Flavor-Videos: Enhancing the Flavor Perception of Food while Eating with Videos

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ABSTRACT

People are typically involved in different activities while eating, particularly when eating alone, such as watching television or playing games on their phones. Previous research in Human-Food Interaction (HFI) has primarily focused on studying people's motivation and analyzing of the media content watched while eating. However, their impact on human behavioral and cognitive processes, particularly flavor perception and its attributes, remains underexplored. We present a user study to investigate the influence of six types of videos, including mukbang - a new food video genre, on flavor perceptions (taste sensations, liking, and emotions) while eating plain white rice. Our findings revealed that participants perceived positive emotional changes and reported significant differences in their augmented taste sensations (e.g., spicy and salty) with different food-based videos. Our findings provided insights into using our approach to promote digital commensality and healthier eating (digital augmentation without altering the food), highlighting the scope for future research.

CCS CONCEPTS

• **Human-centered computing** → **Interaction paradigms**; **User centered design**; **User studies**.

KEYWORDS

Human-Food Interaction, Mukbang, Food Videos, Flavor Perception, Taste Sensations, Liking, Emotions

1 INTRODUCTION

At present, the power of computing and technology is spreading into our ubiquitous environments and embedded in our daily interactions, and eating experiences are no exception. For example, it is found from a survey [3] in 2019 that 88% of adults indulge in an activity termed as "Zombie eating", which is the act of starring a particular digital screen while eating. While this number is increasing, indicating an adverse mental and health effect on people, there is a higher research potential in exploring the digital technology integration into and around eating habits to be used for novel interactions and a pleasurable eating experience.

In addition, modern urbanization, solitary job lifestyles, and more recently, the effects of the COVID-19 pandemic have all contributed to a change in eating habits from group dining to solo dining [11]. Since social distancing rules are still intact in many countries, people's social lives have been drastically impacted concerning meeting friends, hangouts, and having meals together. Research has studied that solo dining has a negative impact on the physical and mental health of humans [28, 30], and thereby decreased enjoyment of food [52, 64]. In the effort of reducing solo dining and subsequently trying to attain social life digitally, people tend to use technology to mimic a lot of activities, and eating is no exception. Even though the stereotypical picture portrays that technology has a negative effect on people's food and beverage experiences, continuous research efforts have been made to promote digital commensality with technology via activities such as: 1) "Skeating" (Skype + Eating = Skeating [62]) or "Zoom happy hours" where people eat together with a remotely located friend via Skype or Zoom [11], and 2) watching "Mukbang", which is the act of eating alone while watching a mukbanger or broadcaster eat, through a digital screen (TV or YouTube) [5, 62].

Recent research in Human-Food Interaction (HFI), which is an emerging research area that examines the intersection of practices surrounding food eating, human interaction, and technology [2, 39], has gained importance in studying the influence of digital multisensory inputs relating to sight, sound, taste [56], touch [49], and smell [55] on human food eating experiences [7, 48, 54, 57]. Several studies have highlighted different eating behaviors based on the media content being watched (in terms of content quality, duration, and pace of the content, the sound effects surrounding

it) while eating [13, 37, 66]. However, to our knowledge, little to no research has been done to explore the effects of visual media content, especially the videos watched while eating, on people's flavor perceptions in terms of taste sensations, liking, and emotions. To fill this clear research gap, we present a study that hypothesized that videos watched while eating using digital technology could positively enhance an enjoyable eating experience in terms of taste sensations, liking, and emotions.

To study this, we conducted a user study where participants evaluated six different types of videos while eating plain white rice, and reported changes in their flavor perceptions with the help of a questionnaire. The six videos: 1) no video (control condition), 2) nature video, 3) cooking video, 4-6) different types of "mukbang" videos were used to be inclusive of a range of food-based and non-food-based videos. Mukbang is a new type of eating show that originated from South Korea (now popular in worldwide), where the mukbanger (or the broadcaster) consumes large amounts of food, and broadcasts it commonly on TV or YouTube. The mukbang videos are usually recorded in high-definition audiovisuals, and it involves interactions with the viewers as well. We incorporated mukbang videos in our study as it is underexplored in HFI. It is also a promising avenue that promotes a multisensory interactive experience and digital commensality.

Our study explored the following research question - "*Do food-based videos watched while eating augment viewers' flavor perceptions in terms of taste sensations, liking, and emotions?*". The two main findings of our study are: 1) food-based videos augment flavors when watched while eating, especially in terms of taste sensations, and 2) food-based videos enhance the eating experience by producing positive emotional changes. The immediate broader impact of this work extends into the 1) food industry, 2) medical industry, 3) digital well-being, and 4) food-flavor customizability. Importantly, this approach can be applied to deliver a pleasurable food-eating experience without restrictions (while still keeping it healthy). For example, astronauts, or people with dietary restrictions, who have restricted flavor access, can have enhanced flavor perception using our visual content based digital flavor augmentation approach.

The rest of the paper is organized as follows. We discuss the related works in Section 2 and in Section 3, we present our study methodology. Then, we present the results of the user study and discuss our research findings in Section 4. We conclude the paper with a summary of the findings, and suggest opportunities for future investigations in Section 5.

2 RELATED WORK

Even though humans eat to survive, everyone has a different way of making it an enjoyable experience. Eating is an evolving activity from infancy to adulthood, and is influenced by various neural mechanisms, parent-child-family interactions, and social-cultural influences [24, 65]. It is a complex and unique experience for humans. Research shows people involve in different activities, such as watching TV, reading a book, or talking with a friend while eating, which are influential and interactive. The interactions surrounding eating are many, out of which the interactions with the surrounding environment and the surrounding people are prominent [14, 20, 74]. Traditionally, food-based research fields such as Psychology, Sociology, and Behavioral studies have explored two main facets of eating: 1) eating behaviors and the surrounding social interactions [13], and 2) creating novel interactions to enhance enjoyable eating experiences [5, 32, 51].

