown in Fig. 4, they first completed a basic information questionnaire and reported their current level of hunger and their emotional state on a 7-point scale. Hunger was assessed with the items, "How hungry do you feel right now?", anchored: 1 = Not at all; 7 = Extremely). Emotional arousal and valence were measured using the Chinese PAD

Emotion Scale (Li et al., 2008). Subsequently, the participants completed one of four conditions as in Experiment 1, with gender balanced across conditions. The sequence of food tastings within each condition was counterbalanced using a Latin square design based on participant sequence. Before tasting, the participants rated the expected tastiness of each food using the item, "How tasty do you expect this dish to be?" (anchored: 1 = Not at all; 7 = Extremely). Participants then tasted a portion of the food (approximately 1.5g) served in a cupcake liner (bottom radius: 3 cm; see Fig. 4A). After each tasting, the cupcake liner was removed, and participants provided evaluations of the food that they had just tasted on a 7-point scale. These post-tasting evaluations included all evaluation dimensions from Experiment 1, along with an additional measure of perceived tastiness, measured with "How tasty did you find this dish?" (anchored: 1 = Not at all tasty; 7 = Extremely tasty). Before proceeding to the next food, the participants were instructed to rinse their mouths out with water until no aftertaste remained. Finally, the participants rated the aesthetic value of the background music on a 7-point scale. All other evaluation items not explicitly detailed in Experiment 2 followed the same wording and scale as in Experiment 1.

3.2. Results

Before the experiment, participants showed a marginally higher level of hunger than the neutral midpoint of 4, $t(128) = 1.91$, $p = 0.058$, and emotional arousal and valence were significantly higher than the neutral midpoint of 0, both ts > 2.23, ps < 0.028, suggesting adequate motivation for food evaluation and a relatively aroused, positive emotional state.

3.2.1. Actual food ratings

2 (Visual Aesthetics: relatively high, low) × 2 (Auditory Aesthetics: relatively high, low) × 2 (Food Type: healthy, unhealthy) mixed-design ANCOVAs were conducted, with participants' ratings of food visual attractiveness, liking, pleasure, and purchase intention after tasting as the dependent variables. Since the alignment between actual tasting experiences and expectations has been shown to affect taste experiences and food evaluations (Piqueras-Fiszman & Spence, 2015), the mean difference in perceived tastiness before and after tasting was used as a covariate. Moreover, pre-experiment hunger level was included as an additional covariate, given that it exerted significant effects on the dependent variables. The effects of the difference in perceived tastiness covariate on the above ratings were all significant, Fs > 8.51, ps < 0.004; the effects of the hunger covariate were also significant for all ratings, Fs > 8.02, ps < 0.005. In additional exploratory analyses that included Gender as a between-participants factor, neither the main effect of Gender nor any interaction involving Gender was significant across the four post-tasting ratings, all Fs < 3.21, ps > 0.076.

Visual attractiveness

The main effect of Visual Aesthetics was significant, with relatively high- (vs. less-) aesthetic food plating being more attractive (4.55 vs. 4.13), $F(1, 123) = 5.65$, p =

0.019, η_p^2 = 0.04. The main effect of Auditory Aesthetics was also significant, with relatively high- (vs. less-) aesthetic music being more attractive (4.57 vs. 4.11), F(1, 123) = 6.88, p = 0.010, η_p^2 = 0.05. The main effect of Food Type was significant, with healthy (vs. unhealthy) foods rated as more attractive (4.52 vs. 4.16), F(1, 123) = 5.78, p = 0.018, η_p^2 = 0.04. The interaction between Visual Aesthetics, Auditory Aesthetics, and Food Type was not significant, F(1, 123) = 2.86, p = 0.093. As in Experiment 1, additional interaction effects are reported in the Supplementary Materials.

Liking

The main effect of Visual Aesthetics was significant, with relatively high- (vs. less-) aesthetic food plating receiving higher liking ratings (4.68 vs. 4.27), F(1, 123) = 7.46, p = 0.007, η_p^2 = 0.06. The main effect of Auditory Aesthetics was also significant, with foods paired with relatively high- (vs. less-) aesthetic music receiving higher liking ratings (4.72 vs. 4.22), F(1, 123) = 10.56, p = 0.001, η_p^2 = 0.08. The main effect of Food Type was significant, with healthy (vs. unhealthy) foods receiving higher liking ratings (4.74 vs. 4.20), F(1, 123) = 12.57, p < 0.001, η_p^2 = 0.09.

