# JMIR Serious Games

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## Contents

### Original Papers

Original Paper

# Development, Usability, and Efficacy of a Serious Game to Help Patients Learn About Pain Management After Surgery: An Evaluation Study

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## Abstract

**Background:** Postoperative pain is a persistent problem after surgery and can delay recovery and develop into chronic pain. Better patient education has been proposed to improve pain management of patients. Serious games have not been previously developed to help patients to learn how to manage their postoperative pain.

**Objective:** The aim of this study was to describe the development of a computer-based game for surgical patients to learn about postoperative pain management and to evaluate the usability, user experience, and efficacy of the game.

**Methods:** A computer game was developed by an interdisciplinary team following a structured approach. The usability, user experience, and efficacy of the game were evaluated using self-reported questionnaires (AttrakDiff2, Postoperative Pain Management Game Survey, Patient Knowledge About Postoperative Pain Management questionnaire), semi-structured interviews, and direct observation in one session with 20 participants recruited from the general public via Facebook (mean age 48 [SD 14]; 11 women). Adjusted Barriers Questionnaire II and 3 questions on health literacy were used to collect background information.

**Results:** Theories of self-care and adult learning, evidence for the educational needs of patients about pain management, and principles of gamification were used to develop the computer game. Ease of use and usefulness received a median score between 2.00 (IQR 1.00) and 5.00 (IQR 2.00) (possible scores 0-5; IQR, interquartile range), and ease of use was further confirmed by observation. Participants expressed satisfaction with this novel method of learning, despite some technological challenges. The attributes of the game, measured with AttrakDiff2, received a median score above 0 in all dimensions; highest for attraction (median 1.43, IQR 0.93) followed by pragmatic quality (median 1.31, IQR 1.04), hedonic quality interaction (median 1.00, IQR 1.04), and hedonic quality stimulation (median 0.57, IQR 0.68). Knowledge of pain medication and pain management strategies improved after playing the game ($P$=.001).

**Conclusions:** A computer game can be an efficient method of learning about pain management; it has the potential to improve knowledge and is appreciated by users. To assess the game's usability and efficacy in the context of preparation for surgery, an evaluation with a larger sample, including surgical patients and older people, is required.

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**KEYWORDS**
evaluation studies; knowledge; pain management; patient education; self care; surgical procedures, operative; video games

## Introduction

Computer games as a medium for learning have been studied increasingly in recent years. Games have the potential to improve attention and motivation as players work on the challenges of the game [1]. "Serious games" is a term which refers to computer games that are designed with education in mind, either for learning or training [2]. Such games are used within health care to affect knowledge, attitudes, or behavior [3].

Serious games can facilitate adult learning with features such as interesting aims, goal-oriented problem-solving, active participation, and use of previous experience, and they can provide continuous feedback, which can stimulate motivation [4]. Furthermore, a debriefing on the performance of the player in the game can facilitate learning, by for example discussing the underlying reasons for choices that the player made in the game. These characteristics fit well with a current approach in health care that emphasizes the importance of patients' empowerment and participation in their own care [5].

Within health care, serious games have been developed for educating both patients and health care professionals. For example, serious games have been tested with the goals of (1) improving patients' self-care for diabetes, asthma, cancer, and Warfarin use and (2) improving diet, pain, mobility, lifestyle, and health-related knowledge [3,6-9]. Within this field, a recent study reported a successful validation of a framework that gamifies self-management of diabetes and its acceptance by patients [10].

Although still inconclusive, many studies on serious games within health care have reported positive outcomes. An example is the game Re-Mission that is intended to help young cancer patients improve their self-care. Players win by destroying cancer cells and other enemies in the body with weapons such as chemotherapy. The game was found to have significant effects on cancer knowledge [11]. Another game, SpaPlay, was designed to help women adopt healthier exercise and dietary behavior and evaluated in terms of effect on nutritional knowledge and body mass index (BMI). The evaluation study showed significant improvement in knowledge and decreased BMI [12].

Games have been used successfully as tools for managing pain, such as affecting the experience of pain and improving pain tolerance through distraction. Both commercial videogames [13] and games specially designed for pain management (eg, Snow World [14]) have proven to improve the pain experience for patients. Electroencephalography-based serious games have also been developed for use by patients, even at home, as tools to help manage their pain, offering a potential alternative to traditional drug treatment [15]. However, to help ensure that patients will use such tools to manage their pain in an effective manner, their knowledge of pain management needs to be improved. In particular, we view serious games as a convenient way to educate surgical patients about how to manage their postoperative pain.

Pain management is an area that currently needs improvement, since the prevalence of postoperative pain remains high, occurring in more than 80% of patients [16,17]. Pain is also common after hospital discharge, with 75% of patients reporting it, and of those, 80% rate their pain as moderate to severe [16,18]. Inadequate pain relief after surgery interferes with postoperative recovery, increases the risk for postoperative complications, increases the risk that the pain will become chronic, and has negative effects on quality of life [19].

Today, surgical patients are being discharged earlier than in previous years and same day–surgery accounts for nearly 70% of all surgery performed [20]. This has put increased responsibility on patients for self-care, including monitoring and treating symptoms such as pain. However, patients do not always follow the instructions they receive about pain management, and many avoid taking pain medications despite being in severe pain [21]. Patient-related barriers to effective pain management, such as their reluctance to report pain and use available analgesics, are well known, both within the population of patients with cancer [22] and patients undergoing surgery [23]. Improved patient education is vital to improve pain management and address such barriers, but providing patients with information alone is not sufficient [21,24,25].

The knowledge expectations of surgical patients are high [26,27] but are insufficiently met [27,28], and patients have requested improvements in this area [29]. They need to understand why managing pain is important and how they can be active participants in their own treatment [17,30]. Patients want information on how to treat their pain after being discharged, what to do if the treatment is insufficient, what side effects of medications to expect, and how to treat those side effects [31].

To pursue optimal health outcomes, there is a need to develop more effective educational interventions, and serious games have shown promising effects in the context of health care and patient education [8,11,12]. In a game environment, patients can not only acquire knowledge, but also move their trial-and-error learning from real life to the game's virtual simulation. Also, the game provides a learning environment where attitudes, such as those that can hinder effective pain management can be explored, discussed, and potentially changed in collaboration with a health care professional.

During the early development and evaluation phase of a serious game, usability and efficacy are primary concerns. Usability is the extent to which a product can be used to achieve specified goals with effectiveness, efficiency, and satisfaction, and part of usability is the user experience that refers to the perceptions and responses to the anticipated use or after using the product [32]. User experience has both pragmatic and hedonic attributes [33]. "Efficacy" refers to the effect of an intervention on proposed outcomes; in the proposed study, we defined efficacy as the power or ability of the game to improve participants' knowledge.

The aims of this study were, therefore, (1) to describe the development of a computer game for surgical patients about postoperative pain management and (2) to evaluate the usability, user experience, and efficacy of the game.

## Methods

This study has a pre- and posttest design and data were collected using multiple methods, including questionnaires, direct observation by a nonparticipant observer, and short semistructured interviews.

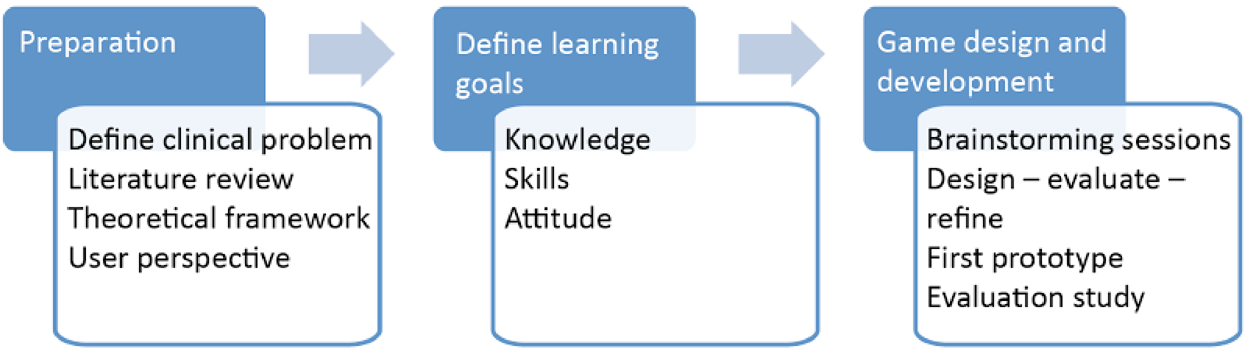
### Development of the Game

In planning the development and evaluation of the game as an intervention we used the first 3 principles of the Intervention Mapping protocol (proximal program objectives, theoretical methods, and practical strategies, and design program) [34], and we intend to use principles 4 and 5 (adoption and implementation) in future work to prepare interventions in the real-life situation of the hospital environment. We also used guidelines on how to develop more effective games and how to conduct research on them [35].

The game was developed and evaluated in an Icelandic setting. The process took place from January 2015 to January 2016. An interdisciplinary team of computer scientists, game and graphic designers, nurse researchers, and clinical nurse specialists (with expertise in the nursing care of surgical patients, patient education, and pain management) collaborated in the design and development of the game. The nurse researchers defined the clinical problem and its context and developed the idea of how a serious game could be used in patient education. The computer scientists and designers, who had expertise in game design and computer programming, contributed by transforming those ideas into a usable game to educate patients about pain management.

The development of the game involved 3 phases: preparation, defining learning goals, and game design and development (Figure 1).

**Figure 1.** An overview of the development of the game.




#### *Phase I: Preparation*

The preparation of the game design began by choosing and defining the clinical problem that the game was to address and searching the available literature for similar games.

The game is intended to help adult patients learn about pain management, a common self-care activity after surgery. Adult learning theories and the middle-range theory of chronic illness [36] were therefore chosen as the guiding theoretical frameworks. From Knowles' theory on adult learning [37], we acknowledged the notions that adult learners are self-directed, they bring their previous experience to the learning, they need to see applications for new learning, and their active participation should be encouraged. From Kolb's experiential learning theory [38] we incorporated the notion that learning occurs through concrete experience, observation and reflection, abstract conceptualization, and active experimentation. Finally, monitoring symptoms, such as pain, and managing them are the core concepts of self-care, and the importance of reflection and decision making is emphasized in the middle-range theory of chronic illness [36].

We integrated data from our previous qualitative study on patients' experiences and their perceptions about both traditional and novel methods to learn about postoperative pain management, including serious games [39]. In that study, patients described unfamiliarity and skepticism toward the use of computer games for educational purposes but they were simultaneously curious, interested, and willing to test such a game if they were invited to do so. It is important to have recommendations and support from health care professionals in the use of such a novel method, and it must be simple to use as patients' cognition may be impaired due to the surgical experience [39]. These findings were considered when designing the story of the game and the interface.

#### *Phase II: Defining Learning Goals*

The learning goals of the game were based on scientific literature regarding pain management and on the expertise of the nurses in the research team. The main learning goal was to improve knowledge about common pain medications that are frequently prescribed after surgery, including how they work, their dosages, effects, and side effects [31]. Additionally, other nonpharmacologic measures to treat pain were introduced, such as rest and distraction. Finally, a numeric rating scale (NRS; 0-10), frequently used in hospitals to teach patients to assess pain severity of patients, was included in the game. This reflected pain intensity and gave users feedback on pain management activities.

### *Phase III: Game Design and Development*

The game was programmed in the C# programming language using the Unity game development environment [40] to be played on Android tablet computers. Table 1 presents the characteristics of the game.

**Table 1.** Characteristics of the game.

| Characteristics | Description |
|---|---|
| Health topic | Self-care of surgical patients: pain management |
| Target players | Adults having surgery |
| Timing | Introduced as part of preparation before surgery and used again after surgery as part of discharge education |
| Game idea | A serious game intended to educate about facts concerning pain medication and strategies for effective pain management in the home environment after hospital discharge |
| Guiding theoretical framework | Middle-range theory of chronic illness, adjusted for surgical patients [36], adult learning [37], experiential learning [38] |
| Type of game | Realistic, educational, simulation |
| Intended outcomes | Knowledge about 4 commonly used pain medications after surgery (name, dosage, effects, possible side effects)<br>Knowledge about nonpharmacological strategies for pain relief (rest, distraction)<br>Knowledge about effective strategies for pain relief<br>Problem-solving skills to control pain intensity<br>Self-care pain monitoring skills<br>Self-care pain management skills<br>Facilitating attitude toward pain management |
| Levels of play | One game session consists of 3 games, each covers a 24-hour day (from 9 am to 9 am next day) with separate goals, and ends with an after-action review |
| User interface and platform | 11.5″ touch screen on a tablet computer (Android) allows for easy use in the hospital environment<br>Interface:<br>Numeric rating scale for pain<br>Pain medication board<br>Button for showing goals<br>Board for daily tasks |
| Avatar | Human character who can walk around the house, use a shower and toilet, cook food, watch television, use a computer, rest on a sofa, lie in bed |
| Virtual environment (setting) | A house with a living room, bedroom, kitchen, bathroom |
| Software | Unity3d (Unity Technologies) |
| Estimated play time | 30 minutes |

Brainstorming sessions were used to ensure that the educational components of the game idea were accurately translated into the design of the game and to develop solutions for the interface, the continuous feedback system, and the after-action review. Such sessions were repeated, and the design of the game refined until a prototype was ready to be evaluated. To help pursue the identified learning goals, the adult learning principle that adults want to learn what is useful and relevant [38] was used to choose the game's story, setting, and core interactions.

#### Story and Setting

The story of the game was designed to be a simulation of a relevant real-life situation, where the player's character (avatar) has returned home from the hospital after having had surgery. By making different decisions about the character's daily activities (eg, choosing between pain medications, performing basic household tasks, and taking time to rest), players can observe how their decisions influence the character's recovery.

The setting (game environment) was designed to look and react like a typical (Icelandic) home, to improve its familiarity to the game's intended audience. Figure 2 shows a screenshot of the game environment with surrounding interface elements; the interface elements will be discussed later on.

