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Immotion - Exergame for Warm Up Guidance and Motivation

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von / by

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Saarbrücken, Monday 14th May, 2018

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Abstract

Past research related to exergames has found that they can help to motivate people to exercise by converting physical activity into an enjoyable game. However, these exergames have been single purpose usually fitness only. In this thesis, we designed an exergame for warm up guidance and motivation to be used in gyms and fitness centers before physically more strenuous exercise. We utilized immersive technologies based on the hypothesis that they can be used as a guiding tool for warm up procedures and would improve motivation to engage in warm up procedures more often. By making the game interactive and appealing, with intervals that last as long as the player chooses to, the warm up procedure undergoes a shift from a repetitive and tiresome activity to an entertaining and challenging necessity. In order to evaluate our exergame, we conduced a user study comparing warm up procedure with a video showing a fitness instructor performing a warm up session to a warm up procedure with our exergame. In both cases, the movements the participants needed to perform were identical. TODO

Acknowledgements

Make the impossible possible, the possible easy, and the easy elegant.
- Moshé Feldenkrais -

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Chapter 1

Study Design

The main goals of this thesis were to develop an exergame which can be used for warm up routine before more strenuous physical activity and to evaluate its effectiveness in terms of guiding the user through the process of warming up. In this chapter we outline the research framework, detail the research methods and present the obtained results.

1.1 Description of the Experiment

This section describes the evaluation of the second version of the Immotion exergame. For this purpose, an approach was adopted that uses a mixture of different tools and user study methods. During this period, data has been logged, surveys have been conducted, and interviews undertaken. Similarly to the evaluation of the prototype exergame (Chapter 2), the obtained results are analyzed in order to determine to which level our proposed solution was effective in the given context and whether it offered a solution to the problem.

1.1.1 Introduction and Goals

The first study evaluated the prototype exergame. Based on the results obtained, comments, and suggestions, the prototype exergame has been modified to better suit the needs of its future users. The primary goal of the second study was to investigate whether our exergame solution can be used as an interactive guide for individuals who do not know how to perform warm up routines. In addition, we examined if the exergame can be used as a solution that motivates individuals to warm up before physically more demanding exercises, and provides an enjoyable game experience. Taking this into account, the research questions we address in this study are as follows:

1. **RQ1: Evaluation of effectiveness** - How effective our proposed solution is in guiding the user through the warm up routine compared to the guidance offered by classic (traditional) methods?

2. **RQ2: Evaluation of perceived usefulness and ease of use** - How useful and easy to use our proposed solution is?

3. **RQ3: Evaluation of the usability** - How usable our proposed solution is?

4. **RQ4: Evaluation of the game experience** - How enjoyable and entertaining our proposed solution is?

In order to evaluate the effectiveness, perceived user experience, usefulness and usability of our gamified solution in the given context, the user base is divided into two groups: *experiment group* and *control group*. The first, experiment group, is the one that interacts with the exergame directly. Contrarily, the control group is presented with the video of a coach (professional) who guides the participant through the warm up routine. This division allows us to infer the influence of our gamified solution, as well as, to assess the main differences in completing the required activities between the two user groups.

1.1.1.1 Hypotheses

Based on the research questions outlined in the previous section, the following hypotheses are established to be tested:

1. H_1: The exergame itself is sufficient for guiding the player through a proper warm up procedure with correct movements.

2. H_2: After the warm up routine is completed using the exergame, player's ROM is increased.

3. H_3: Participants had a more positive perceived warm up experience when using the exergame compared to the participants not using the exergame.

1.1.1.2 Apparatus

The experiment was conducted in the laboratory room in DFKI. The laboratory is presented in Figure 1.1.

FIGURE 1.1: Laboratory.

The following equipment has been used during the experiment:

- Kinect for Xbox One (2.0 2013) motion sensing input devices by Microsoft used for movement detection and controlling the exergame avatar.
- Kinect for Xbox One (2.0 2013) motion sensing input devices by Microsoft used for recording the experiment.
- PC running the game engine.
- Projector used to display the game (video) on the wall in front of the participant.
- Microsoft Band used for gathering skin resistance data.
- Polar H7 Bluetooth Heart Rate Sensor and Fitness Tracker for hear rate and respiratory rate monitoring.
- Camera for taking photos of participants' facial expressions during the warm up procedure.
- Goniometer used for measuring participants' ROM.

Both the Kinect motion sensors have been placed in front of the display panel facing the participant playing the exergame. The participant was instructed to keep at least 2 meter distance from the sensor during the gameplay. This distance was the most optimal in order for the system to function properly in terms of skeleton tracking. The sensor is presented in Figure 1.2.

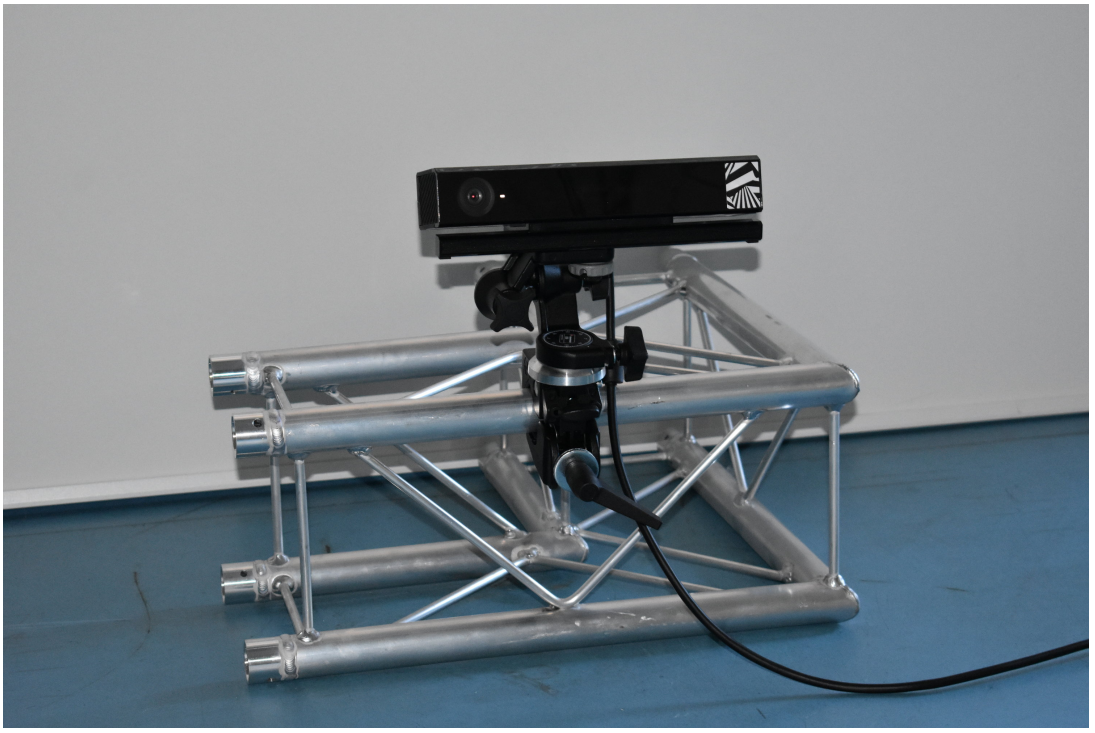

FIGURE 1.2: Kinect motion sensor.

We used XXX projector in order to display the exergame and video to the participant. The projector, depicted in Figure 1.4 was placed above the user so it did not interfere with the game flow. The desktop set up is presented in Figure 1.3.

1.1.2 Methods

In this section we outline the methodology adopted for the Immotion exergame evaluation. For this purpose we utilize the traditional (moderated) usability test since it gives direct input on how real users use the system.

FIGURE 1.3: Desktop set up.

1.1.2.1 Participants

The study has been conducted on Wednesday 28th March, 2018 and Thursday 29th March, 2018 in DFKI. All participants were students from Saarland University. All the participants reported no physical impairment at the time of participating in the study. For recruiting participants, posters were distributed in print, and sent through social media and email (Appendix X). Each participant was given 10 euros cash for taking part in the study. All of the participants were amateur athletes who engage in some physical activity on average 4 times per week. For the study we particularly targeted individuals who exercise in gym or fitness centers and often avoid preforming warm up exercises before more strenuous physical activity. All participants were required to report to the laboratory in gym based clothing, preferably shorts and t-shirt, and all of them performed the required tests in the same location using the same equipment. Before the study, each participant signed a consent form (Appendix X).