Importantly, the interaction between Visual Aesthetics, Auditory Aesthetics and Food Type was significant, F(1, 123) = 4.41, p = 0.038, η_p^2 = 0.03. Simple effect analyses (Fig. 5) revealed that, for healthy foods, food with less-aesthetic plating received lower liking ratings when paired with less- (vs. relatively high-) aesthetic music (4.36 vs. 5.09), t(123) = -2.45, p = 0.063, Cohen's d = -0.44, 95% CI = [-0.80, -0.08], whereas food with relatively high-aesthetic plating showed no significant difference in liking between relatively high- and less-aesthetic music (4.90 vs. 4.62), t(123) = 0.93, p = 1.000, Cohen's d = 0.17, 95% CI = [-0.19, 0.52]. In contrast, for unhealthy foods, food that w~~ith~~as less-aestheticallyplati~~nged~~ showed no significant difference in liking between less- and relatively high-aesthetic music (3.76 vs. 3.84), t(123) = -0.26, p = 1.000, Cohen's d = -0.05, 95% CI = [-0.40, 0.31], whereas food with relatively high-aesthetic plating received higher liking ratings when paired with relatively high- (vs. less-) aesthetic music (5.06 vs. 4.15), t(123) = 2.89, p = 0.018, Cohen's d = 0.52, 95% CI = [0.16, 0.88].

Food pleasure

The main effect of Visual Aesthetics was significant, with relatively high- (vs. less-) aesthetic food plating more pleasant (4.91 vs. 4.45), F(1, 123) = 7.90, p = 0.006, η_p^2 = 0.06. The main effect of Auditory Aesthetics was also significant, with relatively high- (vs. less-) aesthetic music more pleasant (4.94 vs. 4.42), F(1, 123) = 10.41, p = 0.002, η_p^2 = 0.08. The main effect of Food Type was not significant, F(1, 123) = 2.82, p = 0.095. Importantly, the interaction between Visual Aesthetics, Auditory Aesthetics and Food Type was significant, F(1, 123) = 7.90, p = 0.006, η_p^2 = 0.06. Simple effect analyses (Fig. 5) revealed that, for healthy foods, when food was presented with less-aesthetic plating, the participants reported lower pleasure from food accompanied by

less- (vs. relatively high-) aesthetic music (4.29 vs. 5.08), $t(123) = -2.77$, $p = 0.026$, Cohen's $d = -0.50$, 95% CI = [-0.86, -0.14]. When food was presented with relatively high-aesthetic plating, no significant difference was found between food paired with relatively high- and less-aesthetic music (4.89 vs. 4.88), $t(123) = 0.03$, $p = 1.000$, Cohen's $d = 0.01$, 95% CI = [-0.35, 0.36]. In contrast, for unhealthy foods, when food was presented with less-aesthetic plating, no significant difference was found between food paired with less- and relatively high-aesthetic music (4.05 vs. 4.38), $t(123) = -1.07$, $p = 1.000$, Cohen's $d = -0.19$, 95% CI = [-0.55, 0.16]. When food was presented with relatively high-aesthetic plating, the participants reported greater pleasure from food accompanied by relatively high- (vs. less-) aesthetic music (5.42 vs. 4.43), $t(123) = 3.27$, $p = 0.006$, Cohen's $d = 0.59$, 95% CI = [0.23, 0.95].

