Senior's Acceptance of Head-Mounted Display Using Consumer Based Virtual Reality Contents

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Abstract. Head-mounted display has been commercialized and have made a considerable market in the virtual reality industry. While many seniors have interest to the consumer head-mounted display, the opportunity to experience the head-mounted display is still very limited. Hence this paper aims to resolve whether the current contents or products are acceptable and to clarify the challenges to discuss solutions. To investigate on this issue, an event to experience head-mounted display took place within a regional event for seniors at Kashiwa city in Japan. During the event, voluntary participants were asked to answer the questionnaires. The questionnaire was gathered from 5 seniors over age 60 and 10 young under the age 60. The seniors acceptance level was not so high in contrast to the young. However, positive results indicated seniors enjoyed experiencing the head-mounted display contents, willing to experience more opportunities, and also highly recommend to experience to others.

Keywords: Senior · Head-mounted display · Acceptance · Virtual reality

1 Introduction

Recently, head-mounted display (HMD) has been commercialized and have made a considerable market in the virtual reality industry. While it has become one of the successful virtual reality consumer products, it still requires technological knowledge to use as a home device. Meanwhile, many seniors are aware of consumer head-mounted display through broadcast on television. However, the opportunity to experience the HMD is still very limited.

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Supporting seniors are an important aspect within the aging society including to provide entertaining contents for their daily life. Therefore, providing the opportunity to experience a consumer type HMD to the senior is important. However, it is assumed that there are several challenges to resolve in order to provide a good experience to seniors using the HMD. Some of the challenges assumed or known, is about the aspects of physical depression due to age affecting virtual reality experience, and the complexity of the HMD use. To clarify the challenges, in this paper, a HMD experience event and questionnaire were prepared within a regional event for seniors.

2 Head-Mounted Display

Within the topic of this paper, we would first need to clarify the principles for virtual reality to understand the HMD's affections to the seniors. There are several well-known definitions or principles of virtual reality such as, the $I = 3$ [1] which is composed of *Immersion, Interaction, Imagination*, and AIP cube [2] which is composed of *Autonomy, Interaction, Presence*. While HMD has many possibilities in use such as an MR/AR device [3], recent low priced HMD's device are designed as a closed type HMD with a non see-through monitor placed in front of the field of view. Although they can be configured as a video see-through HMD for MR/AR, recent commercially available HMD contents are made as a VR content.

It has become very popular for consumer video games, with many contributions from Sony (PlayStation VR), Facebook (Oculus, Oculus GO), HTC (HTC Vive) for developing and releasing the HMD to the market. However, as reported in early studies [4] and recent studies [5] still report that game users experience motion sickness. Therefore, understanding the users' characteristics, and following early research literature and proposed guidelines [6–8] is important. However, not all of the released game always follows the suggested guidelines. There are no way the user can recognize whether the VR contents include some motion sickness aspects or not, which may lead to bad first time experience.

2.1 Consumer Market of Head-Mounted Display in Japan

Currently in Japan, there are several consumer HMD products that can be purchased. From a consumer point of view, the consumers' behaviour to purchase can be categorized into several points, such as the design, weight, performance and price. Firstly, it can be categorized into two types based on the difference in components, a smartphone-based type or a dedicated-device type.

A smartphone-based type HMD is fairly cheap and sometimes free, since it basically is just a smartphone mount kit sometimes made from cardboard. Some notable products are Google Cardboard [9], Hacosco [10], GearVR [11] and free companion HMD featured at CardboardClub [12]. Normally, the cardboard type HMD cost few hundred Yen to few thousand Yen according to cardboard quality (from about $1 to $20). When it is plastic manufactured like the GearVR the cost goes slightly up to around five thousand yen (about $50). Since it is fairly cheap

has high portability, it provides many opportunities to people, and is expected and studied such as some serious game with pain management [13].

A dedicated-device type HMD are relatively expensive where the prices range from thirty thousand Yen to twenty hundred Yen ($500 to $2,000). Some notable products are PlayStation VR [14], Oculus CV [15], HTC Vive [16]. Since it is developed with a dedicated display and sensors, these HMD's provides one of the highest quality of virtual reality available for consumers in terms of I^3 or AIP cube. However, usage is still limited whereas the most popular use is within the entertainment field. Therefore, Oculus Go [17] has been released as a relatively cheaper model ($200) for consumers which may not want to pay for more than $500 for an entertaining device.