1.1.2.2 Conditions

First 10 participant who applied for the experiment have been accepted. These participants were sent a pre-test questionnaires (BSA-F, PARQ, and a Demographic questionnaire) that needed to be completed before coming to the experiment. Based on the answers given, the participants were assigned to the control or the experiment group. Each assigned participant took part in a single test session one hour in duration. During this session, all the participants performed

FIGURE 1.4: Projector.

one warm up session, after which they completed a set of questionnaires. Two conditions were evaluated:

1. Warming up with the exergame guiding through the warm up procedure, projected on a wall in front of the participant.
2. Warming up with a video of a professional (coach) guiding through the exact same warm up procedure as induced by the exergame, projected on a wall in front of the participant.

Depending on the group, each participant performed exercise that represent one of the conditions.

1.1.2.3 Control and Experiment Groups

The participants are assigned to each group based on the previously completed self-reported questionnaires. These questionnaires were sent to each participant and needed to be completed before the experiment. Based on the answers provided, each participant was assigned to either control or experiment group. The surveys assessed participants' perceived physical fitness level, warm up preferences, and previous exergames experience.

1.1.2.4 Measures and Metrics

Two separate sets of questionnaires were administered, one prior to the experiment session and one post the session in order to gather self-reported user perception data. The pre-test questionnaires focused on participants' demographic information, overall physical and psychological abilities, hours spent on exercise, frequency and activity of warm up procedures, extent of video gameplay, and reason for playing. The pre-test questionnaires were as follows:

- *Health status.* The current health status of the participants has been assessed via the Physical Activity Readiness Questionnaire (PARQ), which consists of seven dichotomous items [1]. The individual response patterns were used in order to assess if participants were physically able to perform the warm up session.
- Demographic survey with included questions regarding warm up preferences, and previous exergame experience [Appendix].
- *Physical activity screening.* Pre-study physical activity levels have been assessed with a standardized questionnaire Bewegungs und Sportaktivität Fragebogen (BSA-F) [2]. Participants were instructed to indicate for how many minutes per week they performed everyday physical activities (e.g., taking the bike to work; taking a walk) in average during the last four weeks.

The second set of questionnaires have been administered after the completion of the warm up procedure. In these questionnaires participants' level of exertion, emotional state, and game experience have been assessed. The questionnaires were as follows:

- *Perceived exertion.* For assessing the perceived exertion of the warm up session, the BORG rating of Perceived Exertion (RPE) has been utilized [3]. The perceived exertion reflects how difficult and strenuous the performed warm up exercise feels to the participants, combining all sensations and feelings of physical stress, effort, and fatigue.
- *Emotional state.* The pleasure, arousal, and dominance associated with a person's affective reaction to a wide variety of stimuli has been assessed with Self-Assessment Manikin Scale (SAM) [4].
- *Enjoyment of the physical activity.* To test the enjoyment of the physical activity performed, in this case the warm up procedure, the Physical Activity Enjoyment Scale (PACES) has been used [5].
- *System usability.* For assessing the exergame's instrumental qualities (e.g. controllability, effectiveness, learnability), the System Usability Scale (SUS) has been used.

- *Enjoyment of the play.* In order to measure the play enjoyment and experience o the Play Experience Scale (PES) has been utilized [7].

During the experiment, the following metrics were collected from each participants:

- *Range of motion.* The participants' ROM has been measured before and after the warm up routine using goniometer.
- *Heart rate and Respiratory rate.* The participant's heart rate data has been captured and the measured during the warm up procedure using Microsoft Band.
- *Distance.* The overall distance the participants' moved during the warm up routine was measured using Microsoft Kinect.
- *Skin resistance.* TODO
- *Participan's emotion.* TODO

The warm up routine performed by the participant has been recorded using a second Kinect sensor for further analysis of performed movements during the warm up procedure.

1.1.2.5 Tasks

In order to interact with the gamified system, the participants in the experiment group were required to perform a set of general movements. By performing these movements, the participant controlled the game avatar and, by doing so, avoided obstacles and collected coins. Based on the data and feedback gathered from the first study, we limited the movements the participants need to perform in the exergame. That is, only movements that are detectable with high accuracy using only one Kinect device and simplistic enough to be accomplished easily without no prior exercise knowledge or experience were required. These movements were:

- right hand movement up,
- left hand movement up,
- jump right,
- jump left,
- jump up,
- star jump, and
- squat.

Participants who were in the control group and did not interact with the gamified system were required to perform the same set of general movements. However, participants in this group had to follow a video that was projected on the wall in front of them. The video was a recording of a professional (coach) who guided the participants through the warm up routine. By following the video, and thus the coach, the participants were required to execute the same movements in the same order as the participants in the experiment group who interacted with the exergame.

1.1.2.6 Procedure

The study protocol was reviewed and approved by an institutional ethics committee. For data collection, we used a paper and pencil as well as *Google forms* questionnaires. Before the experiment, the lab environment is set up. The Kinect sensor is placed in a correct position and turned on. The PC running the software is started and the projector is enabled. In each session only one participant was present and guided by the researcher. The activities each participant followed are:

- The participant completes the preliminary survey.
- The researcher explains the sensors and tools that are required for the experiment, after which the participant puts them on.
- After the researcher confirms that the sensors are placed in a correct position, we start recording heart rate data.
- The researcher measures the participant's ROM before starting the warm up procedure. The following ROM's are assessed:
  - Left and right shoulder rotation
  - Left and right shoulder extension
  - Left and right hip flexion
  - Left and right hip extension
- After the measurements are completed, the participant rests while the researcher explains what is required from the participant.
- The researcher gives a general explanation on the benefits of a proper warm up routine before physically more demanding exercise.
- The participant moves to the spot marked by the researcher.
- The researcher starts recording the session.

- The warm up procedure begins:
  - If this participant is part of the experiment condition, the game begins with the *Start scene*. The researcher inputs the participant's name and presses the *Start* button. After 5 seconds, the game proceeds with scenes in which the participant is required to perform specific movements in order to avoid obstacles and collect coins. The duration of the game is not fixed and it is played up to the point when the participant feels warmed up enough.
  - In case the participant is part of the control group, the video that displays a coach who instructs the participants which movements need to be performed. As with with the sessions in the experiment group, the duration of the warm up is not fixed and the video is played up to the point when the participant feels warmed up enough.
- After finishing with the warm up routine, the participant takes a rest. The data collection is stopped. During this period the sensors are removed from the participant.
- Researcher assesses the ROM of the participant.
- The participant completes the post-test surveys .

1.1.2.7 Independent and Dependent Variables

1.1.3 Problems/Limitations - Threats to Validity

Our participant sample has an unbalanced gender ratio and a limited age range, which represent a limitation for the study results. Moreover, the arms of the standard goniometer that has been used for measuring participants' ROM were not longer than 12-inches which made it difficult to accurately pinpoint the exact landmark needed for measurement.

1.2 Results

Our subject group included 10 individuals, of which 2 were female and 8 were male. Participants were on average age $\bar{x} = 26.7$ years old ($\sigma = 1.77, x_{max} = 30, x_{min} = 24$), with different levels of education, such as Bachelor's degree (n = 4) and Master's degree (n = 6). Two participants reported to exercise 7 to 8 times per week and only 1 participant 5 to 6 times per week. The majority of the participant either exercise 3 to 4 times (n = 4) or 1 to 2 times (n = 3) per week. The duration of the sport or fitness activity for most of the participant was between 1 and 2 hours long (n = 8). Only 2 participants reported engaging in sports activity with duration less than an hour. The most common exercises the participants reported doing during one fitness or sport session were:

- Anaerobic exercise, such as sit-ups, pull-ups and push-ups, squats and weight lifting (n = 8).
- Team sports such as football, basketball, cricket, handball, etc (n = 4).
- Running outdoors, running on treadmills, and doing yoga (n = 3).
- Cycling and jogging (n = 2).

FIGURE 1.5: Participants during the experiment performing the worm up procedure.

The majority of the participants (n = 7) engage in physical activity alone, while only 3 participant enjoy sports activities performed in a group. The reasons reported by the respondents were time constraint, the monotonous and tiresome nature of the warm up procedure, how the warm up procedure represents an insignificant and negligible activity, and lastly, that no one warms up either. Regarding duration of the warm up session, 6 participants reported spending less than 5 minutes for warming up, while 4 participants reported spending between 5 and 10 minutes for the this preparatory activity. Out of all the participants, 7 stated that they engage in sport specific warm up, whereas 3 reported engaging in general (non-specific) warm up exercises. Half of the participants (n = 5) stated that they do not enjoy warming up in a group. When inquired about preferences regarding warming up when given instruction, 6 participants stated they prefer warming up when given instructions, while 4 participants stated they do not prefer warming up when given instructions. The engagement in playing video games varies among the participants: 1 plays video games daily, 1 few times per month, 1 once per month, 2 once a day, 3 few times per year, and 4 once per year or less. The most common video game types the participants engage in are depicted in Figure 1.6. We observe that the most common game types among participants are racing (n = 5) and sports games (n = 4). In addition, when inquired about participant's previous experience with Microsoft Kinect games, only 1 participant reported having a lot of experience with games in this area. The rest of the participants reported having either non or some experience with Kinect related games.

