Watch Your Flavors: Augmenting People's Flavor Perceptions and Associated Emotions based on Videos Watched while Eating

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Fig. 1. An illustration of augmenting flavors, liking, and emotions when watching food videos while eating

People engage in different activities while eating alone, such as watching television or scrolling through social media on their phones. However, the impacts of these visual contents on human cognitive processes, particularly related to flavor perception and its attributes, are still not thoroughly explored. This paper presents a user study to evaluate the influence of six different types of video content (including nature, cooking, and a new food video genre known as mukbang) on people's flavor perceptions in terms of taste sensations, liking, and emotions while eating plain white rice. Our findings revealed that the participants' flavor perceptions are augmented based on different video content, indicating significant differences in their perceived taste sensations (e.g., increased perception of salty and spicy sensations). Furthermore, potential future implications are revealed to promote digital commensality and healthier eating habits.

CCS Concepts: • **Human-centered computing** → **Interaction paradigms**; **User studies**.

Additional Key Words and Phrases: Human-Food Interaction; Mukbang; Food Videos; Flavor Perception; Taste Sensations; Liking; Emotions

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1 INTRODUCTION AND BACKGROUND

Eating is a typical yet complex daily experience that is integral to human sociality and culture [12]. While it is a sustenance activity for some people, it is unique and pleasurable for others. In order to enhance the eating experience, people usually engage in activities such as talking to a friend or a family member, reading a book, listening to music, or watching something on their phone or the television. At the same time, some people prefer eating alone whereas some eat in groups and share. Some choose to eat at home, while others enjoy eating in social settings. Some like to converse while they eat, while some like it quiet. Thus, it is evident from prior research that the act of eating includes different forms of interactions between food, people, and the surrounding environment [9, 10, 46].

Recent studies in Human-Computer Interaction (HCI) [3], Psychology [19], and Social Sciences [9, 32] have explored two main aspects related to eating: 1) the act of eating and its influence on social interactions, and 2) designing novel interactions for and during the act of eating. Eating is an evolving activity, starting from early childhood, gradually influenced by the eating practices of the family, and evolves to be individualistic for most humans [42]. In light of Human-Food Interaction (HFI), research has profoundly studied how eating has been a commensal activity in many cultures, where two or more people gather around a table to share a meal [3, 9, 12, 38]. While commensality is appropriate only during festival times for some cultures, for others, it is essential for each meal. For example, Tannen et al. [44] discusses the different types of conversations that emerge during Thanksgiving meals, Blum-Kulka et al. [6] explores how the American families and Israeli families have differences in storytelling while eating. Furthermore, Erickson et al. [11] explains the differences in conversational patterns around a dinner table in Italy. In Korea, eating together is a cultural identity where people often eat the same dish with everyone or share food from the same plate [3, 9]. Koreans continue to promote commensality digitally through broadcasts such as “Mukbang” that encompasses the cultural and social values of eating via interactive entertainment [3, 20, 22].

The increase in modern urbanization, solitary work lifestyle, and more recently, the impact of the COVID-19 pandemic has witnessed a shift in the eating behavior from eating together in a group to solo dining [3, 12, 47]. Several studies agree that even though only a few people enjoy it, solo dining behavior may have adverse effects on the mental and physical health of people [16, 18, 33]. Thus, there has been increased research effort to promote social life using digital technologies such as social media to enable social interactions. Technology has been employed extensively to mimic many social activities, and eating is no exception. For instance, ‘Zoom happy hours’ or ‘Skeating’ where a group of people eats together on Zoom or Skype to promote digital commensality [8, 40].