Purchase intention

The main effect of Visual Aesthetics was significant, showing higher purchase intention for relatively high- (vs. less-) aesthetic food plating (4.21 vs. 3.85), $F(1, 123) = 4.11$, $p = 0.045$, $\eta_p^2 = 0.03$. The main effect of Auditory Aesthetics was also significant, showing higher purchase intention for relatively high- (vs. less-) aesthetic music (4.34 vs. 3.72), $F(1, 123) = 12.11$, $p < 0.001$, $\eta_p^2 = 0.09$. The main effect of Food Type was significant, with healthy (vs. unhealthy) foods showing higher purchase intention (4.18 vs. 3.88), $F(1, 123) = 4.04$, $p = 0.047$, $\eta_p^2 = 0.03$. Importantly, the interaction between Visual Aesthetics, Auditory Aesthetics and Food Type was significant, $F(1, 123) = 4.73$, $p = 0.032$, $\eta_p^2 = 0.04$. Simple effect analyses (Fig. 5) revealed that, for healthy foods, when food was presented with less-aesthetic plating, the participants had lower purchase intention for food accompanied by less- (vs. relatively high-) aesthetic music (3.71 vs. 4.59), $t(123) = -2.74$, $p = 0.028$, Cohen's $d = -0.49$, 95% CI = [-0.85, -0.13]. When food was presented with relatively high-aesthetic plating, no significant difference was found between food paired with relatively high- and less-aesthetic music (4.41 vs. 4.01), $t(123) = 1.26$, $p = 0.842$, Cohen's $d = 0.23$, 95% CI = [-0.13, 0.58]. In contrast, for unhealthy foods, when food was presented with less-aesthetic plating, no significant difference was found between food paired with less- and relatively high-aesthetic music (3.47 vs. 3.64), $t(123) = -0.53$, $p = 1.000$, Cohen's $d = -0.10$, 95% CI = [-0.45, 0.26]. When food was presented with relatively high-aesthetic plating, the participants ~~ha~~expressed~~d~~ a higher purchase intention for food accompanied by relatively high- (vs. less-) aesthetic music (4.71 vs. 3.71), $t(123) = 3.01$, $p = 0.013$, Cohen's $d = 0.54$, 95% CI = [0.18, 0.90].

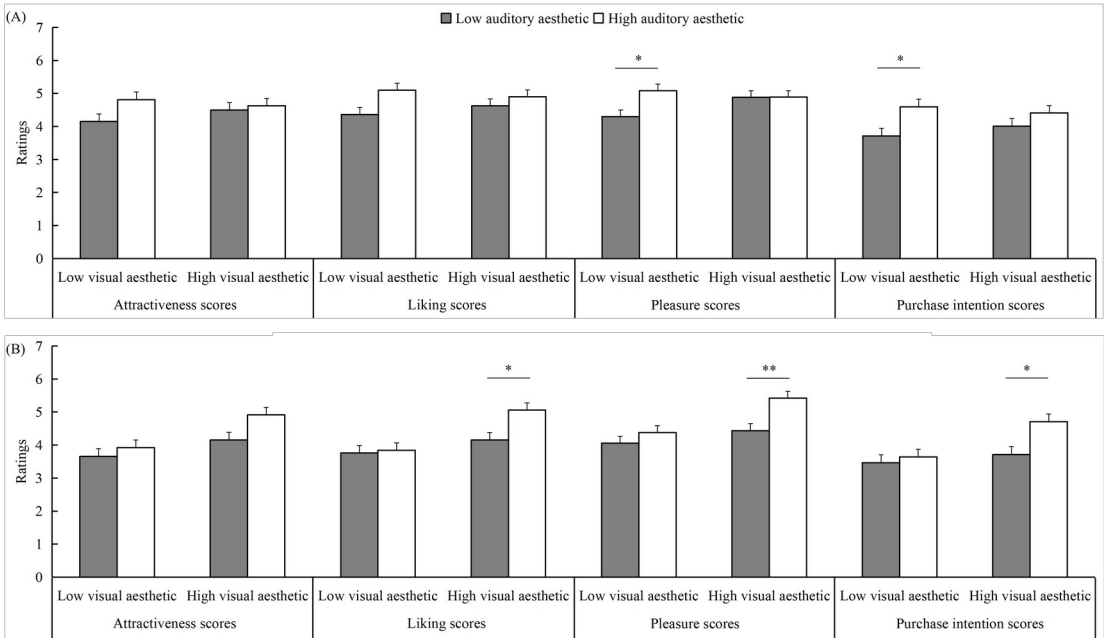


Fig. 5. The mean post-tasting ratings of Visual Aesthetics × Auditory Aesthetics × Food Type in Experiment 2. (A) Mean ratings for healthy foods. (B) Mean ratings for unhealthy foods. Note that the error bars show the standard errors of the means; * denotes $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$.