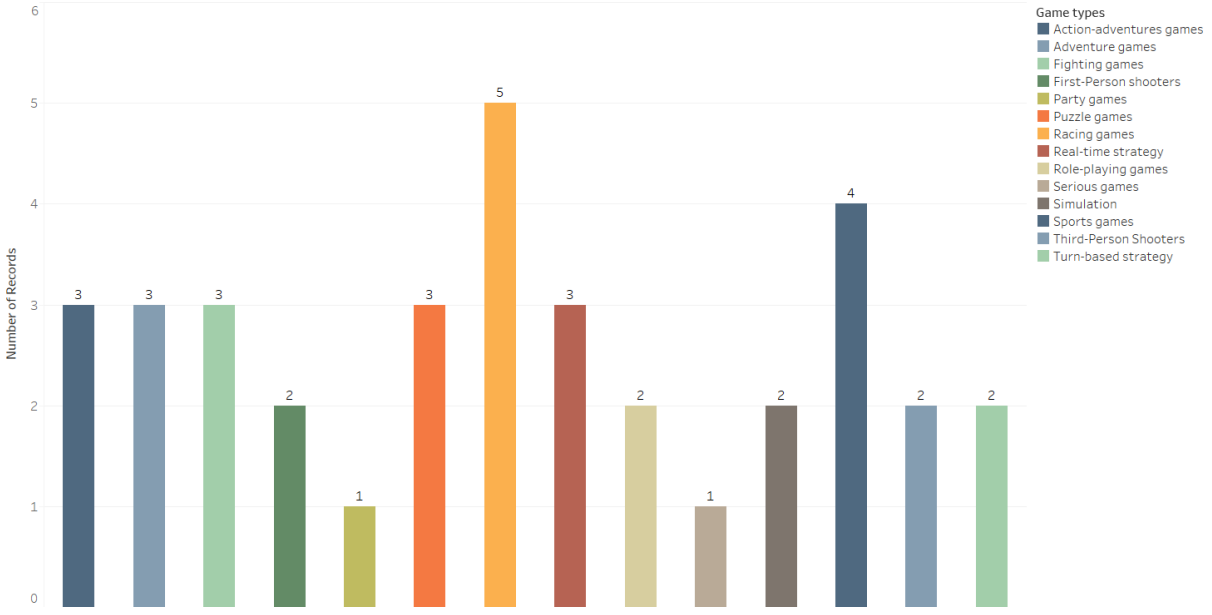

FIGURE 1.6: Game types most often played by the participants.

1.2.1 Range of Motion

The average ROM values for each condition are presented in Figure 1.7 and Figure 1.8. The measures were taken for each condition before the warm up session and immediately the participants completed the procedure. For taking the measures a plastic goniometer with 1 degree increments has been utilized. It can be observed that the average values after the warm up session for all measured joints are higher in each experiment condition.

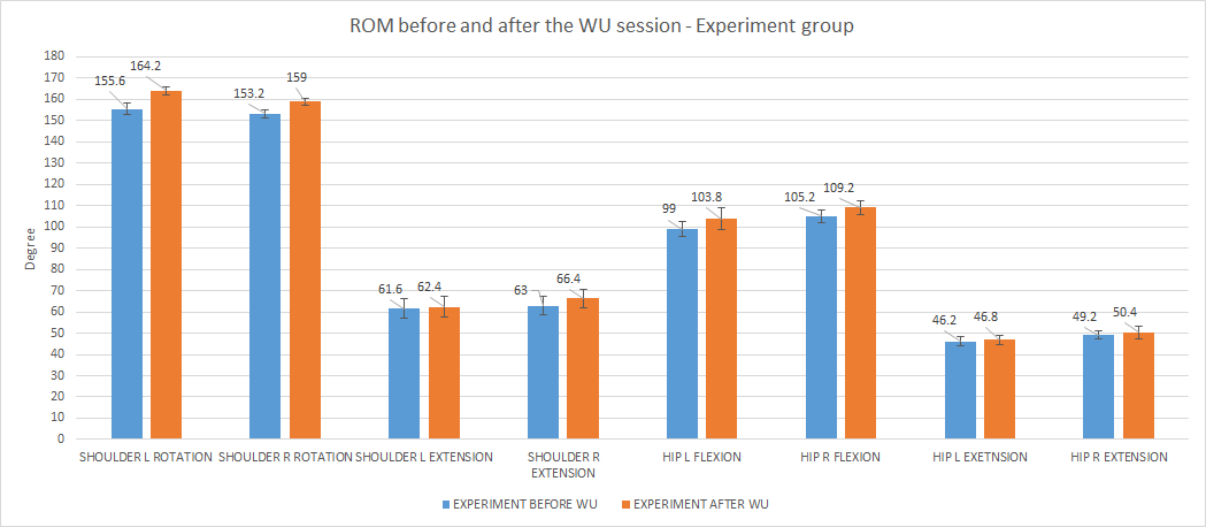

FIGURE 1.7: Summary of ROM results for experiment group.

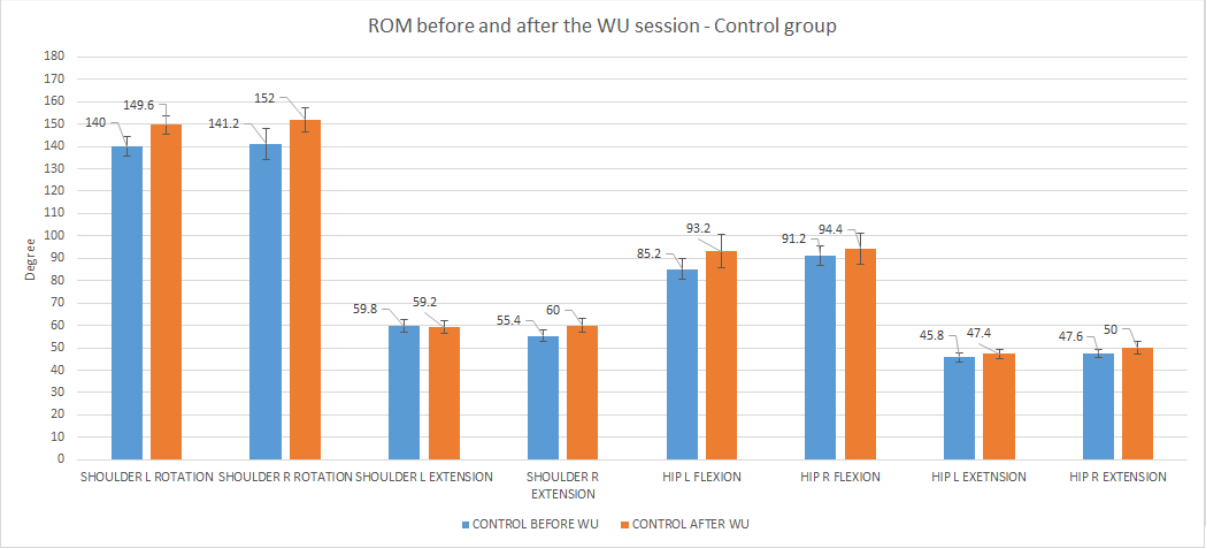

FIGURE 1.8: Summary of ROM results for control group.

1.2.2 Warm Up Duration

The duration of the warm up session has been measured from the game or video start until the moment the participant stopped with the warm up session. The participants have been informed to play the game or follow the video instructions as long as they usually spend on warming up session before some physically strenuous activity. The average warm up duration for the experiment condition was $\bar{x} = 800.4$ seconds ($\sigma = 205.4, x_{max} = 1122, x_{min} = 616$). The average warm up duration for the control condition was $\bar{x} = 444.2$ seconds ($\sigma = 94.2, x_{max} = 576, x_{min} = 345$). The average duration with standard error of the warm up session for each conditions is presented in Figure 1.9. The average duration of the warm up session for the participant in the experiment group who played the exergame is significantly higher compared to the duration of the warm up session for the participants in the control group. That is, interacting with the exergame positively influenced the duration of the warm up session for all the participants in the experiment condition.

