



Research Article

The Effect of Sex Differences and Experience of Using Virtual Reality on Presence

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A B S T R A C T

Presence greatly affects user experience and comfort when using virtual reality (VR). Presence is often associated with personal factors such as sex differences and experience using the instrument. There is a research gap related to presence judging by several studies, so it is an interesting topic for further study. This research aims to identify the effect of sex differences and experience using VR on presence. This study used two approaches namely subjective indicators by employing an Igroup Presence Questionnaire (IPQ) and objective indicators in the form of heart rate (HR) and task scores. The study made use of Kruskal-Wallis and MANOVA to determine whether there is an effect of sex differences and experience in using VR on presence. This study found that the sex variable affects a person's presence when playing VR, especially spatial score on the IPQ test, where women have a higher marginal means value than men. Another finding is that the experience of playing VR affects the delta heart rate, with the result that someone with no experience using VR is higher than those who have used VR before.

INTRODUCTION

Virtual reality (VR) is defined as a digital environment better known as computer-generated imagery (CGI) that can be felt and interacted with by users as in the real world [1]. VR is a real or simulated experience for users who experience visual presence or use visual sense [2]. Meanwhile, VR is a way of describing the conditions of an environment by employing sophisticated technological devices to provide experiences that go beyond reality, commonly referred to as immersive computing technology [3].

VR is not only used as supporting equipment in playing games but has also been developed for various fields and fields in everyday life. The use of VR in the game world adds more real impression and sensation compared to playing on conventional screens and provides new opportunities for the entertainment field [1]. Forty-five percent of industries in the world have applied simulation media in VR to carry out training or training of workers that is usually used to achieve company goals in 18-24 months [4]. One of the applications of VR simulations in worker training by DHL Express serves to improve efficiency and safety in using the Unit Load Device (ULD) with 90% of participants praising the existence of training using VR [5].

Based on a survey conducted by Valve as the company that owns Steam, which was the world's leading game download service provider in June 2019, the use of VR in playing the available games has increased quite significantly from 2016 to 2019 with an increase in monthly usage from 75 thousand in May 2016 to 1 million usages in May 2019 [6]. The existence of VR also supports the increase in players and the popularity of sports or e-sports games that are becoming a trend today. According to Hamari and Sjöblom, e-sport stands for electronic sports which means a form of competition or sports competition using digital games [7]. Based on research conducted in the annual report published by Newzoo in 2019, there are 1.76 billion people who are aware of the existence of e-sports games, and those who are enthusiastic or participate in the development of e-sports amount to as many as 201.2 million people [8].

There is an important aspect that affects the use of VR, namely presence. Presence shows the suitability and how realistic the information provided through a simulated view of a person's senses is two types of presence are put forward [9], namely physical presence or awareness of one's presence [10] and social presence, namely awareness of interacting with virtual characters [11]. The presence of presence is considered important in influencing a person's comfort when using VR by making visual

conditions feel more real. An individual may be very attentive or enjoy the task assigned in VR but without feeling the presence in VR because presence should be formed from one's sensory perception when reaching or interacting with objects in VR [12]. Presence is related to factors such as sex differences and one's experience in playing with digital products, including virtual reality.

Igroup Presence Questionnaire (IPQ) is a subjective measurement method for presence that consists of measuring variables: spatial presence, involvement, and realness from a simulation experience consisting of 14 questions [13]. Although the use of the questionnaire received a considerable amount of criticism because of its subjective and qualitative nature, its use is still the most frequent in presence measurement [14]. Meanwhile, the heart rate (HR) is one of the human physiological measurements that can be measured with inexpensive and continuously measured equipment with a high degree of accuracy. The higher or more specific the gravity of the work, the higher the heart rate of a person involved in the activity or task performed [15].

The physiological measurement of heart rate is the best measurement tool because the measurement has little effect if there is movement at the time of measurement [16]. Meehan et al. (2002) also stated that physiological reactions such as heart rate and presence are both higher when representing a high presence value, indicating that the heart rate measuring instrument does show a correlation with the higher the changes in heart rate value, the higher the perceived presence [17]. Changes in heart rate (Δ Heart Rate) are a suitable measurement to be used as a physiological measurement because each person has a different resting heart rate [17].

Individuals who have more playing experience would have a higher presence than those who have little or no playing experience [18]. Therefore, it was concluded that differences in the experience of playing or using computers did not affect the presence of presence [19]. Another information shows that individuals who have less experience produce a higher presence score than those who have more experience, but it is not proven to affect presence [20]. Presence is also influenced by sex differences, with men having a higher presence than women. Previously, Gamito et al. has done and proven in his research that even sex differences do have an influence on presence with differences in the level of presence felt by men and women [20]. While Felnhofer et al. used the sex differences factor as well, but it was proven that there was no effect on presence. Therefore, in this study, the sex differences factor is reused to prove whether sex differences have an influence on presence or not [21].

