


## RESEARCH ARTICLE OPEN ACCESS

# Tune Your Appetite: How Music Impacts Food Choice, Intake, and Emotions During a Meal

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## ABSTRACT

Auditory cues, such as music, can potentially impact our eating behavior. In the present study, the effects of listening to music that varied in liking while consuming a meal on hunger, meal duration, food intake, and hedonic ratings were investigated. Measures of emotion were also obtained to understand the changes in meal duration, and both food intake and a 10-point visual analogue scale rating. A crossover experimental design involving 66 participants (27 males, 39 females) was employed, in which participants consumed lunch in a control condition, and while listening to music that they either liked or disliked. The results showed that listening to liked music significantly increased eating time, the intake of healthy food, and the consumption of afternoon snacks. Conversely, listening to disliked music significantly increased the consumption of unhealthy food. Additionally, the study explored the role of emotions in explaining these changes. It was found that ratings of hunger were higher, and more negative emotions were evoked, when participants consumed lunch while listening to disliked music. The silent and liked music conditions, which evoked more positive emotions, resulted in higher ratings of food pleasantness, overall liking of healthy and unhealthy food, and food satisfaction. Overall, the findings of this study highlight the significant influence of music upon appetite, food liking, and emotional responses during a lunch meal, emphasizing the potential practical applications in promoting healthier eating behaviors in real-world food-eating environments.

## 1 | Introduction

The influence of music on food intake has been a focal point in current research. Stroebele and de Castro's (2006) study reported that listening to music during lunch significantly increased meal duration, fat intake, and meal size compared to a music-free setting. Thomas and Smith (2009) found that elderly participants diagnosed with dementia consumed 20% more calories, particularly from carbohydrates, and spent more time at the table when music was played during mealtime. Further exploring the impact

of different music genres on calorie intake, Hussain et al. (2020) noted that classical music led to significantly lower consumption of crisps. Wansink and van Ittersum's (2012) study in a fast-food restaurant demonstrated that a "fine dining" atmosphere and soundscape reduced food consumption and led to higher food ratings. Taken together, these studies underscore the significant influence of music on food intake, affecting the amount and variety of foods consumed. However, although these descriptive studies focused on the impact of music on food intake, they did not identify the underlying mechanisms or psychological factors

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driving these effects. Only van den Tol et al. (2022) explored how different types of music affect food consumption as a function of emotional state, finding that “music for discharge” and “music for solace” led to the reduced consumption of chocolate and crisps. These findings suggest that the emotional response induced by different types of music may mediate the effect of music on food intake, though little research has been undertaken to confirm these relationships.

The impact of music on food choice and feelings of hunger and fullness has likewise generated interest on account of its health implications; however, the literature presents conflicting findings. In a study by Huang and Labroo (2019), participants exposed to high-pitched music tended to choose lower calorie and healthier food, suggesting that the acoustic properties of music can influence food choice. Conversely, Kaiser et al. (2016) found no significant impact of music types on food choice or consumption. Thus, although some studies indicate that music affects food choices, further research is needed to explore various musical characteristics, genres, and individual music preferences that may influence food choice.

Insights on how music may influence hunger are limited. Blass et al. (2006) observed higher hunger ratings when participants watched television compared to dining with music, suggesting that television viewing may distract individuals from recognizing satiety cues. Studies by Higgs and Donohoe (2011), Higgs (2015), Robinson et al. (2014), and Whitelock et al. (2018) have endorsed distraction as a key factor in explaining changes in food intake due to the effects of environmental stimuli (e.g., television or computer games). However, Çetin et al. (2023) found no significant differences in participants’ energy intake or perceptions of hunger and fullness across different music genres (Western classical vs. rock) and volume levels (60 vs. 80 dB). Therefore, although there is a suggestion that music might indirectly influence hunger by increasing awareness of fullness, more targeted research is needed to understand the relationship between music and feelings of hunger. Future studies measuring pre- and post-meal hunger levels under different music conditions could provide a clearer understanding of this potential connection.

Meal duration can be influenced by music, with familiarity and tempo playing key roles. Kaiser et al. (2016) found that unfamiliar background music and English pop songs extended meal duration compared to familiar German pop songs. Slow-tempo music has also been linked to prolonged meal duration, as observed by Wansink and van Ittersum (2012) in a study where individuals exposed to soft jazz ballad instruments spent longer eating compared to those in a fast-food restaurant with loud, fast-paced music. Similarly, Mathiesen et al. (2022) demonstrated that slow background music resulted in slower eating during lunch. Although these studies establish a connection between music and meal duration, further research is essential to understand the underlying cognitive and behavioral mechanisms driving this relationship. Exploring whether music influences emotions that encourage mindful eating habits leading to a slower meal pace could inform the development of healthier eating strategies.

Listening to music while eating enhances the food experience by influencing perceptual processes through the emotions evoked by the music. Studies by Kantono et al. (2016), Kantono et al. (2018),

Kantono et al. (2019), and Lin et al. (2022) showed that listening to liked music increased positive emotions, impacting how participants perceived the flavor of chocolate ice cream. Pertinently, positive emotions enhanced sweetness perception, whereas negative emotions amplified bitter and creamy attributes. Additionally, Kantono et al. (2016) noted that disliked music reduced pleasantness ratings across a selection of chocolate ice cream varieties, whereas liked music increased pleasantness ratings. This overall increase in perceived pleasantness with liked music was linked to the generation of positive emotions, encouraging participants to provide positive assessments of stimuli, aligning with the Affect Infusion Model (Forgas 1995). The emotional valence of music (pleasant vs. unpleasant) appears to play a critical role in shaping our perception of different flavor components in food. The findings in the literature highlight the complex relationship between emotions, taste perception, and music preferences, suggesting that positive emotions toward music can influence judgments of food pleasantness and enjoyment, in line with classical conditioning or mood affect theories.

The complex relationship between music, emotions, and food behaviors suggests that emotions evoked by music can significantly impact food perception, and so it is important to consider both musical and psychological factors in understanding food consumption. The objective of this research is to investigate the effects of music on food intake, satiety, and food choice. This study adopts an inductive approach with nondirectional hypotheses that focus on the potential influence of music on meal consumption. The hypotheses include:

1. Music liking will influence food intake: Participants consuming a meal while listening to music varying in liking will exhibit variations in food intake quantity compared to a silent environment.
2. Music liking will impact satiety perception: The perception of fullness post-consumption will differ for participants exposed to liked or disliked music during the meal compared to being in a silent setting.
3. Music liking will influence food choice: Participants listening to liked or disliked music will make different food choices compared to when in a silent environment.

These hypotheses are justified by the complex relationship between music, emotions, and food behaviors, as well as the theoretical significance of exploring how music liking can affect food consumption patterns. By systematically analyzing these dimensions with respect to diverse music conditions and emotional responses, the study hopes to provide valuable insights for enhancing individuals’ eating experiences and overall well-being.

## 2 | Materials and Methods

### 2.1 | Participants

Participants were recruited through poster advertisements. This research was reviewed and approved by the Auckland University of Technology Human Ethics Committee (AUTEC 19/289). Before the study commenced, all participants provided written informed consent. The inclusion criteria included being between the ages

**TABLE 1** | Food items used in the current study.

Type of food	Amount (g)	Energy per portion (kJ)
Cheesy chicken burger	138.5	1689.9
Cookies chunky chocolate chip	100	473.3
Choc fudge brownie	80	1128
Salad with telegraph cucumber, cherry tomatoes, chicken shaved roast	150	458.3
Bananas	80	134.4
Mandarins	80	134.40
Grapes green	80	216.0

of 18 and 65, being in good health, nonsmokers, not currently dieting, and not diagnosed with any metabolic disease or hearing loss. Participants with food allergies (such as gluten, milk, sugar, eggs, wheat, chicken, and food preservatives), those following vegan, vegetarian, or kosher diets, or individuals with medical conditions, an eating disorder, or taking medication that could affect appetite or body weight, were likewise excluded from the study.

## 2.2 | Food Stimuli

In a preliminary study, the food and afternoon snack items to be used in the main experiment were chosen on the basis of the perceived healthiness. Using a 10 cm visual analogue scale with anchors ranging from “Healthy” to “Unhealthy,” a focus group of 30 participants were selected from 14 lunch items and 10 snack items (*re*: Appendix 1.1). The snack items were served in portions recommended on the packaging, and the serving size for the fruits was in accordance with the recommendations of the New Zealand Ministry of Health, as outlined in the 13th edition (2018) of the New Zealand Food Composition Tables. Subsequently, three food and one afternoon snack items were selected from each of the healthy and unhealthy categories for use in the actual experiment.

In this study, participants were served a lunch meal consisting of both healthy and unhealthy food items (*re*: Table 1), with an approximate energy value of 3106.3 kJ. The research examined the effects of consuming these food items under a control condition (silence), as well as during exposure to either liked and disliked music. The unhealthy meal options included a chicken burger, cookie, and chocolate brownie, whereas the healthier choices comprised a chicken salad (featuring chicken roast, cucumber, and cherry tomatoes) alongside a selection of fruits (mandarins, green grapes, bananas). Throughout the study, participants were given a 20-min timeframe to freely select and consume the food items as much or as little as they wanted. Two hours later, participants returned to the laboratory and were given the choice of a healthy afternoon snack (banana), an unhealthy afternoon snack (crisps), or both.