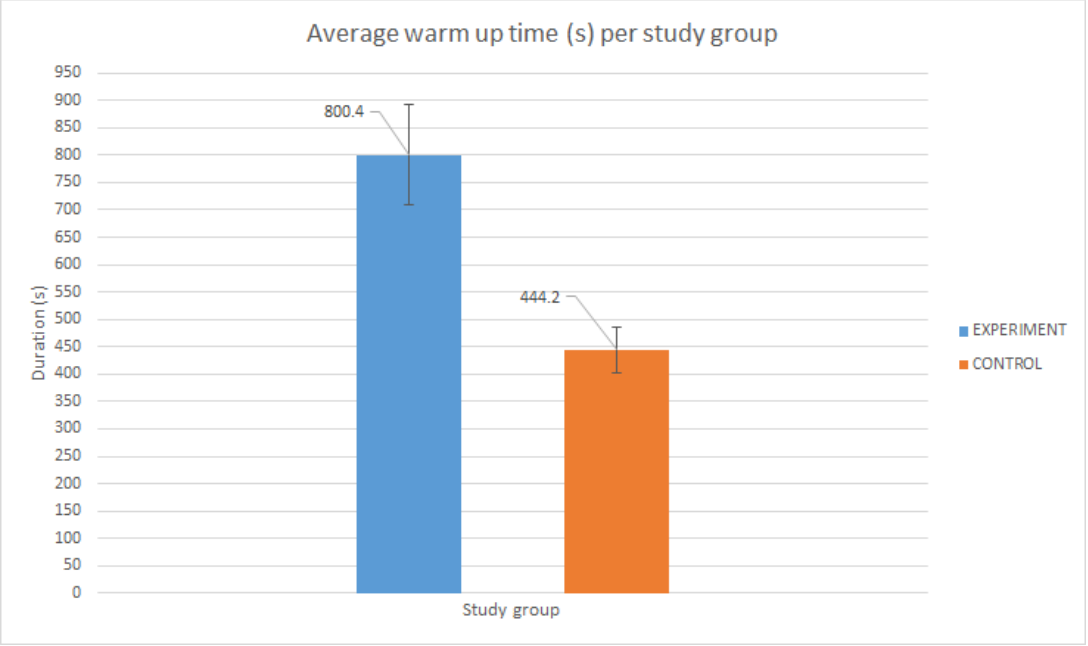

FIGURE 1.9: Average WU duration with standard errors per study group.

1.2.3 Heart Rate

The heart rate data has been captured and monitored using Polar H7 Bluetooth Heart Rate Sensor and Fitness Tracker in order to determine the exercise intensity of a warm up session. The heart rate has been measure from the beginning of the warm up session until the moment the participant declared being warmed up enough for a subsequent hypothetical physical activity. The average maximum heart rate for the participants in the experiment group was $\bar{x} = 174.20$ ($\sigma = 7.01, x_{max} = 186, x_{min} = 170$). The average maximum heart rate for the participants in the control group was $\bar{x} = 158.8$ ($\sigma = 10.06, x_{max} = 169, x_{min} = 144$). Figure 1.10 presents the average heart rates with standard errors per condition. From the figure is evident that the participants in the experiment condition reached higher heart rate levels compared to the participants in the control condition.

FIGURE 1.10: Average heart rate per study group.

The individual heart rate data for each participant is depicted in Figure 1.11. It can be observed, as previously pointed out, that the participants in the experiment group who interacted with the exergame solution, reached higher level of heart rates during the warm up session compared to the participants in the control condition. Furthermore, from the figure is evident that the duration of the warm up session for the participants in the experiment group is significantly longer also.

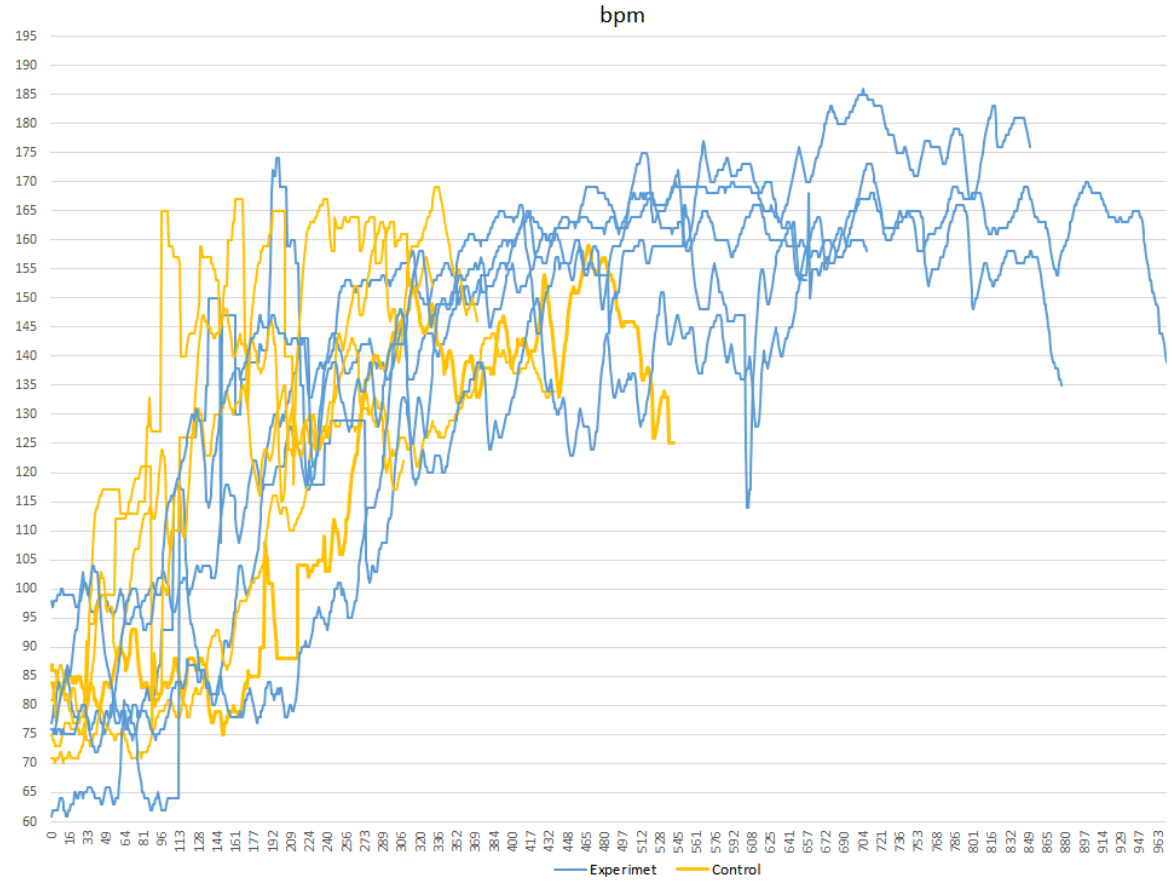

FIGURE 1.11: Heart rate data for each participant. The color represents the condition the participant belongs to.

For each participant we calculated the zone of the target heart rate (T_{HR}) based on the maximum heart rate using the Karvonen method. A number of formulas are used to estimate HR_{max} [wiki]. Tanaka, Monahan, & Seals (2001) proposed the following formula for calculating HR_{max}

$$THR_{max} = 208 - (0.7 * age) \tag{1.1}$$

The resting heart rate R_{HR} have not been measured during the experiment session. Hence, we utilized the generalized values for R_{HR} based on age groups []. Since our participant engage in sports activities sami-regularly, we opted for the *average* generalized R_{HR} values. The heart rate reserve (HS_R) represents the difference between participant's heart rate at rest and heart rate at maximum effort, and has been calculated as follows:

$$HR_R = THR_{max} - R_{HR} \tag{1.2}$$

The Target minimum heart rate (THR_{min}) has been calculated for each participant using the following formula:

$$THR_{min} = HR_R * 0.5 + R_{HR} \tag{1.3}$$

Following, the Target moderate heart rate (THR_{mod}) has been calculated as follows:

$$THR_{mod} = HR_R * 0.7 + R_{HR} \tag{1.4}$$

Lastly, the Intense target heart rate (THR_{int}), to be reached during extreme-intensity anaerobic exercise, is calculated as follows:

$$THR_{int} = HR_R * 0.85 + R_{HR} \tag{1.5}$$

If the participant's heart rate falls into the middle of the (T_{HR}) range, that means the participant is exercising at moderate intensity (roughly 50 to 70% of THR_{max}). In case it verges toward the upper limit, the participant is exercising at high intensity (70 to 85% of THR_{max}). Figure 1.12 presents the calculated target zones for the participants.

