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Immotion - Exergame for Warm Up Guidance and Motivation

Masterarbeit im Fach Informatik
Master's Thesis in Computer Science
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Contents

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 .

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Physical Activity Readiness Questionnaire (PAR-Q) and You

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly:

YES	NO		
☐	☐	1.	Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
☐	☐	2.	Do you feel pain in your chest when you do physical activity?
☐	☐	3.	In the past month, have you had chest pain when you were not doing physical activity?
☐	☐	4.	Do you lose your balance because of dizziness or do you ever lose consciousness?
☐	☐	5.	Do you have a bone or joint problem that could be made worse by a change in your physical activity?
☐	☐	6.	Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?
☐	☐	7.	Do you know of any other reason why you should not do physical activity?

If you answered:

YES to one or more questions

Talk to your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want – as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- Start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- Take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively.

Delay becoming much more active:

- If you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or
- If you are or may be pregnant – talk to your doctor before you start becoming more active.

Please note: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Physical Activity, Exercise, and Sport Questionnaire (Bewegungs- und Sportaktivitaet Fragebogen; BSA-Fragebogen or BSA-F)

BSA-Fragbogen

1	Sind Sie berufstätig (auch Hausfrau/-mann) oder in Ausbildung?			
	☐ ja	⇨ weiter mit Frage 2	☐ nein	⇨ weiter mit Frage 3

2	Ihre Berufstätigkeit bzw. Ausbildung umfasst …			
sitzende Tätigkeiten	☐ keine	☐ eher wenig etwas	☐ eher mehr	☐ viel
mäßige Bewegung	☐ keine	☐ eher wenig	☐ eher mehr	☐ viel
intensive Bewegung	☐ keine	☐ eher wenig	☐ eher mehr	☐ viel

3	An wie vielen Tagen und wie lange haben Sie die folgenden Aktivitäten **in den letzten 4 Wochen** ausgeübt?		
Zu Fuß zur Arbeit gehen (auch längere Teilstrecken)	an …… Tagen während der 4 Wochen	ca. …… Minuten pro Tag	nicht gemacht ☐
Zu Fuß zum Einkaufen gehen	an …… Tagen während der 4 Wochen	ca. …… Minuten pro Tag	nicht gemacht ☐
Radfahren zur Arbeit	an …… Tagen während der 4 Wochen	ca. …… Minuten pro Tag	nicht gemacht ☐
Radfahren zu sonstigen Fortbewegungs-zwecken	an …… Tagen während der 4 Wochen	ca. …… Minuten pro Tag	nicht gemacht ☐
Spazierengehen	an …… Tagen während der 4 Wochen	ca. …… Minuten pro Tag	nicht gemacht ☐
Gartenarbeit (z. B. Rasen mähen, Hecke schneiden)	an …… Tagen während der 4 Wochen	ca. …… Minuten pro Tag	nicht gemacht ☐
Körperlich anstrengende Hausarbeit (z. B. Putzen, Aufräumen)	an …… Tagen während der 4 Wochen	ca. …… Minuten pro Tag	nicht gemacht ☐
Körperlich anstrengende Pflegearbeit (z. B. Kinder betreuen, Kranke pflegen)	an …… Tagen während der 4 Wochen	ca. …… Minuten pro Tag	nicht gemacht ☐

4	An wie vielen Tagen und wie lange haben Sie die folgenden Aktivitäten **in den letzten 4 Wochen** ausgeübt?		
Treppensteigen	an …… Tagen während der 4 Wochen	ca. …… Stockwerke pro Tag	nicht gemacht ☐

5	Haben Sie **in den letzten 4 Wochen** regelmäßige sportliche Aktivität betrieben?			
	☐ ja	⇨ weiter mit Frage **6**	☐ nein	⇨ weiter mit Frage xy

6	Um welche sportliche(n) Aktivität(en) handelt es sich dabei?		
A ..... (bitte hier eintragen)	**B** ..... (bitte hier eintragen)	**C** ..... (bitte hier eintragen)
Aktivität **A** habe ich in den **letzten 4 Wochen** ca. …… Mal ausgeübt, und zwar bei jedem Mal für ca. …… Minuten	Aktivität **B** habe ich in den **letzten 4 Wochen** ca. …… Mal ausgeübt, und zwar bei jedem Mal für ca. …… Minuten	Aktivität **C** habe ich in den **letzten 4 Wochen** ca. …… Mal ausgeübt, und zwar bei jedem Mal für ca. …… Minuten

BORG RATING OF PERCEIVED EXERTION (RPE)

