ISSN 2278-3091
Volume 8, No.1.6, 2019
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse5781.62019.pdf
https://doi.org/10.30534/ijatcse/2019/5781.62019

Enhancing Food Taste Experience with 360^0 Immersive Virtual Reality (IVR)

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ABSTRACT

Virtual reality (VR) is an immersion technology that has evolved in the study of human-food interaction. Researchers found VR technology can alter people's perception of taste by what they experienced in their surroundings. Therefore, the paper presents a preliminary investigation on taste experiences through 36o^o immersive virtual reality (IVR) video. The objective is to identify the potential elements that could possibly influence one's taste experience through visual and environmental stimuli from Malaysian case study. A focus group consists of 21 multi-racial undergraduate students volunteered in this study. An explanatory sequential design method was used to analyze the food taste experience and its perception. Whereas the immersion was measured using Positive and Negative Affect Schedule (PANAS) and Presence questionnaires. The results showed positive correlation in all 12 Presence elements (presence, engagement, immersion, flow, usability, emotion, judgment, experience consequences, technology adoption, environment, auditory and experience consistency). While the PANAS results indicated high positive effect on four elements (interested, excited, enthusiastic, and inspired). In addition, respondent's perceptions were also analyzed against aforementioned results to add semantic understanding on food experiences through 36o^o IVR. The paper concludes by discussing future work and its relation to human-food interaction interests.

Key words : Immersive Virtual Reality (IVR), 360^0 video, Food experience, Human Food Interaction (HFI), perceptions

1. INTRODUCTION

Malaysia is a country that has multi – ethnic population that consists of Malay, Chinese, Indian and the indigenous people. The diversity influences the language, norms, culture and culinary heritage. Eating local food has been an integral part for the Malaysian which create added value in food tourism industry. Food tourism can be defined as visiting food exhibitions, food festivals, restaurants and specific locations for which food tasting and experiencing food are the primary factors for travel [1] – [3].Globally, the interest in food tourism has increased due to globalization, strategic certification particularly "halal" compliant, food security, food legislation agriculture policy. Food is also associated with a country's pride that reflect national identity. The rapid rise of food network television channels (e.g BBC Food UK, Food Channel Australia, Food Network US) globally, showcasing respective country's delicacies increased people consumption and interests on food. In addition, the notion of "foodstagramming", food hashtags and instagrammable food trends are popular among social media users which gives appealing food experience through visual cues and sound effects. Past researches shows the environmental and visual food cues do contribute to one's appetite and food craving [4], [5], [6], [8] [9]. In addition, the food's texture, appearance, feel, smell, taste, temperature and even the sounds produced while consuming the food contribute a great impact in gaining food experiences [6], [7]. Thus, influence one's perception and eating behaviour.

The demand of virtual reality (VR) content in games, entertainment, education, medical and businesses has increased [10], [11], [12], [13], [14]. Today, the use of 360^0 immersive virtual reality (IVR) video is considered as a promising audio-visual technology in the tourism industry for marketing tool as it creates engaging interaction through immersion of the surrounding scenes thus heighten psychological experience of users [15]- [19]. As eating is a multi-modal experience and rarely as an isolation process it is important to understand how 360^0 immersive virtual reality (IVR) video can revolutionizing the food taste experience by making possible the priori food previewing and accessing food location-based information in an interactive manner.

2. LITERATURE REVIEW

2.1 Human Food Interaction (HFI) and Food Experience

Human-food interaction (HFI) studied on multisensory interactions to create, modify and enhance food related experiences [20]. In the literature, HFI in relation to food experiences are discussed from multidimensional constructs such as social and cultural interaction around food [21], environmental [22], physiological influences and perceptual cues [23], [24] virtual reality/augmented reality [25] and

behavior/emotions [26]. Most of these works produce valuable knowledge on how to optimize our food interactions for positive food taste experiences [27]. In recent years, there have been numerous works that explore the relationship between technology and the gustatory as well as the olfactory sense [27], [28]. Interaction designers have recently begun to explore the usage of technology such as VR and augmented reality (AR) [29] to enhance or modify experiences through immersion. Works such as project by Ranasinghe et al. [23] who developed the "Spoon and Bottle" prototypes that can be used to virtually manipulate the taste of food or drinks and may help to replace possibly harmful artificial flavorings. A similar approach to alter the gustation sense was done by Narumi et al. [24] through "MetaCookie" that uses augmented reality and smells to overlay a cookie with visual and olfactory information thereby changing the perceived taste of the cookie. Project "Nourished" artificially stimulates all senses to offer eating experiences without caloric intake [30]. Whereas, a virtual reality game called "You Better Eat to Survive" by Arnold et. al [32] involves two-player immerse in virtual reality by eating real food to survive and ultimately escape from a virtual island. The aim is to create cross-modal game experience through cooperative eating and social interaction.