Condition	Exepriment					Control				
ID	1	2	3	4	5	6	7	8	9	10
RHR	72	72	72	72	75	72	72	72	74	72
HR Reserve	117.8	118.5	117.1	115.7	116.2	117.8	115	117.8	115.1	117.1
THRmin	130.9	131.25	130.55	129.85	133.1	130.9	129.5	130.9	131.55	130.55
THRmod	154.46	154.95	153.97	152.99	156.34	154.46	152.5	154.46	154.57	153.97
THRint	172.13	172.725	171.535	170.345	173.77	172.13	169.75	172.13	171.835	171.535
THRmax	189.8	190.5	189.1	187.7	191.2	189.8	187	189.8	189.1	189.1
Max HR	173	170	174	186	168	159	144	155	167	169

FIGURE 1.12: Computed target zones for participants in each condition.

It can be observed that the maximum heart rates of the participants in the experiment group obtained during the warm up fall in the middle and lower range of high intensity exercise. Only one participant's (ID = 4) heart rate was close to the maximum target heart rate (THR_{max}). On the other hand, the maximum heart rate of the participants' in the control group fall in lower range of high intensity exercise with one participant (ID = 7) in the middle range of moderate intensity exercise zone. Figure 1.13 depicts the distribution of maximum heart rates participants reached during warm up session in both condition per exercise intensity zones. Figure 1.13 depicts three distinct zones (*Low, Moderate, and High* intensity zones) that were computed based on participants' age, resting heart rate, and heart rate reserve (Figure 1.12). The figure gives a clearer overview of the intensity of the warm up performed in both condition. It can be observed that the participant in the experiment group reached higher levels of exertions compared to the participants in the control group. This can be attributed to the duration differences between the conditions.

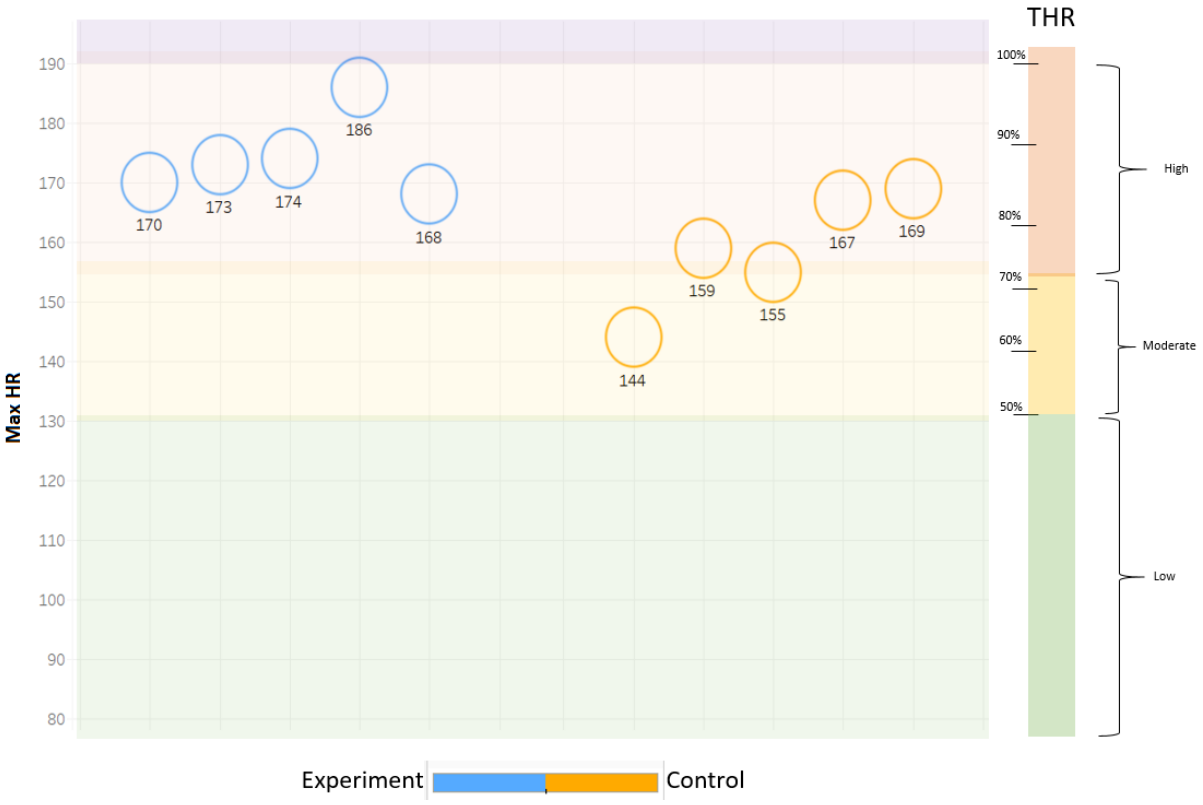

FIGURE 1.13: Target heart rate with exercise intensity for each participant

In general, participants reached the target minimum heart rate relatively promptly. Overall, we conclude that participants in both conditions reach an elevated heart rate sufficient to continue with the more strenuous physical activity. The results, however, suggest that the duration .. Lastly, we compared the times participants in the experiment and control conditions reached target minimum and moderate heart rate. Figure 1.14 depicts the differences between the conditions.

It can be observed that the participants in the control group have reached both target heart rate much faster than the participants in the experiment group.

1.2.4 RR data

The average RR data per condition is presented in Figure 1.15.

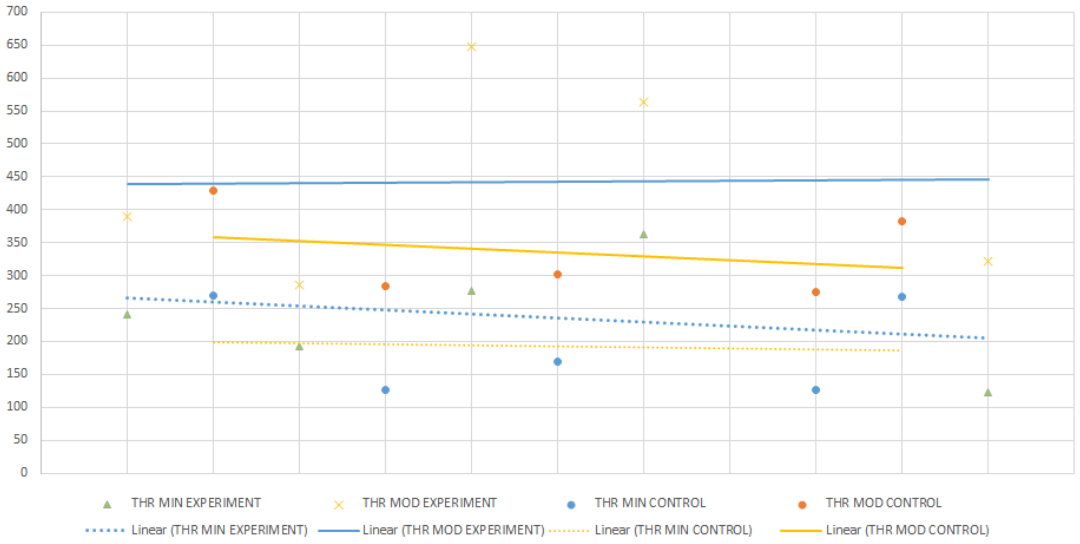

FIGURE 1.14: Minimum and moderate target HR.

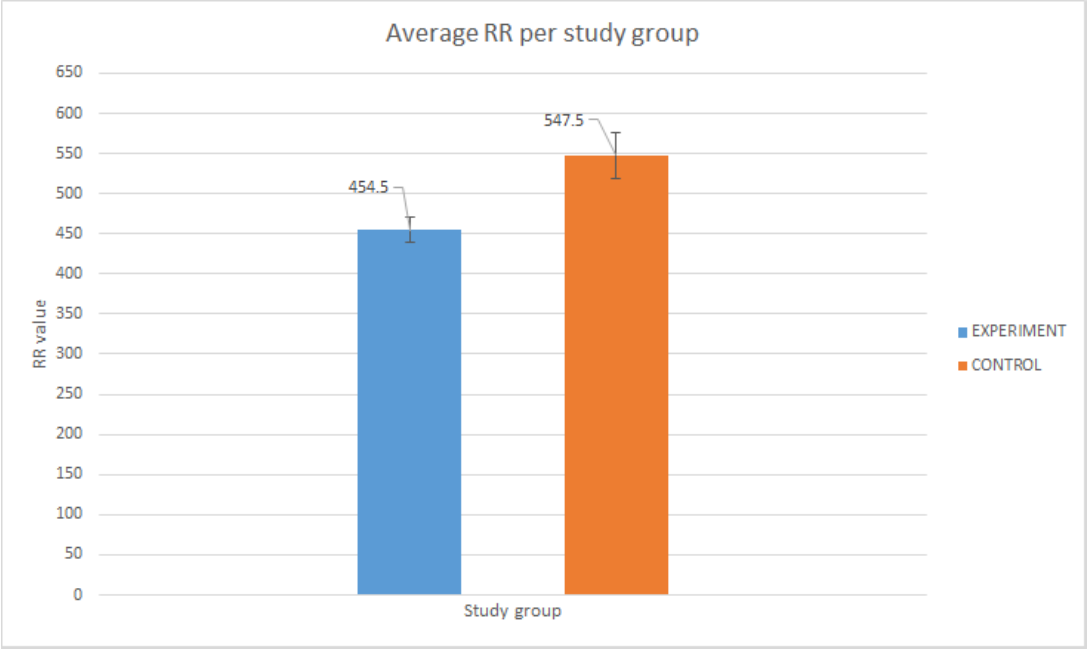

FIGURE 1.15: Average RR per study group.