A person's experience affects the level of presence one has with people who have more experience would have a higher presence than people who have less experience [22]. Meanwhile, another researchers concluded that sex differences do not affect the level of presence of each person as evidenced in the three presence variables produced that are not influenced by the sex differences factor [21].

Based on previous research, it can be seen in these kinds of research that examining the interaction between sex differences

and experience using VR is still very limited, and there are still gaps or differences in opinion judging by the resulting conclusions. Research to identify the influence of sex differences and experience using VR is very important because of the limited studies conducted in this field. This study aims to investigate whether sex differences and playing experience affect the presence aspect when using VR and test whether there is a relationship between the results of the human's physiological measurements (using heart rate) and subjective indicators (through the Igroup Presence Questionnaire), and whether the results obtained can provide recommendations for future use of VR.

METHOD

This research adopted a within-subject experimental design approach, which was carried out at the Laboratory of Work Design Analysis and Ergonomics, Parahyangan Catholic University, Bandung. In this study, two factors were observed, namely sex differences (A1 = male participants and A2 = female participants) and experience using VR (B1 = never using VR and B2 = having used VR). There are still different points of view regarding the definition between sex and gender [23]. However, the current debates have something in common: distinguishing sex by biological differences (labelling men and women) while gender is different from cultural differences. Sex differences often have physical identities such as chromosomes, genitals, and hormones. However, gender differences in femininity and masculinity are culturally and socially. In this study, the term sex is used because the differences observed between men and women are only physical or biological.

This study involved 52 participants aged 21-24 years old, with the following details: 13 male participants who had never used VR (A1B1), 13 men who had used VR (A1B2), 13 women who had never used VR, using VR (A2B1), and 13 women who had used VR (A2B2). The experience of using VR is divided into 2 levels, namely participants who have never used VR and participants who have used VR at least once. The data collection time is in the range of 08.00 to 12.00. Each participant spent one full hour (60 minutes) in the study.

Research Instruments

The following are some of the supporting devices used during the data collection process. First, the Oculus Rift S VR device. This device consists of one head-mounted display (HMD) and two controller sticks (Figure 1). The computer equipment (PC) whose main specifications are in the form of an Intel i7 processor, 32GB of RAM, and an NVIDIA RTX 2070 graphics card, has a display port and USB 2.0 type port. Secondly, a Samsung Galaxy Watch Active smartwatch that can measure the user's heart rate continuously. The software that must be downloaded consists of Steam, Oculus, and the Beat Saber game. Steam software is required for downloading the Beat Saber game which can be seen in Figure 2, while the Oculus software is required to be able to activate and control the VR device used.

Beat Saber is not a game that is purely considered a physical activity game because it does not require extreme movements such as jumping or running when playing. Even Beat Saber is

included in cognitive games because there are several basic activities such as distinguishing symbols and shapes from blocks that must be hit and avoided and require high concentration and attention. Cognitive games are activities that require the brain's ability to think, including body flexibility and require memory when doing work, the ability to visually distinguish objects, and the ability to increase focus our attention on activities carried out in games [24].



Figure 1. User with Oculus Rift S



Figure 2. Beat Saber User Interface [25]

Data Collection Procedure

Participants must fill out a consent form and a brief explanation of the procedure for how to play and use the VR tool. Installation of a heart rate measuring device on the participant's wrist, a VR device on the participant's body, and placing the participant in a determined position provided that the participant's space is large enough so that he or she can move freely when carrying out tasks in the game. Each participant had to listen to the same song for the total duration of 20 minutes. After the participants had finished carrying out the six tasks, the participants had to fill out the IPQ, which consists of 14 questions. Participants who had finished filling out the IPQ left the research room and declared to have finished carrying out the task as research participants.

The results of this study are that the IPQ will be processed in a statistically descriptive manner (based on mean value and standard deviation). This instrument can range from the form of tests of general knowledge, a person's ability, health simulations, to a questionnaire for a survey [26]. From the participant's changes in heart rate data, the results of the IPQ questionnaire and the task score of the VR game several tests were carried out such as the normality test and influence test with the Kruskal Wallis test and MANOVA, to be continued with the Post Hoc test

with a p-value <0.05. Multivariate Analysis of Variance (MANOVA) is simply ANOVA, which is used for cases with several dependent variables [27]. Meanwhile, the Kruskal-Wallis test is a test of variance analysis for non-parametric data [28].