3.2.2 The mediating role of pleasure and perceived tastiness of foods

To clarify the mediating role of pleasure (derived from actual tasting, the same below), moderated mediation analysis was conducted using mixed-effects regression models, and Participant was included as a random intercept. Auditory Aesthetics was entered as the independent variable, pleasure and perceived tastiness as mediators, and purchase intention as the dependent variable. Visual Aesthetics and Food Type were included as moderators, whereas hunger and tastiness discrepancy were included as covariates. The same cluster-bootstrap procedure, significance criteria, and Bonferroni correction as in Experiment 1 were applied.

As shown in Fig. 6 and Table S1 (see Appendices), Auditory Aesthetics predicted pleasure from food tasting in a pattern moderated by Visual Aesthetics and Food Type (X → M1). Specifically, less-aesthetic music reduced pleasure for healthy foods with less-aesthetic plating, $b = -0.79$, $p = 0.042$, 95% CI = [-1.38, -0.18], whereas relatively high-aesthetic music increased pleasure for unhealthy foods with relatively high-aesthetic plating, $b = 0.99$, $p = 0.008$, 95% CI = [0.40, 1.56]. Pleasure significantly influenced food purchase intention (M1 → Y), $b = 0.56$, $p < 0.001$, 95% CI = [0.43, 0.67]. Individuals' pleasure predicted perceived tastiness across all conditions (M1 → M2), $b = 0.78$, $p < 0.001$, 95% CI = [0.68, 0.90]. However, Auditory Aesthetics did not directly predict perceived tastiness (X → M2), $b = 0.11$, $p = 0.235$, 95% CI = [-0.06, 0.27]. Perceived tastiness positively predicted purchase intention (M2 → Y), $b = 0.44$, $p < 0.001$, 95% CI = [0.33, 0.57].

Most importantly, the indirect effect of Auditory Aesthetics on food purchase

intention via pleasure was significant when healthy food was presented with less-aesthetic plating, indirect effect = 0.44, 95% CI = [0.10, 0.79], and unhealthy food was presented with relatively high-aesthetic plating, indirect effect = 0.55, 95% CI = [0.22, 0.90]. The indirect effect of Auditory Aesthetics on food purchase intention via perceived tastiness was not significant, indirect effect = 0.05, 95% CI = [-0.03, 0.12]. The serial indirect effect via pleasure and perceived tastiness was significant both when healthy food was presented with less-aesthetic plating, serial indirect effect = 0.27, 95% CI = [0.06, 0.52], and when unhealthy food was presented with relatively high-aesthetic plating, serial indirect effect = 0.34, 95% CI = [0.13, 0.61]. The index of moderated ~~moderated~~ mediation for the serial indirect effect was 0.49, 95% bootstrap CI = [0.15, 0.94], indicating that the moderation of the serial indirect effect by Visual Aesthetics differed by Food Type. None of the conditional direct effects of Auditory Aesthetics on food purchase intention was significant, *p*s > 0.248. Therefore, Auditory Aesthetics affected purchase intention both via pleasure and via the sequential pathway from pleasure to tastiness for healthy foods with less-aesthetic plating and unhealthy foods with relatively high-aesthetic plating.

