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Effects of background sound on consumers' sensory discriminatory ability among foods

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ABSTRACT

This study aimed to examine accustomed and preferential levels of background sound in eating atmospheres across different demographics (Experiment 1) and to determine whether background sound affects the ability to discriminate overall differences between food/beverage samples (Experiment 2). A total of 244 individuals reported to experience a louder atmosphere, where individuals were more likely to interact with others, during dinner than breakfast and snack time. Furthermore, more than half (58.8%) of the respondents preferred eating while having a conversation. Only 3.7% of the respondents preferred eating in silence. In Experiment 2, 58 participants were asked to conduct overall difference tests of potato chips (original versus lightly salted) and carbonated sodas (original versus sugar free) in the presence of five sound conditions: (1) carbonation sound, (2) crisp chewing-sound, (3) classical music, (4) shadowing task, and (5) white noise. The discrimination performance was found to be less influenced by background sound in potato chips when compared to the carbonated soda, highlighting the possibility that foods with high levels of mastication sound are less susceptible to background noise. While listening to and repeating a newscast (shadowing task), 41% of the participants were able to discriminate overall sensory difference between the two different carbonated sodas, but in the presence of carbonation sound 71% of the participants were able to distinguish between the two sodas. In conclusion, our findings strengthen the claim that conversation is popular and preferred in eating atmospheres, but it may alter participants' ability to discriminate an overall difference between different foods or beverages.

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1. Introduction

While consuming foods or beverages, our brains receive sensory inputs from multiple routes, and these inputs are not processed independently (known as "multisensory integration"). In other words, food perception can be influenced by one or a combination of five senses such as sight, taste, smell, touch, and hearing. Among the five sensory domains, relatively little attention has been paid to the influences of auditory cues on food perception. However, it is worth noting that people often consume foods and drinks in the presence of not only sounds elicited by the ingestion process, but also environmental sounds.

Sounds elicited by mastication or swallowing process can influence food perception such as crispness (Christensen & Vickers, 1981; Zampini & Spence, 2004) and carbonation (Zampini & Spence, 2005). For example, if certain fruits or vegetables produce crunchier sounds upon first bite, consumers typically assume that they are fresher (e.g., apples or bell peppers). In another study by Zampini and Spence (2005), participants were instructed to consume sparkling water while listening to pre-recorded carbonation sounds through headphones, and the sound level of the recordings was manipulated. Sparkling water was perceived as having a higher level of carbonation when the sound level was greater, even though all samples had the same amount of carbonation. That is, the congruent sound of carbonation increased perceived intensity of carbonation.

Previous studies have demonstrated that background noises, sounds that have less particular connection to the food consumed, also modulate food perception. Woods et al. (2011) demonstrated that background noise unrelated to the food being consumed decreased taste perception. More specifically, sweetness and saltiness intensity ratings were significantly lower in the presence of loud background noise compared with a quiet background noise. In contrast, Stafford, Fernandes, and Agobiani (2012) observed that sweetness intensity ratings of five different alcoholic beverages were significantly higher in the presence of music compared with

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other distracting conditions such as a shadowing task. In contrast, Fiegel, Meullenet, Harrington, Humble, and Seo (2014) demonstrated that flavor intensity ratings of chocolate and bell peppers were not significantly different among the four different genres of background music.

Likewise, previous research on the influences of auditory cues has been limited to the perceived intensities of specific sensory attributes such as odor (Crisinel, Jacquier, Deroy, & Spence, 2013; Seo, Gudziol, Hähner, & Hummel, 2011; Seo & Hummel, 2011; Seo, Hähner, Gudziol, Scheibe, & Hummel, 2012; Seo, Lohse, Luckett, & Hummel, 2014), flavor (Crisinel & Spence, 2011; Fiegel et al., 2014; Woods et al., 2011), taste (North, 2012; Spence & Deroy, 2013; Stafford, Agobiani, & Fernandes, 2013; Stafford et al., 2012; Woods et al., 2011), and texture (Christensen & Vickers, 1981; Vickers, 1987; Woods et al., 2011; Zampini & Spence, 2004, 2005). However, since the overall perception of a food is often developed through multiple sensory inputs, the influence of auditory cues should be dependent on not only individual sensory attributes, but also the integration of multiple attributes.

Herein, a question may rise as to how frequently people are exposed to the background sound, as well as what type of background sounds are often experienced in everyday life. Surprisingly, there is a lack of information regarding ambient sound conditions that are present during mealtime in daily life. Earlier research has highlighted the effects of background sound, whether music or noise, on consumers' perceived intensities and their amount of consumption. Adding to previous discoveries, the first part of this study (Experiment 1) was designed to explore areas of background sounds during mealtime using a survey. In particular, Experiment 1 aimed to examine perceived and preferred level of background sound during mealtime in everyday life. This survey served as a precursor to Experiment 2 which explored the effects of these sounds on food perception. More specifically, employing various background sound conditions, Experiment 2 aimed to determine whether these background sounds influence consumers' ability to discriminate overall difference perceived during the mastication and drinking process of common foods/beverages.