The energy values are expressed in units of kilojoules (kJ). All values are calculated on the basis of the energy-producing components of the food, including carbohydrate, protein, fat, and alcohol, with and without the inclusion of dietary fiber

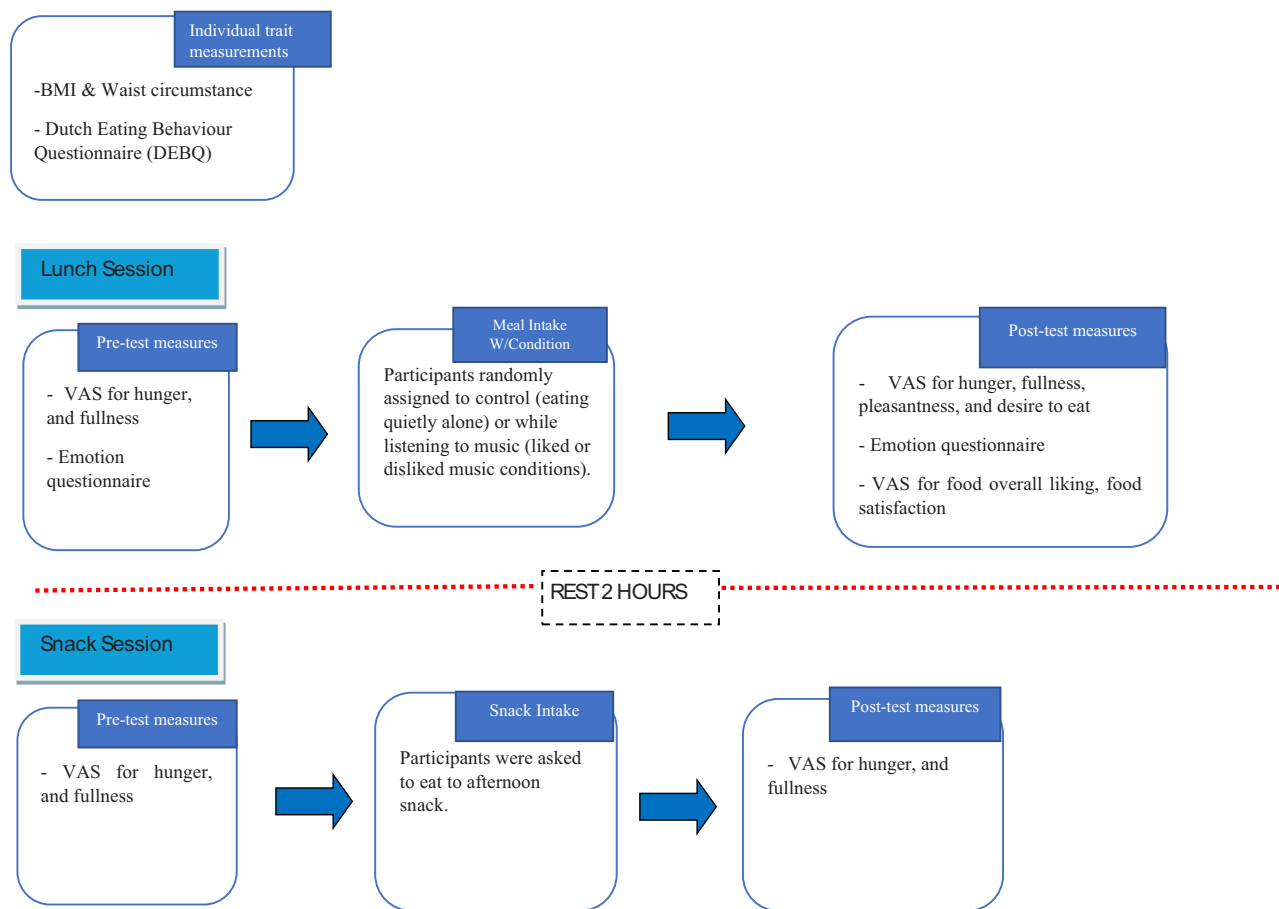
and organic acids (New Zealand Institute of Plant and Food Research 2018). For more detailed information, the concise 13th edition of the Food Composition Tables, available at <https://www.foodcomposition.co.nz/downloads/concise-13-edition.pdf>, can be referenced.

## 2.3 | Music Selection

On the day of the experiment, participants were asked to develop a music playlist based on their individual liking (Balasubramanian et al. 2018; Liljeström et al. 2012). Each participant was asked to select three songs they liked and three songs they disliked, enabling a personalized approach to music selection. The chosen music was then rated using an unstructured 10 cm line scale, anchored with “extremely dislike” and “extremely like” at each end. The music with the lowest and highest liking scores was categorized as disliked and liked music, respectively. The music was accessed via Spotify and played through a Sennheiser headset (Model: HD 518, Sennheiser Electronics GmbH and Co. KG). Participants subsequently listened to their liked and disliked music while consuming a lunch meal.

## 2.4 | Self-Reported Emotion

Self-reported emotions were assessed using the Check All That Apply (CATA) method (Ng et al. 2013). A list of 20 emotions was identified by a focus group of thirty participants, who were asked to select the emotions they experienced after consuming the meal in a silent condition, as well as when listening to liked or disliked music. The emotional terms were chosen from the profile of mood states questionnaire (McNair et al. 1971), the multiple affect adjective checklist-revised (Lubin and Zuckerman 1999), positive and negative affect scale (Watson and Clark 1988), and the Geneva affect label coder (Scherer 2016). The final list of 20 emotion terms comprised 12 positive emotion terms (positive, active, at ease, relaxed, calm, energetic, enthusiastic, excited, interested, joy, pleasant, and satisfaction) and 8 negative emotion terms (tired, alone, drowsy, boredom, tense, dissatisfied, exhausted, and contempt). In the main experiment, participants were required to select the emotions they experienced immediately after consuming a meal under the different sound conditions. All emotional response data were acquired using an online platform (Qualtrics, Ohio). Definitions of the 20 emotions were provided to the



**FIGURE 1** | Overview of one of the three experimental sessions making up the experimental design.

participants to ensure their understanding of the terms (*re*: Appendix A.1).

## 2.5 | Procedure

Figure 1 provides an overview of the experimental procedures. To begin, a questionnaire was completed by participants at home the day before their scheduled participation in the first experimental session. Participants were required to disclose their weight, height, and waist circumference, as well as complete the Dutch Eating Behavior Questionnaire (van Strien et al. 1986), which assesses restrained eating, emotional eating, or external eating tendencies using a Qualtrics online survey.

Each participant attended three experimental sessions in which they consumed food twice (lunch and later an afternoon snack) under conditions of silence, liked music, or disliked music, resulting in six food intake intervals. The study was scheduled between 11:00 a.m. and 1:00 p.m. to ensure that all participants completed the experiment during their lunchtime. For the afternoon snack intake, the sessions were conducted between 1:00 p.m. and 3:00 p.m. In the control condition, participants consumed food in quiet, whereas in the liked and disliked music conditions, participants listened to music they liked or disliked, respectively, while consuming the food items. A within-subject design was used, with participants randomly assigned to one of the three conditions in the first session. Each participant experienced the

three conditions with no greater than a 1-week interval between them, occurring on the same day and at the same time of day. The experiments were conducted in the Auckland University of Technology sensory laboratory to ensure a well-controlled environment for all study procedures.

Sixty-six participants were chosen to carry out the experiments under conditions aimed at achieving a statistical power of 0.90–0.95, based on a Cohen's *d* value of 0.8. On the day of food evaluation, participants were required to have breakfast, but not lunch, and refrain from eating for at least 1 h before the start of the experiment, ensuring that participants had sufficient appetite to complete the study. Upon arrival at the laboratory, participants were briefed on the study's objectives and were asked to provide their informed consent by signing a consent form. Participants were informed that the topic of the research was to examine their food intake on different test days rather than to measure the musical effects on food choice. The experiment was conducted using the Qualtrics online survey platform.

Questions regarding satiety level and food ratings (food pleasantness, food enjoyment) were presented in four separate sections (before eating lunch, after eating lunch, before eating the snack, and after eating the snack). During each of three sessions, participants were served three healthy and three unhealthy lunch food items, and their satiety level was determined using a 10 cm visual analogue scale with anchors ranging from 0 (Not at all) to 10 (Extremely) for hunger and fullness. Before eating, participants

were asked to evaluate their desire to eat, food pleasantness (overall, flavor, appearance), and anticipated food enjoyment. Participants provided ratings for these measures using a 10 cm visual analogue scale with anchors ranging from 0 (Not at all) to 10 (Extremely).

Participants were then given 20 min to consume a variety of healthy and unhealthy food items, as much or as little as they desired, with water (350 mL) available at room temperature. To assess meal duration, an experimenter sat out of sight with a stopwatch and began timing as soon as the participants began to eat and stopped the timer when the last bite of the meal was swallowed, or when the participant declared that they had finished eating. Satiety levels, pleasantness, and emotional responses were obtained after participants consumed the meal. In addition, participants were asked to rate their satisfaction, overall liking, and perception of healthiness of the food items. The liking and satisfaction of food items were rated using a 10 cm unstructured line scale anchored from 0 (Dislike extremely) to 10 (Like extremely) and from 0 (Not at all satisfied) to 10 (Extremely satisfied).

Before leaving, participants were reminded to attend the afternoon snack session, in which they were provided with an afternoon snack to be consumed 2 h after the lunch meal and were asked to refrain from eating and engaging in strenuous physical activities beforehand. When returning for the afternoon session, participants indicated their satiety level with reference to the afternoon snacks provided. The afternoon snack consisted of two items: one healthy and the other unhealthy. Participants were informed that they can eat as much or as little as they desired. After consuming the snack, participants reported their post-satiety level.

To monitor food intake, measurements of food quantity were taken both before and after the consumption of both the main meal and snack. This approach allowed for a comprehensive assessment of participants' eating behavior and satisfaction levels throughout the study (Dalton et al. 2013). These values were converted to energy (kJ) based on the nutritional information published on the McDonald's New Zealand ([www.mcdonalds.co.nz](http://www.mcdonalds.co.nz)) and Mrs. Higgins (<https://www.mrshiggins.com/products>) websites, as well as the NZ Food Composition Data for Nutrition Information (New Zealand Institute of Plant and Food Research 2018) (<https://www.foodcomposition.co.nz/downloads/concise-13-edition.pdf>).

## 2.6 | Statistical Analysis

For the Dutch Eating Behavior Questionnaire (DEBQ) results, descriptive statistics were computed for each dimension, including restraint, emotional, and external eating. The emotion data obtained using CATA were dichotomized into two categories (0 = not selected/1 = selected), and the frequencies of emotional responses under different music conditions were determined. Multidimensional alignment (MDA) was used to analyze CATA data (Carr et al. 2009; Esmerino et al. 2017) by determining the cosine value between music conditions and emotion attributes. By calculating the cosine of the angle (ranges  $-1$  to  $1$ ) formed between each attribute and condition, it is possible to determine

which attributes have a strong relationship with each music condition (Lin et al. 2022). Absolute cosine values lower than 0.707 indicate no relationships (Carr et al. 2009).