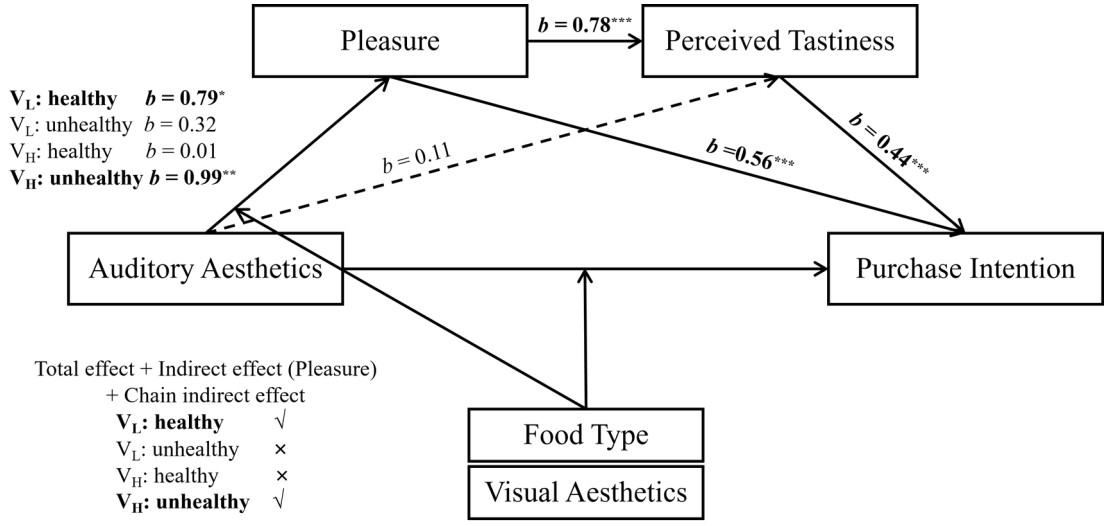


Fig. 6. Mediation analysis in Experiment 2 showing the effect of Auditory Aesthetics on post-tasting food purchase intention through the pleasure and perceived tastiness from foods, moderated by Visual Aesthetics and Food Type. V_L represents less-aesthetic plating and V_H represents relatively high-aesthetic plating. Bold rows represent statistically significant paths in the model estimation under the relevant conditions. * denotes $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$.

3.3. Summary

Experiment 2 revealed two main findings: First, the multisensory enhancement effect observed in Experiment 1 changed after actual tasting, differing as a function of the type of food. Specifically, when healthy food was presented with less-aesthetic plating, less- (vs. relatively high-) aesthetic music significantly reduced liking, pleasure and purchase intention, but this effect was absent when visual aesthetics was relatively high. In contrast, relatively high-aesthetic music further elevated

evaluations of unhealthy food with relatively high-aesthetic plating, but not when the plating was less-aesthetic.

This suggests that the impact of audiovisual aesthetic match after tasting depends on both the aesthetic value and food type. When healthy foods lack visual aesthetics, congruent auditory aesthetics can reduce food evaluation, but when visual aesthetics is already strong there is limited additional gain. Conversely, unhealthy foods that already signal strong hedonic value benefit most from congruent high audiovisual aesthetic cues across modalities (Piqueras-Fiszman & Spence, 2015).

Second, audiovisual aesthetic values influenced purchase intention through the pleasure derived from the food and exerted effects through a chain mediation involving both perceived pleasure and tastiness, differing for food type. Specifically, for healthy food with less-aesthetic plating and unhealthy food with relatively high-aesthetic plating, relatively high-aesthetic music increased perceived pleasure, which contributed to greater purchase intentions. The sequential indirect effect through pleasure and perceived tastiness was also significant in both conditions, indicating that changes in pleasure may further contribute to purchase intention through perceived tastiness (Reinoso-Carvalho et al., 2020).

These findings suggest that audiovisual aesthetic effects may involve overlapping affective and taste-related pathways across different food types, jointly shaping post-tasting food evaluations

4. Discussion

4.1. Summary of results

Several key findings emerged from the present research. First, audiovisual aesthetic effects were observed in pre-tasting food evaluations. When visual and auditory cues corresponded in their relative perceived aesthetic value, their evaluative effects were amplified. This pattern extends the ‘~~‘~~beauty is good, ugliness is risky~~’~~’ bias (Castagna et al., 2021; Griffin & Langlois, 2006; Hagtvedt et al., 2008; Hoegg et al., 2010) from a single sensory modality to audiovisual aesthetic information. The positive amplification is also consistent with the halo effect (Lawless et al., 1997), whereby positive affective responses extend to judgments of other attributes (Reinoso-Carvalho et al., 2019; Spence et al., 2013). From a crossmodal correspondence perspective, the present manipulation concerns correspondence in relative perceived aesthetic value at a higher-order evaluative level rather than shared semantic identity. Compatible audiovisual aesthetic information may also facilitate processing fluency, which tends to promote more positive affective and aesthetic evaluations (~~Reber et al., 2004;~~ Chen et al., 2025; Reber et al., 2004). In addition, aesthetic cognition models suggest that perceptual information contributes to subsequent affective and value-related evaluation (~~Leder et al., 2004;~~ Chatterjee & Vartanian, 2014; Leder et al., 2004), providing a theoretical basis for the observed role of pleasure. At the same time, aesthetic-value correspondence may overlap with affective correspondence, because similar emotional or valence responses can contribute to crossmodal

associations (Palmer et al., 2013). Thus, audiovisual aesthetic matching may amplify evaluative information rather than uniformly improving food evaluations.