**Figure 2.** The game's interface. Below center: the player's avatar. At left, from top to bottom: button to access pain medication, current Pain Level indicator, current Side Effect. At right, from top to bottom: Current in-game time and listing of player tasks for the current day. At top middle, from left to right: buttons to review the tutorial, review the day's primary objective, call the (fictional) hospital for help, pause the game, and exit the game. Screenshot translated from Icelandic.


### Core Interactions

The game's interactions were designed to simulate 2 types of activities that are highly relevant for recent surgery patients: (1) keeping up with the activities of everyday life, including household chores (eg, doing the dishes) and regular self-care (eg, taking a shower) and (2) managing their postoperative pain through various methods (eg, taking medication, resting, or enjoying distractions). To simplify the user interface, every activity was designed to be accessible with only a few taps on the screen (eg, tapping on the kitchen sink will cause the avatar to walk to the sink and do the dishes).

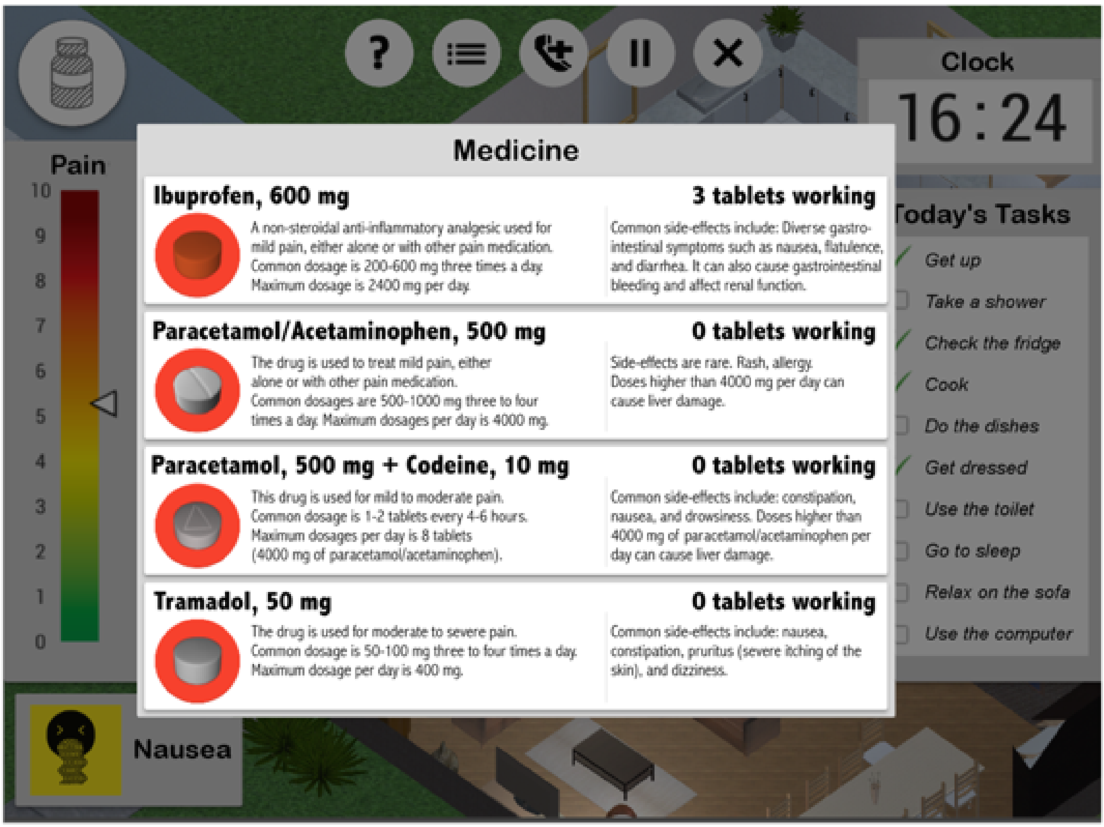
Experiential learning [38] emphasizes learning by doing. To apply this theory in the context of the game, we ensured that all of the game's interactions are driven by an underlying, scientifically informed model of pain and the effects of different medications.

### Pain and Medication Model

A computational model of pain and medication effects was designed for the game using both scientific data and professional expertise. The model controls how each activity affects the avatar's pain level, as shown by the NRS at the left of Figure 2. For example, any medication taken will decrease pain after an onset time, but it will lose effectiveness over time (Figure 3). Medication can also trigger the occurrence of side effects under conditions where they are known to be likely (eg, nausea can result from taking excessive amounts of codeine). Side effects appear both as icons in the interface (Figure 2) and as unique animations on the player's avatar.

As the avatar's pain becomes more severe, the model causes their mobility to decrease, making it more difficult to perform the activities that require movement around the house. Furthermore, the model occasionally and randomly simulates a real-life situation in which the pain becomes unmanageable (NRS ≥8) and does not respond to pain medication. The help button (middle button, top of Figure 2) gives contact with a (fictional) health care provider, and after the consultation the pain intensity decreases to 5 (representing the patient having received and implemented some helpful advice).

**Figure 3.** The medication board: by tapping the tablet icons (marked with red circles), the player can choose between 4 different pain medicines and read about their effects, possible side effects, and how many tablets are currently in effect. Screenshot translated from Icelandic.




### Objectives and Motivation

The primary value of the pain and medication model is that it allows patients to learn useful information through exploration and discovery without risking their immediate health; they can try out different courses of action in a safe, virtual environment, including those that might be harmful if they were performed in real life. Self-care theory [36] also holds that it is important for self-care learning to provide multiple opportunities to practice monitoring pain intensity and making pain management decisions. To promote players to practice and explore different alternative types of decisions, each game session consists of playing through 3 days in the avatar's life, and on each day, the player is encouraged to pursue a new set of goals, some of them extreme. Specifically, 3 particular goal sets were chosen (one for each day) to encourage players to explore a wide range of different pain management strategies; they were

Day 1: "Take as little pain medication as possible"

Day 2: "Keep pain severity under 3 on an NRS regardless of side effects from pain medication"

Day 3: "Keep pain severity under 5 the whole day"

To motivate players to pursue the given goals, each player is given a rating from 1 to 3 stars at the end of each day, indicating how well they succeeded at achieving the goals of that day. Each day ends after a preset amount of in-game time has passed.

To motivate players to perform the daily tasks around the house and provide an additional avenue for feedback, the avatar occasionally produces small bubbles of text that represent the character's (fictional) "inner monologue." They appear both at random (for fun) and to provide information about the avatar's pain status (eg, "I wonder what's on TV?" or "I can feel the medication working…").

### Outcomes and Debriefing

Learning through debriefings, where a learner is encouraged to review and analyze his or her experience after the fact, provides a fundamental link between the experience of playing and learning [41]. According to the literature, debriefings should focus on at least 3 elements: (1) what was done in the activity, (2) how well the activity worked for the learner, and (3) how the learning could be applied [42]. To support this kind of learning in the game, a mechanism was designed to record a log over time of 2 sets of information: the progression of the avatar's pain level and the time and identity of each activity that the player performed (including both task completion and medication consumption). At the end of each in-game day, a graph of information appears (Figure 4) that overlays these 2 sources of information, allowing the player (potentially with assistance from a health care provider) to review and analyze the events that occurred during the day.

**Figure 4.** A panel showing a timeline of the previous in-game day. The black line shows the progression of the avatar's pain level over time. Red nodes indicate activities that impaired pain relief, orange nodes indicate doses of medication, and green nodes indicate activities that relieved pain. Yellow outlines show the occurrence of side effects. Screenshot translated from Icelandic.


## Participants

Participants in the study were recruited from the public via a Facebook advertisement (n=11) and through a snowball method (n=9). Included were adults who use computers in daily life, but health care professionals, people with chronic pain, and people using pain medication regularly were excluded. Those were excluded because they had more knowledge and experience of pain management, including use of pain medication, than the target group of patients who are expecting to have surgery. We included people with and without prominent health problems (other than chronic pain) to reflect the targeted patient population. For ethical and practical reasons, patients were not included in this first evaluation of the game. The study was approved by the Bioethics Committee of Iceland (VSN-15-164) and conforms to the Helsinki Declaration [43]. All participants gave their informed consent by signing a form that explained the study.

## Data Collection

Data were collected from December 2015 to January 2016 by the researchers BI and KB, who are clinical nurse specialists and experienced in both qualitative and quantitative research methods. The testing and the pre-post testing data collection were done individually in one session, which took place in a hospital office and lasted approximately 90 minutes. Baseline data was collected first, and then the participant received a tablet computer and a simple, oral explanation of how to play the game. The playing session was video-recorded and directly observed by the researcher, who also took notes during the observation (nonparticipatory observation).

After playing, the participant filled out a questionnaire and was interviewed by the researcher. The semistructured and video-recorded interviews lasted from 8 to 15 minutes. They covered 2 main topics: Knowledge acquisition ("Please describe what this game was about." "How did you make decisions in the game?" "Did you learn anything new and if so, what?") And, usability ("What do you think about this method of learning about pain management?" "What was easy and not so easy while playing?" "How did you perceive the game character (the avatar)?" "How can the game be improved?").

## Measures

### *Usability*

Usability was assessed with 2 instruments: AttrakDiff2 and the Postoperative Pain Management Game Survey (POP-MGS). AttrakDiff2 is an instrument used to evaluate an interactive product [44]. It consists of 28 7-step items whose poles are opposite adjectives, and each set is ordered into a scale of intensity. The instrument has 4 subscales, each with 7 anchored items, which measure pragmatic quality (PQ), attractiveness (ATT), and hedonic quality (HQ), including identification (HQ-I) and stimulation (HQ-S) [45]. Possible scores are −3 to +3. A high HQ-I score implies a high perceived capability of communicating identity to others, or how users identify with the software in social context. A high HQ-S score implies a high degree of perceived novelty, stimulation, and challenge, which encourages development of the user's skills and knowledge. A high PQ score primarily implies high usability, (ie, that it is task-related and reflects usefulness and ease of use. The ATT score summarizes the whole experience of the software [33]. The Icelandic version of the AttrakDiff2 has previously been validated [45]. The internal consistency of the scale in this study (Cronbach alpha) was .75.

POP-MGS is an adjusted version of a previously validated instrument based on variables identified in the technology acceptance model [46]. The 12 items measure perceived ease of use and usefulness of a simulation software and the design of its interface. Response options range from 0 to 5 on a Likert-type scale, where 0 means "strongly disagree" and 5 means "strongly agree" (reflecting higher usefulness and ease of use). The internal consistency of the scale in this study (Cronbach alpha) was .83.

### *Efficacy*

Efficacy was measured using the Patient Knowledge About Postoperative Pain Management questionnaire (PAK-PPM), a 15-item instrument specially designed for the purpose of this study and reflecting the educational content of the game. The multiple-choice questions are based on a literature review and the clinical expertise of the authors. The scale has 5 components of postoperative pain management: pain after surgery (2 items), common pain medications and their dosages (7 items), pain management strategies (2 items), side effects of the treatment (2 items), and what to do if problems arise (2 items). Each item offers 6 alternatives to choose from; one of them is the correct answer, and the remaining 5 (including one which is "do not know" to the item's question) are incorrect answers. Scores are graded according to the proportion of correct answers. The face validity of the PAK-PPM was established in advance by administering it to 5 individuals, not included in this study, resulting in minor adjustment and the addition of one response option ("do not know"). The internal consistency of the scale in this study (the Kuder-Richardson formula 20) was .68.

### *Demographic and Background Data*

Demographic and background data were collected with questions on age, sex, education, employment, chronic illnesses, the use of computer, smartphone and computer games in daily life, health literacy and attitude toward pain management. Health literacy was assessed with 3 screening items [47]. Attitude toward pain management was measured with Icelandic Barriers Questionnaire II, [48] a 27-item instrument which is divided into four subscales. The instrument was adjusted such that referrals to "cancer pain" were changed to "surgical pain." Participants rate the extent to which they agree with each item on a 6-point Likert-type scale ranging from 0 (do not agree at all) to 5 (agree very much). Higher scores reflect higher barriers to pain management. Internal consistency (Cronbach alpha) in this adjusted version of the instrument was .91.

The whole battery of questionnaires was pilot-tested by 5 individuals, to verify that the adjusted instruments were easily understood. No changes were required after that.

## Data Analysis

### *Quantitative Data*

Descriptive statistics (median and interquartile range [IQR]), frequencies, and proportions (%) were used to describe the sample characteristics, as well as knowledge, barriers to pain management, and usability as appropriate for nonnormally distributed data. The Wilcoxon signed-rank test was used to compare knowledge scores for the PAK-PPM total scale before and after testing the game. IBM SPSS-23 statistics were used for this analysis (IBM Corp). The video recordings of the playing session were analyzed by measuring how long time it took the participants to play the game, counting how often they needed assistance and how often they ran into problems while playing.

### *Qualitative Data*

Qualitative data were collected from the observations (free text notes) and from the interviews (open-ended questions). Data were analyzed with a directed approach to content analysis to validate the results of the survey on usability and efficacy (knowledge acquisition). With this approach, codes are derived from theory or relevant research findings and defined before or during data analysis, thus supporting or extending the existing theory [49]. The 2 concepts of usability and efficacy were chosen as categories for coding beforehand. The 2 researchers (BI and KB) took notes while watching and listening to the video recordings from the observations and interviews and categorized them as either "usability" or "knowledge." The content was discussed between the researchers until agreement was reached and a summary of the interview with each participant was written.

# Results

## Characteristics of the Participants and Patient-Related Barriers

We recruited 20 people in the study. Their median age was 45 (range 24-67), they all used computers (n=20) in daily life, and most used smartphones (n=18) and played games (n=14) on the computer. Seven people had chronic illness, and health literacy was high (Table 2). The total score of the Barriers Questionnaire II was median 2.03 (IQR 0.77) on a scale of 0-5, and the highest barriers were found in the "harmful effects" subscale (median 2.71, IQR 1.71), followed by "physiological effects" (median 2.38, IQR 0.90), "communication" (median 0.58, IQR 1.27), and "fatalism" (median 0.00, IQR 0.33).