A total score for hunger was calculated by summing the scores for hunger, fullness (reversed scoring), and desire to eat. Pre- and post-liking scores were obtained by averaging the food pleasantness and enjoyment scores for a meal. Post-average food liking and satisfaction were obtained by averaging the scores for healthy and unhealthy food items. Multi-way ANOVA was performed to explore the influence of music (or silence) on meal duration and energy intake, food pleasantness and enjoyment, food liking and satisfaction, and hunger ratings. In these analyses, participant characteristics (BMI, waist circumference, age, and gender) and psychological traits (DEBQ) were included as covariates, and interaction terms were included (i.e., Condition  $\times$  Age, Condition  $\times$  BMI, Condition  $\times$  Gender). Post hoc Tukey's honestly significant difference (HSD) test was applied if statistical significance was observed ( $p < 0.05$ ). Partial eta squared ( $\eta_p^2$ ) was reported as a measure of effect size (Cohen 1988: small = 0.01; medium = 0.06; large = 0.14).

Multiple factor analysis (MFA) was employed to analyze the influence of consuming food under different sound conditions (silence, liked music, and disliked music) on a range of factors including emotions, food pleasantness, food liking, enjoyment, satisfaction, food intake, and meal duration. This analytical approach enables the concurrent analysis of datasets containing different variables in order to explore the relationship between samples and variables (Escofier and Pagès 2014). Previous studies have utilized MFA to explore the correlation between sensory responses and emotional measurements during food consumption under music conditions varying in liking (Kantono et al. 2018; Kantono et al. 2019) and sound pleasantness (Lin et al. 2022). All statistical analyses were performed using XLSTAT v. 2021.5 (Lumivero, USA).

## 3 | Results

### 3.1 | Participant Characteristics

A total of 66 participants, including 27 males and 39 females, successfully completed the three experimental conditions: silence, liked music, and disliked music. The mean age of the participants was  $26.67 \pm 6.26$  years. The participants had an average BMI of  $23.35 \pm 3.54$  and a waist circumference of  $82.94 \pm 14.56$  cm. On average, the scores for dietary restraint, emotional eating, and external eating as measured by the DEBQ method were  $2.76 \pm 0.90$ ,  $2.67 \pm 0.96$ , and  $3.37 \pm 0.67$ , respectively. Participant attributes were measured at the beginning of each of the experimental sessions and are reported as mean  $\pm$  standard deviation in Appendix A. 4. There were no significant differences across gender, age, or BMI for the silent, liked music, and disliked music conditions (all  $p > 0.1$ ) in terms of hunger, energy intake, meal duration, food pleasantness, enjoyment, overall liking, and satisfaction ratings for the silent, liked music, and disliked music conditions. In addition, the DEBQ dimensions (restraint, emotional, and external eating) did not influence hunger, energy intake, meal duration, food pleasantness, enjoyment, overall

liking, and satisfaction ratings for the silent, liked music, and disliked music conditions (all  $p > 0.1$ ).

### 3.2 | Overall Effects of Music on Meal Duration and Energy Intake

The multi-way ANOVA analysis indicated a significant main effect of music condition on energy intake during lunch. The results revealed that meal duration significantly differed across the three conditions ( $F_{(2,197)} = 4.178$ ,  $p < 0.0001$ ,  $\eta_p^2 = 0.21$ ), as shown in Figure 2A. Participants consumed food for a significantly longer duration ( $M = 15.28$  min) when listening to liked music compared to disliked music ( $M = 10.18$  min) or when eating lunch in silence ( $M = 13.23$  min). Moreover, participants ate less unhealthy food ( $F_{(2,197)} = 5.634$ ,  $p = 0.005$ ,  $\eta_p^2 = 0.052$ ) and more healthy food ( $F_{(2,197)} = 5.028$ ,  $p = 0.007$ ,  $\eta_p^2 = 0.03$ ) while listening to liked music compared to disliked music or the silent condition (see Figure 2B).

Figure 2C (i) and (ii) shows the intake of snacks 2 h after the lunch meal under different music conditions. Participants in the liked music condition consumed significantly more of the unhealthy, salted crisps ( $F_{(2,197)} = 11.381$ ,  $p < 0.0001$ ,  $\eta_p^2 = 0.07$ ) than when they consumed food in the silent and disliked music conditions. However, there were no significant differences between silent and disliked music conditions. The consumption of banana as a healthy snack was significantly higher in the liked music ( $F_{(2,197)} = 4.716$ ,  $p = 0.010$ ,  $\eta_p^2 = 0.043$ ) condition compared to the disliked music condition, but the differences failed to reach significance with the silent condition.

### 3.3 | The Effect of Music on Rating of Food Pleasantness and Enjoyment

After consuming lunch, participants rated the food's overall pleasantness as well as the flavor, appearance, and enjoyment. A multi-way ANOVA revealed a significant main effect on overall pleasantness ( $F_{(2,197)} = 28.60$ ,  $p < 0.0001$ ,  $\eta_p^2 = 0.23$ ), flavor pleasantness ( $F_{(2,197)} = 26.8$ ,  $p < 0.0001$ ,  $\eta_p^2 = 0.22$ ), appearance pleasantness ( $F_{(2,197)} = 21.464$ ,  $p < .0001$ ,  $\eta_p^2 = 0.18$ ), and enjoyment ( $F_{(2,197)} = 40.145$ ,  $p < 0.0001$ ,  $\eta_p^2 = 0.29$ ). Of note, the ratings for both pleasantness and enjoyment were significantly lower when participants were listening to disliked music while eating lunch compared to listening to liked music or when eating in silence (*re*: Figure 3).

### 3.4 | Overall Liking and Satisfaction Ratings of Healthy and Unhealthy Lunch Food Items

A multi-way ANOVA was performed to examine the main effect of music on food liking and satisfaction. As shown in Figure 4, liking and satisfaction ratings of seven food items immediately following consumption varied under the different music conditions. Healthy food items that included salad ( $F_{(2,197)} = 11.961$ ,  $p < 0.0001$ ,  $\eta_p^2 = 0.14$ ), banana ( $F_{(2,197)} = 10.549$ ,  $p < 0.0001$ ,  $\eta_p^2 = 0.10$ ), orange ( $F_{(2,197)} = 11.563$ ,  $p < 0.0001$ ,  $\eta_p^2 = 0.11$ ), and grapes ( $F_{(2,197)} = 13.142$ ,  $p < 0.0001$ ,  $\eta_p^2 = 0.12$ ) had significantly lower overall liking scores under the disliked music condition compared to the silent

and liked music conditions (see Figure 3A). In terms of food satisfaction (Figure 4B), healthy food items that included salad ( $F_{(2,197)} = 16.239$ ,  $p < 0.0001$ ,  $\eta_p^2 = 0.14$ ), banana ( $F_{(2,197)} = 11.463$ ,  $p < 0.0001$ ,  $\eta_p^2 = 0.11$ ), orange ( $F_{(2,197)} = 11.481$ ,  $p < 0.0001$ ,  $\eta_p^2 = 0.11$ ), and grapes ( $F_{(2,197)} = 13.028$ ,  $p = 0.0001$ ,  $\eta_p^2 = 0.12$ ) similarly had significantly lower food satisfaction scores under the disliked music condition compared to the silent and liked music conditions. However, for unhealthy food items, only the chicken burger ( $F_{(2,197)} = 4.443$ ,  $p = 0.013$ ,  $\eta_p^2 = 0.04$ ) resulted in a significantly lower satisfaction score during the disliked music condition compared to the liked music condition. No significant differences were observed between participants when they ate in silence or when they were listening to liked and disliked music in terms of perceived healthiness ratings of healthy and unhealthy food items (Figure 4C). Food health ratings showed that the chicken cheesy burger, chocolate brownie, and chocolate cookies were considered the unhealthiest products by participant, whereas salad, grape, orange, and banana were rated as more healthy.

### 3.5 | Effect of Music Conditions on Hunger Ratings

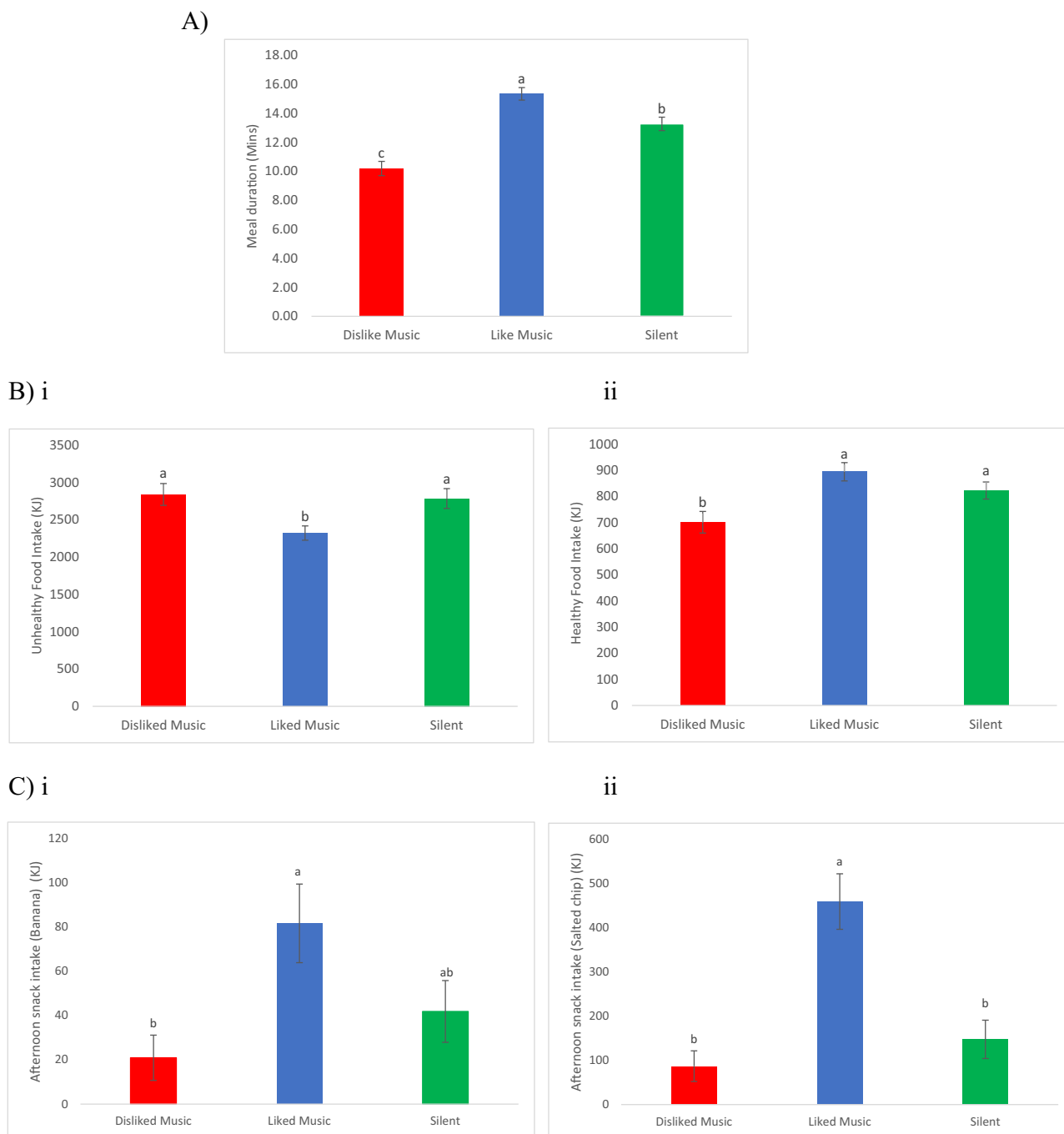
A multi-way ANOVA for hunger ratings immediately after the consumption of lunch revealed that when participants listened to disliked music, their hunger ratings were significantly higher than when they listened to liked music or silence ( $F_{(2,197)} = 5.379$ ,  $p = 0.006$ ,  $\eta_p^2 = 0.09$ ), as shown in Table 2. Additionally, the results showed that pre-snack ( $F_{(2,197)} = 11.959$ ,  $p < 0.0001$ ,  $\eta_p^2 = 0.05$ ) and post-snack ( $F_{(2,197)} = 13.811$ ,  $p < 0.0001$ ,  $\eta_p^2 = 0.05$ ) hunger ratings were significantly higher in the disliked music condition than the liked music and silent conditions.