For years, in many cultures, food consumption has been related to the "commensality" aspect of eating. Commensality refers to the act of eating a meal together with people, along with positive social interactions [20, 27, 59]. Commensal feasting or eating together is a vital social activity in many cultures. It is one of the main reasons that sets the human race different from other species [31, 42, 62]. Different cultures adopt unique patterns of commensal eating that determine an appropriate time and location for social engagement, experiences for building and improving social ties, and also allows individuals to construct their identity [27]. Research suggested the differences in commensal eating patterns in cultures such as Italy [17], the United States, Israel [9], India, and Korea [5, 13, 67]. Especially in Korean culture, eating together is a cultural hallmark that is followed to this date. Koreans actively encourage broadcasts like "Mukbang", which combines the cultural and social virtues of dining with interactive entertainment. It is also gaining popularity worldwide to promote digitally commensality [8, 33, 35, 62].

Mukbang (먹방) is a digital food-eating broadcast that has its origin from South Korea and gaining popularity around the globe. The video streamers, also known as mukbangers, eat large quantities of food and broadcast it along with high-quality audiovisuals [5, 13, 51]. Research by Anjani et al. [5] and Choe [13] extensively discussed the different types of interactions the mukbangers have with their audience, same as game streamers. The mukbangers: 1) actively describe the flavor associations of food-related to smell, taste, texture while eating, 2) eat the food without talking, 3) have a story-line (such as a podcast), or their life events shared while eating, 4) eat with other people in the broadcast, and 5) give live feedback to the comments, and some of them even get rewards (e.g., star balloon emojis) from their audience for an enjoyable experience [1].

Several research attempts have been done to study mukbang in the lens of the motivation behind watching it [5, 32], the content differences [13, 51], and more recently on digital commensality [6, 11, 13, 27]. Research by Anjani et al. [5] explored mukbang watching motivations, attitude, and reflection with the help of a survey and follow-up interviews. The work by Choe [13] discussed the various types of mukbanger's interactions with the viewers by analyzing 67 different mukbang videos. They mentioned that mukbang is an evolving interaction tool to connect physically separated people (for various reasons) through eating food in a tech-supported world. Ceccaldi et al. [11] investigated the use of video conferencing during eating with the help of a survey. The study mentioned the use of technology to build social connections, and digital commensality. The work by Aucoin [6] explained mukbangers' influential nature and emotional connections to the fans to build a virtual commensal community. Although much research has been done to identify the potential of mukbang in various aspects, no research has studied their influence on flavor perceptions of people when being watched while eating. Most of the prior research on mukbang is published as either concept, review, or survey papers. Very few user studies in

[1] https://www.youtube.com/user/bjummma

this area have been conducted previously. No research has focused on evaluating mukbang with users while eating, which is the focus of our study.

Recent developments in the field of Human-Food Interaction have led to a renewed interest in studying the influence of human multi-senses (taste [56, 57], smell [55], touch [49], sound, and sight) on flavor perception of food [7, 48, 54]. Generally, visual and auditory senses are highly researched in comparison with the other senses such as thermal, taste, and haptic stimuli. However, recent research in HFI mainly focuses on creating and enhancing multisensory interactions related to the food eating experience [2, 60, 69, 70]. Although it is still yet underexplored, few studies have explored the flavor perception with taste sensations, including all the five basic tastes [25, 47, 53], while all others have examined only one or a combination of few basic tastes. In addition, studies have also evaluated flavor perceptions based on the changes in the visual projections of the shape, color, or size of the food [43, 44], and the sound of eating [68, 71, 73]. Research by Andersen et al. [4] reviewed the influence of digital food photography on consumer eating behavior. Wang et al. [72] conducted a consumer study in the United Kingdom with 32 participants to understand the effectiveness of color changes on flavor perception in a Virtual reality environment. Much of the early work has been done to explore the influence of different media content on people's eating behavior. For instance, studies have been done on the quality, duration, sound effects, and pace of the media content being watched [13, 37, 66]. However, research that focuses on the media content in HFI does not examine the influence of digital media content, especially videos, on people's flavor perception. Furthermore, none of the research has been done to explore emotional augmentation in relation to technological means. This research gap is the focus of the study presented in this paper.

3 EXPERIMENTAL SETUP

In this section, we discuss the process for identifying different video types and samples for the study, the characteristics of the participants, and the methodology of our user study. Our study analyzed the influences of different video types watched while eating on flavor perceptions, especially related to taste sensations, liking, and emotions. We used six different types of videos - no video (control condition), a non-food-based video, and four food-based videos in the study. The objective of these videos was to deliver flavor enhancements through visual [45, 61, 63] and audio [1, 71] stimuli, without physically or chemically modifying the food samples being assessed.

3.1 Videos

The videos for the study have been chosen to be inclusive of both food and non-food-based categories [2]. The list of video types used in the study is listed in Table 1.

- The control condition had no video displayed. This was labelled as "no video".
- The "nature video'' had different natural sceneries, including snowy mountains, waterfalls, cloud-surrounded green mountains, and rocky mountains. It also included a gentle and repetitive relaxing tone [Table 1: No.2].
- The "cooking video" was a food preparation video of Mexican rice by a chef. The video was pleasing as it displayed the intricacies of the chef's culinary skills while cooking in detail [Table 1: No.3]. In this condition, we did not include sounds due to two reasons: 1. The sounds attached to the videos were only related to the cooking process and not related to eating sounds, and 2. It contained music that might affect participants' perception which was out of the scope of our study.
- The "conversational mukbang video" had a company of three people eating spicy noodles and spicy pork dumplings on the side. The mukbanger in the video (Stephanie Soo [3]) is one of the most followed mukbanger on YouTube and has an energetic personality. The mukbangers were of Asian origin and they ate with chopsticks. The mukbangers' body language and facial expressions clearly showed that the dish was spicy [Table 1: No.4]. As rice-only conversational mukbang videos were rare, spicy noodle was selected as a replacement. Furthermore it enabled us to study the effects of 'spicy' sensation on participants' perceptions.
- The "mukbang video" displayed a mukbanger with Asian descent eating white rice with boiled egg and spicy chicken curry. The mukbanger ate with her hands and gave clear indications with her expressions to denote that the food was spicy. This particular video was chosen for this study as it also used the same food sample (white rice) used in the study. There were no conversations in this video and the same video was played as two different video conditions - with and without sound. The sound effects of this video were typical of a mukbang video where the eating sounds (chewing, swallowing, biting) intend to give an Autonomous Sensory Meridian Response (ASMR) effect [Table 1: No.5,6].