**Table 2.** Characteristics of participants and results from health literacy screening.

| Background | N=20 |
| --- | --- |
| Age | Median 45 years (range 24-67) |
| **Sex** | |
| Women | 11 |
| Men | 9 |
| **Education** | |
| Basic education (≤9 years) | 2 |
| College | 4 |
| University | 14 |
| **Employment** | |
| Office/marketing | 4 |
| Technology/development/research | 4 |
| Education | 3 |
| Management | 2 |
| Servicing/catering/travel/industry | 4 |
| Other | 3 |
| Chronic disease? (yes) | 7 |
| **Use of information technology in daily life (yes)** | |
| Computer | 20 |
| Smartphone | 18 |
| Tablet | 15 |
| Play games in a computer, smartphone, or on a tablet? (yes) | 14 |
| **Health literacy screening[a]** | |
| **How often do you have problems learning about your medical condition because of difficulty understanding written information? (n=19)** | |
| Never | 11 |
| Occasionally | 6 |
| Sometimes | 1 |
| Often | 1 |
| Always | 0 |
| **How often do you receive help with reading hospital material? (n=19)** | |
| Never | 12 |
| Occasionally | 3 |
| Sometimes | 2 |
| Often | 2 |
| Always | 0 |
| **How confident are you filling out medical forms? (n=20)** | |
| Extremely | 13 |
| Quite a bit | 4 |
| Somewhat | 1 |
| A little bit | 1 |
| Not at all | 1 |

[a]Brief questions to identify patients with inadequate health literacy [47].

### Usability and User Experience

The game session (including the introduction, the 3 games, and the after-action review) took 34 minutes on average. The attributes of the game measured with AttrakDiff2 received median scores above 0 in all dimensions; highest for attraction (median 1.43, IQR 0.93) followed by pragmatic quality (median 1.31, IQR 1.04), hedonic quality interaction (median 1.00, IQR 1.04), and hedonic quality stimulation (median 0.57, IQR 0.68). The items on ease of use and usefulness as measured with the POP-MGS received a median score of 3.00 (IQR 1.75) to 5.00 (IQR 2.00) (possible scores 0-5) for all items except "I did not have any technical problems using the game" (Table 3). The observation through video-recording during testing showed that 15 participants asked for help, each 1-5 times (median 2 times), usually because of technical problems such as the avatar freezing or getting stuck in walls or not being able to proceed from one in-game day to another.

In the interviews, participants confirmed the ease of use, and while some found it easy enough to give to older people: "My mother is 83 but I think she could use this" (male, 42 years), others found it unsuitable for the very old. All participants managed to finish the session with minimum assistance but the observation revealed that the people with good computer skills were quicker to grasp what to do and how. The observations noted participants' engagement while playing, and both the survey and interviews confirmed that they enjoyed playing the game.

The perceptions of participants about the game character (avatar) differed. Most male participants could identify with the "young male avatar." Some of the female players however perceived the avatar as a young male they were taking care of while others identified with it and perceived it as an "it" and without a specific gender.

**Table 3.** Ease of use and usefulness of the game (Postoperative Pain Management Game Survey (POP-MGS); score 0-5; N=20).

| Items | Median (IQR[a]) | % of participants who fully agree |
|---|---|---|
| **Part 1: Ease of use** | | |
| I found it easy to learn to get the game to stop or start | 5.00 (2.00) | 55 |
| It was fun using this simulation | 4.00 (2.00) | 30 |
| The way in which information was presented on the screen was clear | 4.00 (1.00) | 15 |
| It was easy to learn how to use the game | 4.00 (1.75) | 20 |
| I found the activity easy to follow | 4.00 (1.00) | 5 |
| The quality of video was good | 3.00 (2.50) | 25 |
| I found the game easy to navigate | 3.00 (1.75) | 10 |
| I did not have any technical problems using the game | 2.00 (1.00) | 15 |
| **Part 2: Usefulness** | | |
| If I had recently had surgery or was preparing for one and the postoperative period, it would be helpful to get feedback from an expert on my pain management | 5.00 (0.00) | 85 |
| I think the game would be a useful addition to other education about pain management | 5.00 (1.00) | 55 |
| I think a simulation like this might encourage people who are recovering from surgery to learn about pain management | 5.00 (1.00) | 60 |
| If I was recovering from surgery, I think the game would encourage me to learn about pain management | 4.00 (1.00) | 35 |

[a]IQR: interquartile range.

The participants suggested additions and improvements to the game, both on the game mechanics, such as receiving more continuous feedback, but also on other pain management strategies, which will be considered in the next version of the game. For example, they suggested adding more nonpharmacologic methods to relieve pain and methods to prevent and treat the side effects of pain medication.

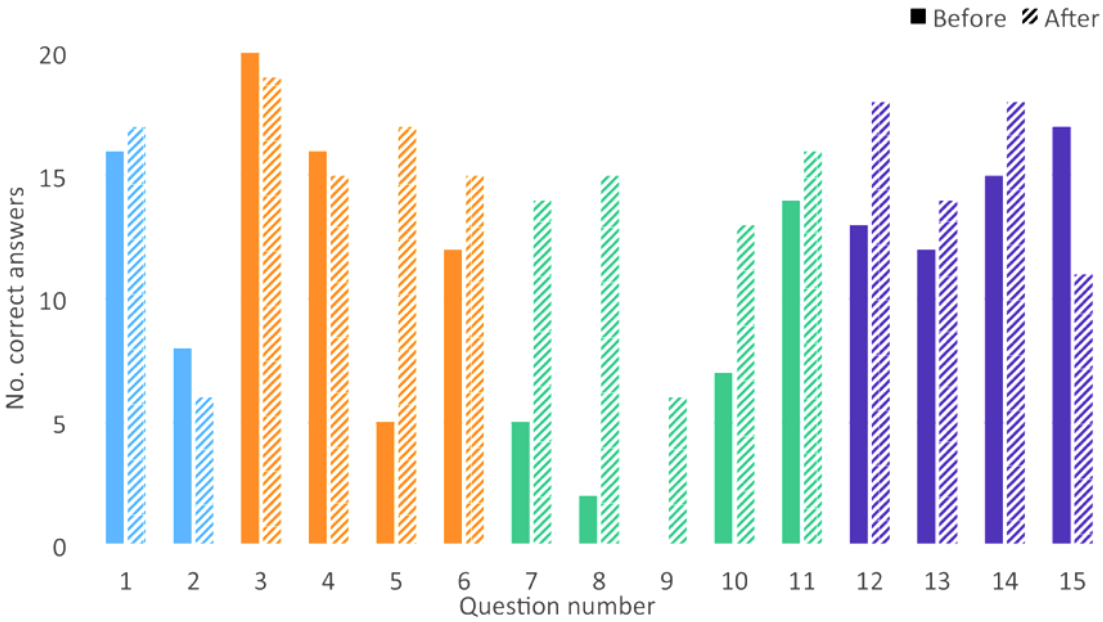
### Knowledge About Pain Management

From the questionnaire (PAK-PPM) we found that knowledge increased immediately after playing the game, from 54% correct answers before playing the game to 71% after (Z=−3.244, *P*=.001). Of the 20 participants, 18 improved their scores, one decreased his score, and one kept the same score. In 11 out of 15 questions the number of correct answers increased after playing the game (Figure 5). The number of correct answers increased most in items about pain medications and dosages. Smaller increases in the number of correct answers were found in items about postoperative pain and management strategies. In the item about seeking help in case of signs of complications (question 15), the number of correct answers decreased.

In the interviews, 16 participants said they had learned something new, while 4 said that they did not learn anything new because they had already acquired the knowledge from prior surgery and/or use of pain medication. Nearly half of the participants (n=9) said that one of the most important lessons learned was the importance of taking medications regularly instead of waiting for the pain to become intolerable, as they sometimes did in reality: "I learned the attitude that it is okay to take medication regularly, not to wait until the pain has reached the limit one can tolerate" (male, 40 years). They also learned about the effects and side effects of different medications and how to use multimodal pharmacologic and nonpharmacologic approaches (eg, that pain relief is promoted by resting or using distraction such as watching television or using the computer).

The participants also confirmed our theoretical assumption that they used previous knowledge from their own experience and life situations while learning with the help of the game: "I never chose the Ibuprofen because my doctor forbade me to use it when I had surgery" (female, 61 years).

**Figure 5.** The number of correct answers for each of the 15 items in the knowledge test (Patient Knowledge About Postoperative Pain Management questionnaire) before and after playing the game. Questions 1-2 (blue) are about pain after surgery, questions 3-6 (orange) about different types of pain medication, questions 7-11 (green) about the dosages of the same medication and pain management strategies, questions 12-15 (purple) about medication side effects and how to react to unexpected situations.




## Discussion

This is, to our knowledge, the first paper describing the development and evaluation of a serious game that has the purpose of teaching surgical patients about postoperative pain management, including the use of pain medications and effective pain management strategies. The results of this evaluation indicate that a serious game may indeed be a useful and an attractive option for prospective surgical patients to learn about pain management.

### Efficacy

There was an increase in participants' knowledge about pain management, especially about individual medication dosages and side effects, but also about pain management strategies such as regular medication intake and combining pharmacologic and nonpharmacologic approaches. Knowledge acquisition is the most common outcome measured in serious games in general [50] and studies have shown beneficial effects in such games within health care [51]. However, there has been a call for more advanced use of games focusing on affective, motivational and physiological outcomes, and behavior change outcomes in general to improve health-related outcomes [50,51]. The participants in this study were quite positive toward pain management and reported similar attitudes in the Barriers Questionnaire as both cancer patients and a sample from the public in previous Icelandic studies [48,52]. Their main concern seemed to be the harmful effects of pain medication in relation to surgery. In another study on pain experience and barriers to pain management, for Chinese patients undergoing thoracic surgery, even higher total barrier scores were reported, with the main concerns being pain medication tolerance, inhibition of wound healing, time intervals, and distraction [23]. The positive results from the current study indicate that our serious game can indeed be developed further to support more advanced health-related outcomes and address in more detail the misconceptions and attitudes that may hinder optimal pain management. For these purposes, the after-action review plays an important role and can be used as a starting point in the debriefing between patients and health care providers to initiate discussions about such barriers.

Although the game was able to improve the knowledge of the players, it remains uncertain if and how this type of learning can facilitate translation of knowledge into optimal behavior. Answering these questions would require a complex intervention study [53] with follow-up and well-defined long-term outcomes. Examples of outcome measures that would be important to measure are postoperative pain intensity, optimal recovery, knowledge, and satisfaction with patient education, with the participation of surgical patients. We are planning such a study as part of our future work.

### Usability

The participants in this study rated the usability of the game rather highly as confirmed both in the interviews and through the observations. They were engaged in the game the whole time and many enjoyed playing it. They also associated themselves with the avatar, either as themselves or as someone they sympathized with. It has been proposed that using avatars increases social presence, and allowing players to choose an avatar that they would like to represent them has resulted in greater satisfaction than when the only option is a standard male or female avatar [54,55]. Therefore, it should be considered that offering more choices of avatars could add to both engagement and the overall learning experience. Motivation is triggered by engagement and fun. The motivational appeal that games possess and which give them potential benefits in health education lie in their opportunities for active, exploratory, and experiential learning within a safe environment [8]. This is built into the design of the game: it is active because you need to complete the tasks, it is exploratory because of the different goals on different days, and it is experiential because of the consequences that are built into the mechanics.

The idea of playing a game to learn about pain management after surgery was well received by the participants in this study. They had different views on how appropriate it would be for older patients and those without computer skills, but nonetheless found it suitable in the case of prospective surgery (particularly for people with problems reading written material), and simple and easy enough to navigate for a wide range of users. Older adults are playing more games than in prior decades, for example, 26% of game players in the United States are 50+ years of age [56], and they report cognitive benefits and few difficulties in playing [57]. Age should therefore not be a hindrance for use with patients. However, the participants also confirmed findings from our earlier qualitative study [39] that although a game is an attractive addition to traditional methods, it should be introduced carefully and used under the supervision of health care providers. This supports our intention to introduce the game initially to patients before surgery (for practice purposes) and then again as part of their discharge education to support further learning.

### Strengths and Limitations

The participants in this study were recruited from the general public, but the results might be different if surgical patients tested the game. Several factors, such as anxiety and impaired cognition due to anesthesia and medications may affect their learning capabilities during the perioperative period [39]. However, the game is intended for patients undergoing surgery and, as theoretically all people may need surgery at some point in their lives, it was reasonable to assume that the participants in our study could sufficiently envision the situation of undergoing surgery and therefore act as real patients would. The participants had a wide variety of experience and skills in game playing and included people who design and evaluate games, as well as people with and without chronic diseases. While this group may not have been representative of surgical patients in general, it gave the evaluation an amount of variance that is feasible for such studies. On the other hand, it may also have caused some heterogeneity in the data, as the participants may have approached the game with different expectations. The sample size (n=20) was selected according to recommendations for collecting quantitative usability metrics [58]. Facebook was deemed a feasible channel to seek a wide variety of participants who fulfilled the inclusion criteria, as 74% of the Icelandic population are registered users of this social media network [59].

No validated instrument was available to measure changes in participants' knowledge. The questionnaire designed for this study was useful in detecting changes in knowledge and had acceptable internal consistency, but it needs to be developed and validated further as it lacks established content and construct validity. Finally, since the postgaming test was implemented immediately after playing the game, we could not assess knowledge retention over a longer time.

### Conclusions

A serious game can be an efficient method to learn about pain management; it can improve knowledge and is appreciated by users. To assess the game's usability and efficacy in the context of surgery, further development followed by an evaluation with a larger sample is required, including surgical patients, older people, and people with diverse health literacy.

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## Authors' Contributions

BI, KB, SZ, DT, and TJ worked on game design. BI, KB, SZ, IT, and TJ contributed to study design. BI and KB were involved in data collection.