### 3.6 | Ratings of Emotion After Eating a Lunch Meal Under Different Music Conditions

Green values indicate a high positive correlation ( $> 0.707$ ) between the emotion attribute obtained after consuming the lunch meal under the silent, liked music, and disliked music conditions. Orange values indicate a high negative correlation ( $\leq 0.707$ ) between the emotion attribute obtained after consuming the lunch meal under the silent, liked music, and disliked music conditions.

MDA was used for analysis of CATA results (Carr et al. 2009; Esmerino et al. 2017) by determining the cosine value between music conditions and self-reported emotions after participants consumed a lunch meal. Table 3 presents the emotions that were positively and negatively correlated with the different eating conditions using the first two dimensions of the CA bi-dimensional map. Cosine values greater than 0.707 (Carr et al. 2009) indicate a strong relationship between the music conditions and emotion attributes.

After consuming the lunch meal in silence, participants reported the positive emotions of relaxation, calmness, interest, comfort, satisfaction, and positivity. While listening to liked music, participant reported the positive emotions of excitement, pleasure, happiness, joy, and amazement. However, listening to disliked



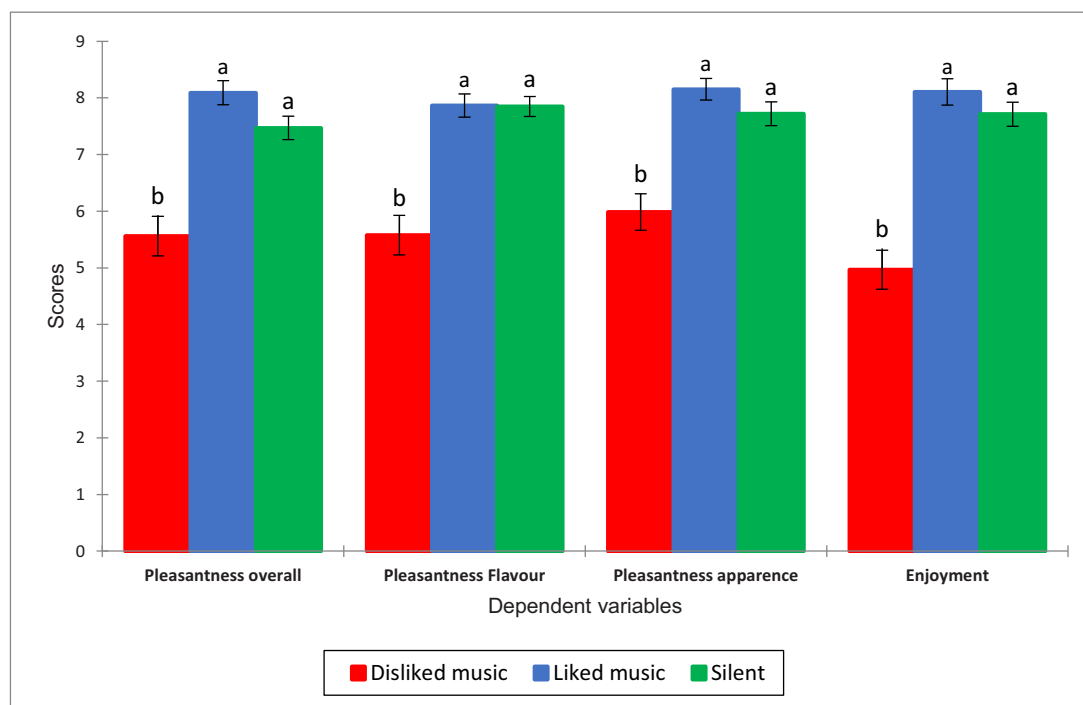
**FIGURE 2** | Food intake and meal duration during the control (silent) and the liked and disliked music conditions. The results are expressed as mean  $\pm$  standard error (SE). Different superscripts (a, b) indicate significant differences at  $p < 0.05$ . (A) Meal duration of lunch meal; (B) (i) food intake of unhealthy (chicken cheeseburger, cookie, and brownie), and (ii) healthy (salad, banana, orange, and grapes) lunch items; (C) afternoon snack intake of (i) banana, and (ii) salted crisps.

music was associated with the negative emotions of tiredness, tension, boredom, dissatisfaction, drowsiness, exhaustion, and contempt.

### 3.7 | A Multifactorial Model Relating Self-Report Measures, Food Intake, and Music Condition

Figure 5 illustrates the MFA biplot, which summarizes the relationship between participants' emotions, hunger ratings, meal

duration, food intake (healthy and unhealthy food), afternoon snack intake (healthy and unhealthy snack), and food ratings (liking of food appearance, food overall liking, and satisfaction) while consuming food under different music conditions. MFA enables the concurrent analysis of datasets containing different variable sets (Escofier and Pagès 2014), for example, to explore the linkages between sensory responses and emotional measurements during food consumption under music conditions varying in liking (Kantono et al. 2018; Kantono et al. 2019) or sound pleasantness (Lin et al. 2022). The first (F1) and second (F2)



**FIGURE 3** | Food pleasantness and enjoyment during control (silent) and the liked and disliked music conditions. The results are expressed as mean  $\pm$  standard error (SE). Different superscripts (a, b) indicate significant differences at  $p < 0.05$ .

**TABLE 2** | The mean hunger ratings assessed before and after the lunch meal, as well as before and after the afternoon snack, under silent (control), liked music, and disliked music conditions.

	Silent (control group)	Liked music	Disliked music	<i>p</i> value (df = 2, 197)
Hunger before lunch	7.76 $\pm$ 0.20 <sup>a</sup>	7.79 $\pm$ 0.21 <sup>a</sup>	7.77 $\pm$ 0.19 <sup>a</sup>	0.896
Hunger after lunch	0.97 $\pm$ 0.17 <sup>b</sup>	1.06 $\pm$ 0.14 <sup>b</sup>	1.77 $\pm$ 0.27 <sup>a</sup>	0.006
Hunger before afternoon snack	2.30 $\pm$ 0.22 <sup>b</sup>	2.65 $\pm$ 0.26 <sup>b</sup>	3.86 $\pm$ 0.33 <sup>a</sup>	<0.001
Hunger after afternoon snack	0.83 $\pm$ 0.16 <sup>b</sup>	0.89 $\pm$ 0.11 <sup>b</sup>	2.29 $\pm$ 0.34 <sup>a</sup>	<0.001

Note: The results are presented as mean  $\pm$  standard error. Different superscripts (<sup>a</sup>, <sup>b</sup>) (across rows) indicate significant differences at  $p < 0.05$ .