A survey [2] from 2019 reported that 88% of adults eating alone are involved in a phenomenon called “Zombie eating”, which is the act of staring at digital screens while eating. Research by Tal et al. [43] has documented that people consumed higher quantities of food while they watch selective TV content with high-definition content [31], fast actions, and sound variations. There are several studies consistent with exploring eating habits of people based on digital media content, their properties (e.g., with and without sound, duration, and the pace of the content), and the food being eaten [9, 24, 31, 43]. Research in HFI is gaining momentum on several fronts [5, 29, 30, 34–37], including studying the impact of digital multisensory components (sight, sound, taste, touch and smell) on human cognitive functions related to food and dining (e.g., flavor perception, liking, emotions). However, there is a clear research gap in HCI to study the effects of media content, especially videos watched while eating, on flavor perceptions and related attributes. This rising ubiquity and limited research attention have motivated the current research study. Hence, for the study presented, we hypothesized that different video content watched while eating positively influences participants’ flavor perception in terms of taste sensations, liking, and emotions, as depicted in Fig. 1.

The primary research question explored in this study was "Do Videos being watched while eating augment people's flavors perceptions in terms of taste sensations, liking, and emotions?". We conducted a user study with 35 participants who evaluated changes in their flavor perception with six different videos watched while eating white rice. In this study, we focused on investigating the changes in taste sensations, liking, and emotional attributes of flavor perception with the help of a questionnaire. A nature video (non-food), cooking video (food-based), three types of "mukbang" videos (food-based), along with the control condition (no video) were evaluated in the study. Mukbang (먹방), short for muknunbangsong (먹는방송), is a concept that originated in South Korea and gaining popularity worldwide. The broadcasters or the 'mukbangers' eat exorbitant amounts of food and subsequently broadcast (live or pre-recorded) with high contrast visuals and high definition sounds of eating actions (biting, chewing, slurping) [3, 32]. There are four main styles of mukbang videos: 1) The mukbanger eating the food silently, 2) The mukbanger eating and talking about their flavor experience (taste, smell, appearance, texture), 3) The mukbanger sharing a story or about their life during eating, and 4) The mukbanger providing live responses to online viewers while broadcasting [3, 9, 32]. Among these, in our study, we utilized three styles except the mukbang with live responses. We adopted the mukbang concept as they are interactive, influential, provide a sense of digital commensality, and deliver a multisensory experience [3, 20, 22].

The contributions of this work are twofold. Food-based videos watched while eating: 1) augment taste sensations, consequently the flavors, and 2) produce positive emotional changes in participants, which would result in an enjoyable eating experience. Thus, the future work based on these findings will explore potential health applications to reduce calorie intake while increasing the enjoyment of food and beverages.

2 EXPERIMENTAL SETUP AND EVALUATION

The key purpose of this study was to explore the effects of watching different types of videos while eating, on participants' flavor perception in terms of taste sensations, liking, and elicited emotions. The study presented six different types of videos ranging from no video (control) to different types of food and non-food-based videos. These videos were intended to provide flavor augmentations with visual [27, 39, 41] and auditory input [1, 45], without altering the food sample being tested.

2.1 Videos

The videos used the study[1] have been selected to include both food and non-food-based categories.

- The "no video" where there was no video played was selected as the control condition.
- The "nature video" depicted various natural sceneries, such as waterfalls, snowy, rocky, and cloud-surrounded green mountains. It also included a calming sound that was mild and monotonous.
- The cooking video showed a chef cooking Mexican Rice and serving it. The video provided an aesthetically pleasing visual of the ingredients and the cooking process in detail.
- The conversational mukbang video displayed three people sitting together while eating spicy noodles and conversing. The mukbanger guided the conversations with a cheerful, happy, and social personality. The mukbangers gave clear indications with facial expressions that the food was spicy.
- The mukbang video included a mukbanger eating plain white rice with spicy chicken curry and boiled egg. The mukbanger was of an Asian origin and was eating with hands. This particular video is selected as it shows a scenario where plain white rice (same as in the study) is paired with a spicy curry. The mukbanger gave clear

[1] https://youtube.com/playlist?list=PLUDInjx-7b0uNqTaX4RLV5JMpli--H0iH

signs with her facial expressions to express the spiciness of the food. The same video was played with and without sound during two different conditions. The sound in the video consists of mukbanger's eating actions, namely, biting, chewing, swallowing, and breaking the food into edible portions to deliver an Autonomous Sensory Meridian Response (ASMR) effect.