The duration of all the videos were nearly 2.40 minutes, except the nature video, which was 2.30 minutes long. Before tasting the sample, the participants were asked to watch a shorter clip of the same videos. This was done to see whether the videos were adequate enough to enhance taste sensations without having to eat any food. The shorter clips were 30 seconds long, except the conversational mukbang video that was 27 seconds long, and the cooking video 40 seconds long. All the videos were downloaded and cropped based on the study requirements from YouTube.

3.2 Eating sample selection

The food sample for testing used in the study was the Minute Microwavable Instant Ready-to-Serve (RTS) White Rice [4]. The reasons for choosing white rice for the study are:

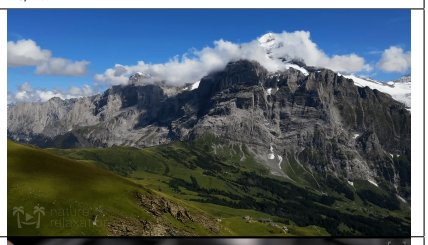
- White rice is a familiar food for people from different cultures as it is well known to be the staple diet for more than 50% of the global population [22].
- Except for the conversational mukbang video, all the other food-based videos used in the study had white rice as the food being displayed.

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

[3] https://www.youtube.com/c/StephanieSoo

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

Table 1: List of Videos used in the study

No.	Video	Type	Food displayed	Still frame of the video
1.	No Video	Control	N/A	N/A
2.	Nature Video with sound	Non-food based	N/A	
3.	Cooking Video without sound	Food-based	Mexican Rice	
4.	Conversational Mukbang Video with sound	Food-based	Spicy Noodles	
5.	Mukbang Video without sound	Food-based	White Rice with Spicy chicken curry	
6.	Mukbang Video with sound	Food-based	White Rice with Spicy chicken curry	

- Cooked white rice contains sensory attributes that are very mild, and there is no significant after taste associated with it [12].
- The study intended to explore flavor augmentation with the videos watched while eating a bland food rather than a food packed with different flavors (e.g., fried chicken, potato chips).

3.3 Method

3.3.1 Participants and Recruitment. Our user study was approved by the University of Maine's Institutional Review Board. We recruited thirty-five participants from different parts of the United States via social media (Facebook and LinkedIn) for the study, who were 18 - 50 years of age (M =26.1, S.D = 6.9). Among the participants, 46% were female, 51% were male, and 3% gender fluid. The inclusion criteria for the study were: 1) having a habit of watching something on a digital screen while eating, and 2) having no level of auditory, visual, smell, or taste blindness. The participants attended the study from the environment of their choice, particularly where

they usually eat (40% Bedroom, 29% Office room, 14% Living room, 11% Dining room, and 6%, Kitchen). All the participants collected two cups of rice sample, approximately 125g each, a day before the study session. They were informed to have access to a microwave during the study, as the sample had to be microwaved according to the package instructions before the testing session.

Zoom[5] video conferencing and the Qualtrics[6] survey platform were used to conduct the study remotely. Due to COVID-19 restrictions (on hold Central Location Testing - CLT), we conducted the study remotely using Home Use Tests (HUT) in order to explore the participants' eating behavior in their comfortable surroundings for realistic correlations [10, 29, 40].

The study moderator conducted the study with the participants on Zoom. To eliminate order bias, the video clips were played in random order from the moderator's computer through share screen mode [26, 38]. Also, to prevent bias and distractions, the moderator's mic and webcam in Zoom were switched off during the session. Before data collection, the participants signed an informed consent form, which informed them about the study and the safe storage of their data without any connection with their personal information. The majority of the study sessions took place throughout the day, with a few in the late afternoon. Each study session took an average of 43.3 minutes to complete, and participants were awarded with a $10 Amazon gift card at the conclusion of each session.

3.3.2 Questionnaire and Evaluation. We used the Qualtrics software to create the survey questionnaire for the study. As shown in Fig. 1, the study was divided into four sections: 1) Demographics, 2) Video Only, 3) Video + Eating, and 4) End of Survey.

3.3.3 Demographic Section. After signing the consent forms, the participants provided their general demographic information. In addition, their initial emotional states were also recorded in the demographic section. The data from this phase helps to uncover the changes in emotions before and after study sessions (i.e., watching the videos while eating).

3.3.4 Video evaluation Section. The participants were asked to microwave the rice sample right after completing the demographic section. Following that was the video evaluation, which had two sections: 1) Video only, and 2) Video + Eating. Both the Video only and Video + eating sections were repeated for each video condition, as explained in Fig. 1. All the participants watched all six videos during the study. The following parameters were used to assess influence of videos watched while eating on flavor perception.

- A 9-point hedonic scale [36] from "1 - Dislike extremely" to "9 - Like Extremely" was used to record participants' overall liking for each sample given. After watching the video while eating, the participants were asked to rate the overall liking towards the flavor of the rice sample.
- To evaluate the taste sensation changes in terms of basic tastes and other taste related sensations, a matrix table with a list of attributes ('salty', 'bitter', 'sweet', 'sour', 'umami', 'spicy', 'bland', 'mouthwatering', 'craving for the food being displayed', and 'satisfied just by watching it') on a 4- level scale (none, mild, medium, strong) was used as shown in Fig. 2.
- The changes in emotions with respect to the videos watched while eating was recorded using EsSence Profile, which is a commonly used emotion measurement scale in food-based studies [34]. There are 39 emotional attributes that are divided into three categories (positive, negative, and neutral) in the scale we used. The participants used Check-all-that-apply (CATA) method [46] to select the different emotions they felt while watching a video and eating, similar to the user study done by [54].

3.3.5 End of Survey Section. At the end of the study, participants chose their favorite video among all the videos displayed during the study. It assisted in determining if there was a relationship between their most liked video and their reporting on overall liking, emotions, and flavor perceptions. Following that, the participants rated their agreement or disagreement on a 5-point Likert scale to the following statements related to their overall experience.

- *'I would enjoy watching food cooking videos while eating'.*
- *'I would enjoy watching others eat huge amounts of food'.*
- *'I would enjoy the ASMR sound of others eating'.*
- *'I felt like I am eating with someone while watching someone eat'.*
- *'When watching other people eat spicy food, I feel like I am eating spicy food as well, even though my food was bland'.*

The participants provided additional oral feedback and their participation was acknowledged with a compensation at the end.

4 RESULTS AND DISCUSSION

The main findings of our user study using six different video conditions are explained and discussed in this section. The XLSTAT[7] Sensory software (Version 2020.5.1) was used to analyze all of the data collected from the study. An Analysis of Variance (ANOVA) was conducted at a significance level of 95% Confidence Interval (CI) for the overall liking and taste sensations perceived based on the videos. Post-hoc analysis with Bonferonni corrections was conducted wherever necessary. Correspondence Analysis (CA) was conducted to explore the correlation between each video condition and the recorded emotions from the participants' responses based on their elicited emotions.

4.1 Taste Sensations - Video only

The changes in participants' perception of various taste sensations just by watching different videos were assessed using one-way repeated measures ANOVA, followed by post-hoc analysis with Bonferroni corrections. As demonstrated in Fig. 3, there were significant differences in the overall influence of video content on people's taste sensations.

The findings indicated that each video content has a different influence on the participant's taste sensation perceptions. For instance, for participant A, watching the mukbang video with the spicy chicken curry induced a spicy taste sensation that would be significantly different from the spicy taste sensation induced by

[5] https://zoom.us/
[6] https://www.qualtrics.com/
[7] https://www.xlstat.com/

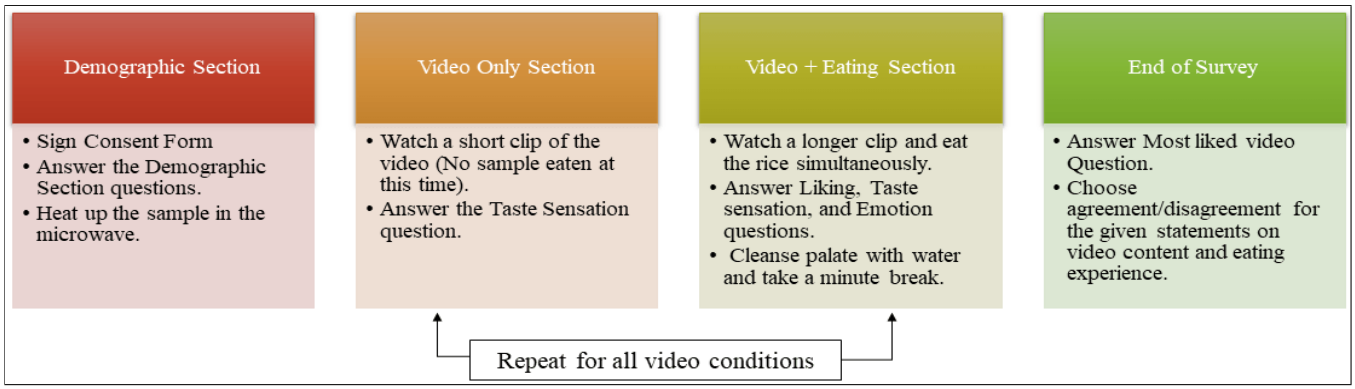


Figure 1: Step wise visualization of the questionnaire outline for all participants upon receiving each sample.

Select all the taste sensations you feel after watching the video

	None	Mild	Medium	Strong
Salty	○	○	○	○
Bitter	○	○	○	○
Sweet	○	○	○	○
Sour	○	○	○	○
Umami	○	○	○	○
Spicy	○	○	○	○
Mouthwatering	○	○	○	○
Craving to eat that food	○	○	○	○
Satisfied just by watching it	○	○	○	○

Figure 2: The Matrix table with the list of taste sensations and the level of sensation provided for recording the taste sensations

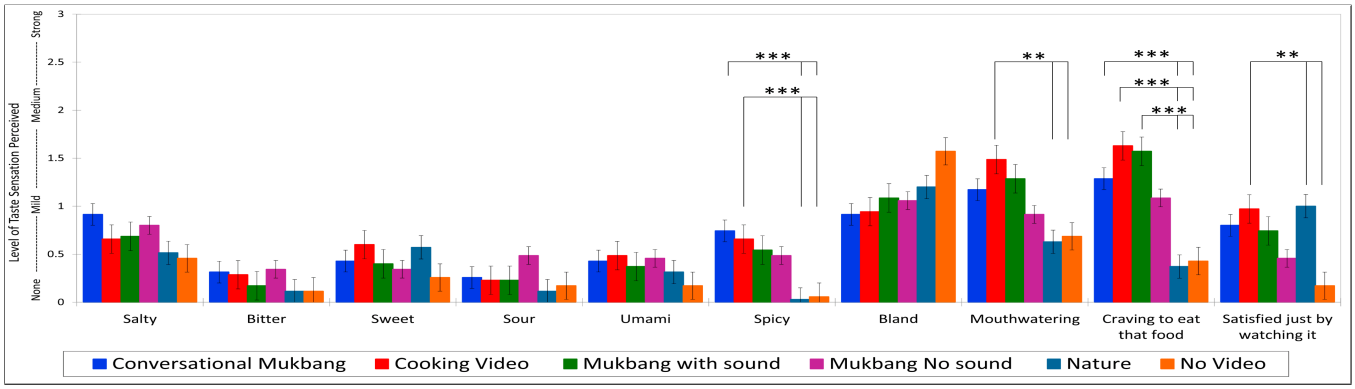


Figure 3: Taste sensations perceived during Video only condition (*p<0.05, **p<0.01, ***p<0.001)

just watching the conversational mukbang video with spicy noodle. From the data, it is clear that, without tasting the sample, and just by watching the videos, taste sensations (basic taste + related sensations) such as 'spicy' ($F = 5.32$, $p = .00$), 'mouthwatering' ($F = 3.75$, $p = .003$), 'craving' ($F = 8.64$, $p < .0001$) and, 'satiation' ($F = 4.29$, $p = .001$) were significant at p-value < .05. In the case of the spicy sensation, conversational mukbang video and cooking video had significantly higher influence in spicy taste augmentation compared to nature video or no video conditions. Cooking video had a significantly higher effect on sensations such as 'mouthwatering', 'craving', and 'virtual satiation' compared to other video conditions. The observation was consistent with previous research [45, 61, 63], which showed that people developed precognition (expectations) of taste sensations just by visual observation. This finding also displayed the potential for digitally enhancing taste sensation with videos, which can be beneficial for people to satisfy their cravings virtually by watching videos (without indulging in overeating or unhealthy eating habits).

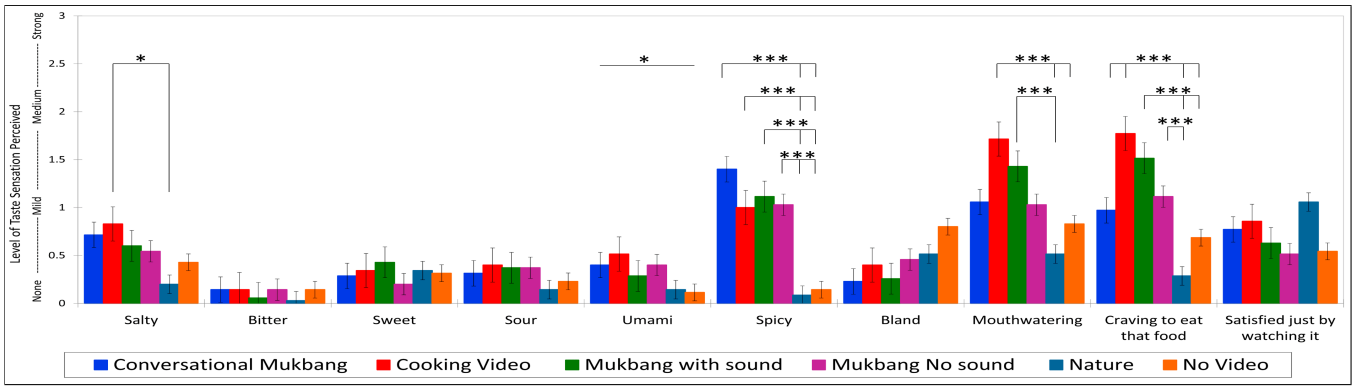


Figure 4: Taste sensations perceived during Video + Eating condition (*p<0.05, **p<0.01, ***p<0.001)

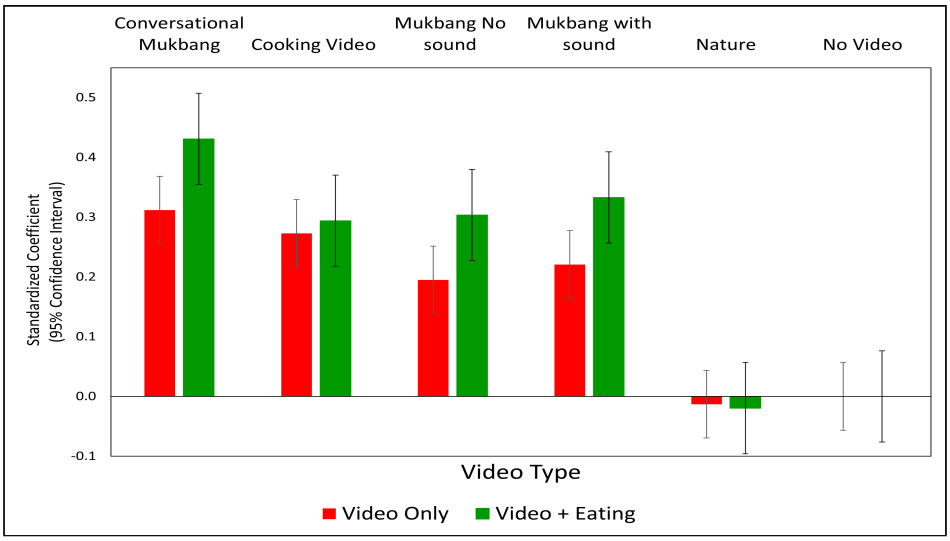


Figure 5: Comparison of Standardized Coefficients for Spicy taste perception between Video only and Video + Eating conditions

4.2 Taste Sensations - Video + eating

We conducted a one-way repeated measure ANOVA, with Bonferroni corrections to analyze data regarding the changes in participants' taste perceptions when watching videos while eating rice. From Fig. 4, it is evident that there were significant differences in the overall effect of the video content, on people's taste perceptions as they eat food. Taste sensations such as 'salty' ($F = 2.62$, $p = .026$), 'umami' ($F = 2.45$, $p = .035$), 'spicy' ($F = 10.88$, $p < .0001$), 'mouthwatering' ($F = 5.45$, $p < .0001$), and 'craving' ($F = 8.63$, $p < .0001$) showed a significant difference with respect to different videos (especially food-based), that were displayed to the participants while eating the white rice. The finding was in agreement with research by [13] on the influence of a viewer's eating behavior by digital influencers (e.g., mukbangers, food vloggers). An interesting finding was that, with the changes in expressions of the mukbanger when eating spicy food, the taste augmentation for the participants also changed. The participants quoted in their feedback session, *"I definitely 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"*.

To further understand the effects of particular types of videos on taste sensations that showed significant difference, the standardized coefficients were analyzed as shown in Fig. 5. Standardized coefficients showed the relative strength of the influence of a video on the taste sensation [18]. In the case of the spicy taste sensation, there was a significant difference in the video content's effect in both Video only and Video + Eating conditions. Furthermore, in both cases, same four video categories (Conversational Mukbang, Cooking Video, Mukbang with and without sound) had significant differences. Based on Fig. 5, it was clear that the strength of the influence was higher in Video + Eating compared to Video only condition. The data was proposed to be helpful to understand which video content can be played to enhance a particular taste sensation for people. For example, suppose a person is eating bland food, but they want to feel that they are eating something spicy. In that case, they could watch a conversational mukbang video with spicy food while eating to enhance the sensation of spicy feeling rather than

watching a nature video where they do not perceive any spiciness. The finding also promotes digital augmentation of the taste and thereby avoids the need to physically or chemically alter the food, which makes it a healthier alternative [21].

4.3 Emotions associated with the videos

A correspondence analysis factor map as shown in Fig. 6, displayed the various emotions perceived by the participants with respect to the different videos played while eating. The axes F1 and F2 of the CA map captured a relatively higher variability in the emotion data (72.8%). On the positive side, the F1 axis accounts for 'mild' emotion, whereas it accounts for 'daring' emotion on the negative side. The F2 axis spans from 'nostalgic' (good) to 'disgusted' (negative) emotions. Majority of the emotions expressed by the participants in response to the videos they watched while eating were positive. None of the videos were associated with any negative feelings, such as 'disgusted', 'aggressive', or 'worried'.

Most participants mentioned that their initial emotional states are related to 'secure', 'loving', and 'adventurous' emotions. The reason could be due to the fact that the participants were excited to participate in the study, and also felt comfortable and loved in their own home/workplace, rather than a controlled environment (e.g., a lab) [10]. Participants did not associate mukbang with no sound video to any particular type of emotion. Similarly, participants did not display any level of emotional differences for the no video (control) condition. The nature video, as predicted, was associated with emotions such as 'calm, 'satisfied', 'peaceful, and 'whole', since the videos featured diverse tranquil natural views.

In the category of food-based videos, the conversational mukbang video was linked to a wide number of emotions such as 'happy', 'energetic', 'friendly', and 'joyful'. These emotions matched the mukbanger's personality, who was showing excitement when trying spicy food, while directing cheerful and friendly discussions during the video as seen in Fig. 7 (a). This finding indicated that the conversational mukbang video content was well received by the participants. This observation was also linked to the commensality effect, which occurred when people enjoy the social aspect of dining with others. One of the participants commented on their commensal experience after watching the conversational mukbang video and eating white rice, *"I liked the conversational mukbang as **I felt like I am eating with them** rather than just eating alone"*. Additionally, the results also demonstrated that when viewers were eating and watching mukbang videos, feeling of digital commensality would be induced.

Participants related the mukbang with sound video with positive emotions such as 'good', 'quiet', and 'tame', which might be due to the relaxing impact of ASMR elicited by mukbang videos [6]. One of the participants explicitly commented about the calming effect of the mukbang video, *"I don't really like watching them eat but the sound is soothing at some point"*. Noticeably, some of the participants commented, *"I like the sound of the mukbang better cos without it, it was boring"*, *"I didn't like food eating without sound but I enjoyed the sound of food eating"*, which would account for the participants not associating any emotion to the mukbang no sound.

Interestingly, the participants associated emotions such as, 'good-natured', 'tender', 'understanding' and 'polite' with the cooking video. The emotional states were more in relation with the way the chef handled the food ingredients and prepared the food as shown in Fig. 7 b, than just the visuals of the video itself. The finding also supported the prior research [50], where participants were able to relate themselves well with the influencers. Regarding the cooking video, one of the participants made a special comment that, *"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"*. The observations from the feedback opened an avenue for future research on studying the eating behavior changes with people who normally watch a non-food content while eating.

Future work of this study should also explore the effects of mirror neurons on human emotions and perception. Mirror neurons in the human brain helps an individual to be in tune with or empathize with the emotions of another individual [19]. Although mirror neuron activation with static and dynamic media (images Vs.videos) processing has been studied earlier [15, 16, 41], the results from this study could be a stepping stone in understanding emotional activation by mirror neurons in food related scenarios.