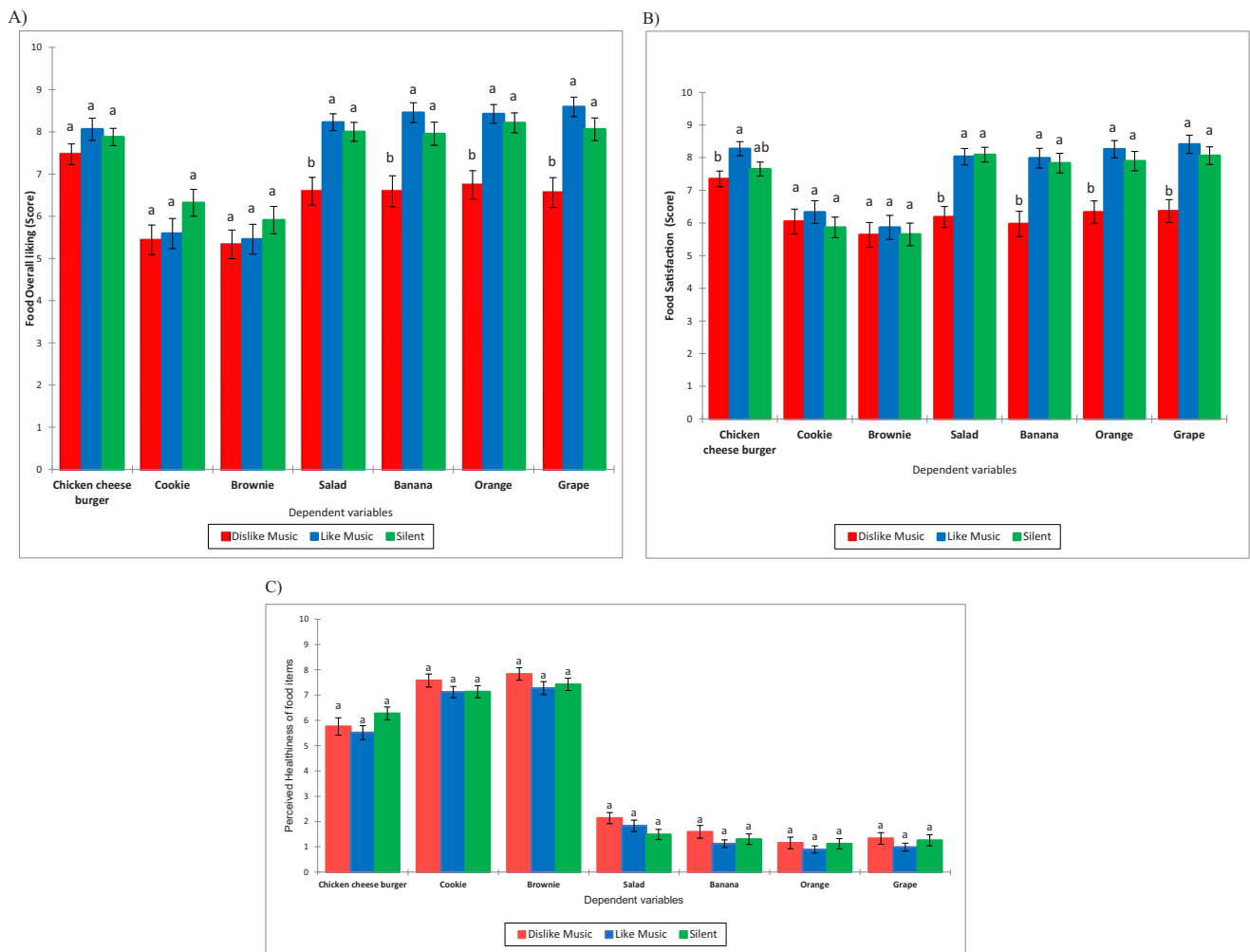
dimensions of the MFA explain 79.33% and 20.67% of the variance in the data, respectively (*re*: Figure 5). Consuming food while listening to liked music resulted in high positive scores along F1, which correlated with longer meal duration, higher intake of healthy lunch items, healthier afternoon snack choices (i.e., banana), as well as higher overall liking of healthy food, overall food pleasantness, pleasantness of flavor and appearance, and healthy food satisfaction ratings. Positive emotions (i.e., relaxed, excited, pleasure, happy, active, joy, amazed, satisfaction, and positivity) were also associated with liked music. Conversely, consuming food while listening to disliked music resulted in a high positive score along F1, which correlated with increased post-eating lunch hunger, unhealthy food intake, and negative emotions such as tiredness, dissatisfaction, tension, drowsiness, exhaustion, and contempt. Disliked music was also correlated with a higher intake of unhealthy snacks. Factor 2 (F2) explained 20.67% of the variability in the data and was associated with eating in silence, which had high positive scores along F2 and

correlated with emotions of feeling alone, calm, interested, and at ease.

## 4 | Discussion

### 4.1 | Listening to Liked Music During a Meal Influenced the Time Spent Eating Food, Healthy Food Intake, and Afternoon Snack Intake

This is the first study to demonstrate that participants spent significantly more time eating their lunch meal while listening to liked music compared to listening to disliked music or silence. Previous studies by Kaiser et al. (2016), Wansink and van Ittersum (2012), and Mathiesen et al. (2022) have shown that music can influence the duration of meal consumption. For instance, Kaiser et al. (2016) found that background instrumental jazz music led to significantly more time spent eating a German meal compared



**FIGURE 4** | Post-consumption ratings of food under control (silent), and the liked and disliked music conditions: (A) food overall liking; (B) food satisfaction; (C) perceived healthiness of unhealthy (chicken cheeseburger, cookie, and brownie) and healthy (salad, banana, orange, and grapes) lunch items. The results are expressed as mean  $\pm$  standard error (SE). Different superscripts (a, b) indicate significant differences at  $p < 0.05$ .

to German music. Similarly, Wansink and van Ittersum (2012) observed that participants in a sound-attenuated dining room with soft jazz ballad playing ate their food significantly slower than those in a fast-food restaurant setting. Moreover, Mathiesen et al. (2022) demonstrated that participants who consumed lunch while listening to slow music ate significantly slower than those who ate in silence. They also found that slow-tempo music led to a significantly longer lunch duration compared to fast-tempo music. The weight of the evidence thus indicates that the presence of sound can influence meal duration and thus has the potential to influence eating pace during a meal, with potential implications for food intake.

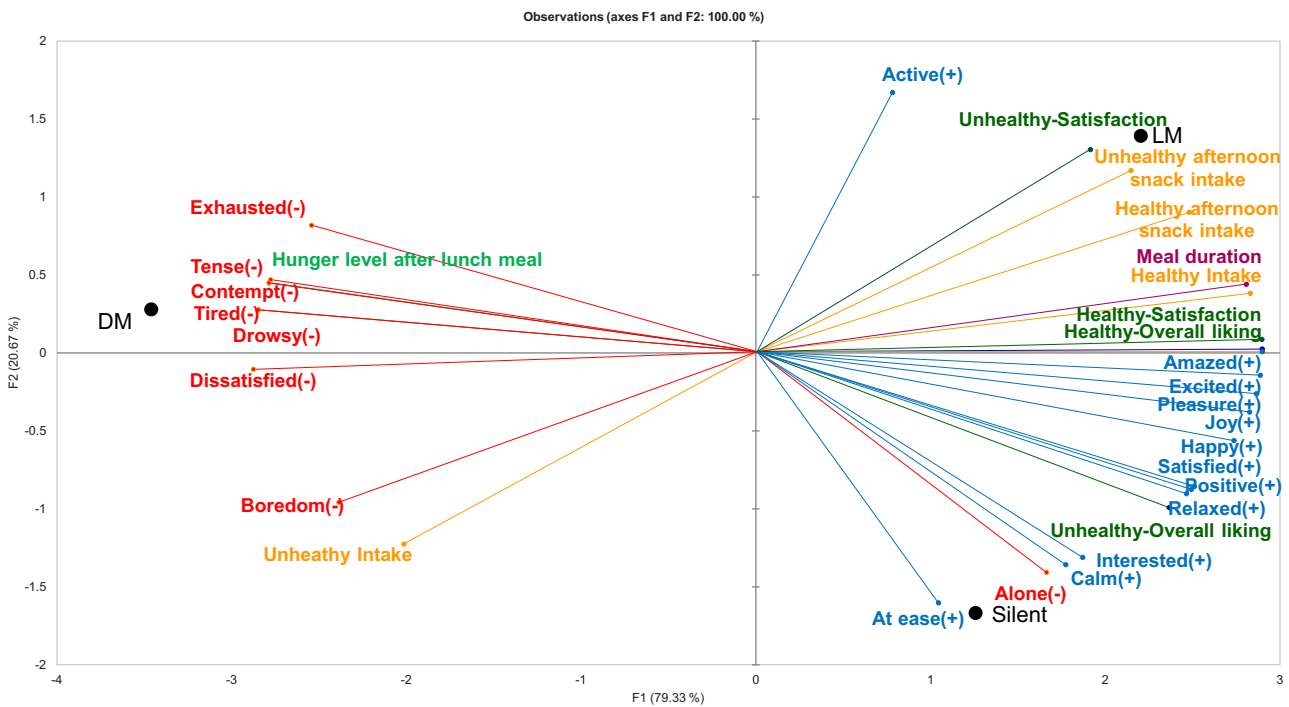
In the current study, it was hypothesized that consuming a meal while listening to music varying in liking would influence food intake compared to a silent environment. The results showed that consuming lunch while listening to liked music significantly increased healthy food intake compared to the disliked music and silent conditions. Studies have shown that listening to music can influence food intake. Stroebele and de Castro (2006) found that listening to background music while eating led to significantly greater consumption compared to a no-music condition. This

suggests that music may either increase appetite or the enjoyment of the eating experience, or both. Privitera et al. (2014) showed that listening to highly arousing music led to significantly higher consumption of healthier food items, such as carrot sticks and apple slices, compared to participants who were exposed to a low-arousal movie. These studies suggest that highly arousing dining environments may have a positive impact on healthy food intake. Huang and Labroo (2019) further showed that when participants listened to high-pitched but pleasant music they were more likely to order healthier food compared to normal or low-pitched music. These studies suggest that music can influence food consumption and buying behavior, with background music potentially increasing overall food intake, highly arousing music promoting the consumption of healthier food items, and music with a specific pitch potentially influencing food choices toward healthier options. Results from the current study further showed that liked music increased healthy food intake, which is a novel finding as participants selected the music themselves.

It was also hypothesized that participants would make different food choices under the music conditions compared to a silent environment. Results in this study showed that listening to liked

**TABLE 3** | Cosine values obtained by correspondence analysis that shows the correlation between check-all-that apply (CATA) emotion attributes under silent and music (liked and disliked music) conditions after consuming a lunch meal.