All the videos were approximately 2.40 minutes long. The participants watched a shorter clip of the same videos before tasting the sample which was 30 seconds long. The shorter clips were played to evaluate if the video only (without eating) was enough to augment taste sensations without eating any food.

2.2 Food sample selection

The Minute Microwavable Instant Ready-to-Serve (RTS) white rice [2] was used as the food sample tested in the study. The white rice was chosen because 1) rice is a common food item everyone is familiar with, 2) plain rice does not have much flavor and no after taste, 3) it matched the food items used in the videos except in the conversational mukbang video where spicy noodle was used, and 4) it is easy to evaluate how flavor perceptions were augmented with the videos while eating bland food for participants instead of a flavorful food (e.g., fried chicken) that has many flavors attached to it.

2.3 Method

2.3.1 Participants and recruitment. The study was reviewed and approved by the Institutional Review Board at the «removed for blind review». Thirty-five participants (46% Males, 51% females, 3% gender fluid) who were in the age range of 18 - 50 years (M = 26.1, S.D = 6.9) were recruited via email and social media (Facebook and LinkedIn) from different regions of the United States for the study. The participants were required to have the habit of watching something on their phone, TV, or computers while eating. They were additionally required to be void of any level of smell, taste, visual or auditory impairments. The participants were asked to attend the study from where they usually eat their meals (e.g., living room, office space, dining room). Two cups of rice sample, 125g each, were sent to the participants before the study.

The study was conducted remotely via Zoom video conferencing service and the Qualtrics survey platform. We decided to conduct the study remotely using Home Use Tests (HUT) due to the COVID-19 restrictions on Central Location Testing (CLT) and study the participants in their familiar environments for realistic comparisons [7, 17, 26]. The participants were in a Zoom session with the study moderator, who ensured the study went smoothly. The videos were played from the moderator's computer on share screen mode in random order to avoid order bias [15, 25]. The study sessions were conducted mainly during the daytime, while a few were in the late afternoon. The average duration taken to complete each study session was 43.3 minutes, and the participants were compensated with a $10 Amazon gift card at the end of their session.

2.3.2 Questionnaire and evaluation. The questionnaire for the study was created using the Qualtrics software. The study was divided into four sections: 1) Demographics, 2) Video only, 3) Video + Eating, and 4) End of survey.

2.3.3 Demographic section. The participants signed an informed consent form and provided their general demographic details. Then, participants' emotional state was recorded to assess any changes in emotions before and after the study sessions.

[2] https://minuterice.com/products/white-rice-ready-to-serve/

2.3.4 Video evaluation section. After completing the demographics, the participants microwaved both the cups of rice as per the package instructions. Then they moved to the video evaluation, which had two sections: 1) Video only and 2) Video + Eating. The participants repeated the video evaluation for every video condition. The flavor perception was evaluated with the following factors.

- The overall liking towards each sample (at the end of each session) was recorded using a 9-point hedonic scale with "1 - Dislike extremely" and "9 - Like Extremely" as the anchor labels of the scale [23].
- Participants reported their taste perceptions on a matrix table based on primary taste sensations and other food perception-related attributes: 'salty', 'bitter', 'sweet', 'sour', 'umami', 'spicy', 'bland', 'mouthwatering', 'craving for this food', and 'satisfied just by watching it'. Feedbacks were collected on a 4-level scale, namely none, mild, medium, and strong.
- The emotion responses were collected using the EsSence Profile [21], a popular scale used in food-related studies to measure emotions. It contains 39 emotion-related terms categorized into positive, negative, and neutral emotions. Similar to [34], the participants had to Check-all-that-apply (CATA) from the list of emotions in the EsSence Profile [28].

2.3.5 End of survey section. Finally, the participants were interviewed for their oral feedback and were compensated for their time. All the data collected from the study were analyzed with XLSTAT Sensory software (Version 2020.5.1).

3 RESULTS AND DISCUSSION

For the analysis, one-way repeated measures Analysis of Variance (ANOVA) at 95% confidence level were employed. Subsequently, post-hoc tests (where stated) were conducted using the Bonferroni correction at a 95% confidence level. Moreover, a Correspondence Analysis (CA) was performed to explore the correlation between the elicited emotions in each video condition.