2.2 Immersive Virtual Reality (IVR)

Immersive Virtual Reality (IVR) is an immersion technology which connect user to a computational devise (e.g. head mounted device (HMD)) that can simulate computer generated, real and virtual environment. IVR leverage within three basic principles which are – immersion, interaction and user involvement with the environment. This technology creates an audio-video visuals experiences through its feeling of presence or 'being there' (perceptual and narratives) in the virtual world, or in the case of a networked computer environment, co-presence or 'a sense of being there with others' [32]. Today, the emergence of 360^0 IVR videos brings cinematographic perspective combining entertainment, visual navigation and sound simultaneously which has the potential to increase immersion of viewers [33]. A study in [34] report a relationship between the feeling of presence and the emotional involvement through experiences that stimulate the sensation that the viewer is present. This helps in the development of one's empathic emotions. It is also known that emotions play an important role in decision making and reflection on automatic responses since they influence learning and how we understand, describe and react to the environment and ourselves.

2.3 Perception cues

For this research theoretical lens, we refer to the Immersive-Environment and Human Interaction Model by [35] (Figure 1) as the reference guidelines to explore further on the understanding of user perceptions in food taste experiences.

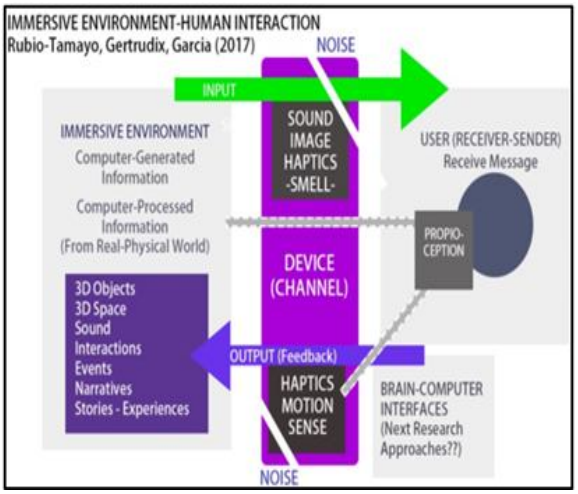

Figure 1: Immersive Environment – Human Interaction Model [32].

- *Visual and auditory cues in perceptions*

There are five of human senses including taste, smell, touch, sound, and sight. Researchers have outlined that all our five senses are associated to influence food experiences [37]. For example, people learn to associate colors of food/drink (e.g. brightness, odor) with how the food could affect people's taste and flavor perceptions [36]-[39]. Visual presentation of food also invokes multisensory flavor experiences in diverse brain regions particularly when a person is hungry [43]. Besides visual, auditory has become the important sense of flavor. Multisensory perception of food attributes such as crispy, crackly, crunchy, carbonated, and even creamy are vital in one's perception towards crispiness and freshness [36] – [37]. Furthermore, a sound or music have said may alter the perception, evaluation and intake of food in various ways [39]-[43].

- *Ambient and atmospheric cues in perceptions*

Researchers have found that atmospheric lighting, background music and background noise have all influenced taste and taste perception [40]. A study demonstrates that not only ambience in a restaurant can influence people's taste and flavor but also the natural environment, the color of a hallway and all around us can also affect our dining experience [41]. This sensory 'experience' is technically speaking a multimodal perception which influence food taste experience [42]-[44].

3. METHODOLOGY

3.1 Instrument development

For the development of 360^0 IVR video content, we create five food scenes (Figure 1 and Figure 2) namely *roti canai, yong tau foo, nasi lemak assam laksa* and *cendol* that represent the top most famous cuisine which represent Malaysia multicultural identities. Each scene was shot at different places (e.g. street food stalls, food court and restaurants) within Klang Valley. The duration for each scene is in between 3 to 4 minutes. The panoramic scene was captured using Insta360 Air, tripod for better viewing and Vivo S9 smartphone for the screen display.

Figure 2: 360^o IVR scene – eating cendol at the street stall

Figure 3: 360^o IVR scene – eating assam laksa at the food court

Figure 4: 360^o IVR scene – eating yong tau foo at the restaurant

3.2 Participants

The focus group in this research are consists of 21 multiracial undergraduate students from various universities in Klang Valley. They are recruited based on open invitation via social media platform. A total of 12 females and 9 males in their early 20s volunteered in this study. As this research is still at the exploratory stage with an aim to identify in general the possible dimensions of perceptual cues hence race and gender will have no triggered effect in the analysis.