1.2.5 PACES

The PACES test consists of 18 questions in a 1 to 7 Likert scale and it was originally designed to measure positive affect associated with involvement in physical activities in college students (Kendzierski and DeCarlo, 1991). Figure 1.20 summarizes the results for all questions. It shows that the ratings for the experiment condition are consistently higher with respect to the control condition. Figure 1.17 depicts the average scores for the conditions. It can be observed that the average score for the control condition is $\bar{x} = 89.8$ ($\sigma = 11.97, x_{max} = 104, x_{min} = 71$), which is already high, but for the experiment condition

is even higher $\bar{x} = 114.4$ ($\sigma = 5.98, x_{max} = 125, x_{min} = 111$). After performing a normality test on the scores ($W_{exp} = .91, W_{con} = .98, pB = X, pG = X$), we compared the two means with a paired t-test ($\alpha = 0.05$) and we found a significant difference; t(8) = 4.11, p = ?. The 95% confidence interval is [?; ?]. Therefore, we can conclude that the participants perceived a difference between the two conditions and that warming up by using the exergame positively affects the physical activity enjoyment.

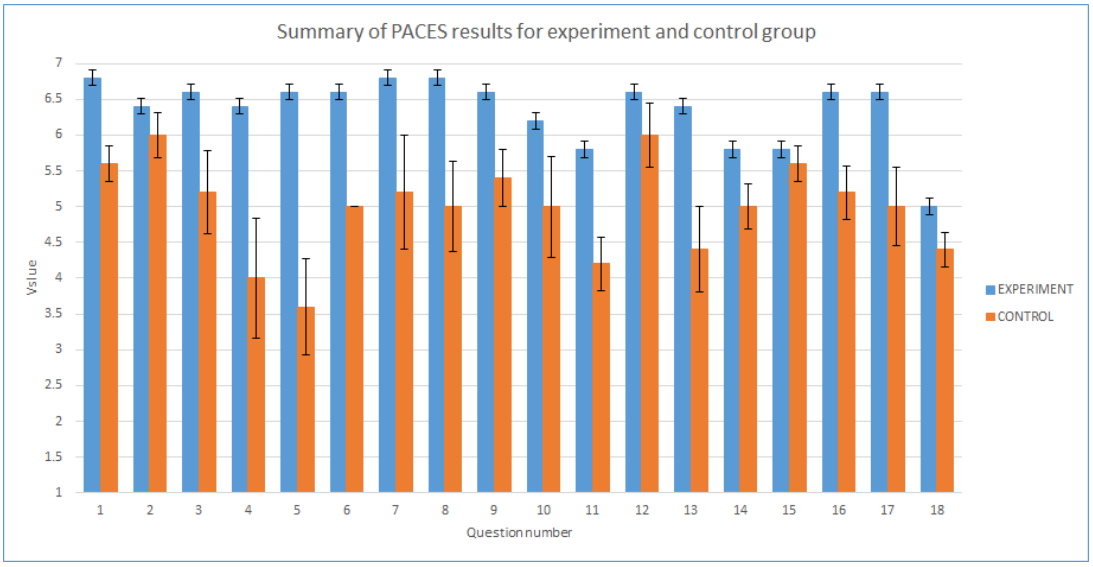

FIGURE 1.16: Summary of PACES results for control and experiment group.

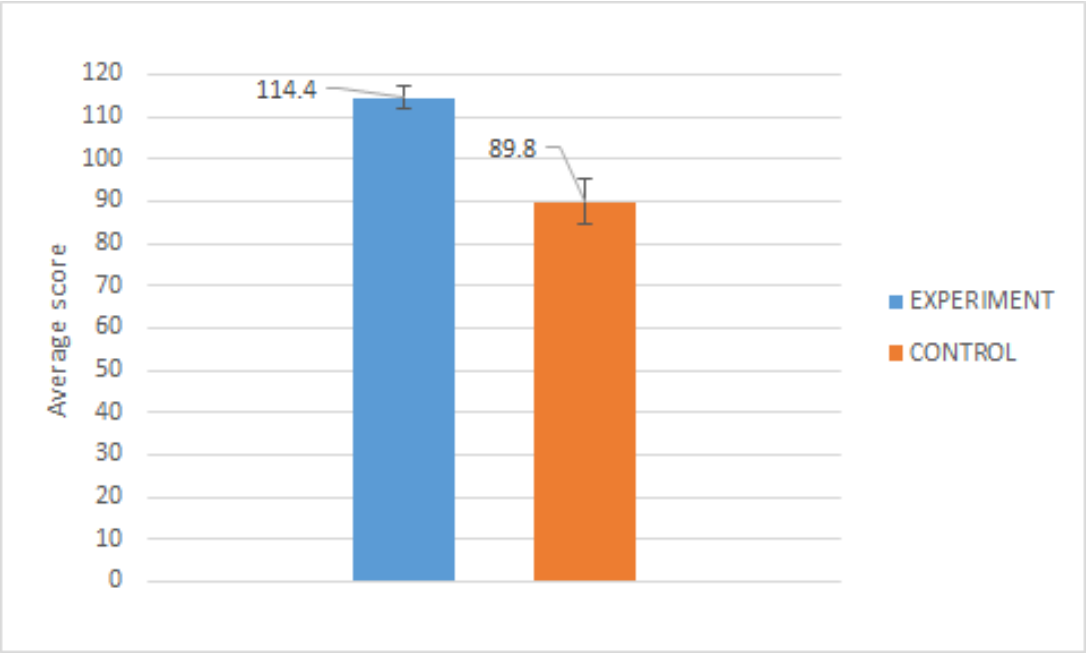

FIGURE 1.17: Average PACES scores for control and experiment condition.

1.2.6 SUS

The System Usability Scale is a reliable tool for measuring the usability of a system under tests. It consists of a 10 item questionnaire with five response options for respondents from strongly agree to strongly disagree. The sum of the 10 items in the questionnaire leads to a general measure of perceived usability of the system. The participants' scores for each question are converted, added together and then multiplied by 2.5 to convert the original scores of 0-40 to 0-100. Even though the scores are 0-100, these are not percentages and should be considered only in terms of their percentile ranking. Based on research, a SUS score above a 68 would be considered above average and anything below 68 is below average. The summary of the SUS scores is presented in Figure 1.18. Only the participants in the experiment condition evaluated took the SUS questionnaire. The SUS for our exergame average score is $\bar{x} = 76.7$ ($\sigma = 8.16, x_{max} = 90, x_{min} = 72.5$). This implies that our system usability received *excelent* adjective rating and a B on a grade scale [6].

The SUS average scores per question is depicted in Figure 1.19. It can be observed that the participants found that the various functions in the exergame have been well integrated and that they felt very confident using the exergame. Furthermore, all the participants agreed that people would learn to use the exergame very quickly. Also, they did not find the exergame unnecessarily complex or having any unconsistencies during gameplay. They also thought that it was not difficult or awkward to use, and that getting familiar with the game was pretty straightforward and fast. When asked if they would like to continue playing the game frequently, 3 participants agreed with this statement, 1 neither agreed nor disagreed, and 1 disagreed.

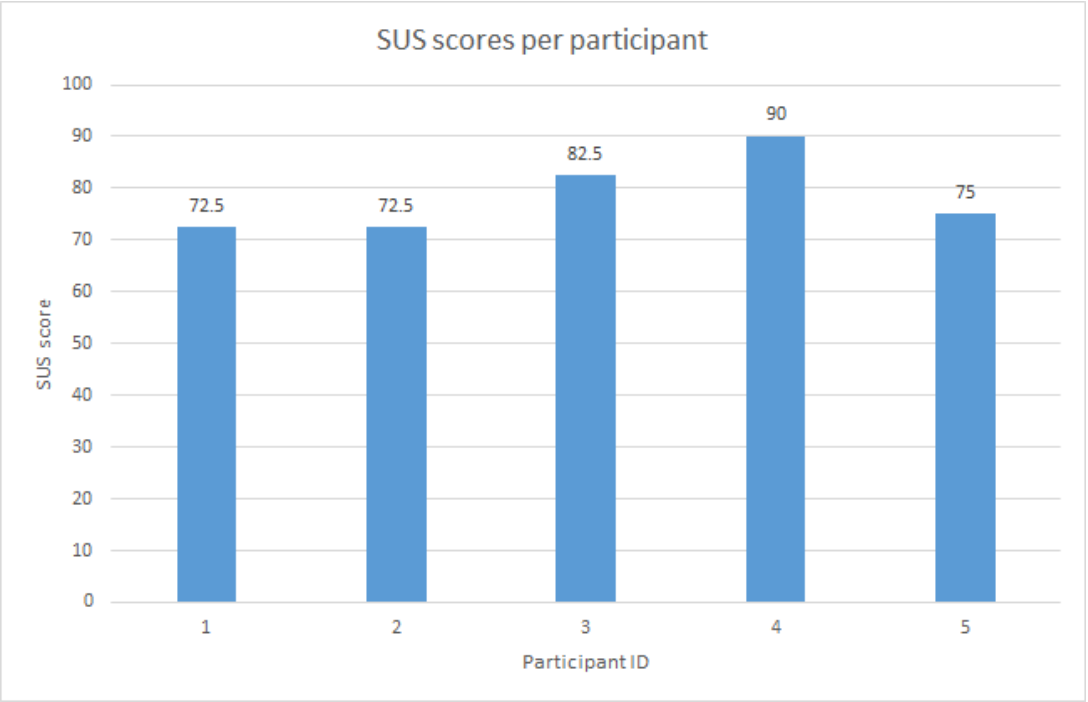

FIGURE 1.18: Summary of SUS results per participant.

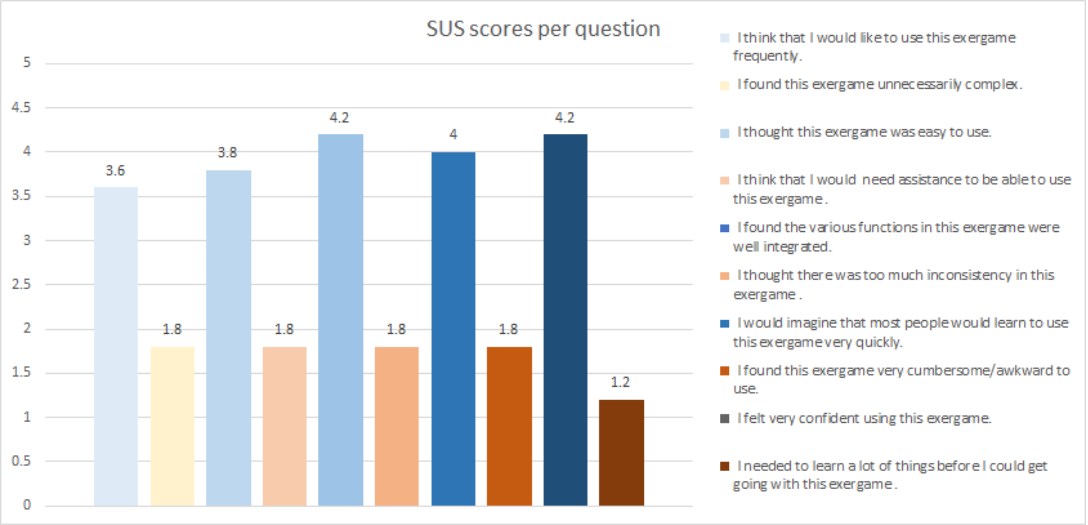

FIGURE 1.19: Summary of average SUS results for each question.

1.2.7 PES

The Play Experience Scale is a valid and reliable 20 item questionnaire with five response options for respondents from strongly agree to strongly disagree [7]. It has been utilized in order to assess play experience, usability, and enjoyment of our exergame. The PES scale collects responses across five experiential dimensions which are labeled:

- Freedom - when individuals are free in a play context, they are able to perform the actions they wish to perform.

- No extrinsic - addresses if the respondents feel there are consequences to their play.
- Play direct - addresses the play itself.
- Autotelic - when experience is autotelic, an individual engages in it solely for its own rewards. That is, the experience is intrinsically motivating.
- Focus - targets the states of immersion and concentration during play. It is related to engagement and flow and the items in this category reflects on the loss of concern and focused concentration.

Figure 1.20 summarizes the PES results for each question. TODO: 16item scale vs 20item scale.

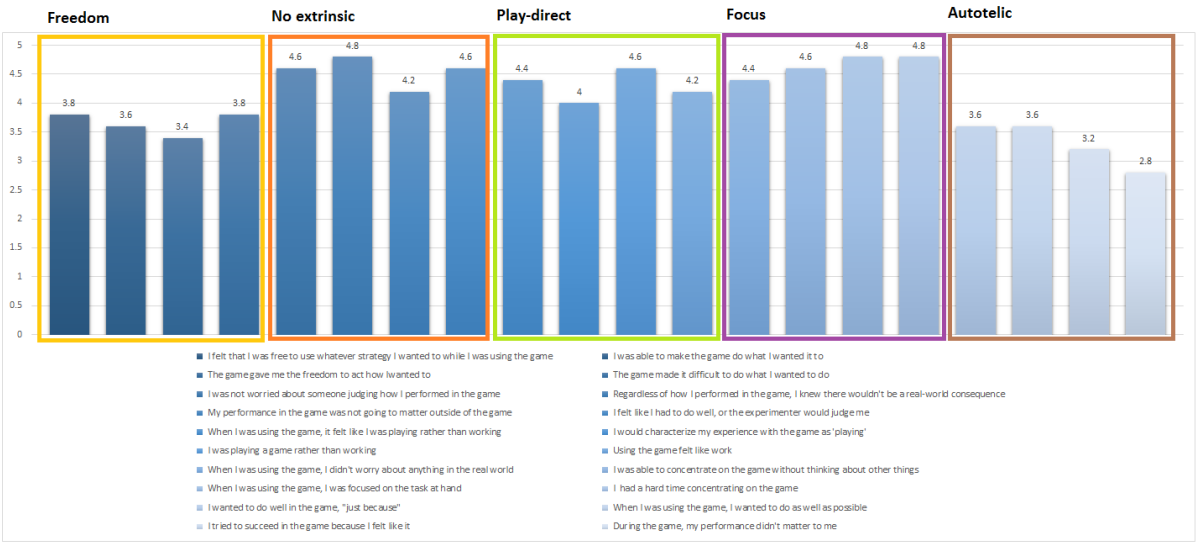

FIGURE 1.20: Summary of average PES score for each question.

It can be observed that

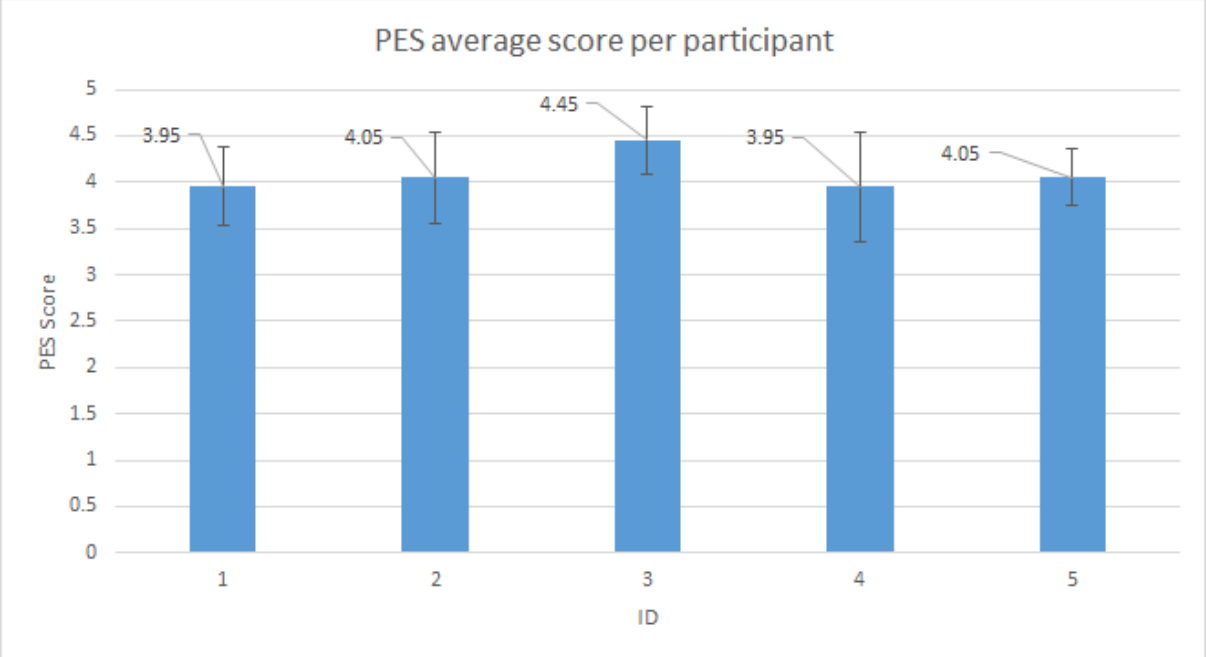

FIGURE 1.21: Summary of average PES score for participants.