3.1 Taste Sensations - Video only

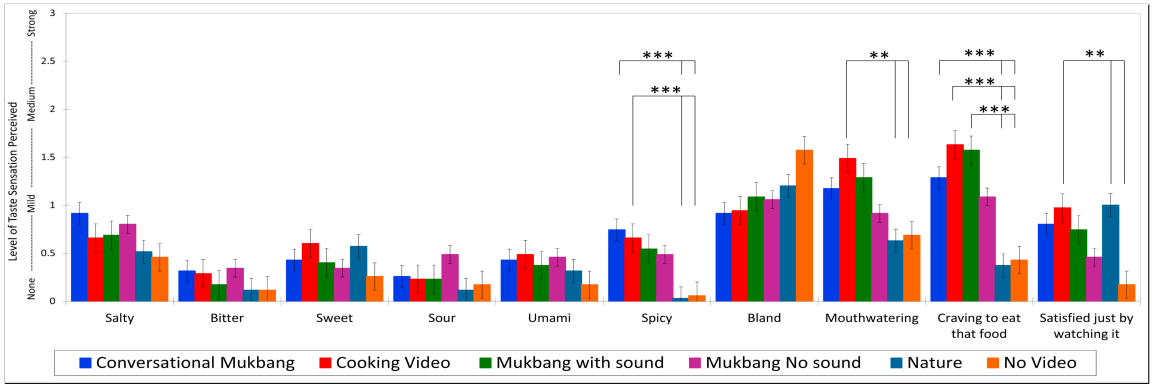

Fig. 2. Taste sensations perceived just by watching the videos (*p<0.05, **p<0.01, ***p<0.001)

A one-way repeated measures ANOVA with Bonferroni corrections showed that there were significant differences in overall effects of the video content on participants' expected taste sensations just by watching videos (without eating),

as shown in Fig. 2. For example, just by watching a video, there is a significant difference in the participant's expectation of a spicy sensation (F = 5.32, p= .00). Other sensations, such as mouthwatering (F = 3.75, p = .003), craving (F = 8.64, p < .0001), and virtual satiation (F= 4.29, p =.001) also showed a significant difference at p-value < .05 with respect to different videos before tasting the sample. Noticeably, in the case of the spicy sensation, conversational mukbang video and cooking video had a significantly higher effect in augmenting the spiciness than both nature video and no video conditions. This finding is in accordance with the prior research findings from [27, 39, 41] where just by seeing (visual observation), people develop precognition (expectations) of flavor sensations. Hence, the results indicate that there is a possibility to digitally enhance people's taste sensations using different food-based video content. This could also lead people to avoid indulgent or overeating habits just by watching a video to satisfy their cravings.

3.2 Taste Sensations - Video + eating

Similarly, a one-way repeated measures ANOVA with Bonferroni correction was conducted to analyze the changes in participants' taste sensations by watching videos while eating plain rice, as displayed in Fig. 3. Similar significant differences were noticed in participants' perceived taste sensations as they eat food while watching videos. Basic taste sensations such as salty (F = 2.62, p = .026) and umami (F = 2.45, p = .035) as well as other sensations including spicy (F = 10.88, p < .0001), mouthwatering (F = 5.45, p < .0001), and craving (F = 8.63, p < .0001) displayed significant differences with different food-based videos that were displayed while eating the sample. Another intriguing finding that merits further investigations is the participants' reports on taste augmentations based on mukbanger's expressions. Some of the specific comments they mentioned are: *"I felt the food spicy when I watched the spicy food video for sure", "With the super spicy one, with their expressions, I felt my rice was spicy as well".* This data provides insights on enhancing a