4.4 Overall Liking and Feedback

The results of the overall liking of the videos while eating showed a positive trend (M > 5.0), although the ANOVA results were not significant at 95% CI. The observation could be explained by the small sample size of this study, which additionally was a Home Use Test, to show much variance in the data [23]. Another potential explanation for this observation could be related to the satiety of eating two cups of rice and the random order in which each video was displayed. Also, the perception of flavors could be different for each participants based on the different video attributes (e.g., voice, food, lighting, and sound variations). Interestingly, the mean values of overall liking scores were above the neutral level (M > 5.0), which indicated the values were towards the positive liking side for four video conditions: nature video with the highest mean value (M = 5.8), followed by conversational mukbang video (M = 5.6), cooking video (M = 5.57), and mukbang video with sound (M = 5.45). The no video (control) condition had a neutral score (M = 5.23), which depicted that it was neither liked or disliked by the participants. The mukbang video without sound (M = 4.7), which was on the negative side of the scale, indicated the participants' slight dislike towards it. The results from the overall liking of rice along with the video content being watched was very closely related to the data on choosing the most liked video. 34% of the participants liked the cooking video the most, which was followed by 20% liking the conversational mukbang video, and another 20% liking the nature video as their top choice. Interestingly, 17% of the participants mentioned that they liked the mukbang video without sound most and only 9% liked the mukbang video with the sound. The contradiction in the overall liking score in this condition (where mukbang with sound had higher liking), could be due to the random presentation order of the videos [26, 38]. For instance, some participants could have watched the mukbang with sound video at the very beginning of the study and given their overall liking score to that particular condition. After watching all the videos, their preference of the video could have changed; hence, participants denoted their higher

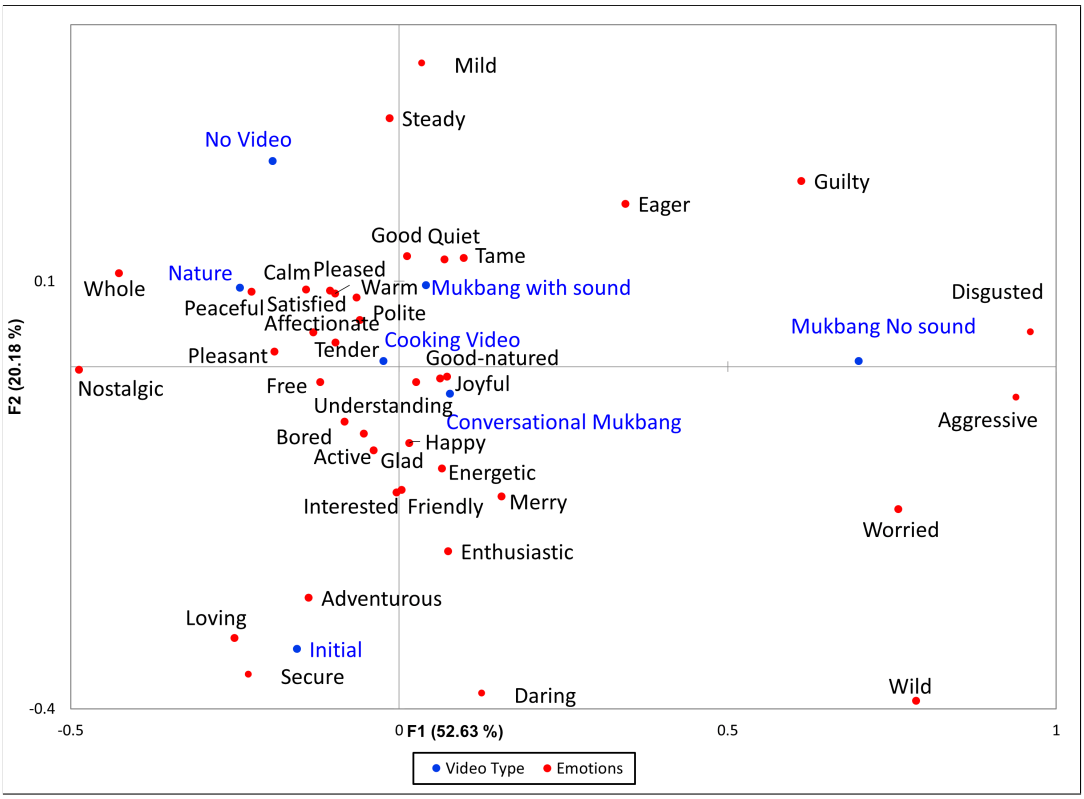


Figure 6: Correspondence Analysis factor map of the different videos watched while eating and elicited emotion (Axes F1 and F2: 72.80%. F1 axis accounts for 'mild' emotion, whereas it accounts for 'daring' emotion on the negative side. The F2 axis spans from 'nostalgic' (good) to 'disgusted' (negative) emotions.)

Figure 7: (a) Picture of the cheerful personality of the mukbanger in the conversational mukbang video; (b) Picture of the chef carefully adding salt while cooking the Mexican rice dish

liking towards mukbang without sound videos compared to mukbang with sound. None of the participants selected the no video condition to be most liked, and this corresponded to the neutrality in their overall liking scores for that condition.

It is evident from the findings that, with the videos watched while eating, especially food-based videos, positive flavor augmentation was possible. Also, in their oral feedback, the participants mentioned, *"I did not like the sound at all. I did not like watching*