This test was conducted using MANOVA. The factors observed were sex differences, experience using VR, and the interaction of these two factors. The sex differences factor is divided into two, namely male and female. This sex differences are based on the physical differences that distinguish between male and female. This physical difference between male and female can be proven based on body composition that can be clearly seen, such as male who generally has greater muscle and bone mass than female, and the percentage of body fat content is less than female [29].

Meanwhile, the experience factor in using VR is also divided into two, namely having used VR and never using VR. Each of these factors, including their interactions, was tested against five dependent variables that responded to this test. MANOVA is only used to determine whether differences in factors cause differences in results in responses but cannot determine which level or type of factor is more specifically significant.

RESULTS AND DISCUSSION

This research was conducted by collecting data in the form of participant changes in heart rate data, IPQ scores (REAL, SPATIAL, INV), and task scores from the games played by participants, namely Beat Saber. Data processing were used to identify whether there was an influence from sex differences and experience using VR on the presence or not. Each task in the form of a song produces a game score so that each participant produces six scores based on the six tasks carried out. Based on the six task scores generated by each participant, the average score for each participant was obtained. The IPQ used in this study uses a five-point Likert scale. Scale 1 indicates strongly disagree, scale 2 indicates disagree, scale 3 indicates neutral, scale 4 indicates agree, and scale 5 indicates strongly agree.

Next is the data processing stage. Data processing was carried out by testing the reliability and validity of the IPQ, testing the effect of sex differences and experience using VR on heart rate responses, task scores, spatial IPQ variables, IPQ involvement variables, and IPQ realness variables. Table 1 is the result of the calculation of the reliability test on the IPQ with the resulting Cronbach's Alpha value for each question item and the IPQ.

Because the Cronbach's Alpha of IPQ is above the value of 0.8 (the minimum requirement for the questionnaire is said to be good and reliable [26], the IPQ can be said to be reliable and can be continued to the validity test stage by calculating the correlation value of each question item. According to Cohen, one way to test the validity of an instrument is to use the Bivariate Pearson's Correlation or Pearson Product-Moment Correlation

Table 1. Cronbach's Alpha of IPQ

Variable	Cronbach's Alpha
SP	0.852
INV	0.824
REAL	0.735
IPQ	0.804

(PPMC) method [30]. Bivariate Pearson's Correlation produces a correlation coefficient that measures the strength and direction of the linear relationship between pairs of variables, whose correlation is denoted by the symbol ρ (rho). Table 2 is the result of the validity test carried out.

Based on the validity test, the IPQ has met these two requirements so that it can be continued to the next data processing stage. Table 3 is the descriptive result of research. Based on descriptive statistical results, all scores on the IPQ variable stated the highest score by women, so descriptively it concluded that women have a higher level of a presence than men do. In addition, based on the mean results of objective indicators, it was found that the highest changes in heart rate and task scores were made by female participants, especially female participants who had never used VR. However, these results must be proven in further processing, namely by means of an effect test. The influence test was used on sex differences and experience factors using VR with changes in heart rate response (Δ Heart Rate), task score, spatial, involvement, and realness.

Table 4 shows the result of the calculation of the effect test between all factors and all responses. Based on the results of the effect test conducted, it turns out that only the sex differences factor affects the IPQ spatial score with a p-value of 0.008 <0.050. It also shows that sex and experience affect presence. Because there is an effect on spatial by sex differences and there is an effect on changes in heart rate by experience, a significance test has been employed to determine whether the difference in effect is significant or not. Meanwhile, the effect of other factors on other responses was not tested further because it has been proven that other factors, namely the interaction of the two factors have no effect on the elements of presence.

In the Post Hoc test, the influence of sex on the IPQ score has two levels, namely male and female. Because there are only two levels, there is no need for further testing, and it is sufficient to assess it using the estimated marginal means (Female = 4.006 and Male = 3,467). These results indicate that subjectively from the IPQ questionnaire (spatial aspect), women feel a higher presence than men (Table 4).

The experience of playing VR affects participants' delta heart rate results, where the estimated marginal means from a delta heart rate of someone who has never used VR is higher than participants who have used VR before (Never used VR = 32.77; Have never used VR = 24.92).

The last data processing performed was a correlation test between subjective indicators (IPQ) and objective indicators (heart rate and task scores). Based on the results of the correlation test, only

the variables in the IPQ in the form of spatial, involvement, and realness are correlated. Meanwhile, the heart rate and task scores do not correlate with each other and do not correlate with the IPQ. Therefore, subjective indicators and objective indicators are not correlated. This shows that the simultaneous use of subjective and objective indicators is still not effective. Table 5 shows the results of the correlation test conducted between variables on subjective indicators and objective indicators.