## Conflicts of Interest

None declared.

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## Abbreviations

**ATT:** attractiveness
**BMI:** body mass index
**HQ:** hedonic quality
**NRS:** numeric rating scale
**PAK-PPM:** Patient Knowledge About Postoperative Pain Management questionnaire
**POP-MGS:** Postoperative Pain Management Game Survey
**PQ:** pragmatic quality


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Original Paper

# Guidelines for the Gamification of Self-Management of Chronic Illnesses: Multimethod Study

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## Abstract

**Background:** Gamification is the use of game elements and techniques in nongaming contexts. The use of gamification in health care is receiving a great deal of attention in both academic research and the industry. However, it can be noticed that many gamification apps in health care do not follow any standardized guidelines.

**Objective:** This research aims to (1) present a set of guidelines based on the validated framework the Wheel of Sukr and (2) assess the guidelines through expert interviews and focus group sessions with developers.

**Methods:** Expert interviews (N=6) were conducted to assess the content of the guidelines and that they reflect the Wheel of Sukr. In addition, the guidelines were assessed by developers (N=15) in 5 focus group sessions, where each group had an average of 3 developers.

**Results:** The guidelines received support from the experts. By the end of the sixth interview, it was determined that a saturation point was reached. Experts agreed that the guidelines accurately reflect the framework the Wheel of Sukr and that developers can potentially use them to create gamified self-management apps for chronic illnesses. Moreover, the guidelines were welcomed by developers who participated in the focus group sessions. They found the guidelines to be clear, useful, and implementable. Also, they were able to suggest many ways of gamifying a nongamified self-management app when they were presented with one.

**Conclusions:** The findings suggest that the guidelines introduced in this research are clear, useful, and ready to be implemented for the creation of self-management apps that use the notion of gamification as described in the Wheel of Sukr framework. The guidelines are now ready to be practically tested. Further practical studies of the effectiveness of each element in the guidelines are to be carried out.

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**KEYWORDS**

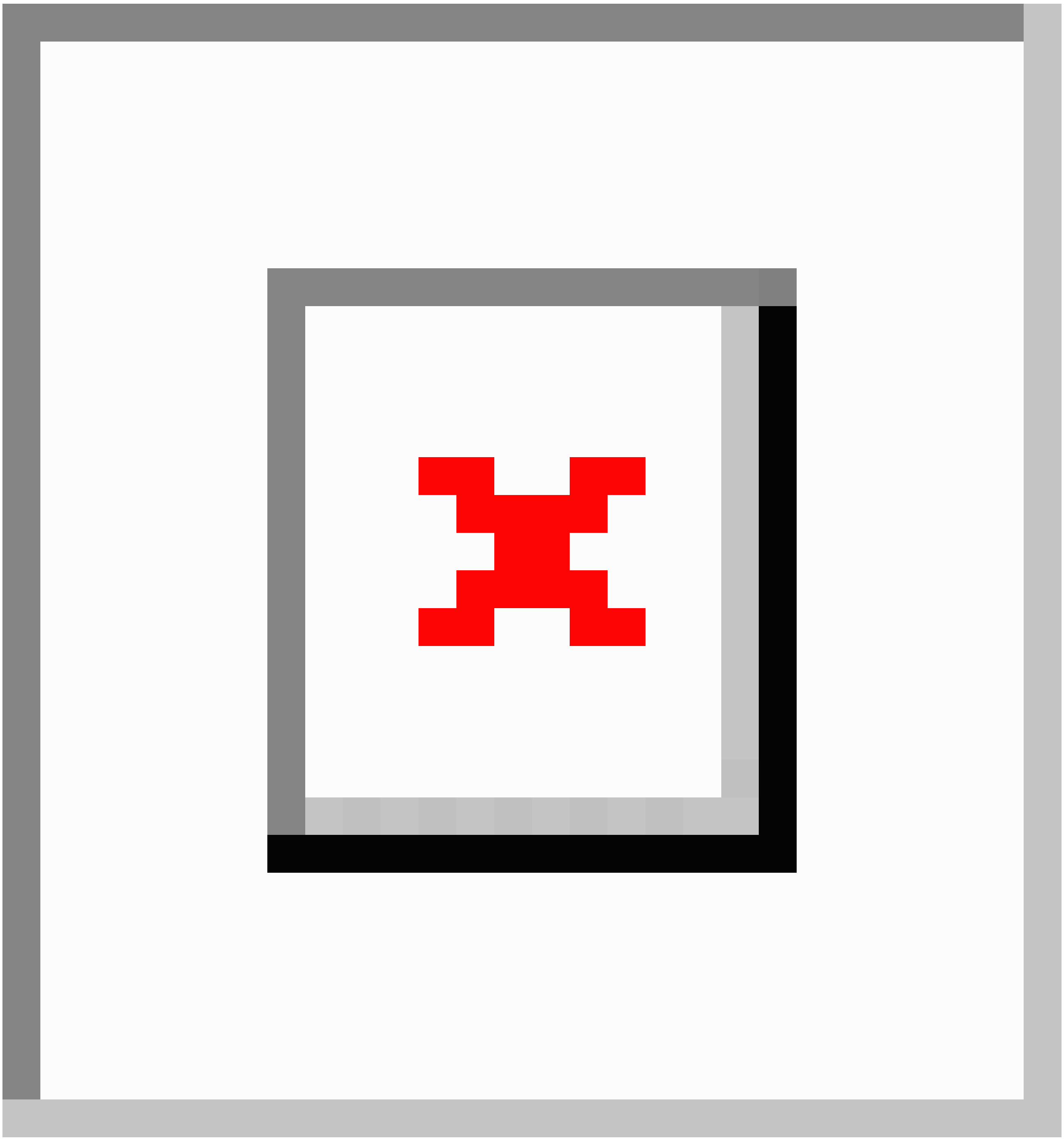
gamification; health care; behavior change; self-management; chronic illnesses

## Introduction

The use of gamification in health care is receiving a great deal of attention in both academic research and the industry [1-13]. Gamification is the use of game elements and techniques in nongaming contexts [14]. It is employed in different areas including health care to facilitate engagement and behavioral change and increase motivation [15,16]. The attention given to gamification is due to its perceived usefulness and benefits, especially when dealing with chronic illnesses and daily self-management by patients [3,17,18]. Chronic illnesses require repetitive but important tasks that could be made easier to handle with gamification. Thus, it could be of interest for developers to gamify health and fitness apps. However, it can be noticed that many gamification apps in health care do not follow any standardized guidelines [1], which might affect the overall experience of the users. For instance, users could get bored with using a certain gamified app if it only includes gamification in an arbitrary way [19,20]. In health care apps, especially ones that target self-management of chronic illnesses, developers are advised to take into consideration many aspects of the concept of gamification and its relation to self-management.

To overcome a shortage in the literature, we introduced the Wheel of Sukr framework [21], which is a framework for the gamification of self-management of chronic illnesses that combines behavior changing methods, game techniques, and techniques of self-management of chronic illnesses. The Wheel of Sukr consists of 8 themes: fun, esteem, growth, motivation, sustainability, socializing, self-representation, and self-management. Each theme includes a number of elements as shown in Figure 1.

**Figure 1.** The Wheel of Sukr [21].



The framework was validated by the authors using a mixed method study [22]. Medical doctors, psychologists, and gamification experts were interviewed and diabetic patients took part in answering a questionnaire that measures their attitudes toward the concepts covered by the framework. The results suggested that patients are keen to see self-management apps containing the concepts of the Wheel of Sukr. Also, the findings of the interviews suggest that experts see the need of gamification as represented in the framework in the area of self-management of diabetes and other chronic illnesses.

Nevertheless, the Wheel of Sukr is a theoretical framework and so is considered a high-level construct. To establish a transition from the theoretical side to the practical side, the framework and its content should be translated into a set of guidelines that can be applied practically by developers. Such guidelines should contain definitions, instructions, and suggestions that target developers who can then gamify self-management of chronic illnesses apps or systems.

This paper presents a set of guidelines based on the Wheel of Sukr framework [21,22]. The guidelines (see Multimedia Appendix 1) were assessed during expert interviews and discussed with developers in focus groups. The purpose of the expert interviews was to ensure that the guidelines represent the framework accurately and comprehensively. The purpose of the focus group discussions with developers was twofold. The first aim was to collect their views on the clarity, usefulness, and ease of implementation of the Wheel of Sukr guidelines. The second was to test if they could think of practical ways to gamify apps based on the guidelines.

## Methods

### Criteria for Creating the Guidelines

As mentioned earlier, the guidelines were built based on the Wheel of Sukr. Similar to the framework, the guidelines contain 8 themes, each of which is divided into 5 sections as shown in Table 1.

The Wheel of Sukr guidelines are designed such that they can be tailored to the goals and objectives of each app or system and its audience. For example, the type of badges and points could be different if the app is targeting children with diabetes as opposed to adults.

Experts from academia assessed the guidelines, and these assessments were discussed with developers in focus groups. The group of experts and the group of developers did not overlap in our study.

### Expert Interviews

Qualitative data were collected through expert interviews. The aim of the interviews was to conduct a formative evaluation of the guidelines to ensure that they represent the framework accurately and comprehensively. The experts were selected from the University of Southampton. They were identified and contacted in person or through email by the first author. The experts were from one or more of the following areas: game development, user experience, and gamification. The interviews were conducted by the first author.

In each interview, the interviewer started by explaining the background of the study and the framework. Next, the expert was presented with the guidelines and was asked to read one theme at a time. Next, the interviewer asked the expert to provide their evaluation and their answers to a number of open-ended questions.

Semistructured interviews were conducted with experts in developing apps and games, experts in design and user experience, and game experts in academia. The interviewer stopped conducting interviews after reaching a point of saturation. This is when data becomes redundant and no new data are found [23]. Saturation was achieved after interviewing 6 experts. The duration of each interview was 50 minutes on average, and each interview was recorded for analysis. After that, the interviews were transcribed verbatim and were analyzed using a thematic approach. The data were coded with tags that represent the 8 themes of the guidelines. Similar sets of data were identified and categorized.

**Table 1.** Sections of the guidelines.

| Section | Purpose |
|---|---|
| Theme | A general construct containing elements that share the same goal. |
| Definition | The general idea of the theme is defined. |
| Goal | The purpose of the theme and its elements is stated. |
| Description | The theme and its elements are elaborated. |
| Application | The theme is translated into pointers to help in implementation. |

### Focus Group Interviews

The focus group method was chosen to gather the views of developers on guideline clarity, usefulness, and ease of implementation. In particular, we wanted to find out the clarity of the content of the guidelines (such as definition, goals, etc) to the developers. Also, we wanted to find out if the developers thought that the guidelines could potentially help them in creating gamified apps for self-management of chronic illnesses. Last, we wanted to know if the developers thought that implementing the Wheel of Sukr into an app would be feasible and if they could think of practical ways to gamify apps based on the guidelines. The selected developers are PhD students and postdoctoral researchers in computer science, Web technology, and software engineering at the University of Southampton. When a candidate participant was approached, they were asked if they had experience in developing apps to be included in the study, regardless of their level.

In this study, 5 focus groups were conducted. Each one consisted of 2 to 4 developers, resulting in 15 participants. After conducting the 5 focus group interviews, a point of saturation was reached where no new data were found. The main criterion for choosing the developers to be included in the sample is that they have experience in developing apps.

Each focus group session started with an overview of the research. Next, developers were presented with the guidelines to read. After reading each theme, the developers were asked to rate the guidelines for that theme based on 3 aspects: clarity, usefulness, and ease of implementation. In particular, they were asked to choose a score from 1 to 9 (1 being negative and 9 being positive). Then, they were asked to discuss the guidelines and raise any concerns about the content.

At the end of each focus group session, snapshots of an app for self-management of diabetes, which was arbitrarily chosen and does not contain gamification, were presented to the developers. They were asked to use the guidelines to suggest improvement to the app. The interviews were audiorecorded after getting the consent of participants, transcribed, and analyzed based on themes of the Wheel of Sukr. Finally, ethical approval was obtained from the ethics committee at the University of Southampton prior to conducting the interviews (reference number 20757).

# Results

## Expert Interviews

### Overview

The expert interviews were aimed at confirming that the Wheel of Sukr guidelines as a whole are comprehensive, clear, and reflect the framework (the Wheel of Sukr).

Experts acknowledged the importance of introducing such guidelines. They provided a number of suggestions that were taken into account. Overall, experts thought that the guidelines provide good guidance for developers and have enough information to help them in this area. Moreover, they said that the way the guidelines are arranged flows nicely. The expert comments and feedback are divided based on the themes of the framework.

### Fun

The discussion showed that there is a general consensus amongst the experts that this part of the guidelines is understandable, easy to use, and comprehensive. They also agreed that the points discussed in the guidelines are fundamental in making the self-management experience fun and rewarding. Moreover, the experts agreed that the guidelines are general enough to be used in creating different apps. As one expert stated, “It is very clear and it is not very specific that it can only be applied to a single case which is good.”

Nevertheless, one issue that needed clarification is the use of competition in the context of chronic illnesses self-management. The competition should not be associated with the self-managing tasks themselves or the results of the medical tests but rather with the number of times the user interacts with the system or the level of engagement the user has with the community, thereby gamifying the experience of self-managing. Consequently, a clarification remark was added to the competition element in the guidelines.

Some experts suggested considering the use of other core dynamics or other manifestations of the collection core dynamic. From a game design point of view, the badges and points are manifestations of the core game design collection. This manifestation is the most used in gamification in general. However, this does not mean that developers are limited to this form of core design. In light of this finding, the guidelines for the fun theme were improved. Other core design elements were mentioned in a way that is still true to the research and the framework of rewarding the user, not just creating a game-like experience. It is important to keep in mind the goal of the fun part of the guideline, which is to make the experience of self-managing chronic illnesses efficient while being enjoyable and positive.