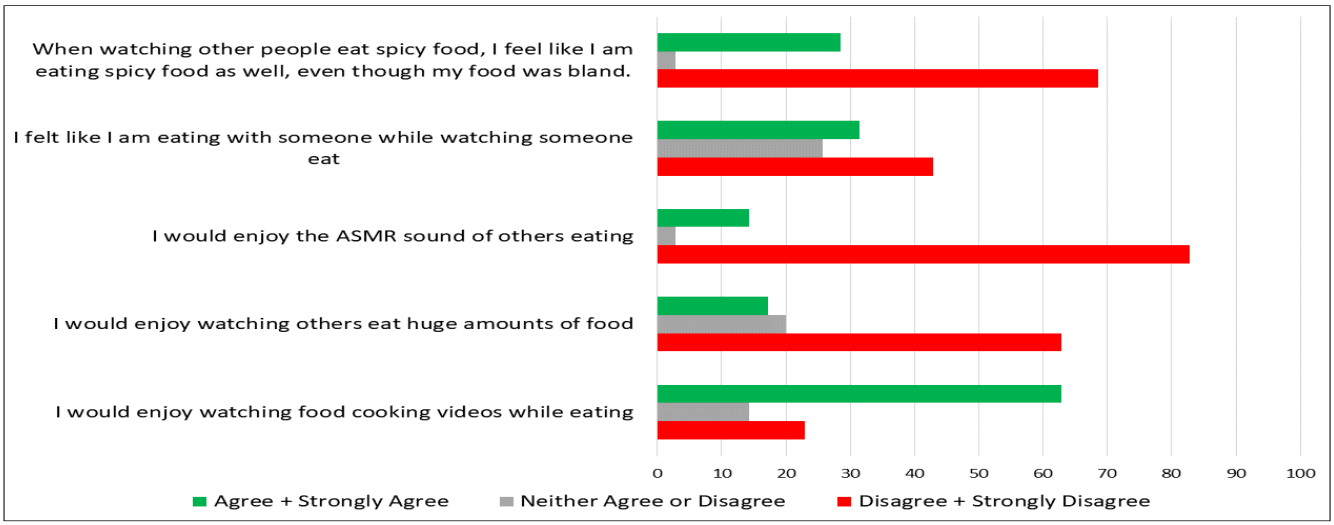


Figure 8: Feedback (Agreement - Disagreement) responses for the statements provided about the videos watched while eating

it either but I definitely felt that my food changed flavor", "I did not like watching people eat. The sound is annoying but I definitely 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". This finding was supported by the participants' feedback based on the statements provided related to their experience, as shown in Fig. 8. We noticed that 28.57% of the participants felt that flavor augmentation could be achieved by watching videos while eating. There was 31.43% agreement about the digital commensality when eating and watching videos. Surprisingly, 62.86% of the participants mentioned that they would enjoy watching cooking videos while eating.

We recorded participants eating behaviors in the demographic section, particularly their habit of watching videos while eating. Unfortunately, we have not studied their dietary habits (eating disorders, diet restrictions). This will be included in future studies as it enables correlating flavor experiences based on participants' dietary patterns.

Despite promising trends, the idea of mukbang is not yet commonly recognized worldwide. Only three of the 35 participants had heard, or watched mukbang videos before the study, which promised scope for future studies with people, with and without the knowledge of mukbang. Some participants mentioned that they do not enjoy the concept of mukbang due to several reasons: 1) the mukbanger ate with their hands, which was not a common food eating practice in the United States, 2) the mukbangers ate a huge amount of food compared to a regular food portion, and 3) hearing the exaggerated sound of food eating was new to most of them. Since the participants were not able to relate to the eating behavior of the mukbanger (i.e., influencer) due to above reasons, they inclined towards a dislike. Another feedback that merit further research was when the participants mentioned that their liking would have increased if:

(1) the mukbanger ate the same food as the viewer. For example, the mukbanger eating fried chicken, and the participant also eating fried chicken as they watch the mukbang. They commented, *"I don't watch anything related to food videos cos I feel I am not eating good enough food. If the food I ate has same food the person ate, I would have enjoyed it"*, and
(2) the mukbanger ate the same portion and had the same eating habits as the viewer (e.g., Asian mukbanger and an Asian participant vs. Asian mukbanger and an American participant).

5 FUTURE IMPLICATIONS

The future implications of this research work extend into a wide range of fields, including food and beverage customization for people on restricted diets due to their medical conditions (e.g., diabetes, high blood pressure, other chronic illnesses). We also envision developing novel human-food interactions in the neuromarketing field. There is a constant challenge involving understanding the effects of different factors on consumers' enjoyable eating experience in the areas mentioned above. Our research lays the path for a better understanding of how visual stimuli could influence mealtime enjoyment.

Due to the rise of the COVID-19 pandemic and solitary lifestyle, people generally utilize digital media (such as mobile phones, laptops, or TV) while they eat. Our research shows that watching food-based videos, especially mukbang videos, fosters digital commensality and delivers an enjoyable dining experience with enhanced flavor sensations. Furthermore, people on restricted diets (e.g., people with diabetes who cannot have high levels of sugar, people with high blood pressure who should limit their salt intake) may benefit by choosing appropriate mukbang content to watch during their mealtime to enhance their salty or sweet sensations without actually adding the physical ingredient to the food. These potential future options highlight the relevance of this work and the necessity to expand it to include the creation of a video library with the videos organized according to flavor-profile category (e.g., salty videos, spicy videos, social videos, and the likes).

6 CONCLUSION AND FUTURE WORK

In this paper, we presented the results of our user study to evaluate prospective flavor augmentations in terms of taste sensations, liking, and emotions with videos watched while eating. The results of our study showed that 1) videos watched while eating had a positive taste augmentation effect on people, without the need for altering the food with physical or chemical flavoring agents, 2) different types of videos influenced the different types of taste sensations on participants, 3) there were positive emotional changes while watching food-based videos, especially mukbang videos, which promised an enjoyable eating experience, and 4) participants' elicited emotions were different for different types of videos. Our research also provided insights on watching mukbang videos while eating to encourage digital commensality to avoid lonely eating. One of the significant findings was the positive effect conversational mukbang videos had on people's emotions while eating. It also showed that participants associated a particular mukbanger's facial reactions with taste sensations. For example, the mukbanger's facial expressions of eating spicy food made the viewers feel they were eating spicy food, even though they were eating white rice, which had a bland taste.

Although there is a need for further exploration, our paper exemplified the potential of augmenting flavor perceptions digitally with the help of videos watched while eating. However, one major limitation of this study is the small sample size due to the pandemic restrictions, which led to difficulty in recruiting people for the study. Therefore, in the future, we intend to: 1) study the data in relation to the participants' personality traits to evaluate behavioral changes based on their personalities, similar to the research done by Samant et.al [58], 2) obtain data from neurological and dermal sensors to understand the effect of the video stimuli, 3) continue the evaluation with a bigger sample size (n >70) and a different set of food items, 4) study the effect of different video genres on participants' flavor experiences and 5) evaluate the effect of other factors such as sounds, smells, ASMR, as well as the effects of the ambient environment on people's flavor perceptions, liking, and emotions.

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