3.3 Data analysis

The research opted for explanatory sequential design method. The first stage is to collect quantitative data through the study of presence using 360^0 IVR. The self-reported immersive questionnaires are used to measure presence based on user experience with 360^0 IVR adopted from [45] while the after effect of 360^0 IVR interaction is measured through Positive and Affect questionnaires (PANAS) by [46]. All these items are measured through Likert scales. For this purpose, we used descriptive analysis to analyze the data. For the second stage, an in-depth interview is conducted to probe further on the respondent's perceptions based on the answered presence questionnaires. Both data are consolidated through thematic analysis to explore possible perception dimensions.

4. ANALYSIS AND FINDINGS

- *Presence Questionnaires*

Table 1: Presence Questionnaire results

Presence Elements	Analysis		
	Mean	***Median***	***Mode***
Presence	3.9	4.00	4.00
Engagement	3.9	4.00	4.00
Immersive	3.71	4.00	4.00
Flow	3.95	4.00	4.00
Usability	4.10	4.00	5.00
Emotion	3.86	4.00	4.00
Judgment	4.19	4.00	4.00
Experience Consequences	2.43	2.00	1.00
Technology Adoption	3.95	4.00	4.00
Environment	3.67	4.00	3.00
Auditory	3.43	4.00	4.00
Experience Consistency	3.67	4.00	4.00

Based on Table 1., there are 12 Presence elements which consists of questionnaires on *'Presence', 'Engagement', 'Immersion', 'Flow', 'Usability', 'Emotion', 'Judgment', 'Experience Consequences', and 'Technology Adoption'*. Overall the results have shown high frequency occurrence for all elements. The highest Presence elements is 'Usability' with significant value of 5.0. Whereas, elements such as 'Presence', 'Engagement', 'Immersion', 'Flow', 'Emotion',

'Judgments', 'Technology Adoption', 'Auditory', and ' Experience Consistency' have significant value of 4.0. This indicates that the IVR gives a better experience in each Presence elements towards participants even though, 'Environments' and 'Experience consequences' elements are among the lowest values.

- *Positive and Negative Effect (PANAS) Questionnaires*

Table 2. Positive Effect Questionnaire results

Positive Questionnaire Elements	Analysis		
	Mean	***Median***	***Mode***
Interested	4.10	4.00	4.00
Distressed	1.52	1.00	0
Excited	3.38	4.00	4.00
Strong	1.24	0	0
Enthusiastic	2.67	3.00	3.00
Proud	1.81	1.00	0
Alert	2.05	2.00	0
Inspired	2.76	3.00	4.00
Determine	1.90	1.00	0
Attentive	2.33	3.00	0
Active	1.90	1.00	0

PANAS questionnaires consists of 20 effects that has been categorized into two categories (Table 2 and Table 3) which are the positive and negative effects. Based on Table 2, there are 11 positive effects shown in the results. The highest significant value 4.0 consists of 'Interested', 'Excited' and 'Inspired'. Whereas element of 'Enthusiastic' shows the value of 3.0. These highest frequency occurrences showed the positive outcomes of 360^{o} IVR experiences. For other positive effect elements such as 'Distress', 'Strong', 'Proud', 'Alert', 'Determine', 'Attentive' and 'Active' showed the null value and have no significant effect to the participants.

Table 3:. Negative Effect Questionnaire results

Negative Questionnaire Elements	Analysis		
	Mean	***Median***	***Mode***
Upset	0.71	1.00	0
Guilty	0.62	0	0
Scared	0.71	1.00	0
Hostile	0.81	0	0
Irritable	0.95	1.00	0
Ashamed	0.81	1.00	0
Nervous	1.33	1.00	0
Jittery	0.67	0	0
Afraid	0.71	1.00	0

In Table 3 there are 9 negative effect shown in the results. in table. The negative effect such as 'Upset', 'Guilty', 'Scared', 'Hostile', 'Irritable', 'Ashamed', 'Nervous', 'Jittery', and 'Afraid' shows the result value of highest frequency occurrence of 1.0. Whereas based on the Mode, all negative effect returns the value of 0 which indicate the positive correlation in negative effect answers. In other words, participants do not feel of all these Negative Effect while using the 360^{0} IVR.