Second, exploratory analyses suggested that audiovisual aesthetic effects varied by Gender. Female participants exhibited the enhancement effect across different levels of visual aesthetics, whereas male participants showed this effect primarily when food plating was less aesthetic. This pattern was further reflected in the mediation results. For female participants, the indirect effect of Auditory Aesthetics on purchase intention through pleasure was significant under both levels of Visual Aesthetics, whereas for male participants, this indirect effect was significant only under less-aesthetic plating. This pattern may suggest that male participants relied less on auditory aesthetic cues when relatively high-aesthetic visual cues were already present. Such exploratory gender-related differences are consistent with previous evidence that men and women may differ in their sensitivity to food-related sensory cues and neural responses to food stimuli (Chao et al., 2017; Michon et al., 2009; Toepel et al., 2012). Nevertheless, because Gender was examined as an exploratory participant-level factor, these findings should be interpreted cautiously and warrant further confirmatory investigation. Taken together, women's broader sensitivity to visual aesthetic cues provides a comprehensive account for the more robust multisensory enhancement.

The multisensory enhancement effect after tasting depended on food type, with congruent auditory cues amplifying evaluations primarily when healthy foods lacked strong visual aesthetics or when unhealthy foods already carried high aesthetic value. Notably, this effect emerged only after actual consumption, highlighting the role of consumption-related input in activating reward circuits. Regions such as the orbitofrontal cortex, insula, and nucleus accumbens are involved in processing multisensory food-related information to form a unified representation of food reward. Activity within this reward-related network is modulated by real taste experience (Rolls, 2011; Verhagen & Engelen, 2006). For healthy foods with less-aesthetic plating, congruent low-aesthetic auditory cues may have provided weak reward signals across modalities, reducing overall evaluation. When healthy foods are presented with relatively high-aesthetic plating, the reward circuits are already strongly activated by the visual and taste inputs. Because neural reward processing exhibits nonlinear saturation, additional congruent auditory cues contribute only minimal incremental enhancement, explaining the absence of effect in this condition (Spence, 2020d; Zampini & Spence, 2012) and aligning with evidence that auditory context often has a modest influence on tasting evaluations (Spence et al., 2014c).

In contrast, unhealthy foods carry high intrinsic hedonic value and strongly activate reward circuits even under low visual or auditory aesthetics. Congruent high-aesthetic auditory cues synergistically amplify reward activation, especially when combined with high visual aesthetics, thereby enhancing pleasure, perceived tastiness, and overall evaluation (Motoki et al., 2023). Predictive coding models suggest that congruent sensory cues reduce the mismatch between expected and actual taste,

strengthening affective engagement and flavor perception (Clark, 2013; Morales & Berridge, 2020). Thus, the food-type dependent multisensory enhancement reflects the interaction of reward baseline, crossmodal congruency, and predictive coding dynamics. Healthy foods with less-aesthetic audiovisual cues exhibit decreased evaluation, while unhealthy foods with high inherent reward benefit most from congruent audiovisual cues, producing synergistic hedonic amplification.

After tasting, audiovisual aesthetic effects on purchase intention operated through pleasure and perceived tastiness in a manner that varied by Food Type and Visual Aesthetics. For both healthy foods with less-aesthetic plating and unhealthy foods with relatively high-aesthetic plating, the indirect effect of Auditory Aesthetics through pleasure was significant, as was the sequential indirect effect through pleasure and perceived tastiness. In contrast, the indirect effect through perceived tastiness alone was not significant. These findings suggest that pleasure served as the initial affective pathway linking auditory aesthetics to purchase intention, while perceived tastiness contributed subsequently within the sequential pathway.

These results align with evidence that taste attributes and hedonic reward responses are differentially encoded in the brain's reward circuitry, with higher tastiness food eliciting stronger neural representations in value-processing regions such as the orbitofrontal cortex than healthiness (Londerée & Wagner, 2020). The neural representation of food becomes increasingly distinct as tastiness increases. This enhanced neural sensitivity to tastiness suggests that for inherently rewarding, unhealthy foods, congruent audiovisual aesthetics not only elevate emotional pleasure but also intensify perceived tastiness, creating an additional pathway to purchase intention.