### Esteem

There was strong support for this part of the guideline and the way in which it is presented. This is evident when one expert said, “The way you described how they [the elements] need to be implemented in terms of the leaderboard and the progress bar is a very coherent way to represent how to encourage esteem both in the community (the external) and the internal in terms of how the person sees himself in that community.”

One point of clarification is that it is important to consider what the users might not want to share with others. For example, in self-managing diabetes some people might not be comfortable sharing their blood glucose levels. This issue was raised by one of the experts, and the guidelines were modified accordingly.

Another expert stressed the importance of creating the respect and admiration feelings for the user: “I believe this is extremely important because of the way that the user needs to know their progress and keep track.” The expert also mentioned the value of having reputation in the community: “It is also important to enable the user to be recognized by the community as a ‘super user’ or something like that.”

Moreover, it was pointed out that in the chronic illnesses communities the content of this theme is particularly useful. This is due to the fact that it allows those who do well in self-management to be an example to others and inspire them without pointing out to other users that you have to be like him or her. As the expert said, “Those who keep track of their self-management activities and do well, they will become an example and an encouragement to others in the community, and it will happen naturally.” Additionally, on using an app for self-management that has the elements of the esteem theme, the expert said, “In this environment the motivation could be even stronger than that of [other entertainment games] because it is related to users’ health.”

### Growth

The impression about this part of the guidelines was very positive. Experts acknowledged that the guidelines are easy to understand, comprehensive, and reflect the Wheel of Sukr. This is exemplified in what one of the experts stated: “I agree with the elements that you got...and the way you want to link the system to the point and badges so that the person can see himself or herself growing in terms of changing their behavior and start having more control.”

Regarding the elements achieving goals and baby steps (tiny habits), one expert said, “We need a combination of difficult and easy tasks for the user, and the level of difficulty needs to increase in order to retain engagement. This is because if the user starts becoming an expert in what they do and they managed to change a tiny habit then surely you want to increase the difficulty."

### *Motivation*

The experts agreed on the comprehensiveness and clarity of the content of this guideline. One expert talked about linking intrinsic motivation to the app or system to help users understand that the reason they are feeling better is because of what they are doing in the app. This could be done through "...prompting people you can imagine having things like 'Oh this week you managed to do better than you did last week.'"

Moreover, one of the experts discussed the age aspect and said, "I can see this working for both children and adults. The badges work for all age groups. Perhaps the colors would change and the theme but the elements work well for all the ages."

Overall, the motivation guidelines were clear and comprehensive. This is exemplified in what one of the expert said: "You have considered two very important components of motivation. The one that comes from within and the one that I can develop from either what I see or that can hopefully feed my inner motivation." The expert continued by saying that using both type of motivations would lead to increased engagement ("in something that is interesting and fun"), as well as allowing users to grow ("so that their inner self can be truly motivated and keep good health and the activities of self-management"). Thus, no changes were made to the motivation guidelines.

### *Sustainability*

The common viewpoint among the experts was that the content of this guideline is comprehensive and clear. They expressed a strong view that this theme is a very important part of the guideline. Experts indicated the importance of reminding the user to use the app or to perform the self-management activities through using triggers, which could be in the form of a text or a sound.

The storyline and theme elements received the most attention. One expert expressed enthusiasm about the storyline element by saying, "It is very important—I really like this element in this theme. It is the way to actually make it [the experience of self-managing] meaningful. It creates the context where you can jump into that world and 'find the magic.'" Another expert linked the story element back to intrinsic motivation: "In intrinsic motivation you seem like you are trying to say I want to point out to people that these things are being beneficial to their health, which you might communicate via story or you might communicate via some other means." The expert continued saying that the storyline could be used as a motivator in this context.

Another expert suggested that we separate the definition of storyline and themes. Regarding the difference between the 2 elements, the expert said the theme is "the background that the user might connect to, to begin with," while the storyline "is about controlling progress and the arc the player takes through their experience and on that note it might be important to think about what is the arc for the user for this system." Furthermore, the expert discussed the way the developer will implement the storyline. They indicated that the developer must know the expected path the user will take to be able to manage their chronic illness in a good way. They must know the pace and the structure of the story that they are going to use. They also must consider the arc and structure of the story and how it will be connected to the game in order to create engagement. As the expert said, "The idea is that at the beginning you get the user or players attention and get them engaged in the experience, and then you relax that because you get impact with the user when you have acceleration. You have series of microclimatic before you have the big climax at the end and then relax." Moreover, the standard design practice with regard to pacing and story structure should apply.

### *Self-Representation*

The experts agreed that the content of this guideline is easy to understand and comprehensive. Expert agreed that it is important for the user to be able to change their avatar in a way that enables them to identify with the app. Giving users a way to express themselves would possibly increase their investment in the app.

The autonomy element is important in the context of self-managing chronic illnesses because giving the user control over their choices and activities could lead to patient empowerment. As one of the experts said, "How in control you are in a process, I can see how that is important to people managing conditions with these kinds of technology."

### *Socializing*

The general reaction to this theme was very positive as well. The experts thought that this part is straightforward, easy to understand, and comprehensive. As one of them said, "I agree with everything here, because I can see it on Twitter and social media you have groups for all chronic conditions and people get together, they support each other they understand they go through the same thing and they are there for each other." The expert continued that peer support specifically is very important in the context of gamifying self-management of chronic illnesses. The expert said, "...we feel connected with someone we know understands because we are going through the same thing and it is different to hear it from someone who is speaking from a different place."

### *Self-Management*

The expert consensus on the guidelines for the self-management theme was that it is comprehensive and clear. As one expert said, "I agree with all the elements and especially the alert element, which I think is very important because it is required to help those who want to learn how to self-manage or to guide them on what to do."

Regarding the alert element, experts agreed on its importance in the context of self-managing. As one expert said, "We tend to think about self-management oh you are independent you don't need help, but this is not the case; it is just the person is prepared to know who to contact how to do what steps to follow to keep the condition under control. So alert is very important."

One expert linked this theme to the esteem theme by saying, "You are essentially talking about communicating two types of information. One is about the status of the system and the game and it is covered by the esteem theme. The other one about the underlying status of their illness."

### Focus Group

#### Overview

In this section, we present the findings of the focus group discussions with developers. As explained earlier, the developers were handed the set of guidelines and snapshots of a nongamified app for self-managing diabetes. They were asked to read the guidelines and discuss them theme by theme. After reading each theme, they were asked to rate it from 0 to 9 (0 the lowest rating and 9 the highest) in terms of clarity, usefulness, and ease of implementation. The average scores of each theme contained in the guideline are shown in Table 2. It should be noted that these scores reflect the opinions of developers on the guidelines. Clearly, the results show a very positive opinion toward the guidelines.

**Table 2.** Score table (ratings from 0-9).

| | Clarity | Usefulness | Ease of implementation |
|---|---|---|---|
| Fun | 7.5 | 7.7 | 7.1 |
| Esteem | 7.1 | 7.3 | 7.1 |
| Growth | 7.1 | 7.7 | 7.3 |
| Motivation | 6.1 | 7.7 | 5.5 |
| Sustainability | 7.8 | 8.1 | 7.5 |
| Self-representation | 7.5 | 7.8 | 7.9 |
| Socializing | 8.1 | 7.9 | 8.0 |
| Self-management | 8.3 | 8.2 | 8.4 |

#### Fun

One of developer said, "I have very little background of gamification but now I can read this and understand what these elements are and what I am supposed to do." Another developer said, "Your guidelines adapt with what exist now [in the area of Web and app development] and it is very clear. ...our lives depend on collecting points and rewards." It was evident that the fun theme elements are very clear as many of the developers managed to relate those elements to apps that they have been using, in particular health and fitness apps in which gamification aspects have been used.

The notion of sharing achievements between users, which was mentioned in the Application section of the fun theme, needed some clarification. In particular, the interviewer explained that the achievement element is not about sharing private medical results. Instead, it is about sharing the points collected or badges as a result of good self-management practices. Consequently, the guidelines were updated with this clarification.

Overall the developers were satisfied with the fun theme. One developer said, "From developers point of view I think these provide good guidelines; things to keep in mind while designing your app." Another one said, "The guideline is general enough to help developers create different gamified apps."

#### Esteem

The clarity of the theme is exemplified in what one developer stated: "I think it is clear and it goes well with the fun theme." However, one point that needed clarification is the leaderboard. The interviewer explained that it is not calculated based on test results (eg, the blood glucose test results), but it is based on the activities of self-management—the tasks required (eg, the number of times the user entered their test results or the number of times the user achieved their goals). As indicated in the guidelines, the developer can add on this or change the leaderboard mechanism as long as they keep in mind the sensitivity of the data collected and not compare users based on their test entries (eg, their blood glucose levels).

#### Growth

One developer said, "This is for me quite useful and the description is clear," which is in accordance with the general impression with the other developers as can be seen in Table 2. One point that needed clarification is that feedback does not mean feedback from other users; this type of feedback could be a part of the socializing theme as a matter of peer support. The feedback here is from the app itself. For example, when the user log their test results, a doctor character or another character can show up and reassure the user that they are doing a good job, or it could simply be a notification that appears containing a relevant message.

#### Motivation

Next, even though the ease of implementation for the motivation theme was low compared to the other themes, developers managed to come up with a number of examples on how to implement intrinsic and extrinsic motivations after some discussion. One of the examples given by developers was asking the user about their favorite animal and that would be their companion throughout the app. The only way to take care of their companion is by logging their data and performing the self-management tasks. Another example was to provide users with tips and information to maintain healthy lifestyle, which could enhance their motivation.

Overall, developers found the guidelines of the motivation theme useful. As one developer said, "The information is useful for the developer that there are 2 types of motivation that they can implement."

### Sustainability

Developers mentioned the challenge and difficulty of carrying on the elements of the sustainability theme and how the guidelines are helpful. Developers thought that if these elements were included in some of the apps they have used, they would have continued using them.

The elements trigger and nudge needed some clarification, as one of the developers could not distinguish between the two. Thus, the description of both elements in the guideline was edited to eliminate any future misconceptions. The trigger element is when a person is reminded to perform a behavior through visual or audio cues. On the other hand, the nudge is positive reinforcement and an indirect signal toward a nonforced act.

The satisfaction with this theme is summarized with the following statement: "The description of the storyline and theme is very helpful to me. And for the nudge it is useful because every time the user uses the app they get to enter their glucose which can help the users log everything daily and very intuitively. Also the reminders are useful for users, so if they forgot to use it they will remember. So I think this is very clear!"

### Self-Representation

In this section, the ability element needed some clarification. Thus, it was clarified to show that when designing tasks or challenges, the developer should consider the varied abilities of users. For instance, some users might find it difficult to perform certain tasks. Therefore, simplifying the tasks is highly recommended. On using avatars, one developer said, "It creates a link between the user and app and lets the user engage with the app more."

Overall, developers agreed that the self-representation part is clear (see Table 2). As one of the developers said, "It completely connects with what we have been discussing and I know how to implement everything here."

### Socializing

At this stage some developers started to see connections between the different themes of the whole guideline. As one developer stated, "This helps me understand the fun theme and esteem theme better, because it means people will share their achievements so they can engage more with the app." Other developers supported the notion that the social aspect enables users to not only share their achievement with their peers but also with family and friends. This was summarized in the following statement: "It is useful to be connected with family, and they can see your progress and they will comment positively and then you will feel better." Overall, the developers did not raise any issues regarding this theme and hence no modifications were made.

### Self-Management

One of the developers said, "The points are quite clear, and I like the idea of adding the visualization because obviously they can clearly see the trends." Another developer stated, "I think this is important. The logbook will help users check their progress, and the visualization would give users a straightforward impression on their progress." The concepts contained in this theme were familiar to many of the developers, as some of them expressed that they have applied many of its elements in developing projects that they have worked on previously. No clarification was required for this theme, and hence the content of the guidelines has not been changed.

Finally, at the end of each focus group session developers were presented with the snapshots of a nongamified self-management app for diabetes, and they were asked if they could use the guidelines to suggest ways to implement gamification in this app. It was noted that developers were confident that the guidelines would enable them to transform a nongamified app into a gamified one. This includes those developers who had some misconceptions on some of the elements (before being clarified by the interviewer).

# Discussion

## Principal Findings

The use of gamification for health care purposes presents a tool that could enhance patient self-care [6,24,25]. Gamification could be thought of as a motivation tool and incorporates a number of behavioral change methods [5,26,27]. In the context of self-management of chronic illnesses, gamification could turn daily tasks of self-managing the illness into a rewarding and engaging activity [25]. However, as mentioned in the introduction, there is a shortage in developer guidelines. Current implementations of gamification in health care do not follow any specific guidelines [1]. Hence, this work fills the gap by providing a set of guidelines for developers.

This paper provides a set of guidelines for developers to gamify the self-management of chronic illnesses. The guidelines are based on the 8 themes of the Wheel of Sukr framework along with their elements [21,22]. The results from both studies, the expert interviews, and the developer focus group sessions show that the guidelines are clear, usable, easy to implement, and reflect the Wheel of Sukr. Specifically, the expert interviews ensure that the content of the guidelines reflect the framework and are comprehensive and sound. On the other hand, the focus group sessions with developers show the opinion of the end user of the guidelines (the developers) on the clarity, usefulness, and ease of implementation of the guidelines. After the expert interviews were conducted, the data were analyzed, and the guidelines were updated according to the findings. Subsequently, the guidelines were discussed in focus groups with developers, and the guidelines received a final update according to those findings.

The in-depth discussions with experts from academia in the fields of game and app design and user experience indicated that the guidelines cover adequate information. They also noted that the guidelines would be useful for developers of self-management apps. Moreover, the experts discussed the importance of the elements in the guidelines for users (specifically, the community aspect and how it can provide peer support and the flow and ability element where the different abilities of users are taken into consideration while designing the tasks). Furthermore, the focus group sessions with developers showed that the guidelines could be useful in creating gamified self-management apps for chronic illnesses. This was evident when developers were shown a self-management app that does not include gamification elements and they managed to use the guidelines to suggest specific ways to implement gamification in the app.