	Silent	Liked music	Disliked music
Tired (-)	-0.776	-0.925	0.994
Alone (-)	0.701	-0.292	-0.202
Tense (-)	-0.874	-0.844	0.998
Boredom (-)	-0.423	-0.998	0.847
Dissatisfied (-)	-0.838	-0.879	1.000
Drowsy (-)	-0.841	-0.877	1.000
Exhausted (-)	-0.885	-0.831	0.996
Contempt (-)	-0.861	-0.858	0.999
Calm (+)	0.846	-0.065	-0.422
Interested (+)	1.000	0.472	-0.837
Relaxed (+)	0.881	0.836	-0.997
Excited (+)	0.574	0.994	-0.926
Pleasure (+)	0.572	0.994	-0.926
At ease (+)	0.995	0.383	-0.779
Happy (+)	0.614	0.987	-0.944
Active (+)	-0.595	0.423	0.064
Joy (+)	0.384	0.995	-0.824
Amazed (+)	0.424	0.998	-0.847
Satisfied (+)	0.935	0.757	-0.978
Positive (+)	0.908	0.801	-0.990



**FIGURE 5** | The multiple factor analysis (MFA) biplot showing changes in negative emotions (red), positive emotions (blue), intake of healthy and unhealthy lunch food, and healthy and unhealthy afternoon snack (orange), meal duration (purple), as well as food ratings (dark green) that include hunger after eating lunch (light green), food enjoyment, food pleasantness (overall, appearance, flavor), overall liking of healthy and unhealthy food, and satisfaction of healthy and unhealthy food among participants consuming food under silent, liked music (LM), and disliked music (DM) conditions.

music during lunch significantly increased the intake of afternoon snacks. This is consistent with previous research suggesting that distractions during a meal can lead to increased healthy and unhealthy snack consumption later in the day. Conversely, paying attention to a meal and focusing on the food being eaten may reduce subsequent snacking behavior. Robinson et al. (2014) reported that listening to an audio book while eating significantly increased snack intake later in the day compared to those who focused on the sensory aspects of their food. Another study investigated the effects of playing a computerized card-sorting game while eating lunch on later snack intake (Oldham-Cooper et al. 2011). They found that participants who were distracted during lunch reported feeling less full and consumed significantly more biscuits compared to those who were not distracted. Furthermore, Higgs and Donohoe (2011) reported that focusing on food during a meal led to significantly less afternoon cookie intake compared to reading an article about food or being in a silent control condition. However, Whitelock et al. (2018, 2019) failed to find significant differences in later snack intake between focused attention and control group conditions. It is worth noting that Whitelock's two studies may have lacked a genuine distracting condition, which could explain the absence of significant differences. Taken together, these studies suggest that distraction during a meal can lead to increased snack consumption later in the day, which aligns with the findings of the present study. Conversely, paying attention to a meal and focusing on the sensory aspects of food may help reduce subsequent snacking, as evidenced by the study by Higgs and Donohoe (2011).

#### 4.2 | Eating a Meal While Listening to Liked Music or in Silence Increased Food Pleasantness and Satisfaction

The rating of food pleasantness increased while listening to liked music and in the silent conditions, which is consistent with previous research on the influence of music on food pleasantness and enjoyment. Novak et al. (2010) demonstrated that listening to comforting music significantly increased food enjoyment compared to loud music. Fiegel et al. (2014) found that background music influenced flavor pleasantness and the overall impression of milk chocolate, with participants rating it as more pleasant when listening to jazz music compared to hip-hop music. However, there were no significant differences across conditions in the pleasantness ratings of red bell peppers. The influence of music on taste perception has also been demonstrated in other studies. Kantono et al. (2016), investigating the impact of background music varying in valence (pleasant, neutral, and unpleasant) on the hedonic ratings of chocolate ice cream (dark, bittersweet, and milk), reported that pleasant music significantly increased perceived pleasantness ratings of dark and bittersweet chocolate ice cream, while unpleasant music significantly decreased pleasantness ratings for all types of chocolate ice cream. These studies support the findings of the current study, where listening to liked music during a meal was associated with increased food pleasantness ratings, suggesting that music can induce emotions that subsequently influence the pleasantness of food.

In the current study, listening to liked music or eating in silence significantly increased satisfaction ratings for healthy food items

compared to the disliked music condition. This aligns with previous research by Spence et al. (2013), who explored the effect of classical music and silent conditions on the enjoyment and perception of three different types of wine. Their findings demonstrated that participants found an acidic wine and a high-tannin wine significantly more enjoyable when tasting them while listening to classical music compared to a silent condition. Taken together with the current findings, there is emerging evidence that music can have an impact on people's enjoyment for food.

#### 4.3 | The Liked Music and Silent Conditions Increased the Overall Liking and Satisfaction of the Food

An effect of music was observed on food liking and satisfaction ratings in the current study. Liked music and the silent condition significantly increased the overall liking ratings for both healthy and unhealthy food compared to disliked music. This finding is supported by previous studies that have shown a positive impact of music on food liking. For instance, Fiegel et al. (2014) studied how different types of music influenced the perception of chocolate, reporting that participants significantly liked milk chocolate more when listening to jazz compared to hip-hop. Furthermore, Guedes et al. (2023) explored the impact of high ("Fruit of Lore," 80 BPM) and low ("Walk of Destiny," 152 BPM) sweetness soundtracks on the liking of food high (carrots and cookies) and low (cucumbers and 0% sugar cookies) in sweetness. The results showed that listening to high-sweetness music increased liking ratings for both vegetables and cookies compared to listening to low-sweetness music. These studies align with the findings of the current study, suggesting that music has the potential to influence overall liking and satisfaction ratings of food items. The findings suggest that liked music and specific music genres can improve the enjoyment of both healthy and unhealthy food options, highlighting the potential role of music in influencing food perception and liking.

Satisfaction is regarded as a crucial metric in marketing (Andersen and Hyldig 2015). The present study demonstrated that both liked music and silent conditions significantly increased the satisfaction ratings of a chicken burger and healthy food items when compared to the disliked music condition. In support of these findings, Caldwell and Hibbert (2002) investigated the effects of music tempo (fast and slow) on dining satisfaction in restaurants. Their results showed that listening to fast-tempo music, which generally induces higher arousal levels, was positively correlated with customer satisfaction. Additionally, Wansink and van Ittersum (2012) explored the effects of lighting and music on food satisfaction and found that dining in an atmosphere with candlelight accompanied by soft jazz ballad resulted in significantly higher ratings of food satisfaction compared to conditions with bright light, loud noise, and music commonly heard fast food restaurants. Observational studies have also shown that participants in pleasant and relaxing environments tend to experience increased food liking and enjoyment, regardless of whether the food is healthy or unhealthy (Wansink 2004).

#### 4.4 | The Relationship Between Positive Emotions and Food Intake, Pleasantness, Liking, Enjoyment, and Satisfaction

Emotional responses play a crucial role in understanding the effect of music on food intake. Our findings showed that listening to liked music while consuming lunch evoked more positive emotions. This, in turn, was associated with increased consumption of healthy food, as well as higher ratings of pleasantness, liking, enjoyment, and satisfaction, compared to both a silent condition and when participants listened to disliked music.

Few studies have examined the relationship between music, emotions, food intake, and ratings of food pleasantness, liking, enjoyment, and satisfaction. The current findings support the notion that music can influence emotions, which, in turn, can impact food intake, pleasantness, liking, enjoyment, and satisfaction. van Strien et al. (2013) found that individuals in a joyful mood consumed fewer calories compared to those in a sad mood. Additionally, Huang and Labroo (2019) explored the effect of high-pitch music on mood and healthy food choices. Their results showed that high-pitch music was rated as more pleasant and comforting, and listening to this type of music significantly increased the likelihood of choosing healthy food options. This suggests that music may positively influence mood and subsequently influence food choices toward healthier options, where emotions may potentially play a moderating or mediating role between music and food choices. Furthermore, van den Tol et al. (2022) determined the effects of listening to music or silence on snack intake. Their results showed that participants in a comforting music condition, which elicited fewer negative emotions, consumed significantly less chocolate and popcorn compared to when they were listening to angry or sad music, which elicited a more negative mood state. Taken together, these studies support the notion that music can influence emotion which, in turn, can impact food intake, pleasantness, liking, enjoyment, and satisfaction. The specific type of music listened to may play a crucial role in determining these outcomes, as music preference is a very personal attribute.

#### 4.5 | Negative Emotions Contribute to Increased Unhealthy Food Intake, and Higher Hunger Level After Eating Lunch

In this study, negative emotions were significantly higher when participants listened to disliked music while eating lunch, compared to both the liked music and silent conditions. This outcome aligns with findings from previous studies that negative emotions can be evoked by disliked music. For instance, Kantono et al. (2019) reported that listening to disliked music elicited significantly more negative emotions compared to silent, neutral, and liked music conditions. Similarly, Xu et al. (2019) demonstrated that negative emotions were evoked when listening to a café-machine soundscape while eating chocolate ice cream compared to café-forest and café-bird soundscapes. Lin et al. (2022) further found that eating ice cream while listening to disliked music and unpleasant sounds evoked more negative emotions compared to liked music, pleasant sounds, and silent conditions. These findings highlight the influence of emotions on human eating

behavior and specifically the impact of negative emotions on food consumption.

It was hypothesized in the current study that satiety would differ after consuming a lunch meal while listening to music compared to a silent condition. Interestingly, our study showed that hunger levels were significantly higher after consuming a lunch meal while listening to disliked music, compared to liked music and silent conditions. This finding is in line with previous studies that have explored the effect of emotions on hunger levels. For example, Macht (1999) explored the influence of emotions such as anger, fear, sadness, and joy on hunger levels and food intake. This study reported that hunger levels were significantly higher when experiencing anger, compared to fear and sadness. Moreover, Macht's study found that during episodes of anger, participants experienced increased fast, irregular, and careless eating directed at any food available. Swami et al. (2022) further demonstrated that participants reporting significantly higher feelings of anger and irritability had greater self-reported levels of hunger compared to those experiencing positive emotions.

#### 4.6 | Strengths and Limitations

A strength of this study is that participants were able to self-select the music they listened to, endowing confidence that the liked and disliked music conditions faithfully represented their music preferences. Consequently, this study did not investigate the effect of music characteristics (e.g., tempo or pitch) on food choices and food intake, as this is difficult to control for when participants are self-selecting the music. However, it is acknowledged that the effect of music tempo and pitch could potentially impact on food choices (Caldwell and Hibbert 2002; Zellner 2014). Additionally, the participants were drawn from New Zealand, and the specific foods used were representative of their cultural context, potentially limiting the generalizability of the results to other population groups (Wanich et al. 2018). Another limitation was that emotional measurements were only carried out at the end of the food-eating period, providing limited insights into the temporal effects of listening to music on food choices. Although the study revealed a significant impact of music on food intake and emotions, further in-depth analysis may consider repeated emotional measurements, a longitudinal study, testing different music genres, and including electrophysiological measures when consuming food.

#### 5 | Conclusion

The present study aimed to investigate the effects of music, varying in liking, on eating behavior. The results revealed that listening to music when consuming a meal can significantly influence hunger ratings, meal duration, as well as food intake, pleasantness, enjoyment, overall liking, and satisfaction. Specifically, participants reported significantly higher hunger ratings when they listened to disliked music during a lunch meal, and participants ate for longer and consumed more healthy food items and snacks more when listening to liked music compared to the silent and disliked music conditions. In addition, participants listening to music they preferred rated the food items significantly higher in terms of food pleasantness, enjoyment, overall liking,

and satisfaction compared to when they listened to disliked music. The emotional responses of participants were further measured to elucidate how music influenced food intake and hedonic ratings of food items during a meal. Listening to disliked music while consuming the lunch elicited negative emotions and was associated with higher hunger scores. Conversely, the silent and liked music conditions evoked positive emotions that increased pleasantness, liking, enjoyment, and satisfaction of food. These findings highlight the importance of understanding emotional responses to better understand the impact of music on hunger levels, meal duration, food intake, food liking, and satisfaction. This information can have practical applications in real-world food-eating environments to promote positive emotions and potentially influence healthier food choices.