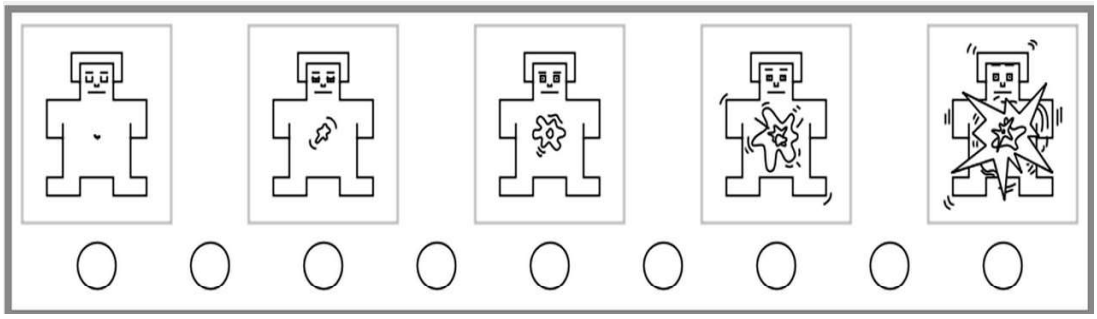
While performing the warm up activity, we would like you to rate your perceived perception of exertion. This feeling reflects how difficult and strenuous the performed warm up exercise feels to you, combining all sensations and feelings of physical stress, effort, and fatigue. While you rate your perceived exertion, please do not concern yourself with factors such are leg pain or shortness of breath, but try to focus on your overall feeling of exertion.

Please look at the rating scale below and select a number that best describes your level of exertion.[1] The scale ranges from 6 to 20, where 6 means "*no exertion at all*" and 20 means "*maximal exertion*". Choose the number from below that best describes your level of exertion.Value 9 corresponds to "*very light*" exercise. For a healthy person, it is like walking slowly at his or her own pace for some minutes. Value 13 on the scale is "*somewhat hard*" exercise, but it still feels OK to continue. Value 17 is "*very hard*" and corresponds to very strenuous exercise. A healthy person can still go on, but he or she really has to push him- or herself. It feels very heavy, and the person is very tired. Value 19 on the scale is an extremely strenuous exercise level. For most people this is the most strenuous exercise they have ever experienced.

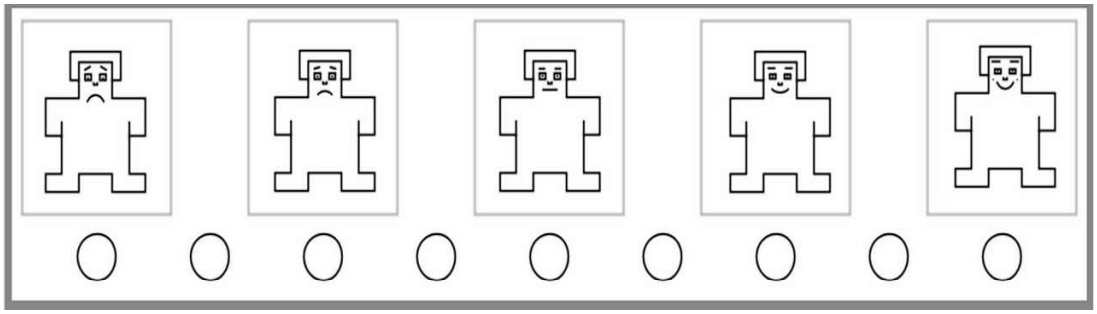
[1] https://www.cdc.gov/physicalactivity/basics/measuring/exertion.htm

#	**Level of Exertion**
6	No exertion at all
7	
7.5	Extremely light (7.5)
8	
9	Very light
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard (heavy)
16	
17	Very hard
18	
19	Extremely hard
20	Maximal exertion

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.



Physical Activity Enjoyment Scale (PACES)

#	Item
1	I enjoy it; I hate it
2	I feel bored; I feel interested
3	I dislike it; I like it
4	I find it pleasurable; I find it unpleasurable
5	I am very absorbed in this activity; I am not at all absorbed in this activity
6	It's no fun at all; It's a lot of fun
7	I find it energizing; I find it tiring
8	It makes me depressed; It makes me happy
9	It's very pleasant; It's very unpleasant
10	I feel good physically while doing it; I feel bad physically while doing it
11	It's very invigorating; It's not at all invigorating
12	I am very frustrated by it; I am not at all frustrated by it
13	It's very gratifying; It's not at all gratifying
14	It's very exhilarating; It's not at all exhilarating
15	It's not at all stimulating; It's very stimulating
16	It gives me a strong sense of accomplishment; It does not give me any sense of accomplishment
17	It's very refreshing; It's not at all refreshing
18	I felt as though I would rather be doing something else; I felt as though there was nothing else I

1. Introduction

This document contains the English version of the Game Experience Questionnaire. The development and testing of the Game Experience Questionnaire is described in project Deliverable 3.3.

The Game Experience Questionnaire has a modular structure and consists of :

1. The core questionnaire
2. The Social Presence Module
3. The Post-game module.

In addition to these modules, a concise in-game version of the GEQ was developed.

All three modules are meant to be administered immediately after the game-session has finished, in the order given above. Part one and two probe the players' feelings and thoughts while playing the game; Part 3, the post-game module, assesses how players felt after they had stopped playing.