4.2. Application

In summary, the present study demonstrates that the matching of the aesthetic value of food plating and background music can produce multisensory enhancement effects in food consumption. By examining both pre- and post-tasting evaluations, this research showed how aesthetic alignment between visual and auditory cues can amplify pleasure and tastiness, ultimately increasing purchase intention. These findings contribute to the literature on multisensory interventions in consumer psychology by identifying Food Type as a boundary condition of audiovisual aesthetic effects, while further showing that pleasure and perceived tastiness provide pathways through which these effects can influence purchase intention. Gender-related differences additionally emerged as an exploratory individual-difference pattern. More broadly, previous servicescape research has shown that music, scent, color, and other ambient cues can jointly influence consumer evaluations and behavioral responses in retail and hospitality settings (Lin, 2004; Mattila & Wirtz, 2001; Roschk et al., 2017). While marketers have traditionally prioritized visual aesthetics in product design (Wu et al., 2017), the present findings further highlight the value of considering multiple sensory cues in the design of food-related consumer experiences.

As a multisensory marketing strategy, it allows consumers to engage with richer

sensory inputs (Kim et al., 2021), offering actionable insights for product design and brand storytelling. As consumers often rely on emotional experiences when making judgments (Clore et al., 2001), enhancing the pleasure of healthy foods through crossmodal aesthetic design may reduce preferences for unhealthy options. This sensory-based approach holds promise in addressing health challenges such as the global obesity crisis, which remains a central concern for public health initiatives (Turnwald & Crum, 2019).

4.3. Limitations and future directions

As with any study, several limitations should be considered. First, this study focused on visual and auditory modalities, which are central to eating experiences. However, this captures only part of the multisensory nature of food perception, which also involves olfactory, gustatory, and somatosensory inputs (Hutmacher, 2019; Rolls, 2015). As such, future research could incorporate other senses, such as olfaction, to better capture the holistic impact of multisensory inputs in food evaluation (Velasco et al., 2014). Second, although we compared online and offline contexts, the offline setting still slightly differed from real-world consumption (Spence et al., 2021). Moreover, this study controlled for differences between expected and actual taste, but did not systematically manipulate the discrepancy between them. Future work could explore how varying degrees of expected-actual taste discrepancy influence audiovisual aesthetic enhancement, and whether larger gaps lead to assimilation or contrast effects (Piqueras-Fiszman & Spence, 2015), thereby helping to clarify the boundaries of the amplification effect. Third, the participants in the present study were predominantly young Chinese university-aged adults, which limits the demographic, age, and cultural diversity of the samples. Moreover, aesthetic responses to music may be shaped by cultural exposure, familiarity with musical conventions, and learned expectations. Future research should therefore examine whether the present audiovisual aesthetic effects generalize across broader age groups and cultural backgrounds. Fourth, Experiment 1 was conducted remotely and therefore provided relatively limited control over auditory and visual presentation conditions. Although participants completed the task in a quiet setting and the procedure was remotely monitored, actual playback volume, room acoustics, screen characteristics, and attentiveness could not be standardized as tightly as in a laboratory setting. Experiment 2 partially addressed this limitation by using more standardized laboratory presentation conditions. Future research could further replicate the pre-tasting effects under fully controlled audiovisual presentation conditions. Finally, tThe findings should therefore be interpreted with respect to the relative perceived aesthetic value of the specific stimuli used. Future research could employ multiple independently pretested musical and visual exemplars within each aesthetic condition and systematically assess potentially relevant perceptual and affective characteristics.

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CRediT authorship contribution statement

Xin Lin: Data curation, Formal analysis, Methodology, Writing – Original draft preparation. **Junyang Ma**: Data curation, Writing – review & editing. **Jianping Huang**: Conceptualization, Supervision, Validation, Writing – review & editing. **Charles Spence**: Writing – review & editing.

Data Availability Statement

The data and experimental materials are available on the Open Science Framework (OSF) at https://osf.io/gu5fq/.

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