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### Conflicts of Interest

The authors declare no conflicts of interest.

### References

Andersen, B. V., and G. Hyldig. 2015. "Consumers' View on Determinants to Food Satisfaction. A Qualitative Approach." *Appetite* 95: 9–16. <https://doi.org/10.1016/j.appet.2015.06.011>.

Balasubramanian, G., A. Kanagasabai, J. Mohan, and N. P. Seshadri. 2018. "Music Induced Emotion Using Wavelet Packet Decomposition—An EEG Study." *Biomedical Signal Processing and Control* 42: 115–128. <https://doi.org/10.1016/j.bspc.2018.01.015>.

Blass, E. M., D. R. Anderson, H. L. Kirkorian, T. A. Pempek, and I. Price. 2006. "On the Road to Obesity: Television Viewing Increases Intake of High-Density Foods." *Physiology & Behavior* 88, no. 4–5: 597–604. <https://doi.org/10.1016/j.physbeh.2006.05.035>.

Caldwell, C., and S. A. Hibbert. 2002. "The Influence of Music Tempo and Musical Preference on Restaurant Patrons' Behavior." *Psychology & Marketing* 19, no. 11: 895–917. <https://doi.org/10.1002/mar.10043>.

Carr, B., J. Dzeroska, R. Taylor, K. Lanza, and C. Pansini. 2009. "Multi-dimensional Alignment (MDA): A Simple Numerical Tool for Assessing the Degree of Association Between Products and Attributes on Perceptual Maps." In *Proceedings of the Pangborn Sensory Science Symposium*, 26–30. Elsevier.

Çetin, C., A. Ayaz, G. Samur, and A. Akyol. 2023. "Music genre and volume do not modulate energy intake, short-term satiety, and mood states: A randomized controlled trial." *Psychology of Music* 51, no. 4: 1101–1118. <https://doi.org/10.1177/03057356221129320>.

Cohen, J. 1988. *edition 2. Statistical power analysis for the behavioral sciences.* Hillsdale. Erlbaum.

Dalton, M., G. Finlayson, E. Esdaile, and N. King. 2013. "Appetite, Satiety, and Food Reward in Obese Individuals: A Behavioral Phenotype Approach." *Current Nutrition Reports* 2: 207–215. <http://10.1007/s13668-013-0060-4>.

Escofier, B., and J. Pagès. 1984. "Multiple factorial analysis: A method to compare groups of variables." *Data Analysis and Informatics* 3: 41–55.

Esmerino, E. A., E. R. Tavares Filho, B. Thomas Carr, et al. 2017. "Consumer-Based Product Characterization Using Pivot Profile, Projective Mapping and Check-All-That-Apply (CATA): A Comparative Case With Greek Yogurt Samples." *Food Research International* 99: 375–384.

Fiegel, A., J. F. Meullenet, R. J. Harrington, R. Humble, and H. S. Seo. 2014. "Background Music Genre Can Modulate Flavor Pleasantness and Overall Impression of Food Stimuli." *Appetite* 76: 144–152. <https://doi.org/10.1016/j.appet.2014.01.079>.

Forgas, J. P. 1995. "Mood and judgment: the affect infusion model (AIM)." *Psychological bulletin* 117, no. 1: 39.

Guedes, D., M. Prada, E. Lamy, and M. V. Garrido. 2023. "Sweet Music Influences Sensory and Hedonic Perception of Food Products With Varying Sugar Levels." *Food Quality and Preference* 104: 1–5. <https://doi.org/10.1016/j.foodqual.2022.104752>.

Hess, J. M., Q. Wang, C. Kraft, and J. L. Slavin. 2017. "Impact of Agaricus bisporus mushroom consumption on satiety and food intake." *Appetite* 117, 179–185. <https://doi.org/10.1016/j.appet.2017.06.021>.

Higgs, S. 2015. "Manipulations of Attention During Eating and Their Effects on Later Snack Intake." *Appetite* 92: 287–294. <https://doi.org/10.1016/j.appet.2015.05.033>.

Higgs, S., and J. E. Donohoe. 2011. "Focusing on Food During Lunch Enhances Lunch Memory and Decreases Later Snack Intake." *Appetite* 57, no. 1: 202–206. <https://doi.org/10.1016/j.appet.2011.04.016>.

Huang, X., and A. A. Labroo. 2019. "Cueing Morality: The Effect of High-Pitched Music on Healthy Choice." *Journal of Marketing* 84, no. 6: 130–143. <https://doi.org/10.1177/0022242918813577>.

Hussain, M., H. Egan, R. Keyte, and M. Mantzios. 2020. "Exploring the Environmental Manifestation of Types of Music on Reinforcing Mindfulness and Concurrent Calorie Intake." *Psychological Reports* 124, no. 6: 1–18. <https://doi.org/10.1177/0033294120967276>.

Kaiser, D., S. Silberberger, C. Hilzenden, and N. Stroebele-Benschop. 2016. "The Influence of Music Type and Transmission Mode on Food Intake and Meal Duration: An Experimental Study." *Psychology of Music* 44, no. 6: 1419–1430. <https://doi.org/10.1177/0305735616636207>.

Kantono, K., N. Hamid, D. Shepherd, et al. 2018. "The Effect of Music on Gelato Perception in Different Eating Contexts." *Food Research International* 113: 43–56. <https://doi.org/10.1016/j.foodres.2018.06.030>.

Kantono, K., N. Hamid, D. Shepherd, Y. H. Lin, S. Skiredj, and B. T. Carr. 2019. "Emotional and Electrophysiological Measures Correlate to Flavour Perception in the Presence of Music." *Physiology & Behavior* 199: 154–164. <https://doi.org/10.1016/j.physbeh.2018.11.012>.

Kantono, K., N. Hamid, D. Shepherd, M. J. Yoo, G. Grazioli, and B. T. Carr. 2016. "The Effect of Background Music on Food Pleasantness Ratings." *Appetite* 44, no. 5: 244–255. <https://doi.org/10.1177/0305735615613149>.

Kral, T. V., L. S. Roe, and B. J. Rolls. 2004. "Combined effects of energy density and portion size on energy intake in women." *The American journal of clinical nutrition* 79, no. 6: 962–968. <https://doi.org/10.1093/ajcn/79.6.962>.

Lau, E. R. L., and C. J. Henry. 2017. "No influence of carbonation on glycemic response, gastric emptying, and satiety of sweetened drinks." *Nutrition* 39: 1–7. <https://doi.org/10.1016/j.nut.2017.02.001>.

Liljeström, S., P. N. Juslin, and D. Västfjäll. 2012. "Experimental Evidence of the Roles of Music Choice, Social Context, and Listener Personality in Emotional Reactions to Music." *Psychology of Music* 41: 579–599. <https://doi.org/10.1177/0305735612440615>.

Lin, Y. H., N. Hamid, D. Shepherd, K. Kantono, and C. Spence. 2022. "Musical and Non-Musical Sounds Influence the Flavour Perception of Chocolate Ice Cream and Emotional Responses." *Foods* 11, no. 12: 1784. <https://doi.org/10.3390/foods11121784>.

Lubin, B., and M. Zuckerman. 1999. *Manual for the MAACL-R: Multiple Affect Adjective Check List-Revised*. EdITS/Educational and Industrial Testing Service.

Macht, M. 1999. "Characteristics of Eating in Anger, Fear, Sadness and Joy." *Appetite* 33, no. 1: 129–139.

Mathiesen, S. L., A. Hopia, P. Ojansivu, D. V. Byrne, and Q. J. Wang. 2022. "The Sound of Silence: Presence and Absence of Sound Affects Meal Duration and Hedonic Eating Experience." *Appetite* 174: 106–111. <https://doi.org/10.1016/j.appet.2022.106011>.

McNair, D. M., M. Lorr, and L. F. Droppleman. 1971. *Manual Profile of Mood States*. Educational and Industrial Testing Services.