The methods chosen in this study are expert interviews and focus group sessions with developers. Interviews were chosen to enable in-depth discussion and assessment of the guidelines [28]. The interviewees came from different but relevant backgrounds. This puts them in a position to give vital feedback on the guidelines based on their expertise. Likewise, the input from developers was necessary to ensure that the target group of the guidelines (ie, developers) can comprehend the content of the guidelines and finds them useful and easy to work with. To accommodate the different levels and backgrounds of these developers, a focus group method was most suitable [29]. Indeed, the developers managed to discuss the guidelines among themselves and answer each other's concerns and questions.

There was an agreement from participants in both studies that such guidelines are needed in this area. This is also supported by literature findings, where some researchers argued that current implementations of gamification in health care do not adhere to standard guidelines [3]. Additionally, it was suggested that gamified apps do not reflect the theoretical frameworks and approaches found in literature [1]. In their paper, Seaborn and Fels [1] argue that theoretical work is not studied empirically and the apps and systems that applied some of the theories did not test their validity empirically. However, given that gamification is still considered at an early stage in terms of being applied to the self-management of chronic illnesses, there must be a starting point, and a theoretical framework along with comprehensive guidelines is needed.

In order to find the strengths and weaknesses of the themes and their elements, an empirical study incorporating them within the context of self-managing chronic illnesses must be undertaken. This will help to determine the best practices in gamifying self-management of chronic illnesses (eg, which type of badges and triggers are most effective). This is a subject of a future study to be conducted by the authors.

## Conclusion

This paper presented guidelines for the development of gamified self-management apps and system for chronic illnesses. The Wheel of Sukr framework was translated into a set of guidelines for developers. The guidelines are divided into 5 parts: theme and their corresponding elements (from the Wheel of Sukr), definition, goal, description, and application. The content of the guidelines was discussed in depth with experts from academia using semistructured interviews. The experts had experience in the areas of game development, user experience, and gamification. The findings from the expert interviews suggest that the guideline content is comprehensive and reflects the Wheel of Sukr. Moreover, the experts gave suggestions to enhance the guidelines and those were taken into consideration to update the guidelines. After that, the updated version of the guidelines was discussed with developers in focus group interview sessions to ensure the clarity, usefulness, and ease of implementation. The findings of the focus group interviews show that there is an overwhelming agreement between developers that the guidelines are useful, easy to implement, clear, and can be applied to create self-management gamification apps.

On light of our findings, we believe that the Wheel of Sukr guidelines are ready to be tested practically in the creation of apps for the target patients. In fact, in a future study we aim to design such an app and test it on patients using a longitudinal method.

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## Authors' Contributions

AA proposed the guidelines, conducted the interviews, analyzed the data, and wrote the first draft of the manuscript. GW and AR provided guidance, critical feedback, suggestions to the overall study and participated in editing the manuscript.

## Conflicts of Interest

None declared.

## Multimedia Appendix 1

The Wheel of Sukr Guidelines.

[PDF File (Adobe PDF File), 107KB - games_v5i2e12_app1.pdf ]

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Original Paper

# Medical Student Evaluation With a Serious Game Compared to Multiple Choice Questions Assessment

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## Abstract

**Background:** The gold standard for evaluating medical students' knowledge is by multiple choice question (MCQs) tests: an objective and effective means of restituting book-based knowledge. However, concerns have been raised regarding their effectiveness to evaluate global medical skills. Furthermore, MCQs of unequal difficulty can generate frustration and may also lead to a sizable proportion of close results with low score variability. Serious games (SG) have recently been introduced to better evaluate students' medical skills.

**Objectives:** The study aimed to compare MCQs with SG for medical student evaluation.

**Methods:** We designed a cross-over randomized study including volunteer medical students from two medical schools in Paris (France) from January to September 2016. The students were randomized into two groups and evaluated either by the SG first and then the MCQs, or vice-versa, for a cardiology clinical case. The primary endpoint was score variability evaluated by variance comparison. Secondary endpoints were differences in and correlation between the MCQ and SG results, and student satisfaction.

**Results:** A total of 68 medical students were included. The score variability was significantly higher in the SG group ($\sigma^2$ =265.4) than the MCQs group ($\sigma^2$=140.2; *P*=.009). The mean score was significantly lower for the SG than the MCQs at 66.1 (SD 16.3) and 75.7 (SD 11.8) points out of 100, respectively (*P*<.001). No correlation was found between the two test results ($R^2$=0.04, *P*=.58). The self-reported satisfaction was significantly higher for SG (*P*<.001).

**Conclusions:** Our study suggests that SGs are more effective in terms of score variability than MCQs. In addition, they are associated with a higher student satisfaction rate. SGs could represent a new evaluation modality for medical students.

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**KEYWORDS**

serious game; multiple choice questions; medical student; student evaluation

## Introduction

Student evaluation is one of the most important components of a medical educational program and is used for training and for validating degrees and career options. If handled well, it can improve student motivation for learning and provide educators useful feedback. Medical education cannot be limited to book-based knowledge which is defined as the ability to provide an answer from medical literature [1,2]. It also comprises developing medical skills such as the ability to act to obtain medical data and provide good care to patients [3]. Therefore, given the importance of questioning and the deductive process required to reach the right diagnosis and prescribe the right treatment, proper evaluation modalities are needed based on both book-based knowledge and diagnostic skills. High score variability, defined as the highest score in points obtained between students, is also mandatory to allow representative classification and fair career access based on test results in large student populations. On the other hand, the evaluation modality should also allow for an objective, fast, and inexpensive correction. As such, multiple choice questions (MCQs) are currently the most frequently used modality. Medical serious games (SG), based on virtual reality, are emerging as an alternative way of evaluating medical education [4]. However, they have not yet been evaluated in terms of score variability. In this study, we sought to evaluate medical students' test results with an SG compared with MCQs in terms of score variability, score difference, correlation between scores in MCQs and SG, student satisfaction, and finally whether SGs could be of use to learn and evaluate medical skills for medical students.

## Methods

### Study Design

From January to September 2016, we included all volunteer medical students with previous cardiology validation in two medical schools (University Paris Descartes, Paris, France and University Denis Diderot, Paris, France). Students were randomized in a cross-over design between two groups to avoid order bias. Group 1 started with evaluation by SG and finished with evaluation by MCQs and group 2 performed alternatively. The tests were performed in the examination centers of both medical schools. Both tests lasted 30 minutes and the tests were performed consecutively. The study was approved by the educational committee of both institutions. All students gave their informed consent before inclusion.

### Serious Game

We used a clinical case from an SG (Medusims, Paris, France and iLUMENS, Medical Simulation Department, Université Sorbonne Paris Cité, Paris, France). The SG focuses on the management of atrial fibrillation. It represents a cardiologist and a patient within a free tridimensional (3D) environment within a medical office, and is available on computers and tablets (Figure 1). Students play the role of the cardiologist and ask the patients questions using key words, perform a complete clinical examination with electrocardiogram, and require the prescription of additional tests and medical treatment. Points are awarded if the student asks the patient a correct question or performs the appropriate physical examination. There are no negative points due to wrong answers. Besides the free conduct of the clinical questioning, pop-up questions also arise in the SG during electrocardiogram interpretation, risk score calculation and the potential medical treatment in form of MCQs. Points are also awarded for correct answers to these pop-up questions. An automatic and precise correction is given to the student at the end of the game. Results are expressed out of a total of 100 points divided into four subcategories: clinical examination out of 25 points, diagnosis out of 25, risk score calculation out of 30 and medical decision out of 20 (Figure 1).

**Figure 1.** Serious game illustration (in French).

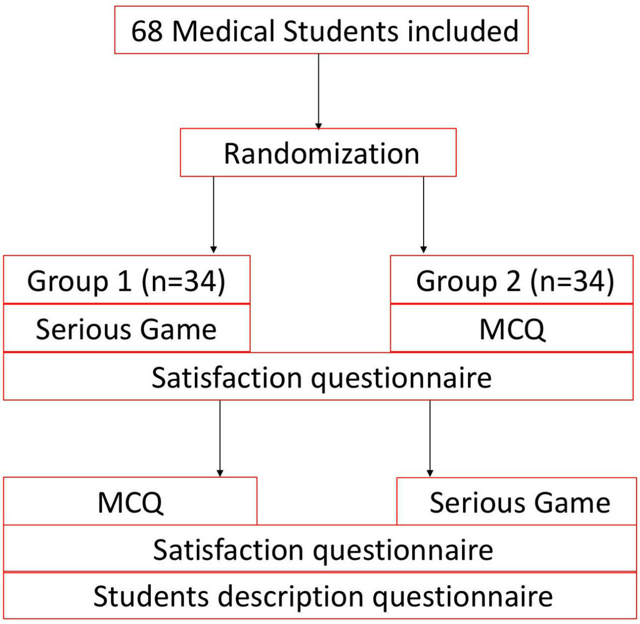

## Multiple Choice Questions

We built an online MCQ test of 15 questions based on the SG clinical case with the same clinical and electrographic presentation. Each MCQ presented five possible answers. The student scored full points if all the selected answers were correct, 50% if one answer was incorrect, and 20% if two answers were incorrect. No points were awarded if three or more answers were incorrect. The correction was aligned to the SG correction giving a final score out of 100 points. A translated version of the MCQ test is available in the Multimedia Appendix 1.

## Satisfaction and Student Description Questionnaires

Questionnaires to record student characteristics and satisfaction were designed by a psychologist from the Medical Simulation Department of University Paris Descartes (iLUMENS, Paris, France). The student satisfaction questionnaire was filled in immediately after each evaluation using website. The student characteristics questionnaire was filled in online at the end of the study protocol to assess the medical degree and whether the student played video games regularly at the time of the study (gamers) or not (non-gamers; Figure 2).

**Figure 2.** Flowchart.



### Objectives and Endpoints

The primary objective of the study was to compare the students' scores at the MCQs and SG tests. The related primary endpoint was therefore the score variability calculated as a variance for each test. The secondary endpoints were student satisfaction with semiquantitative questions expressed from 0 (no, not at all) to 5 (yes, entirely) and the correlation between the test results. Subgroup analysis was performed for SG results between gamers and non-gamers.

### Statistical Analysis

Summary descriptive statistics are reported as mean and standard deviation, median (inter quartile range), or counts (%), as appropriate. We used the *t* test and Mann-Whitney test to evaluate the difference of continuous variables as appropriate. Fisher exact test was used for variance comparison. For score differences, the paired *t* test was used. Finally, the correlation coefficient was calculated between the results of SG and MCQs using the Pearson $R^2$ correlation test. All analyses were performed with SPSS 21.0 (IBM Inc), R 3.3.1 (R Project for Statistical Computing) and Prism GraphPad 7.0 (GraphPad Software Inc).

## Results

### Main Student Characteristics

A total of 68 medical students were included (34 in each group), of which 29 were male (43%) and the mean age was 23(SD 1) years. Students were in their 5th [4-6] year of medical school. All the students owned a cellphone and a personal computer, and subscribed to an Internet connection; 31 (46%) owned a tablet and 21 (31%) a video game console. A past experience of video games was reported by 60 (88%) of students and 22 (32%) were currently playing video games for an average duration of 1.6(SD 3.0) hours per week. The main characteristics of the population according to the allocated group of randomization are detailed in Table 1. There were no significant differences in student characteristics between groups 1 and 2.

**Table 1.** Student characteristics.

| Student description<br>N=68 | Overall | Group 1<br>n=34 | Group 2<br>n=34 | Comparison between groups 1 and 2 (*P* value) |
|---|---|---|---|---|
| Sex (male), n (%) | 29 (43) | 17 (50) | 12 (35) | .22 |
| Age in years, mean (SD) | 23 (1) | 23 (1) | 23 (1) | .26 |
| Year of medical school, mean (SD) | 4.7 (1.0) | 4.7 (0.8) | 5.1 (0.9) | .08 |
| Cardiology internship within the past 12 months, n (%) | 34 (50) | 16 (47) | 18 (53) | .74 |
| Owns a cell phone with Internet connection and social network account, n (%) | 67 (99) | 33 (97) | 34 (100) | >.99 |
| Owns a tablet, n (%) | 31 (46) | 13 (39) | 18 (54) | .20 |
| Owns a computer with Internet connection possession, n (%) | 68 (100) | 34 (100) | 34 (100) | >.99 |
| Owns a video game console, n (%) | 21 (31) | 14 (42) | 7 (20) | .07 |
| Past video game experience, n (%) | 60 (88) | 28 (83) | 32 (94) | .26 |
| Age in years at first video game experience, mean (SD) | 9 (3) | 9 (3) | 9 (3) | .51 |
| Currently playing video games, n (%) | 22 (32) | 14 (40) | 8 (26) | .31 |
| Hours of video game per week, mean (SD) | 1.6 (3.0) | 1.9 (3.7) | 1.3 (2.1) | .65 |

### Test Results

The score variability expressed as variance of the students' results was significantly higher in the SG group ($\sigma^2$=265.4) compared with MCQs group ($\sigma^2$=140.2; *P*=.009), as illustrated in Figure 3. The overall results for each test were significantly lower for SG (mean 66.1, SD 16.3 points) compared with MCQs (mean 75.7, SD 11.8 points; *P*<.001). For both the SG and MCQs, the results were better when the student had already performed the other test before: 62.0 (SD 15.2) points for the SG when it was performed first versus 70.2 (SD 16.5) points when performed second (*P*=.02); 67.4 (SD 8.9) points for the MCQs when it was performed first versus 83.9 (SD 8.1) points when performed second (*P*<.001). No correlation was found between the results of the two tests: $R^2$=0.048 (*P*=.58; Figure 4). No significant difference was observed between gamers (22/68; 32%) and non-gamers (46/68; 68%) for SG results, respectively 65.8 (SD 13.3) versus 66.2 (SD 17.4) points (*P*=.71).