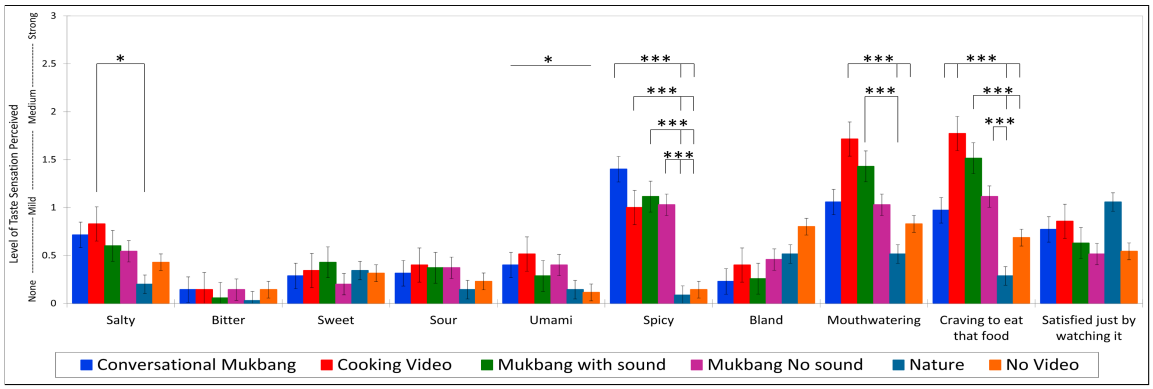

Fig. 3. Taste sensations perceived by watching the videos while eating (*p<0.05, **p<0.01, ***p<0.001)

particular taste sensation with videos. For example, suppose a person is eating bland food and would like to enhance the spicy level. In that case, they could watch a conversational mukbang video with spicy food to enhance the spicy level rather than watching a nature video where they do not perceive any spiciness. Since this approach digitally augments taste sensations, it avoids the need to physically or chemically alter the food, making this a healthier approach [13].

3.3 Emotions associated with the videos

The emotions perceived by the participants with respect to different videos played while eating is shown in a correspondence analysis factor map (Fig. 4). The relative variability in the data revealed by both axes (F1 and F2) was 72.80%. The F1 axis accounts for mild emotion on the positive side and daring emotion on the negative side. The F2 axis extends from nostalgic (positive) to disgusted (negative) emotions. Almost all the emotions reported while eating and watching videos were positive. None of the videos were related to any type of negative emotion such as 'disgusted', 'aggressive', or 'worried'. In general, all the emotions reported at the beginning of the study were towards 'adventurous',

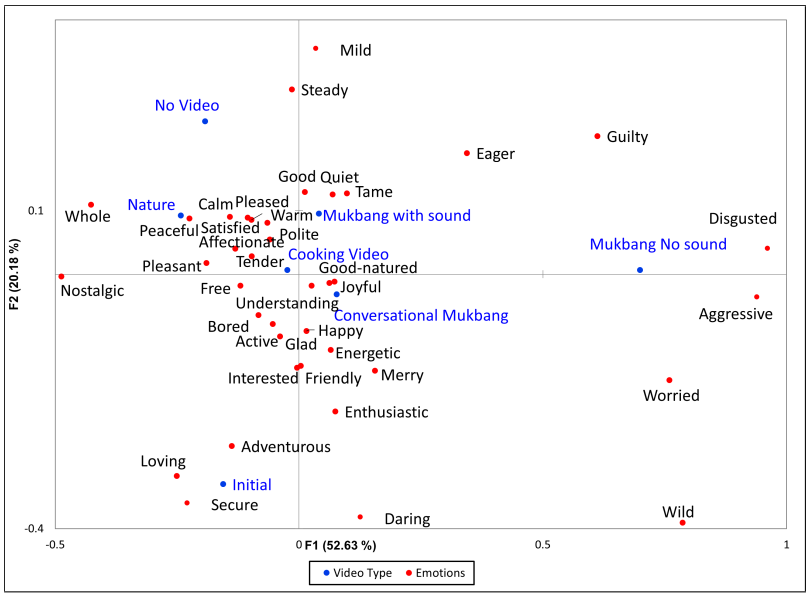

Fig. 4. Correspondence Analysis Map of the different videos watched while eating and elicited emotion (axes F1 and F2: 72.80%)

'loving', and 'secure'. This could be attributed to the fact that the participants felt adventurous to partake in the study and felt safe and loving as they stayed in their comfort environments [7]. Participants did not show any emotional differences for the no video (control) and mukbang no sound conditions. On the contrary, conversational mukbang was correlated to 'energetic', 'friendly', 'happy', and 'joyful' emotions. This was in close accordance with the personality of the mukbanger, who was excited about the food while having friendly conversations throughout the video. It also denoted that the participants could connect well with the conversational video content.