After processing the data from the IPQ questionnaire in a descriptive manner, the data processing also needs to be inferential to the subjective and objective data. Inferential data processing needs to be conducted because the results of the questionnaire obtained tend to be highly subjective and there can be bias due to the questionnaire being filled out based on the

Table 2. Validity Test of the IPQ

Var.	Corr. (ρ)	r (df = 33)	Results
1	0.7567	0.3338	valid
2	0.6549	0.3338	valid
3	0.6022	0.3338	valid
4	0.4681	0.3338	valid
5	0.5201	0.3338	valid
6	0.7019	0.3338	valid
7	0.6908	0.3338	valid
8	0.4341	0.3338	valid
9	0.4011	0.3338	valid
10	0.5987	0.3338	valid
11	0.7798	0.3338	valid
12	0.4304	0.3338	valid
13	0.5655	0.3338	valid
14	0.7188	0.3338	valid

Table 4. P-value of Manova Result

Response	Factor		
	Sex Differences	Experience	Interaction
	Sig.		
Δ Heart rate	0.378	0.021	-
Task Score	0.268	0.104	0.124
Spatial	0.008	0.638	0.114
Involvement	0.251	0.771	0.281
Realness	0.253	0.128	0.917

Table 3. Descriptive Results

Code	Presence Components			Objective Indicators	
	Spatial	Involvement	Realness	Δ Heart Rate	Task Score
	Mean	Mean	Mean	Mean	Mean
A1B1	3.86	3.10	2.77	33.62	57292
A1B2	3.50	2.79	2.44	37.64	67429.67
A2B1	4.08	3.12	3.08	39.17	84647.50
A2B2	4.29	3.33	2.67	28.88	70560

Table 5. Correlation Test Results of Subjective and Objective Indicators

	Δ Heart Rate	Task Score	Spatial	Involvement	Realness
Δ Heart Rate	1	-0.093	-0.221	-0.121	-0.327
Task Score	-0.093	1	-0.074	-0.227	-0.181
Spatial	-0.221	-0.074	1	0.337	0.537
Involvement	-0.121	-0.227	0.337	1	0.307
Realness	-0.327	-0.181	0.537	0.307	1

feelings of the participants themselves, so that certain results that are not following the actual conditions may arise. Meanwhile, objective data do not appear due to subjective bias because they are generated based on the numbers displayed on the physiological signal and performance measurement tools. An example is the result of the heart rate, or the one that appears when the smartwatch measures the participant's physical response, and the participant cannot fill in or determine the heart rate by himself. Also, the objective value is obtained from the scores of the tasks carried out by the participants and cannot be fabricated or determined by the participants because the scores generated follow the performance of the participants themselves.

In accordance with the research of [18] [20] [22], this study shows that the experience of using VR affects the presence of participants, it does appear that the marginal means score from delta heart rate from participants who never used VR tend to be higher than participants who are already experiencing VR. The results of this study further strengthen research that stated that the experience of using VR does influence the user's presence. This research concluded that the presence of participants who have never used VR is higher than those who have used VR, where there is a higher increase in delta heart rate. An elevated delta heart rate is associated with an increase of people's adrenaline. This conclusion is in line with the findings of Meehan, which states that the increase in delta heart rate is proportional to the effect of perceived presence [17].

Another finding from this research that there is an effect of sex differences on presence, with female having a higher presence than male especially in spatial aspect from IPQ test. In addition to being based on physical differences, the results obtained in this study can also be caused by differences in game preferences favored by men and women. Romrell explains that men prefer more competitive games while women prefer games that can practice their skills and have more interaction with components or objects in the game [31]. When connected with the game used, namely Beat Saber, it is very possible that men play only to achieve the highest score or score so that they do not fully enjoy the game. Meanwhile, women enjoy the game more because they feel that the games that are served can improve their skills and enjoy the interactions that occur in the game. Women feel a subjectively high presence effect from the results of the IPQ test scores because they enjoy playing the game more than men who rate success in playing Beat Saber more.