**Figure 3.** Result’s histogram.

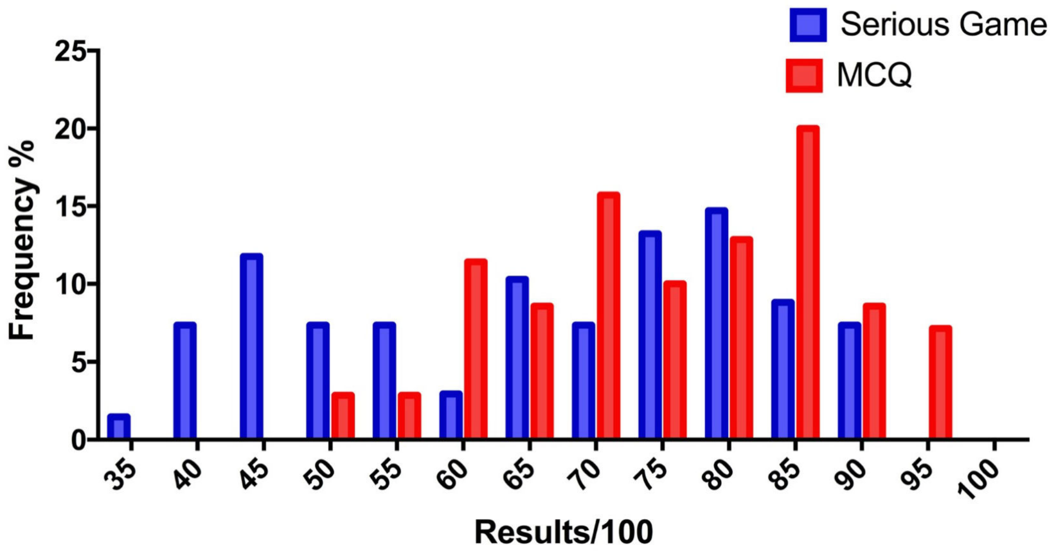



**Figure 4.** Individual test results in the left panel (A) and correlation coefficient in the right panel (B).

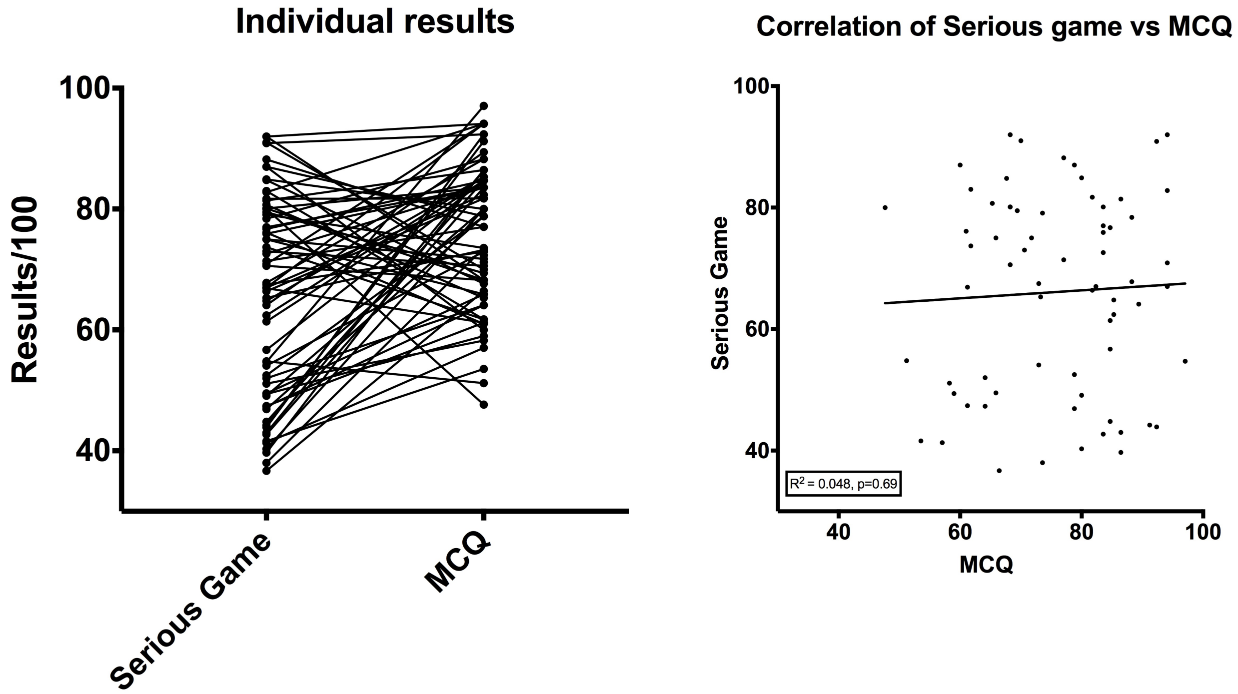


**Table 2.** Satisfaction questionnaire: results are expressed as mean (SD) of numeric ordinal variable from 1 (no, not at all) to 5 (yes, entirely).

| Questions | Serious game | Multiple choice questions | *P* value |
|---|---|---|---|
| Did you encounter difficulties to answer the questions? | 2.18 (1.14) | 2.21 (1.14) | .89 |
| Were you able to concentrate while answering the questions? | 3.93 (0.99) | 3.71 (1.06) | .15 |
| Do you think that this test is close to clinical reality? | 4.21 (0.75) | 2.68 (0.88) | <.001 |
| Did you find this test stressful? | 2.51 (1.05) | 2.30 (1.17) | .24 |
| Did you understand the goal of the test? | 4.24 (0.75) | 3.97 (0.94) | .10 |
| Do you consider that this kind of test represents a proper evaluation? | 3.91 (0.87) | 3.04 (1.02) | <.001 |
| Are you satisfied with your test performance? | 3.05 (1.09) | 3.22 (0.98) | .41 |
| Did you think that your knowledge progressed after this test? | 3.56 (1.09) | 2.42 (0.99) | <.001 |
| Are you satisfied with this type of evaluation? | 3.88 (1.42) | 2.98 (1.53) | <.001 |

**Table 3.** Assessment of serious games as a tool to learn medicine. Results are expressed as mean (SD) of numeric ordinal variable from 1 (no, not at all) to 5 (yes, entirely).

| Assessment of serious games as a tool to learn medicine | Serious game |
|---|---|
| Educational quality | 4.86 (0.35) |
| Feeling of connection or attachment to the serious game | 3.60 (1.19) |
| Possibility of playing with other students | 3.26 (1.18) |
| Possibility of comparing results with other students | 3.44 (1.33) |
| Fun | 3.37 (1.16) |
| Original, innovative or new | 3.90 (0.98) |
| Possibility to adapt level of difficulty | 4.36 (0.68) |
| Availability on smartphone | 4.00 (1.07) |

### Satisfaction Analysis

The satisfaction questionnaires showed a significantly higher overall self-reported satisfaction for the SG compared with the MCQ test. Students reported that the SG was closer to clinical practice, represented a proper evaluation and that they felt to have learned more with the SG than with MCQs, thus representing a better evaluation modality (*P*<.001 for all). Conversely, students did not experience significant differences between the two test modalities in terms of understanding, answering the questions, performance satisfaction or stress generated by the test (*P* value non-significant for all; Table 2).

### Serious Games as a Tool to Learn and Evaluate Medical Skills

The questionnaire was also designed to evaluate whether students thought that SGs could be an interesting tool to learn and evaluate medical skills. Most of the students thought that it could be. The highest ranking points (>4) were educational quality, the possibility of adapting the level of difficulty of an SG and the availability on smart phone (Table 3).

## Discussion

### Principal Findings

This study is the first to compare an SG to MCQs in terms of score variability for medical students. This study demonstrates that the SG was associated with a higher score variability and lower mean score compared with MCQs. Moreover, the SG was associated with significantly higher student satisfaction compared with MCQs. Most medical student evaluation to date is based on MCQ tests which are performed on a large student population. Student grading might therefore be difficult with a sizable proportion of students scoring the same and limited score variability between them. We believe that tests evaluating a large population of medical students should include overall results variability and be of high student satisfaction. For these reasons, we sought to evaluate medical students with a simulation based on an SG compared to MCQs. MCQs evaluate medical knowledge by the means of closed questions, but medical skills and competence are better assessed by on site (bedside) evaluation or simulation [5-8]. While the lines between SGs and simulations are somewhat blurred, an SG represents a virtual world. It is generally played alone with completion based on a score while a simulation is performed on site with an instructor or in a group without score. Several studies have reported higher student satisfaction with simulation compared to MCQs [9,10]. SGs have several potential advantages over simulations to evaluate medical students. Simulation programs are expensive and time-consuming which limits access. Although production of medical SGs is expensive, once the 3D environments have been created it is less expensive to build new SGs using the same environment. Furthermore, they can be easily shared throughout a large medical student community.

SGs also increase the realism of clinical situations [11] and evaluate both medical knowledge and competences via simulation and unguided actions in a 3D environment [12]. Importantly, we believe that SGs exemplify the human desire to play and to master challenges. Besides their potential use as an evaluation tool, SGs might also be an interesting way to train and to teach medicine. The student is drawn "into the game" making medical knowledge and skills more easily transmitted and retained. This use of SGs as a learning tool is supported by our study: students gave a high score for the educational quality of SGs. They particularly appreciated the possibility of accessing SGs with their smartphone and the personalized difficulty feature Finally, SGs also offer the advantage of self-assessment.

Medical education encompasses both medical knowledge and reasoning skills. Although it is simple to develop MCQs to test medical knowledge, it becomes much more challenging to evaluate reasoning skills and global medical skills with MCQs. Interestingly, our study did not find any correlation between the two sets of test results, suggesting that success in MCQs does not predict success in SGs and vice versa. This finding might suggest that good results in an SG are different from pure medical knowledge evaluation and that medical skills might increase result variability since the medical knowledge tested were similar in both tests. If SGs are considered to be closer to medical practice, this finding questions the effectiveness of MCQs in evaluating medical students [10,13]. This finding possibly suggests that the tests evaluate different reasoning skills and abilities to perform.

We acknowledge several limitations in our study. Our study compared two different test modalities evaluating a relatively small number of medical students in managing a cardiology clinical case. Therefore, further studies are needed to confirm our findings in larger student populations and in other medical fields. Although we found an order bias in our study—the second test was associated with better results because of similar questions, retention of the students' answers, and indirect access to the corrections—we believe that randomization in two similar groups allowed us to draw reliable conclusions. As specific questionnaires were designed for this study, no pretest was conducted. Nevertheless, we believe that the questionnaires are valid, since each student acted as is his own control in this study, interpreting the questions in the same way when evaluating two different test modalities. Finally, our sample consisted of volunteer students and we cannot rule out the fact that they might have a particular interest in SGs. This might also limit the generalization of our conclusions to the whole population of medical students.

## Conclusions

SGs potentially represent a new evaluation modality for medical students. Our study suggests that they are more effective in grading medical students with a higher variability of performance. In addition, SGs seem to be associated with higher student satisfaction compared to MCQs.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## Conflicts of Interest

None declared.


## Multimedia Appendix 1

Multiple choice questions test translated in English.

[PDF File (Adobe PDF File), 256KB - games_v5i2e11_app1.pdf ]

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## Abbreviations

**MCQs:** Multiple choice questions
**SG:** Serious games
**SD:** Standard Deviation

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Original Paper

# Gamification in Stress Management Apps: A Critical App Review

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## Abstract

**Background:** In today's society, stress is more and more often a cause of disease. This makes stress management an important target of behavior change programs. Gamification has been suggested as one way to support health behavior change. However, it remains unclear to which extend available gamification techniques are integrated in stress management apps, and if their occurrence is linked to the use of elements from behavior change theory.

**Objective:** The aim of this study was to investigate the use of gamification techniques in stress management apps and the cooccurrence of these techniques with evidence-based stress management methods and behavior change techniques.

**Methods:** A total of 62 stress management apps from the Google Play Store were reviewed on their inclusion of 17 gamification techniques, 15 stress management methods, and 26 behavior change techniques. For this purpose, an extended taxonomy of gamification techniques was constructed and applied by 2 trained, independent raters.

**Results:** Interrater-reliability was high, with agreement coefficient (AC)=.97. Results show an average of 0.5 gamification techniques for the tested apps and reveal no correlations between the use of gamification techniques and behavior change techniques ($r$=.17, $P$=.20), or stress management methods ($r$=.14, $P$=.26).

**Conclusions:** This leads to the conclusion that designers of stress management apps do not use gamification techniques to influence the user's behaviors and reactions. Moreover, app designers do not exploit the potential of combining gamification techniques with behavior change theory.

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**KEYWORDS**

game element; mHealth, motivation; app; behavior change; gamification

## Introduction

In today's society, many people suffer from chronic exposure to stress [1], which is known to be related to mental as well as physical health problems (eg, depression, cardiovascular, and gastrointestinal diseases) [2]. In fact, the American Psychological Association reported both an increase in health problems caused by stress [3] and the experience of stress symptoms in three quarters of the American population [4].

A person's well-being, however, does not solely depend on his or her exposure to stress, but also on the way he or she copes with stress [5]. Coping techniques aim at the reduction, tolerance, or elimination of stress and stress triggers [6]. These techniques are normally taught in single therapy or group interventions. In comparison with this conventional treatment, smartphone apps designed for stress management have been suggested to facilitate considerable financial savings in health care [7]. They also allow users to complete the training in a time and place convenient to them [8]. This idea follows the recent mobile health (mHealth) trend. It aims to help people improve their health through mobile technologies [9] by affecting the user's education, motivation, and adherence [10,11]. mHealth is already being applied to support mental as well as physical health programs [12] and is met with broad acceptance [13].

Stress management apps, like all behavior change programs, must be based on evidence-based content from behavior change theory, such as behavior change techniques [14] and stress management methods [15] to ensure effectiveness [9,16,17] through long-term behavior change [18]. While important, the use of evidence-based content alone has been considered as insufficient to ensure adequate user engagement and motivation [19]. However, both of these aspects have a great influence on an individual's exposure to an intervention program [20]. Since exposure rates are directly linked to effectiveness [19], the integration of gamification techniques in order to increase motivation and engagement in behavior change contexts is an important research topic.

