The Physical Benefits of VR games

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ABSTRACT

Keywords

ACM proceedings; LaTeX; text tagging

1. INTRODUCTION AND MOTIVATION

The aim of this study is to detect the physical benefits in virtual reality (VR) gaming. To get to the goal the heart rate of the subjects is going to be measured in rest and during the game. Also, subjects are asked to fill questionnaire about their exercise and gaming habits. There is also going to be question about the VR game experience. The goal is to see if VR games have physical effects in user and also if user enjoys exercising with the VR game.

While deciding the research area we get motivated by the paper of Finkelstein et al. (2011). Their study was about motivation to exercise by exergames. They designed game called Astrojumper which forces the user to move his/her whole body while playing. Player flies in outer space and swerve around, duck under and jump over virtual planets. They studied the effectiveness of this kind of game by measuring the heart rate before the game session and after the game session. One game session lasted 15 minutes. To get more information about the motivational part of the game they also asked the test users to fill pre- and post-questionnaires. Pre-questionnaire included more general information about users exercise habits and experiment with video games. In post-questionnaire the questions were focused on to the game session. It was shown that virtual reality games have strong potential to motivate to physical activity both adults and children.

Finkelstein et al. (2011) made their research seven years ago and the VR equipment are highly improved since then. In their study a user had a control backpack in his/hers back with many wires leading from there. The game setting in Astrojumper is highly different than what we are using in our study. The monitors are placed around the user while we are going to use VR glasses. Movement trackers are on the forehead, wrists and waist in the Astrojumper. This also forced the user to move his/her whole body while we are having games only with controller sticks. In our study we are using VR glasses with wireless control sticks. In Finkelstein et al. (2011) study they had problems with heart rate measurements during the game session and we try to avoid those problems by using newer technique.

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2. RELATED WORK

2.1 Virtual reality games

If the system consists a human operator, a human-machine interface and a computer it can be called a virtual environment. Environment has three-dimensional space where the objects are placed. [4]. Virtual reality games are characterized by high level of presence and immersion, or the feeling of really being a part of the virtual environment [15].

Adaptation of VR systems has been partly hampered by many users experiencing a set of symptoms similar to motion sickness. This set of symptoms is commonly called cybersickness. Possible symptoms include but are not limited to nausea, dizziness, headaches and fatigue. Studies have estimated that 30 % - 80 % percent of VR users experience these symptoms to some extent [12].

2.1.1 HTC Vive, Oculus and Sony Playstation

In recent years, many new consumer virtual reality systems have entered the market. Commonly these systems include an immersive head mounted display (HMD) and motion controllers. Popular examples of these systems include products such as Oculus Rift, HTC Vive or Playstation VR. Advanced head tracking and motion controllers combine to produce a high level of immersion and allow the user to explore and interact with their immediate surroundings in a natural fashion. Although Amazon sales rankings have recently shown a declining interest in VR devices [6], millions of devices have been shipped worldwide.

2.1.2 Exergames

Exergame term is widely used when video games are played to promote physical activity [10]. Children are easier to motivate to exercise with a fun way and childhood obesity can be prevent by exergames [14]. According to Staiano et al. (2013) children who were competitive exergames did not lose weight while cooperative "exergamers" did. Studies with elderly shows that with them the fun is not the driven force to play but the usefulness of the related physical and cognitive

abilities is. [2]

Study conducted by Plante et al. (2003) found evidence that combining VR with physical exercise can boost the mood benefits associated with normal exercise. In the study people who were immersed in a virtual environment while riding an exercise bike generally reported feeling more energized and less tired than the people in the control group [11].

Fitzgerald et al. (2010) have shown that exergames has been used successfully also in therapy. They used a wobbleboard based on video game to motivate the patients. Their results show that patients are more motivated for training when comparing to those who does similar exercises at a class with a therapist. Dynamic stability in both test groups gained and there were no significant differences between groups. [5]

2.2 Heart rate and exercise intensity

Heart rate measurements have long been used to monitor exercise intensity [1]. A common way to represent exercise intensity using heart rate is to calculate the current heart rate as a percentage of the maximum heart rate:

$$\%HR = \frac{HR}{HR_{max}} \tag{1}$$

Although the maximum heart rate varies greatly between individuals, it can be estimated without measurement if the persons age is known. For example, Robergs et al. (2002) [13] suggest the formula:

$$HR_{max} = 205.8 - 0.685 * age \tag{2}$$

as the most acceptable estimate of maximum heart rate. Gulati et al. [7] propose a slightly different age scaling factor of 0.88 for women. United States Center of Disease Control [3] recommends target heart rates of 50 - 70 % for moderate exercise and 70 - 85 % for vigorous exercise.