- Ng, M., C. Chaya, and J. Hort. 2013. "Beyond Liking: Comparing the Measurement of Emotional Response Using EsSense Profile and Consumer Defined Check-All-That-Apply Methodologies." *Food Quality and Preference* 28, no. 1: 193–205. <https://doi.org/10.1016/j.foodqual.2012.08.012>.
- Novak, C. C., J. La Lopa, and R. E. Novak. 2010. "Effects of Sound Pressure Levels and Sensitivity to Noise on Mood and Behavioral Intent in a Controlled Fine Dining Restaurant Environment." *Journal of Culinary Science & Technology* 8, no. 4: 191–218. <https://doi.org/10.1080/15428052.2010.535756>.
- Oldham-Cooper, R. E., C. A. Hardman, C. E. Nicoll, P. J. Rogers, and J. M. Brunstrom. 2011. "Playing a Computer Game During Lunch Affects Fullness, Memory for Lunch, and Later Snack Intake." *American Journal of Clinical Nutrition* 93, no. 2: 308–313. <https://doi.org/10.3945/ajcn.110.004580>.
- Pagès, J. 2014. *Multiple Factor Analysis by Example Using R*. CRC Press.
- Privitera, G. J., M. Diaz, and M. C. Haas. 2014. "Enhanced Auditory Arousal Increases Intake of Less Palatable and Healthier Foods." *Global Journal of Health Science* 6, no. 3: 1–8. <https://doi.org/10.5539/gjhs.v6n3p1>.
- Robinson, E., I. Kersbergen, and S. Higgs. 2014. "Eating 'Attentively' Reduces Later Energy Consumption in Overweight and Obese Females." *British Journal of Nutrition* 112, no. 4: 561–567. <https://doi.org/10.1017/S000711451400141X>.
- Scherer, K. R. 2016. "What Are Emotions? And How Can They be Measured?." *Social Science Information* 44, no. 4: 695–729. <https://doi.org/10.1177/0539018405058216>.
- Sivakumaran, S. 2019. *The Concise New Zealand Food Composition Tables -13th Edition 2018*. New Zealand Institute for Plant & Food Research Limited.
- Spence, C., L. Richards, E. Kjellin, et al. 2013. "Looking for Crossmodal Correspondences Between Classical Music and Fine Wine." *Flavour Journal* 2, no. 1: 29.
- Stroebele, N., and J. M. de Castro. 2006. "Listening to Music While Eating Is Related to Increases in People's Food Intake and Meal Duration." *Appetite* 47, no. 3: 285–289. <https://doi.org/10.1016/j.appet.2006.04.001>.
- Swami, V., S. Hochstoger, E. Kargl, and S. Stieger. 2022. "Hangry in the Field: An Experience Sampling Study on the Impact of Hunger on Anger, Irritability, and Affect." *PLoS ONE* 17, no. 7: e0269629.
- Thomas, D. W., and M. Smith. 2009. "The Effect of Music on Caloric Consumption among Nursing Home Residents With Dementia of the Alzheimer's Type." *Activities, Adaptation & Aging* 33, no. 1: 1–16.
- van den Tol, A. J., H. Coulthard, V. Lang, and D. J. Wallis. 2022. "Are Music Listening Strategies Associated With Reduced Food Consumption Following Negative Mood Inductions; a Series of Three Exploratory Experimental Studies." *Appetite* 172: 105947.
- van Strien, T., A. Cebolla, E. Etchemendy, et al. 2013. "Emotional Eating and Food Intake After Sadness and Joy." *Appetite* 66: 20–25. <https://doi.org/10.1016/j.appet.2013.02.016>.
- van Strien, T., J. E. Frijters, G. P. Bergers, and P. B. Defares. 1986. "The Dutch Eating Behavior Questionnaire (DEBQ) for Assessment of Restrained, Emotional, and External Eating Behavior." *International Journal of Eating Disorders* 5, no. 2: 295–315. <https://doi.org/10.1016/j.appet.2008.11.007>.
- Wanich, U., D. Sayompark, L. Riddell, et al. 2018. "Assessing food liking: comparison of food liking questionnaires and direct food tasting in two cultures." *Nutrients* 10, no. 12: 1957. <https://doi.org/10.3390/nu10121957>.
- Wansink, B. 2004. "Environmental Factors That Increase the Food Intake and Consumption Volume of Unknowing Consumers." *Annual Review of Nutrition* 24: 455–479. <https://doi.org/10.1146/annurev.nutr.24.012003.132140>.
- Wansink, B., and K. van Ittersum. 2012. "Fast Food Restaurant Lighting and Music Can Reduce Calorie Intake and Increase Satisfaction." *Psychological Reports* 111, no. 1: 228–232. <https://doi.org/10.2466/01.PR0.111.4.228-232>.
- Watson, D., and L. A. Clark. 1988. "Development and Validation of Brief Measures of Positive and Negative Affect: The PANAS Scales." *Personality and Social Psychology* 54, no. 6: 1063–1070.
- Whitelock, V., A. Gaglione, J. Davies-Owen, and E. Robinson. 2019. "Focused Attention During Eating Enhanced Memory for Meal Satiety But Did Not Reduce Later Snack Intake in Men: A Randomised Within-Subjects Laboratory Experiment." *Appetite* 136: 124–129. <https://doi.org/10.1016/j.appet.2019.01.021>.
- Whitelock, V., S. Higgs, J. M. Brunstrom, J. C. Halford, and E. Robinson. 2018. "No Effect of Focused Attention Whilst Eating on Later Snack Food Intake: Two Laboratory Experiments." *Appetite* 128: 188–196. <https://doi.org/10.1016/j.appet.2018.06.002>.
- Xu, Y., N. Hamid, D. Shepherd, et al. 2019. "Background Soundscapes Influence the Perception of Ice-Cream as Indexed by Electrophysiological Measures." *Food Research International* 125: 108564. <https://doi.org/10.1016/j.foodres.2019.108564>.
- Zellner, D. A., C. R. Loss, J. Zearfoss, and S. Remolina. 2014. "It tastes as good as it looks! The effect of food presentation on liking for the flavor of food." *Appetite* 77: 31–35. <https://doi.org/10.1016/j.appet.2014.02.009>.

## Appendix

## Description of Emotions Used in This Study

Emotion attributes	Description
Positive	A positive experience, situation, result etc is a good one
Active	Engaging or ready to engage in physically energetic pursuits
At easy	Showing or involving great activity or vitality
Interested	Having an interest or involvement; not impartial
Satisfied	Peaceful, happiness or calm feeling when an outcome is above expectations
Excited	Very enthusiastic and eager
Relaxed	Free from tension and anxiety
Calm	Not showing or feeling nervousness, anger, or other strong emotions
Joy	A feeling of great pleasure and happiness
Pleasure	A feeling of happy, satisfaction, and enjoyment
Happy	Feeling or showing pleasure or contentment
Amazed	Surprise (someone) greatly; filled with astonishment
Tired	In need of sleep or rest
Alone	Having no one else present
Drowsy	Sleepy and lethargic; half asleep
Boredom	The state of feeling bored
Tense	In or of a state of physical or nervous tension
Dissatisfied	Not content or happy with something
Exhausted	Very tired
Contempt	The feeling that a person or a thing is worthless or beneath consideration

**Ranking of Pilot Tested Food and Snack Items to be Used in this Study. Rating Was Measured Using 10-Point Hedonic Scale Ranging From 1 "Healthy" to 10 "Unhealthy" The results are expressed as mean  $\pm$  standard error (SE). Different superscripts letter (a-h) indicates significant differences at  $p < 0.05$**

Lists of foods	Score (Mean $\pm$ SD)
Pepperoni pizza	7.641 <sup>a</sup> $\pm$ 2.309
Chicken burger	7.476 <sup>a</sup> $\pm$ 2.304
Ground beef and cheese pie	7.000 <sup>a,b</sup> $\pm$ 2.281
Ham and cheese sandwich	6.320 <sup>b,c</sup> $\pm$ 1.977
Spinach quiche	5.621 <sup>c,d</sup> $\pm$ 2.086
Vegetable burger	5.359 <sup>c,d</sup> $\pm$ 2.238
Chicken teriyaki subway	4.748 <sup>d,e</sup> $\pm$ 2.335
Egg sandwich	4.126 <sup>e,f</sup> $\pm$ 2.042
Vegetable sandwich	4.039 <sup>e,f,g</sup> $\pm$ 2.030
Tuna sushi rolls	3.456 <sup>f,g,h</sup> $\pm$ 1.837
No carb burger	3.252 <sup>f,g,h</sup> $\pm$ 2.003
Avocado sushi	3.058 <sup>g,h</sup> $\pm$ 2.023
Chicken teriyaki sushi roll	3.029 <sup>h</sup> $\pm$ 2.069
Chicken caesar pita	3.019 <sup>h</sup> $\pm$ 1.926
Lists of snacks	Score (Mean $\pm$ SD)
Crisps	8.63 <sup>a</sup> $\pm$ 1.951
M&M peanut milk choc	8.282 <sup>a</sup> $\pm$ 2.055
KitKat chunky bar	8.165 <sup>a</sup> $\pm$ 2.044
Shapes-bbq cracker	7.146 <sup>b</sup> $\pm$ 2.106
Popcorn	7.087 <sup>b</sup> $\pm$ 2.501
Chunk choc chips cookies	7.000 <sup>b</sup> $\pm$ 2.270
Muesli bars	3.971 <sup>c</sup> $\pm$ 2.350
Cranberry trio nuts	3.835 <sup>c</sup> $\pm$ 2.307
Dry fruits	2.621 <sup>d</sup> $\pm$ 2.243
Fresh fruits	1.330 <sup>e</sup> $\pm$ 2.031

## Satiety Visual Analogue Scale

Questions	Anchors at each end	References
How hungry are you right now?	Not at all hungry and extremely hungry	Kral et al. (2004)
How do you feel?	Not at all full and totally full	Hess et al. (2017)
How strong is your desire to eat now?	Very weak and very strong	Lau and Henry (2017)
How much of this food do you think you could consume right now?	Nothing at all and a large amount	Kral et al. (2004)
How satiated do you feel?	I am completely empty, and I cannot eat another bite	Hess et al. (2017)

## Food Pleasantness Visual Analogue Scale

Questions	Anchors at each end	References
How pleasant do you find this food overall?	Not at all pleasant and extremely pleasant	Kral et al. (2004)
How pleasant is the appearance of the meal?	Not at all pleasant and extremely pleasant	Kral et al. (2004)
How pleasant do you think this food would taste?	Not at all pleasant and extremely pleasant	Kral et al. (2004)
How much do you think you would enjoy eating this food?	Not at all pleasant and extremely pleasant	Kral et al. (2004)
How does the size of this serving compare with your usual portion?	“A lot smaller” and “a lot larger.”	Kral et al. (2004)
How pleasant do you find this food overall after you consume them?	Not at all pleasant and extremely pleasant	Kral et al. (2004)
How pleasant is the appearance of the meal?	Not at all pleasant and extremely pleasant	Kral et al. (2004)
How pleasant is the taste of the meal after you consume them?	Not at all pleasant and extremely pleasant	Kral et al. (2004)
How much do you think you enjoy eating this food after you consume the food?	Not at all pleasant and extremely pleasant	Kral et al. (2004)

Group	Silent	Liked music	Disliked music
<i>n</i>	66	66	66
Gender (male/female)	28.75 ± 6.91/ 27.03 ± 5.81	28.75 ± 6.91/ 27.03 ± 5.81	28.75 ± 6.91/ 27.03 ± 5.81
Age	26.67 ± 6.26	26.67 ± 6.26	26.67 ± 6.26
BMI	23.35 ± 3.54	23.35 ± 3.54	23.35 ± 3.54
Waist (cm)	82.94 ± 14.56	82.94 ± 14.56	82.94 ± 14.56
DEBQ restraint eating	2.76 ± 0.90	2.76 ± 0.90	2.76 ± 0.90
DEBQ emotional eating	2.67 ± 0.96	2.67 ± 0.96	2.67 ± 0.96
DEBQ external eating	3.37 ± 0.67	3.37 ± 0.67	3.37 ± 0.67

## Participant Characteristics (Results Expressed as Mean ± SD)