Additionally, this could be associated with the digital commensality effect where people enjoy the social time of eating together. One of the participants particularly mentioned, *"I liked the conversational mukbang as* ***I felt like I am eating with them*** *rather than just eating alone"*. This comment provides evidence that mukbang videos elicit a sense of digital commensality for the viewers while eating.

Mukbang with sound video was associated with 'good', 'quiet', and 'tame' emotions. This could be related to the calming effect of the ASMR induced by mukbang videos [4]. For example, one of the participants mentioned, *"I don't really like watching them eat but the sound is soothing at some point"*. Few others mentioned, *"I like the sound of the*

mukbang better cos without sound it was boring", "I didn't like food eating without sound but I enjoyed the sound of food eating".

As expected, the nature video was related to 'calm', 'satisfied', 'peaceful', and 'whole' emotions as the video depicted various serene natural scenes. The cooking video was related to 'tender', 'good-natured', 'understanding', and 'polite' emotions, which depicted that people could emote themselves with how the chef handled the food ingredients and prepared the food. One of the participants commented about the cooking video, *"I'm always watching some tech video or something to learn while eating. So watching something to calm me is making eating enjoyable. I might try this in the future".*

3.4 Overall liking

The overall likings reported in 'videos only' and 'videos + eating' sessions showed a positive trend (M > 5.0), although the ANOVA results showed no significant difference at 95% CI. The small sample size and the Home Use Test could be reasons for the high variance in the data [14]. Although we see positive trends, the concept of mukbang is not yet popular worldwide. Only 3 participants out of 35 participants were aware of mukbang videos. Few participants mentioned that they disliked it as the mukbangers ate big portion sizes. One participant felt nauseous with the mukbang with sound video but enjoyed the same video without sound. They mentioned, *"I felt so nauseous. ASMR was not fun, the sound off was relaxing".*

Interestingly, some participants mentioned that if the video content showed the same food as they eat, they would have liked the video more - *"..., If the food I ate is same as food the person ate I would have enjoyed it", "I would like it if they are eating what I'm eating''.* Though the responses were different, it was evident that there was flavor augmentation with the videos they watched based on their feedback - *"I did not like the sound at all. I did not like watching it either* ***but I definitely felt that my food changed flavor****", "I did not like watching people eat. The sound was annoying* ***but I feel that the food is different. It is not bland. It feels spicy a little****", "It did not feel much different* ***but it felt a little salty****".*

4 CONCLUSION

We presented a study to investigate possible augmentations on taste sensations, liking, and emotions based on different videos watched while eating. Our findings revealed that 1) videos watched while eating augment the taste sensations without the need for physical or chemical flavorings, 2) different types of food-based videos influenced different types of taste sensations, 3) elicited emotions were different based on types of videos watched while eating, and 4) positive emotional changes were reported when food-based videos were watched (especially mukbang videos elicited an enjoyable eating experience). This provides insight on using mukbang videos to encourage digital commensality, thus avoiding lonely eating. Furthermore, it was apparent that the conversational mukbang videos positively affect people's emotions while eating, and augment their taste sensations based on the mukbanger's reactions. For example, the mukbanger's facial expressions of eating spicy food made the participants feel they were also eating spicy food, though they were eating plain white rice. These findings merit further investigations in the future.

Next, in addition to continuing our research on evaluating the effects of video content on people's taste sensations, liking, and emotions, we will focus on studying their impacts on appetite, satiety, and related functions. Further studies will also investigate the effects of personality traits and external multisensory stimuli such as sound, smell, ambient lighting, and temperature on people's flavor perceptions and related cognitive functions.

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