2. Experiment 1

Experiment 1 sought to examine accustomed and preferential levels of background sound in eating atmospheres across different demographics such as age group and gender.

2.1. Material and methods

This study was conducted in conformance with the Declaration of Helsinki for studies on human subjects. The protocol was approved by the University Institutional Review Board of the University of Arkansas (Fayetteville, AR).

2.1.1. Participants

Two hundred and seventy-four volunteers with an age range from 19 to 78 years participated in this survey. A total of 244 (108 men and 136 women; 207 Caucasians, 15 Latinos, 16 Asians, 4 African-American, and 2 Native American) with mean age of 40 years (standard deviation = ±13 years) completely filled out the survey; 30 volunteers did not completely or correctly fill out the survey. All participants were recruited from the community of Northwest Arkansas. Hearing problems were assessed by asking participants to report if they had any hearing impairments. Eight participants (3.3% of participants) reported that they suffered from hearing impairment; their data were also used for data analysis since Experiment 1 was designed to examine general populations' accustomed and preferential levels of background sound in eating atmospheres. In fact, it was reported that 12.7% of the U.S. population aged 12 years and older had bilateral hearing loss based on the result of air conduction pure-tone audiometry (Lin, Niparko, & Ferrucci, 2011). In a similar vein, an ethnically heterogeneous sample was used, which is similar to the ethnical distribution of the local population (Fayetteville, AR).

2.1.2. Survey of accustomed and preferential levels of background sound in eating atmosphere

A questionnaire was composed of four main questions regarding background sound conditions related to eating (see Appendix). Firstly, participants were asked to estimate the average level of background sounds when they consumed four types of meal (i.e., breakfast, lunch, dinner, and snack) during the past week. The ratings were done on 9-point Likert scales ranging from 1 (extremely quiet) to 9 (extremely loud). Secondly, the participants were asked to answer the frequency of seven scenarios of eating atmosphere during the past week for the previously asked meal types. The scenarios included (1) ate alone in silence, (2) ate alone in front of TV, (3) ate alone at computer/at work, (4) ate alone while listening to music, (5) ate at home with others (e.g., friends, family, or coworkers), and (6) ate in a restaurant with others (e.g., friends, family, or coworkers). For each mealtime (i.e., breakfast, lunch, and dinner), the frequency sum of seven scenarios of eating atmosphere during the past week was limited to 7 (i.e., 7 breakfasts per week). For snack time, there was no limit in the frequency sum of seven scenarios of eating atmosphere. Thirdly, the participants were asked to select their most preferred eating atmosphere among the seven examples: (1) in silence, (2) at a noisy restaurant, (3) at a quiet restaurant, (4) in front of TV, (5) while listening to music, (6) while having a conversation, and (7) while using a computer/tablet/phone. Finally, the participants were asked to indicate their preferred level of background sound while eating on a 9-point Likert scale ranging from 1 (extremely quiet) to 9 (extremely loud). Furthermore, participants were asked to answer questions related to their demographic profiles such as gender, age, ethnicity, and hearing problem.

Prior to filling out a questionnaire, participants received general instruction on the survey (e.g., how to use scales). There was no time limit to complete the questionnaire.

2.1.3. Data analysis

Data analysis was conducted using statistical software, XLSTAT (Fahmy, 1993; Addinsoft, New York, NY, U.S.A.; http://www.xlstat.com/en). A three-way analysis of variance (ANOVA) was used to determine whether the perceived sound-level of eating atmosphere in the past week could be affected by type of meal, gender, and age group. In addition, a two-way ANOVA was used to determine whether participants' preferred sound-level of eating atmosphere could be influenced by gender and age group. If a significant difference of mean ratings was indicated by the ANOVA, post hoc comparisons were conducted using Fisher's least significant difference (LSD) tests. A chi-square test was used to examine whether the frequency of the seven eating scenarios in each type of meal were different. Furthermore, the frequency of preferred eating atmosphere was tested using a chi-square test. A statistically significant difference was defined as $p < 0.05$.

2.2. Results

2.2.1. Background sound level of eating atmosphere in the past week

Fig. 1(a) shows that background sound level of eating atmosphere in the past week was different among the four types of meal: breakfast, lunch, dinner, and snack [$F(3,942) = 48.91$, $p < 0.001$]. Participants reported that in the past week they consumed breakfast in the most silent condition, while they consumed