3. SENSING APPLICATION

3.1 Design

Our research is based around VR games. VR game set includes VR glasses, motion controllers, base stations and a computer. The purpose is to track the movement, our goal is to capture the data directly from the VR hardware.

Measuring the heart rate, we use sensor that allows continuous measurement during test. The best solution is to have a heart rate monitor which can be attached to player's wrist since it will not fall or start moving so easily. Additionally, we measure the resting heart rate before performance.

Participants are going to be interviewed before game session, between two game sessions and after both game sessions. Participants are asked to answer questions about their general background, exercising background, gaming background and about the VR game experience. We also ask if user felt any cybersickness during or after the game sessions.

There will be used two different games and each participant will play both. Other game is more hectic, an exergame-like game, and other is easier going.

3.1.1 Cybersickness and heart rate

As mentioned earlier, many VR users experience some degree of cybersickness. High levels of nausea can lead to increased heart rate without any physical activity [9]. In order to find out if the observed increase in heart rate is caused by onset of cybersickness instead of exercise, we ask our test users the Simulator Sickness Questionnaire (SSQ) [8] after the game sessions. The SSQ, which was originally developed for military air simulation use, has been widely used in cybersickness research. The SSQ measures 16 different symptoms on a four-point scale. The symptoms are grouped to three different categories: oculomotor symptoms, disorientation, and nausea. From the raw data a score for each of the three main symptom categories and a total score can be calculated (SSQ-O, SSQ-D, SSQ-N, and SSQ-T respectively). As nausea is the symptom mostly linked with increased heart rate, we will have to keep an eye on the SSQ-N scores.

3.2 Implementation

VR gaming device which includes HTC Vive visor, two motion controllers and two base stations are set in demo room inside Oulu university faculty of information technology and electrical engineering. We gather 17 participants to play two different games and we measure heart rate and movement data from them while they are playing. For heart rate measurement we are using two Fitbit Charge HR wristband devices as other one can be placed on next participant's wrist while he/she is waiting his/her turn. Also, if either of the devices stops working, we can still use the other one for measuring. This way we can ensure data collection and keep the game sessions going on fluently. Data from these devices are synchronized to Fitbit web service via Fitbit mobile application. Heart rate data is extracted from these devices afterwards using 3rd party web service called "Pulse Watch" and exported to csv-file which can be then downloaded for further analyzing. Collected heart rate data will be from each second during game session.

For movement data collecting we are using additional capture software which is run parallel to the VR game. This software will collect position data from VR visor and two motion controllers and save that position data with timestamps to a plain text file for later analysis.

At the beginning the participant is sat down and Fitbit heart rate bracelet is attached to their wrist. Then participants will be interviewed. Interview includes question about their background of exercising, video games and general. They are also asked to fill consent form (Attachment 1). Interview continues after first gaming session with questions about the exact gaming session. After second gaming session participants are interviewed with questions about the latter gaming session. Final interview also includes questions about SSQ, and questions based on their experience about exergames.

We start each game session by introducing participant to the game he/she will be playing. Participant will be given 10 minutes of time to play each of the games. Each participant will be given an ID number which is then used to connect heart rate data, movement data and questionnaire answers together.

4. EVALUATION

4.1 Evaluation plan

Based on the study results, we are trying to find clear evidence that playing VR games really have health benefits

and they activate and inspire people to move more than usually. We are also keen on finding results we did not expect based on interviews and data analysis.

We will compare heart rates of the user between two different VR games to detect if the exergame have raised users heart rate. We also detect the movements of hands and head during game session to compare if the exergame has moved users. By movement detection we exclude users heart rate increase caused by excitement.

Interview results may also be interested here. Even we hope to detect that more hectic game, BeatSaber, moves people more and raises their heart beat than QuiVR, participants may still think that it is neither fun nor exercising. It is also interesting to see if people would more easily recommend exergames to others instead of using those by themselves. It would also be interesting to see whether users rate more hectic BeatSaber being more intense than QuiVR. It is interesting to see if the game order matters to users thoughts.

4.2 Research data

During the game session we gathered three types of data from test users. We gave them a Fitbit bracelet which measured heart rate in real time. We collected qualitative data from users by interviewing users before game session, after first game session and finally after second game session. We also had SSQ interview to participants. We gathered movement data from hand consoles and VR glasses via capture software which was run parallel to the VR game.

4.2.1 Interview data

Test users were at the beginning asked to fill consent form. There their permission to use their data in this study was asked. After users were given their permission, the interviews were continued. First, they were asked some general information about their age and gender. Age information was gathered in order to calculate theoretical maximum heart rate. Low rate of women participants prevents data comparison between genders. In the interview, users' weekly activity with sports and with computer or console games were asked as for background information. Users were also asked if they have used VR applications before. After first phase interview user played ten minutes either BeatSaber or QuiVR game.

After first game session interview was continued by asking how user was feeling after the game. Users' were also asked how intense they would rate the game session in a scale from one to five. User then played ten minutes the second game.

After second game session user were asked again how they feel, and how intense they would rate the game session. To cut off the effect of simulator sickness, user was asked sixteen questions according to Kennedy et al. (1993) SSQ. Next part of the interview we asked if user sees himself/herself playing VR games for exercise meaning and for fun in scale one to five. And for final part we asked, would user play virtual reality games in exercise context and would he/she recommend that to others in scale one to five. Users had also a chance to say any comment about the whole experience.

Interview results about user's physical activity and computer or console game activity, as well as if user would play VR games and if user would play them for exercise purpose or if they would encourage user to exercise more and if user would recommend VR games for exercise purpose to someone else, are shown in Table I. Users were also asked to rank the intense of the game session (from scale 1 to 5) after each session. Their results are shown in Figure 1.

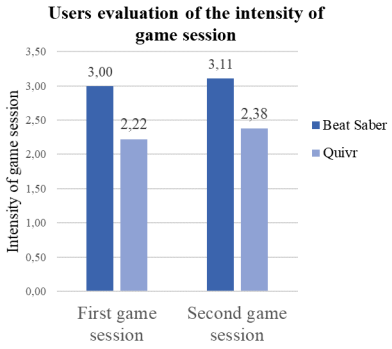

Figure 1: Users evaluation of intense of game session.

5. CONCLUSIONS

This paragraph will end the body of this sample document. Remember that you might still have Acknowledgments or Appendices; brief samples of these follow. There is still the Bibliography to deal with; and we will make a disclaimer about that here: with the exception of the reference to the LaTeX book, the citations in this paper are to articles which have nothing to do with the present subject and are used as examples only.

6. ACKNOWLEDGMENTS

This section is optional; it is a location for you to acknowledge grants, funding, editing assistance and what have you. In the present case, for example, the authors would like to thank Gerald Murray of ACM for his help in codifying this *Author's Guide* and the **.cls** and **.tex** files that it describes.

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Table I: Survey results. Q1: How many times a week you do sports? (at least 30 mins of exercising per time) Q2: How many hours do you usually play computer games or console games in a week? Q3: Could you see yourself playing virtual reality games more often just for fun? Q4: Could you see yourself playing a virtual reality games more often for exercise purposes? Q5: Would VR playing encourage you to exercise more? Q6: Would you recommend VR gaming as an exercise for anyone?

ID	Q1	Q2	Q3	Q4	Q5	Q6
3	2	10	5	5	4	5
4	3	0	5	3	3	3
7	3	7	5	3	2	4
8	4	0	4	4	2	2
10	3	3	5	4	2	3
12	4	1	4	2	4	5
13	2	2	5	3	2	5
16	3	25	5	1	1	2
17	4	0	4	1	3	2
18	5	4	4	1	1	2
22	4	5	4	3	2	2
23	2	5	5	3	4	2
25	1	0	3	4	2	5
26	1	30	5	4	3	3
27	10	4	5	3	2	4
29	3	0	5	4	4	4
30	1	2	5	2	4	5
Avg	3.2	5.8	4.6	2.9	2.6	3.4

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APPENDIX

A. HEADINGS IN APPENDICES

The rules about hierarchical headings discussed above for the body of the article are different in the appendices. In the **appendix** environment, the command **section** is used to indicate the start of each Appendix, with alphabetic order designation (i.e. the first is A, the second B, etc.) and a title (if you include one). So, if you need hierarchical structure *within* an Appendix, start with **subsection** as the highest level. Here is an outline of the body of this document in Appendix-appropriate form:

A.1 Introduction

A.2 The Body of the Paper

A.2.1 Type Changes and Special Characters

A.2.2 Math Equations

Inline (In-text) Equations.

Display Equations.

A.2.3 Citations

A.2.4 Tables

A.2.5 Figures

A.2.6 Theorem-like Constructs

A Caveat for the TEX Expert

A.3 Conclusions

A.4 Acknowledgments

A.5 Additional Authors

This section is inserted by LaTeX; you do not insert it. You just add the names and information in the `\addition-alauthors` command at the start of the document.

A.6 References

Generated by bibtex from your .bib file. Run latex, then bibtex, then latex twice (to resolve references) to create the .bbl file. Insert that .bbl file into the .tex source file and comment out the command `\thebibliography`.

B. MORE HELP FOR THE HARDY

The sig-alternate.cls file itself is chock-full of succinct and helpful comments. If you consider yourself a moderately

experienced to expert user of LaTeX, you may find reading it useful but please remember not to change it.