Part 1 is the core part of the GEQ. It assesses game experience as scores on seven components: Immersion, Flow, Competence, Positive and Negative Affect, Tension, and Challenge. For a robust measure, we need five items per component. As translation of questionnaire items, no matter how carefully performed, sometimes results in suboptimal scoring patterns, we have added a spare item to all components. After the first use of the translated GEQs, scale analyses will be performed to check whether any item should be discarded or replaced.

Part 2, the social presence module, investigates psychological and behavioural involvement of the player with other social entities, be they virtual (i.e., in-game characters), mediated (e.g., others playing online), or co-located. This module should only be administered when at least one of these types of co-players were involved in the game.

Part 3, the post-game module, assesses how players felt after they had stopped playing. This is a relevant module for assessing naturalistic gaming (i.e., when gamers have voluntarily decided to play), but may also be relevant in experimental research.

The In-game version of the GEQ is a concise version of the core questionnaire. It has an identical component structure and consists of items selected from this module. The in-game questionnaire is developed for assessing game experience at multiple intervals during a game session, or play-back session. This should facilitate the validation of continuous and real-time indicators some of the partners in the FUGA project are developing.

2. Game Experience Questionnaire – Core Module

Please indicate how you felt while playing the game for each of the items,
on the following scale:

not at all	slightly	moderately	fairly	extremely
0	1	2	3	4
< >	< >	< >	< >	< >

1 I felt content
2 I felt skilful
3 I was interested in the game's story
4 I thought it was fun
5 I was fully occupied with the game
6 I felt happy
7 It gave me a bad mood
8 I thought about other things
9 I found it tiresome
10 I felt competent
11 I thought it was hard
12 It was aesthetically pleasing
13 I forgot everything around me
14 I felt good
15 I was good at it
16 I felt bored
17 I felt successful
18 I felt imaginative
19 I felt that I could explore things
20 I enjoyed it
21 I was fast at reaching the game's targets
22 I felt annoyed
23 I felt pressured
24 I felt irritable
25 I lost track of time
26 I felt challenged
27 I found it impressive
28 I was deeply concentrated in the game
29 I felt frustrated
30 It felt like a rich experience
31 I lost connection with the outside world
32 I felt time pressure

33 I had to put a lot of effort into it

3. In-game GEQ

Please indicate how you felt while playing the game for each of the items,
on the following scale:

not at all	slightly	moderately	fairly	extremely
0	1	2	3	4
< >	< >	< >	< >	< >

1	I was interested in the game's story	GEQ Core – 3
2	I felt successful	GEQ Core – 17
3	I felt bored	GEQ Core – 16
4	I found it impressive	GEQ Core – 27
5	I forgot everything around me	GEQ Core – 13
6	I felt frustrated	GEQ Core – 29
7	I found it tiresome	GEQ Core – 9
8	I felt irritable	GEQ Core – 24
9	I felt skilful	GEQ Core – 2
10	I felt completely absorbed	GEQ Core – 5
11	I felt content	GEQ Core – 1
12	I felt challenged	GEQ Core – 26
13	I had to put a lot of effort into it	GEQ Core – 33
14	I felt good	GEQ Core – 14

5. GEQ – post-game module

Please indicate how you felt after you finished playing the game for each of the items, on the following scale:

not at all	slightly	moderately	fairly	Extremely
0	1	2	3	4
< >	< >	< >	< >	< >

1 I felt revived
2 I felt bad
3 I found it hard to get back to reality
4 I felt guilty
5 It felt like a victory
6 I found it a waste of time
7 I felt energised
8 I felt satisfied
9 I felt disoriented
10 I felt exhausted
11 I felt that I could have done more useful things
12 I felt powerful
13 I felt weary
14 I felt regret
15 I felt ashamed
16 I felt proud
17 I had a sense that I had returned from a journey

Participant ID: _____ Site: _____ Date: ___/___/___

System Usability Scale

Instructions: For each of the following statements, mark one box that best describes your reactions to the website *today*.

		Strongly Disagree				Strongly Agree
1.	I think that I would like to use this website frequently.	☐	☐	☐	☐	☐
2.	I found this website unnecessarily complex.	☐	☐	☐	☐	☐
3.	I thought this website was easy to use.	☐	☐	☐	☐	☐
4.	I think that I would need assistance to be able to use this website.	☐	☐	☐	☐	☐
5.	I found the various functions in this website were well integrated.	☐	☐	☐	☐	☐
6.	I thought there was too much inconsistency in this website.	☐	☐	☐	☐	☐
7.	I would imagine that most people would learn to use this website very quickly.	☐	☐	☐	☐	☐
8.	I found this website very cumbersome/awkward to use.	☐	☐	☐	☐	☐
9.	I felt very confident using this website.	☐	☐	☐	☐	☐
10.	I needed to learn a lot of things before I could get going with this website.	☐	☐	☐	☐	☐

Please provide any comments about this website: