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Immotion - Exergame for Warm Up Guidance and Motivation

Masterarbeit im Fach Informatik
Master's Thesis in Computer Science
von / by

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begutachtet von / reviewers

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Ich erkläre hiermit an Eides Statt, dass ich die vorliegende Arbeit selbstständig verfasst und keine anderen als die angegebenen Quellen und Hilfsmittel verwendet habe.

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Declaration of Consent

I agree to make both versions of my thesis (with a passing grade) accessible to the public by having them added to the library of the Computer Science Department.

Saarbrücken, January 2018

Marko Vujić

Abstract

Acknowledgements

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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: *experimental group* and *control group*. The first, experimental 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. The exergame itself is sufficient for guiding the player through a proper warm up procedure with correct movements.
2. After the warm up routine is completed using the exergame, the player reached a significantly higher increase in ROM.
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 on (add date). Description of the room - measures to be added. The following equipment has been used:

- Kinect for Xbox One (2.0 2013) motion sensing input devices by Microsoft used for movement detection and controlling the exergame avatar.
- 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 heart rate data.
- Goniometer used for measuring participants' ROM.

TODO: describe where and how is the equipment positioned.

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.

1.1.2.1 Participants

Demographic details of the participants to be added when the study is completed.

Total of $n = X$ individuals participated in the study that has been conducted DATE in DFKI. All participants were students from Saarland University. For recruiting participants, posters were distributed in print, and sent through social media and email (Appendix X). Each participant was given X euros for taking part in the study. All of the participants were amateur athletes who engage in some physical activity on average X 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). TODO: This should be updated later with real data.

1.1.2.2 Conditions

First 20 participant who applied for the experiment have been accepted. These participants were sent a pre-test questionnaires ([BSA-F](#), [PARQ](#), and 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 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. Warmin 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:

- *Physical activity screening.* Pre-study physical activity levels have been assessed with a standardized questionnaire [Bewegungs und Sportaktivität Fragebogen \(BSA-F\)](#) [1]. 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 (TODO: discuss the time frame) weeks.

- *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 [2]. 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].

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 digital games* In order to measure the enjoyment of digital games the [Game Experience/Engagement Questionnaire \(GEQ\)](#) has been utilized. It is a general questionnaire with the goal of being able to be applied to any game regardless of genre or mechanics in order to measure their its user's experience.

(TO BE DISCUSSED: Sport oriented questionnaire (SOQ), Task and Ego Orientation in Sport Questionnaire (TEOSQ), AttrakDiff, User Experience, Exergame Experience questionnaires are also used in some studies.)

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. (TODO)

- *Heart 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.

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, in order to successfully finish the game, 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 as the participant 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 for the following joints: (TODO decide which joint will be measured).
- After the measurements are completed, the participant rests.
- 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 experimental group, the game starts with the start scene where the participant enters his or her name. After 5 seconds, the game proceeds with scenes in which the participant performs 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. During this period the researcher assesses the ROM of the participant.
- After taking the ROM measures, the sensors are removed.
- The participant completes the post-test surveys .

1.1.2.7 Independent and Dependent Variables

Include exactly how you intend to measure each dependent variable. Independent variables are the things you manipulate or control for, such as design's you are testing or the ages of the respondents. Dependent variables are the things you measure, such as success rate, number of errors, user satisfaction, completion time, and many more. Have a clear idea what do you manipulate - independent variables, and what do you want to measure - dependent variables. The most interesting is the intersection - is one design results in a higher task success rate than other.

Independent and dependent variables can be measured by 4 types of data: nominal, ordinal, interval, and ratio. Nominal (categorical) data: groups or categories. Mac vs Windows users, male vs female. These are independent variables, that allows you to segment data by these different groups. Nominal data also includes dependent variables like task success, number of users who clicked link A instead B... Ordinal: ordered data - imdb. In user studies this comes from self-reported data. User states if someone is good better worse... These are relative rankings. You report it by frequencies: for example 40 percent said it is good.

1.1.3 Problems/Limitations - Threats to Validity

Describe any problems/limitations encountered that will help other researchers avoid or account for them if they decide to replicate your experiment.

1.2 Results

This section is an objective report on what the numbers show. You should not try to interpret the meaning of the numbers in this section. Some of the things you may do here are: report means and standard deviations in neat tables indicate the statistics used and levels of significance include graphs, plots, histograms, etc that tell a story about the actual figures obtained Only critical raw data and summary statistics should be included in the actual report. However, you must keep all your raw data in a separate archival report, should anyone (a reviewer in the case of real scientific reporting) need more detail than is provided in the paper.

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 difference 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

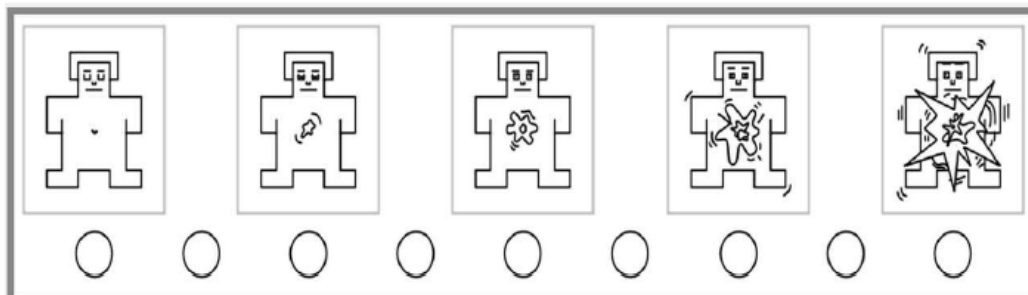
Summarize the report, and speculate on what is to come. Acknowledgements. This section should give thanks to the major people (supervisors, associates) and organizations (sponsoring agencies, funders) that helped you. For example, I would like to thank Ben Shneiderman, whose report framework was used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

Appendices

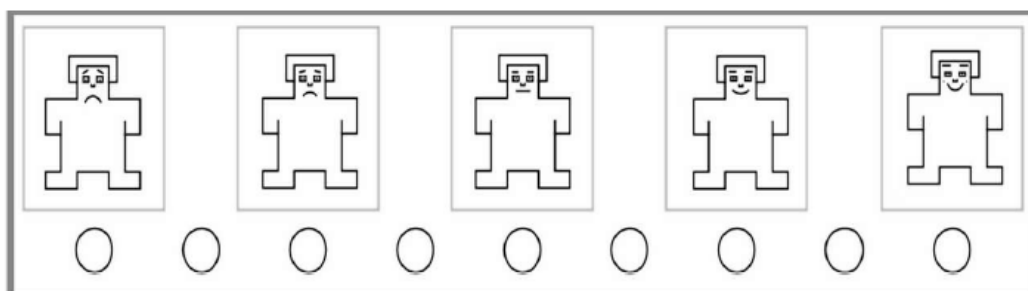
Appendix A

Self-Assessment Manikin Scale

1. The scale rates the arousal of your present feeling. At the low end of the arousal scale are feelings like relaxed, calm, sluggish, dull, sleepy, and unaroused. At the high end of the scale are feelings like stimulated, excited, frenzied, jittery, wide awake, and aroused.



2. The scale rates the valence of your present feeling. At the low end of the valence scale are feelings like unhappy, annoyed, unsatisfied, melancholic, despairing, and bored. At the high end are feelings like happy, pleased, satisfied, contented, hopeful, and relaxed.



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