While the consumer market of HMD in Japan is rapidly increasing, the adoption rate is not that high yet. Using some classical theory of categorizing the consumers as adopters [18], in general, there is a well known diffusion curve to describe cumulative adoption of a new technological innovation [19–21]. The categories are named "innovators", "early adapter", "early majority", "late majority", and "laggard" as it differs in terms of the adoption rate. Innovators are the first adopters which has the positive attitudes to technology, and the laggards are who have extremely negative technology attitudes and therefore never adopt technology among the mainstream [22]. Seniors are relatively are considered to be close to laggards even though they gain some interest in the technologies since their attitudes in changing their life are not as high as the young. However, the attitude does depend on the individual so giving the opportunity and enhancing their interest still may convince seniors to purchase the HMD. In order to realize that situation, giving positive experience to the seniors will be the key, and also that experience shall consider further experience after they have purchased.

2.2 Head-Mounted Display for Seniors

Considerations of adapting the virtual reality technology to the seniors has been addressed in previous research [23]. While there is huge potential of new possible services, there has been many reports about the effect of spatial cognition ability declines due to increasing age. While there is individual difference, it suggests that at some point the individual becomes not capable to recognize the 3D environment as intended [24–26]. Although there are individual differences, some similar aspects can be observed such as motion sickness. There also has been some reports about sickness occurring even with a very simple virtual reality environment which is composed only from one CRT monitor [27,28]. Furthermore, some studies report some seniors may feel extreme sickness which can lead to some of the participants dropping out from the experiment [29,30]. Therefore, it needs cautions for the seniors not to feel too much sickness.

Early studies using high virtual reality environment CAVE [31] and HMD comparing the effect to the seniors showed better results for HMD [32,33]. While the CAVE is considered better in providing higher virtual reality aspects, reduction of some of the aspects such as texture or model of the 3D world may have some possibilities in reducing the sickness. Therefore, while some of the seniors are concerned about the *virtual reality*, interest about the HMD and providing

the experience in HMD still has the capability of adoption to the new technology compared to the CAVE or much higher virtual reality device and experience.

3 Regional Community Event: Luncheon Meeting for Senior People Living Alone

Every year an event named "Luncheon meeting for senior people living alone" is organized at the Toyoshikidai area of Kashiwa City, Chiba Prefecture. Almost 200 local seniors attend this event, and some session within the event is organized by the Institute of Gerontology, the University of Tokyo. Although the event itself is organized by the local city government, the Institute of Gerontology has been significantly cooperating with the government to develop a successful community and social participation for seniors [34]. The 9th annual event was held 8th October 2018 at a facility within the Toyoshikidai area, which had the schedule shown in Table 1.

As showed in Table 1, the luncheon meeting starts at 11:30 with an opening speech for the event, and consists of 2 parts. Part 1 is composed from a 30 min activity time called *cognicise* (cognition + exercise), lunch time, and listen and sing time performed by the local senior electric band (Fig. 1). Part 2 is a session

Table 1. Event schedule of the luncheon meeting.

11:00	Open
11:30–11:50	Opening speech and greetings
Part 1	
11:50–12:20	Cognicise activity
12:20–12:50	Lunch time
12:50–13:20	Concert by the local senior electric band
Part 2	
13:30–15:00	Booth activity time(*)
15:00	Close

(*) The opportunity to experience HMD contents was provided in this session.

Fig. 1. Scenery picture of Part 1 of the luncheon meeting.