Each type of simulation or game has an impact on the results perceived by the participants. The selection of the Beat Saber game itself as the game assigned to participants in this study is Beat Saber, which has a high level of graphic quality. The Beat

Saber game also uses the maximum capabilities and features of the Oculus Rift S VR device. This can be a consideration for further research in the same vein, namely, researchers can run several types of games used in research for each participant or use several games for the research. More combinations or game experiments can also be one of the new factors that will be identified as the influence of presence in addition to gender factors and the experience of using VR used in this study. In addition, Beat Saber is not only a game using the rhythm of a song, but this game also has various characteristics that support an immersive impression for the user when playing it using a VR device. This immersive impression can appear because in the game there is a rotation that follows the rotation of the user's body, changes in height, such as when the user is crouching or jumping, and the shift of the user's body also affects the course of the game. This shows that even though it is a rhythmic game, Beat Saber can still bring users the feeling of being immersed.

Recommendation can also be given to other parties who can be involved in the presence of virtual reality for users. Based on the results of data, some recommendations or suggestions can be given for game developers, or simulation software in VR devices. VR game developers are one of the parties involved in e-sports because the existence of VR strongly supports the popularity of e-sports. The difference between conventional and virtual e-sports games lies in the sensation of playing. Conventional e-sports games only prioritize a target or game score, so they have an uncountable a little sensation of presence. Meanwhile, e-sports games in VR prioritize real sensation or presence when playing so that players are more encouraged not to be disturbed by the target or game score which enables them to play as if they were in the real world.

These recommendations are given based on the results of data processing, namely the influence of sex differences and experience on presence. Developers can elaborate on a VR game that is not focused on the score or the objective of the game itself, namely increasing the interaction or the environment in VR to make it livelier and more attractive to players. Another way is to override the UI (User Interface) which shows the target or task score in VR games. This recommendation can be applied to the game by providing the option for the player to display the game score or not which is included in the settings or settings section of the game. The purpose of this recommendation is that male players can reduce their desire only to fulfill or complete a task without enjoying the game being played so that they can enjoy the game like a female player. With a display that is made like that, it is hoped that the level of presence in men will also increase so that games in VR can be regarded as the feeling of being in a

virtual environment that is more real and can be enjoyed by female and male players. In addition, it is also recommended for game developers to increase the impression of fun and continue to add new features to the game or software developed to increase presence for players who are just trying to use VR for the first time or experienced users.

Other recommendations that can be given are intended for organizers of e-sports games using VR and VR product manufacturers in the future. Another highly recommended way to increase the presence of each individual when using VR is to increase the quality of the VR device itself. The recommendation is to increase the quality of resolution on VR displays because display resolution greatly affects the presence effect felt by its users. The higher the resolution of the display, the higher the presence effect felt by the user because the display in the VR world is more realistic and comfortable to enjoy. An example is the use of the Oculus Rift S device used in research. The Oculus Rift S has a full-screen resolution of 2560 x 1440 pixels, equivalent to 1280 x 1440 pixels per eye. The display resolution on the Oculus Rift S is one of the highest resolutions available on commercially available VR devices. The Oculus Rift S device has a very good sound system quality because it has speakers that have been integrated with the device. The speaker system provides a holistic sensation so that users feel more and more part of a VR environment. The sound system on the Oculus Rift S improves user comfort compared to other products that use external earphones as sound output. This is the reason this study uses the Oculus Rift S as a VR device in research compared to other devices because it can support the presence effect felt by its users. This recommendation for similar studies to be conducted in the future advises researchers to keep using VR devices with the same or higher display resolution than what the Oculus Rift S has to offer.

CONCLUSION

There are three conclusions drawn to address problem. First, based on this research, sex differences are proven to affect presence when using VR. However, the presence is only affected by the spatial variable, which is the feeling of being physically in a virtual environment. In addition, the experience factor has also been shown to have an influence on presence through changes in heart rate (Δ Heart Rate). Second, physiological measurement results or objective indicators do not correlate with the results of subjective indicators so that the two types of indicators are not suitable for simultaneous use, or other alternatives to be used for researching presence can be explored. Third, based on the results of the research, the recommendation that can be given is that game developers or simulation software in VR can make changes to the UI. This UI change can be done by overriding the target or score of the task in the VR game. This recommendation can be applied to games by providing options for players to display game scores or not which can be done in the settings or settings section of the game. This step can be done by placing the score display smaller or made so that it does not block the user's view. This can be used to reduce the ambition of users who only care about scores or only to complete tasks but don't enjoy the game being played.

Furthermore, suggestions are conveyed aimed at readers or other researchers who wish to carry out similar research to avoid mistakes and improve their research performance. First, similar research will use simulations for more diverse games, both score-based and story-based ones. The purpose of this suggestion is that researchers will be able to find more reasons for the conclusions obtained based on the results of data processing. Second, VR game developer or developer can try to implement the UI by overriding the display of the score or target of the game so as not to block or cause any distraction to the user when running the game.

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