- *Interview Analysis*

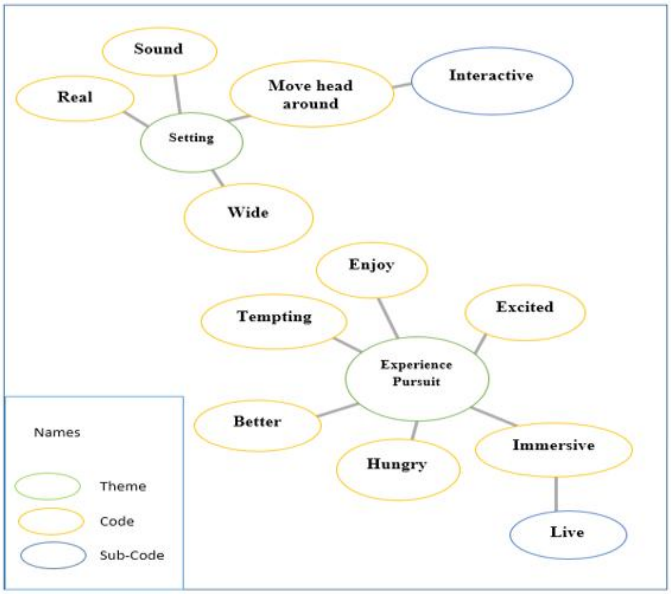

Figure 5: Thematic analysis of the interview

Based on Figure 5, a thematic analysis map is produced to summarize the interview results based on the outcome of immersive and presence self-reported evaluation. There are two main themes with respective sub-attributes emerged from the analysis which are "Setting" and "Experience". Based on the map, these themes can be categorized from a technical and experience perceptions point of views. Table 4, 5, 6 and 7 showed the participants feedback towards presence elements which contribute to the emergence of the themes above. From these attributes, the participants perceptions showed positive feedback on the food taste experiences using 360^{0} IVR. The result in thematic analysis has shown a complementary result towards data gained in quantitative Positive and Negative Affect Schedule questionnaires (PANAS) analysis.

Table 4: Presence effect – "Interested" element interview results

Participates	Quotes form Participants	Codes
P1	I like the sound of the food that person produce and the clearance of virtual environment view that I can view more rather than static. This is so great.	Clear, Wide view
P4	Being able to see and feel VR in 3D motion, but this only static place and I cannot walk.	Head movement
P9	This is one nice experience. VR make me feel hungry by watching people eat along with the sound. It is make me want to taste it.	Nice, Hungry

P12	I enjoy 360 view.	Enjoy (Wide View)
P13	Feel like watching people live like I was there. This is clearer than 2D view.	Live, Clear (Wide View)
P16	This is my new immersive experience.	Immersive
P17	I could feel like I was there as it is real.	Feel, Real (Immersive)
P19	I feel like I actually at that place	Actual (Immersive)
P21	I feel like I actually in the scene, but I don't like background sound.	Actual (Immersive)

Table 5:. Presence effect – "Excited" element interview results

Participates	Quotes form Participants	Codes
P2	I feel excited using this for first time. I can view 360 real environment instead of 2D view.	Excited
P5	It is the fun and interactive way to show contents of food video.	Fun, Interactive
P15	I can feel the experience as I am in the view.	Feel experience (Immersive)
P18	I like if this kind of product in market because I feel excited to experience it.	Excited
P20	I feel like actually at that place. The food looks real and I feel hungry to see the food. I like the environment sound included like the sound of the birds and transportation.	Real , Hungry Sound

Table 6: Presence effect – "Enthusiastic" element interview results

Participates	Quotes form Participants	Codes
P3	I can view better than normal flat screen. Can see 360 environment and I feel hungry watching this.	Better, Hungry
P8	The like the sound this video produce, the combination of real environment surrounding sound and I feels like I am there, but the position is static.	Feels
P11	I can view 360 clear environment of view and the food look tempting.	Clear, Tempting
P14	Food in the video shown looks good enough for me to also has some.	Good

Table 7: Presence effect – "Inspired" element interview results

Participates	Quotes form Participants	Codes
P6	I find it quite immersive, I feel a little like I was there, but my vision little distorted.	Immersive
P7	The video are pretty immersive because I can move around, but this content is kind of boring.	Move head around
P10	I experience the nice environment and food where people usually have outside activity to relax.	Nice, Relax

5. CONCLUSION

The effects of immersion, presence or engagement and physical experiences are among IVR principles to promote sense of realism. This preliminary investigation explore the general perceptions of local participants towards food taste experiences via 360^0 IVR video content. The research wanted to understand on the user's immersive taste experiences using 360^0 IVR. The results produced positive correlation in Immersive elements attributes such as *presence, engagement, immersion, flow, usability, emotion, judgment, experience consequences, technology adoption, environment, auditory* and *experience consistency*. Whereas under Presence effect, elements such as *interested, excited, enthusiastic* and *inspired* show high frequency towards the feelings of presence using 360^0 IVR video content.

These results form a future foundation to further investigate on the effect of 360^0 IVR video content on food taste experience among the locals in a larger context of study. With the cultural diversity, to examine the relationship of immersion, presence and engagement towards food taste perceptions from individual cognitive and affective contexts as well as its implication towards social boding are essential. This can help the researcher to gain better understanding on user food consumptions that has impact on individual food practices which lead to the issue of food sustainability. In the long run, we also believed 360^o IVR videos can be an interactive and persuasive marketing tool in promoting food sustainability and positive food experiences.

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