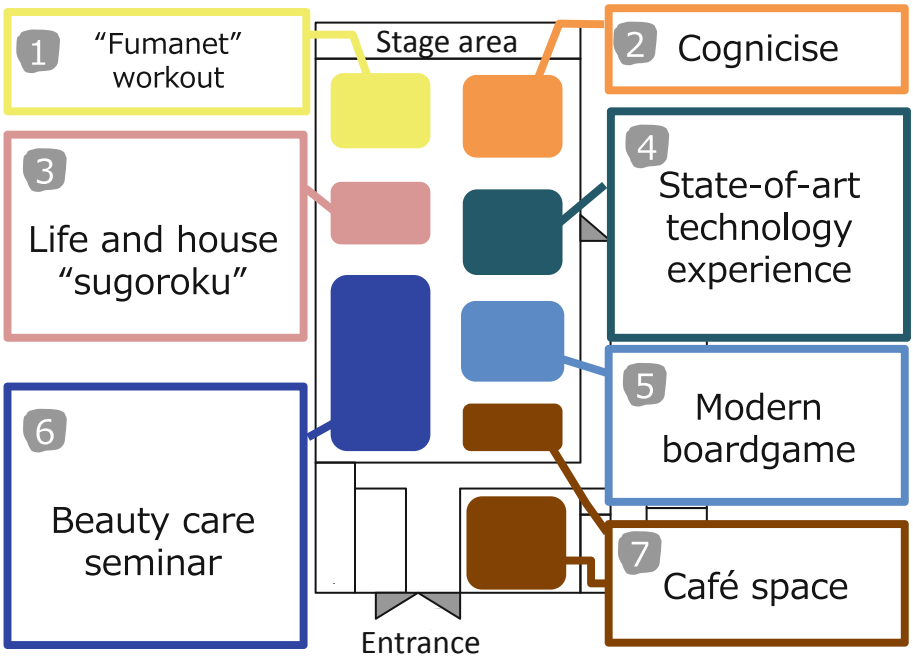

Fig. 2. Overview of the booth areas at the luncheon meeting Part 2. The opportunity to experience HMD contents was provided at the booth "State-of-art technology experience" area.

Fig. 3. Scenery of a senior experiencing a HMD content at the booth.

composed of six small parallel sessions (Fig. 2). Within the booth at *State-of-art technology experience*, an area was prepared for the senior to experience the HMD (Fig. 3). It is to be noted that within the area, a table to experience Internet of Things was also prepared for the seniors. Therefore, the booth was named *State-of-art technology experience* rather than using the words of virtual reality, such as VR or HMD.

Since the research aims to provide consumer level experience potentially leading the seniors to purchase an HMD, Oculus Go was chosen for the device to experience, and the applications were chosen from the application list downloadable at 1st October 2018. For the virtual reality contents, six contents were chosen which were named as *Art experience*, *Aquarium tour*, *CM experience*, *Pop star live event experience*, *Movie experience*, *Comic experience* listed on a simple instruction manual. Seniors chose the contents with their own will, after listening to precautions instructed from the instructor. The informed precautions are as follows (original sentences are written in Japanese).

- Experience time may be limited in case of crowded situation.
- We have carefully selected the VR contents from among the contents publically released by production companies, although, some people may feel VR sickness similar to car sickness by experiencing VR contents.
- The experience can be stoped at any time. Please do note hesitate to tell us if you are not feeling well.

The questionnaire consists of thirteen questions shown in Table 2. The questionnaire was designed based on the usability scale named System Usability Scale (SUS) [35]. Within this research we used Oculus GO for the HMD device to experience, therefore the function was very limited. Therefore, originally, SUS has a question *I found the various functions in this system were well integrated.* though it was skipped within the questionnaire list. However, to calculate the

Table 2. List of the 13 questionnaire to evaluate the seniors HMD experience.

List of questionnaire	
Q01	I enjoyed today's VR experience
Q02	I think that today's VR experience was easy to understand
Q03	I would like to take home the VR device I experienced today
Q04	I think that I would like to introduce VR device to my friends
Q05	I think that I would like to use this system frequently
Q06	I found the system unnecessarily complex
Q07	I thought the system was easy to use
Q08	I think that I would need the support of a technical person to be able to use this system
Q09	I thought there was too much inconsistency in this system
Q10	I would imagine that most people would learn to use this system very quickly
Q11	I found the system very cumbersome to use
Q12	I felt very confident using the system
Q13	I needed to learn a lot of things before I could get going with this system

SUS, respect to the original calculation, the question was calculated as a skipped question, considering it as a 3 within the five-level Likert scale. From Q05 to Q13 was taken from the SUS, and from Q01 to Q04 was prepared to evaluate the satisfaction of the booth experience and further possibilities whether the participants consider using the HMD at their home or not. For comparison, young staff at the event was also asked to voluntarily answer the same questionnaire after their experience of HMD.