1.2.8 Perceived Exertion

The RPE reflects how difficult the performed warm up exercise feels to the participants, combining all sensations and feelings of physical stress, effort, and fatigue. All the participants received standardized instructions and were encouraged to focus upon their overall (wholebody)

perceptions of exertion. Figure 1.22 depicts the average BORG results for each condition.

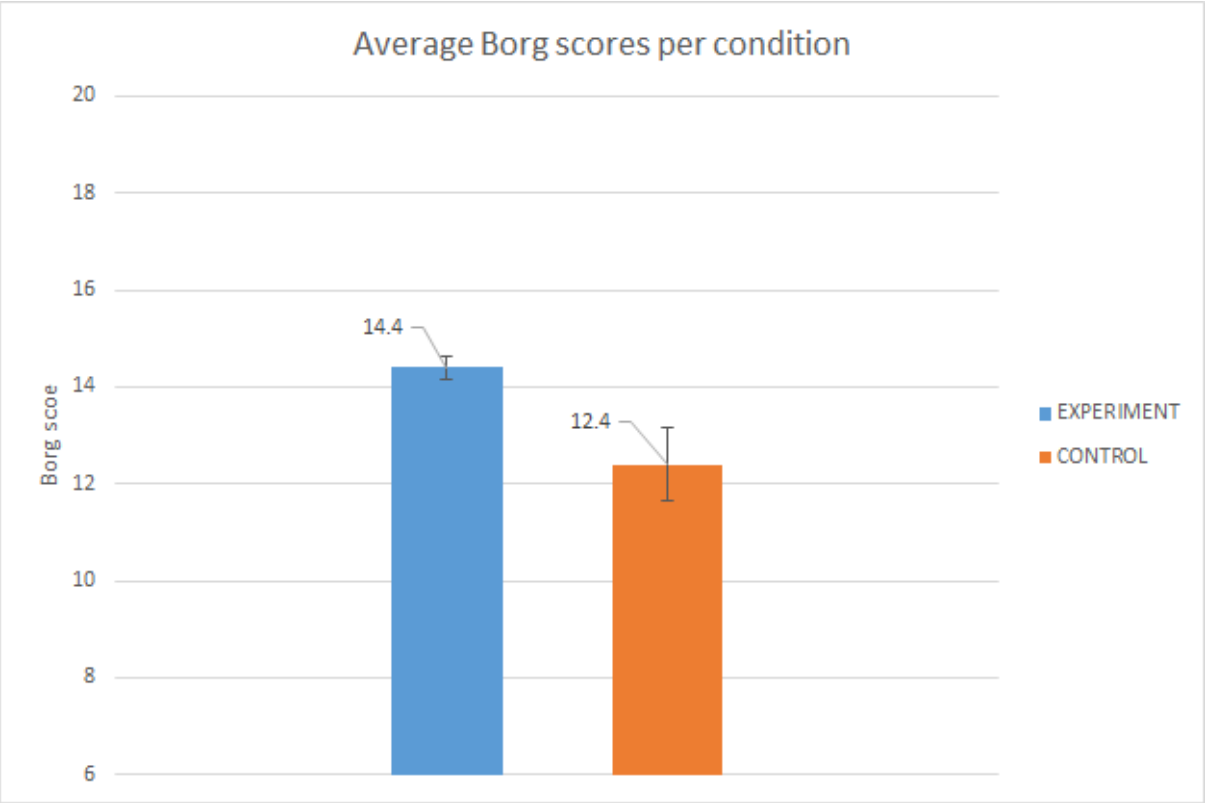

FIGURE 1.22: Summary of BORG results for control and experiment group.

1.2.9 SAM

Figure 1.23 depicts the average SAM results for each condition. : this has been done only after the WU session...

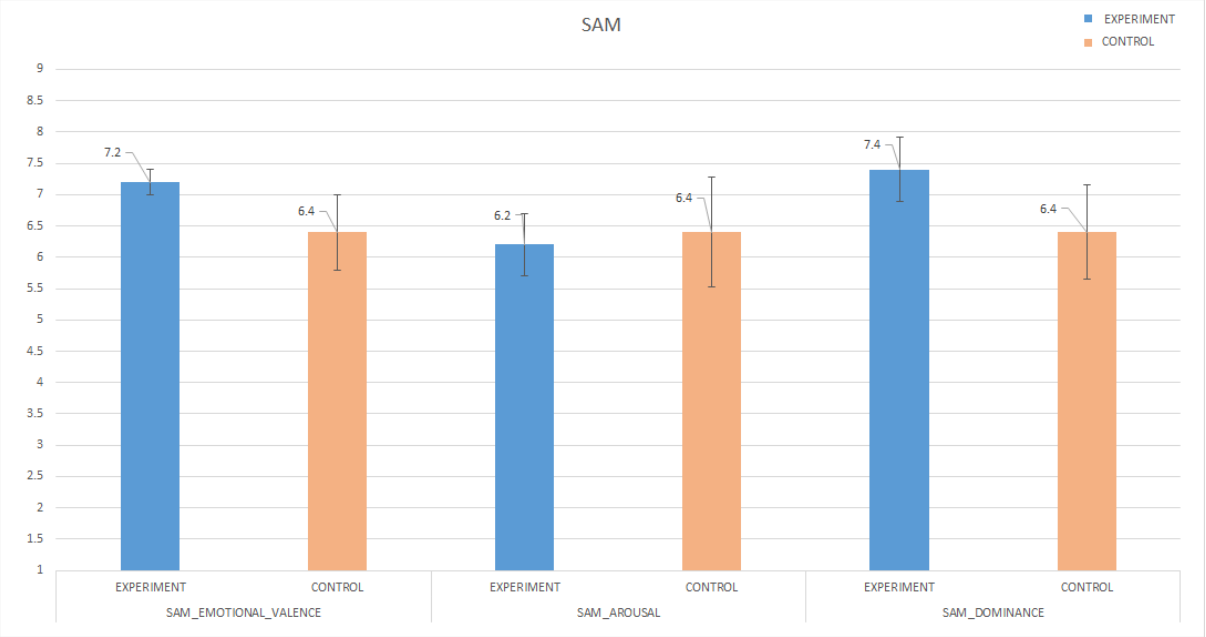

FIGURE 1.23: Summary of SAM results for control and experiment group.

TODO: 1. BSA-F 2. Emotions 3. Post study survey 4. RR data analysis 5. Skin resistance 6. Distance?

1.3 Discussion

Interpret the results. Although you should still try to be as objective as possible, the discussion section should illuminate your critical thinking about the results. Explain what the statistics mean, account for anomalies, and so on.

1.3.1 Interpretation of Results

Discuss what you believe the results really mean. For example, if you find a significant difference for some effect, what does that mean to the hypothesis? Is the different seen an important one?

1.3.2 Relation to other works

How do the results you've obtained relate to other research findings?

1.3.3 Impact for practitioners

As computer scientists, we are particularly concerned with the implications of our findings on practitioners. Should existing interface constructs be designed differently or used in a new context? Do you have suggestions for new designs? How can the findings be generalized?

1.3.4 Critical reflection

Critical reflection is one of the key foundations of science. You should criticize your work (constructively, if possible), indicate possible flaws, mitigating circumstances, the limits to generalization, conditions under which you would expect your findings to be reversed, and so on.

1.3.5 Research agenda

The best experiments suggest new avenues of exploration. In this section, you should reflect and refine your hypotheses, describe new hypotheses, and suggest future research, ie research that you would do if you continued along this path.

1.4 Conclusions

Summarize the report, and speculate on what is to come. Acknowledgements. This section should give thanks to the major people (supervisors, associates) and organizations (sponsoring agencies, funders) that helped you. For example, I would like to thank Ben Shneiderman, whose report framework was used to build this one.

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