4 Results and Discussion

The questionnaire was gathered from 5 seniors over age 60 and 10 youngs under 60. The means and standard deviations of the age of participants and the questionnaire results with SUS score is shown in Tables 3 and 4, for the young and senior, respectively. The young senior was labeled as *Group*, and a one-way analysis of variance was conducted for Q01 to Q04 and the SUS score (Tables 5, 6).

Table 3. Questionnaire results of young participants means and standard deviations on the age, Q01 to Q04, and SUS score.

Group: Young		
Statistic	Mean	SD
Age	29.800	8.176
Q01	4.900	0.316
Q02	4.900	0.316
Q03	3.700	1.636
Q04	4.400	0.843
SUS score	75.500	15.977

($n = 10$, Male = 6, Female = 4)

Table 4. Questionnaire results of senior participants means and standard deviations on the age, Q01 to Q04, and SUS score.

Group: Senior		
Statistic	Mean	SD
Age	71.600	7.436
Q01	4.800	0.447
Q02	4.400	0.548
Q03	3.000	1.871
Q04	4.000	0.707
SUS score	51.500	13.532

($n = 5$, Male = 1, Female = 4)

Table 5. One-way analysis of variance of *Q02* by *Group*.

	SS	df	F	p
Group	0.833	1	5.159	0.041 *
Residuals	2.100	13		

(* $p < .05$)

Table 6. One-way analysis of variance of *SUS score* by *Group*.

	SS	df	F	p
Group	1920	1	8.238	0.013 *
Residuals	3030	13		

(* $p < .05$)

From Q01 to Q04, only Q02 showed a significant difference (Table 5), implying that the seniors may have felt more difficulty compared to the youngs. However, the Q02 mean for senior is 4.4, which is rather high within the five-level Likert scale, indicating that seniors thought *that today's VR experience was easy*

to understand. Although, results from SUS score for senior were 51.5, which is generally low score, considering there are suggestions that score less than 50 should be judged to be unacceptable [36]. According to Bangor [36], score of 50 indicates a serious usability failure rather than *being "half as good" as a product that scores 100*. Therefore, we can discuss that while the HMD experience was easy to understand there are still issues with usability.

For the young SUS score 75.5, according to Bangor's suggestion [36], the score indicates that the HMD experience is within the acceptable range, fairly good but not an excellent score. However, it is to be noted that it indicates that it shows that the HMD experience was not unacceptable, not that it is acceptable. As Lewis [37] points out, it is easier to show that a product is unacceptable than it is to show that it is acceptable. It also needs to consider the fact that to obtain reliable SUS results it is suggested it shall establish the "acceptability" within the number of participants in the hundreds [36].

Overall, consideration about "acceptance" can be argued within the objective point of view of the usability and whether if the usability is high from a subjective point of view. Even from the results of SUS score, the score is affected strongly from the subjective point of view, whereas the score rises if the participant thinks they are successful doing the tasks, even though if the participants were actually failing the tasks. To assess this problem, other scales and methods need to be combined for use [38]. However, if the product/system can be well popularized, if the basics are acceptable, it may be overall may not need to be strictly assessed. Recently, highly advanced products such as television and smartphones have already become popularized even within the seniors. There are many known issues such as the remote television controller becoming complex, or the smartphone becoming a very complex system, although, if there are needs or if there is high interest or desire, the product will well be purchased. Further research can be studied though it is still hard to distinguish if the product was really accepted, or if it is only a consumer behavior [39].

5 Conclusion

To provide a good experience to seniors using the Head-Mounted Display (HMD), this paper focused on the current acceptance level of consumer based HMD. While it is known that there are challenges for seniors using virtual reality devices, it is yet unclear how it may be accepted by the seniors which may not have much skill to use the device. To clarify the challenges, in this paper, a HMD experience event and questionnaire were prepared within a regional event for seniors. Based on statistical analysis, we obtained suggestive results that even while the current consumer based HMD'S SUS score is low, it may still satisfy their need or will. This may suggest that even products with usability difficulties to seniors may still provide high benefits to their life. However, it should be carefully argued with first impressions bias which shall be considered as topics which need to be featured in future research.

Finally, this paper suggests that consumer HMD products are nowadays in the phase to increase free and easily accessible contents to provide new opportunities to experience virtual reality. Especially, while many seniors gain knowledge about state-of-art consumer products through television programs, the opportunity to actually experience or consider buying the products are still low. The opportunities may be delivered through local events such as events held within local comprehensive care programs.

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