Gamification, that is, the use of game elements in nongame contexts, is aimed at making interventions (including mobile apps for behavior change) more enjoyable, motivating, and engaging [21]. As a result, this approach could pose a possible solution to the lack of motivation to follow self-management procedures and to care for oneself, which are often observed in health-related contexts and chronic illnesses [22]. In view of these possibilities, gamification has been suggested to positively influence user behavior and lifestyle [23]. Moreover, it offers a way to provide the user with a feeling of empowerment regarding health-related content and can create a new type of interaction between the user and the app content [24].

Indeed, gamification has already been suggested to positively influence user self-management [22,25]. Moreover, it proved to have positive effects on health and behavioral outcomes [24] and the retention of desired user behaviors [26]. These positive effects are most likely the result of comprehensive motivational support and invoking flow experiences [27,28]. Gamification also helps to make the user feel represented and in control [22] by adjusting techniques to the user's motives [27] and abilities [29]. Invoking user motivation through gamification in this manner is an important way to keep the user's interest [30] and, thus, to increase his or her exposure to the evidence-based content [18].

In fact, it could already be shown that the implementation of gamification in form of rewards for diabetes patients [31] and combinations of gamification techniques for weight management in children can be effective in promoting behavior change through apps [32]. This is further supported by Hamari [33], who showed that the use of gamification techniques can, indeed, increase the use of a service.

Regardless of these facts, gamification in the context of health and wellness [34] as well as the use of gamification aspects in apps targeting health behavior change has only been rarely investigated so far. Mendiola et al [35] investigated the use of gamification (defined as the use of badges, points, and levels) in 234 health apps and found that only 11.5% of the reviewed apps made use of gamification. In contrast to this finding, a study by Schoffman et al [36] classified 57 apps aimed at pediatric weight loss, healthy eating, and physical activity with regard to being a game. They found that 56% of the apps included in their sample matched their criteria for a game. A third study by Payne and colleagues [37] reviewed 52 physical activity game apps with respect to 10 gamification aspects and found that all of the reviewed apps included at least one gamification technique. Moreover, their study found no correlation between the investigated gamification techniques and health behavior theory constructs [37]. In a fourth study, Lister and colleagues [38] reviewed 132 apps from the Apple iTunes Store aimed at health and fitness with regards to their inclusion of 13 behavior change techniques, 6 gamification techniques, and 10 game elements. They revealed a correlation of gamification techniques with both game elements and the evidence-based content, whereas the use of game elements was also correlated with app popularity.

Interestingly, the association between gamification techniques found by Lister and colleagues was only due to the motivational behavior change aspects, namely, social support, providing incentive, goal setting, cognitive strategies, and self-efficacy. Regarding the use of theoretical content, the authors concluded that these apps were greatly lacking in all three categories (behavior change techniques, gamification techniques, and game elements). These findings are in accordance with the assertion that the development of health apps is currently lacking efficient and selective implementation of gamification [39]. Whereas the same might be assumed with regards to stress management apps, the implementation of gamification techniques in the context of stress management has only been studied with respect to the distinction between extrinsically and intrinsically motivating aspects [40]. However, the use of specific gamification techniques has so far never been studied in the context of stress management.

According to the mechanics, dynamics, and aesthetics (MDA) model of Hunicke at al [41], three levels of a gamified experience can be distinguished. The first level, mechanics, refers to the implementation of gamification techniques. As such, this level is immediately visible to the user and can be directly influenced by the designers of an app. Moreover, this level of gamification implementation has great impact on the user's behavior and reactions [41]. The second and third stages are dynamics and aesthetics. In contrast to the first level, these levels can only be influenced by app designers in an indirect way. Both, dynamics and aesthetics, refer to the effects that the use of gamification techniques has on the user [41]. Whereas it is important to determine the effects and reactions a gamified experience causes, it first needs to be investigated whether app designers even make use of gamification techniques. For this reason, an expert review of apps available in the Google Play Store was conducted in order to investigate whether app designers try to influence user behavior through the integration of gamification in the context of stress management.

For this purpose, an extended taxonomy of gamification techniques was developed. As no universal list of game elements exists, a list of features that are found in most but not necessarily in all games [42] was collected. In a first step, this list was based on a publication by Lister and colleagues [38], who identified a total of 6 gamification techniques. Their study distinguished between game elements and gamification. Based on the definition of gamification as the use of game design elements in nongame contexts [42], this study did not differentiate between gamification techniques and game elements. As a result, the taxonomy was further extended. In the second step, a literature search for a list of elements that are characteristic to games was conducted. This search was based on the more general search terms gamification, gamification techniques, and game elements. It resulted in a list of common gamification techniques by Reeves and Read [43], which were added to the taxonomy. In the next step, two more items, “agent” and “secondary game objectives” that were found during the literature research were added. “Agents” have been used in health [44,45], learning-related [46], and behavior change [47-49] contexts for some time now. “Secondary game objectives” have been described as a fundamental element of game design [50]. Examples for the application of this gamification technique include, “World of Warcraft’s” crafting system, “Cut the Rope’s” option for star collection, and “Pirates!” choice to challenge other captains [51]. After establishing a list of common gamification techniques, a literature search was conducted with the specific names of the identified gamification techniques. The purpose of this specific search was to provide item definitions that are common and easy to understand. This strategy resulted in a taxonomy of 17 gamification techniques and their accompanying definitions (see Table 1).

In the last step, all 17 gamification techniques were assigned to one of four categories: economic, social, performance-oriented, or embedding-focused. Economic gamification techniques include economical aspects such as “rewards” [52], which are frequently used in interventions [53], and “economies” [43], that mirror those of the real world. Social gamification techniques have a primary focus on social aspects and, thus, provide social interaction for the user with virtual characters as well as techniques that supply the opportunity for social interaction with other users. Examples for social gamification techniques include “avatars” and “teams” [43]. Performance-oriented gamification techniques such as “leaderboards” [42] and “feedback” [43] offer information on the user’s performance, either in comparison to his or her own previous performance or to the performance of other users, or without direct comparison. Embedding-focused gamification techniques are aimed at the environmental setting and include “three-dimensional (3-D) environments” and “narrative context” [43]. The consequent coding manual in Table 1 provides all investigated gamification techniques ordered by category as well as exact definitions to ensure interrater-reliability.

In addition to the number of used gamification techniques, this study also examined the correlation between gamification and the evidence-based content as presented by Christmann and colleagues [54]. They investigated the use of effective behavior change techniques based on a taxonomy provided by Abraham and Michie [14] and emotion-focused stress management methods in the same body of apps as this study.

This study was the first to investigate the use of gamification techniques in apps aimed at stress management. Its goal was to provide important information on whether designers of stress management apps are trying to influence user behavior through the use of gamification.

# Methods

## Study Design

This study investigated the use of gamification techniques in stress management apps available through Google Play. The selected apps were reviewed by 2 trained, independent raters on their inclusion of 17 gamification techniques (see Table 1 in the Methods subsection Evaluation). Further, the apps were reviewed in regard to a number of additional, relevant aspects (eg, connection to social networks, inclusion of advertisement). Their detailed definitions are provided in Table 2 in the Methods subsection Evaluation.

## App Selection

This review included free apps that were available through Google Play. Apps were identified by using the search terms “stress management,” “stress reduction,” and “stress relief.” For each search term, the first 250 apps were examined according to the following inclusion and exclusion criteria.

First, duplicates and apps not found in the categories “health and fitness” or “ medical” were eliminated. With 563 apps being excluded at this stage, 187 apps remained. Their descriptions were reviewed with the constraint that they had to be in English and aimed at stress management, health, or wellness for healthy adults. Thus, apps whose descriptions focused on children, adolescents, and older adults (n=5) were excluded. In addition, apps targeting anxiety, depression, diabetes, insomnia as well as other medical conditions (n=82), addiction (n=2), weight management (n=13), or beauty and cosmetics (n=2) were excluded from this study. The same was done with apps that clearly focused on content other than stress management (n=8) and apps that could only be used with a wearable device (n=2). Therefore, 73 apps were downloaded and assessed for eligibility.

**Table 1.** Taxonomy of 17 gamification techniques.

| Technique | Definition |
|---|---|
| **Economic** | |
| Marketplace and economies [43] | Offering a virtual currency that establishes an economy in which the user may trade, purchase, auction, receive a salary, and so on as he or she would in real life economy. |
| Digital rewards [38,42,52,57,58] | Include, for example, badges (signal status, aesthetic value), game currency, points, and resources or property (experience points, health, houses); virtual goods (objects, food), powers or abilities (increase as the player progresses), add to record of achievements and validation (marks of approval from others). |
| Real world prizes [38,52] | Include, for example, deals or discounts (similar to a loyalty program), financial prizes (cash prize, voucher), goods or services (tote bag, free massage, car, parking spaces, health savings account contributions, insurance contributions), time (time saved, vacation or time off), and lottery or draw or bet for any of the above. |
| **Social** | |
| Avatar [43] | Ability to represent oneself through a virtual character within the media and excerpt precise control over that representation. |
| Agent [45,46,59,60] | A virtual character that does not represent oneself and provides instructions or support (eg, social support). |
| Competition [38,43] | Competition with other players or between teams to achieve new levels, ranks, reputations through winning challenges, selling digital rewards, building spaces, creating materials, and so on, that are restricted by rules, which are either provided by the program, or user-generated and apply to everyone. |
| Teams [43,52] | Program involves multiple players, who interact and form relationships that allow for collaborative achievements (eg, guilds, multiplayer modes). |
| Parallel communication systems [43] | Allow for interaction with other players via different channels (eg, private, public) through headsets, text, email, and so on within the application. |
| Social pressure [38,52,57,61] | Competitions within or between teams that give the user the feeling he or she has to take part in events (eg, a quest) in order to avoid social consequences. The user is pressured to perform in order to be invited to a further raid or quest or event; feels he or she is needed and, therefore, does not want to let other users down. |
| **Performance-oriented** | |
| Feedback [14,43] | Text or spoken language, visual or auditory feedback that is either temporary or constant and evaluates the user's performance in relation to a set standard or other's performance. |
| Levels [38,43,62] | Levels provide information on the stage of the game. Usually a specific number of points or experience is required in order to reach the next level. New levels can be shown through, for example, differences in optical design, rise in rewards, and increase in difficulty. |
| Secondary game objectives [42,50,51] | Optional aspects or layers or challenges or secondary goals of play (find as many treasures vs complete as soon as possible) that reward the player upon completion or simply exist for their own sake. |
| Ranks of achievement [43,52,62] | Measurement of character development with regards to position and value of a player or player's avatar in the program community. |
| Leaderboards [38,42,57,58,62] | The purpose of a leaderboard is to make simple comparisons by displaying players at the same or different levels, ranked by proximity and recency to oneself. They can be based on player feedback, scores, and promotion. |
| Time pressure [42,43] | Time limits set for completion of tasks or the duration of the usability of specific skills, occurrences, and objects (excluding countdowns on videos and audios). |
| **Embedding-focused** | |
| Narrative context [43,58] | Back stories that guide the action and help to organize character roles, rewards, and group action. |
| 3-D[a] environments [43] | Rendering 3-D graphical models of physical properties that parallel those in the real world, on a 2-dimensional screen. |

[a]3-D: three-dimensional.

**Table 2.** Taxonomy of 8 additional aspects.

| Item | Definition |
|---|---|
| Connection to social network | The app itself provides a connection to a social network (eg, Facebook, Twitter) |
| Advertisement | Pop-up or stationary advertisements are shown within the app |
| Registration or account | Registration is required in order to use the app or some functions of the app |
| Pure e-book[a] | The app consists only of text that may or may not be divided into different chapters |
| Test version | Payment or download of a full version is necessary to receive access to some features of the app |
| Internet connection necessary | The app only opens when an Internet connection is available |
| External links to other websites | Websites are linked in the app, or videos or audios only play with an Internet connection |
| Wearable | The app can also be used with a wearable device |

[a]e-book: electronic book.

Eleven additional apps had to be excluded during the review process. Since the apps were reviewed over a total of 1 month, 3 of the initially selected apps were no longer available at the time of testing. One app had to be excluded during the review process because it could only be used after entering the user's credit card data, whereas another app turned out to be solely focused on fitness aspects without any further indication toward stress reduction. One app consisted only of an external website. Another 4 apps turned out to be only accessible via a membership or company code, whereas yet another app could only be used with a wearable device. A basic outline of the selection process can be found in Figure 1. A more detailed diagram of the app selection process can be found in Christmann et al [54].

Apps that met all inclusion criteria (N=62) were downloaded, installed, and tested by 2 trained, independent raters in October 2015. For this, raters used the device emulator of the development environment Android Studio 1.3 running Android OS 4.4 Android Studio [55]. This approach was not always successful regarding the presentation of some app contents, such as, playing of audio or video, download of data, and display of pages. Therefore, apps for which such problems occurred were subsequently installed on a Nexus S Android smartphone, where both reviewers examined the problematic features.

## Evaluation

As is common procedure [36,56], the apps in this study were reviewed by 2 previously trained, independent raters according to the taxonomy of gamification techniques (Table 1). Reviewer 1 had a background in psychology and reviewer 2 had a background in cognitive science. Both reviewers studied the taxonomy in detail and practiced the evaluation process on approximately 30 apps that had previously been excluded from the study during the selection process. Unclear item descriptions were discussed and revised during this testing phase. This process aimed to ensure a comprehensible and applicable taxonomy. After the training phase was completed, the reviewers went on to review the apps that had met the selection criteria independently from each other.

The reviewing process of this study only included content that was provided by the app itself. Information and features on websites that were linked within the app were not considered. Because all apps allowed the user to progress at his or her own speed, both raters could thoroughly check all features of the apps until it was apparent that no new content was going to be activated. An overall outline of the study procedure is illustrated in Figure 2.

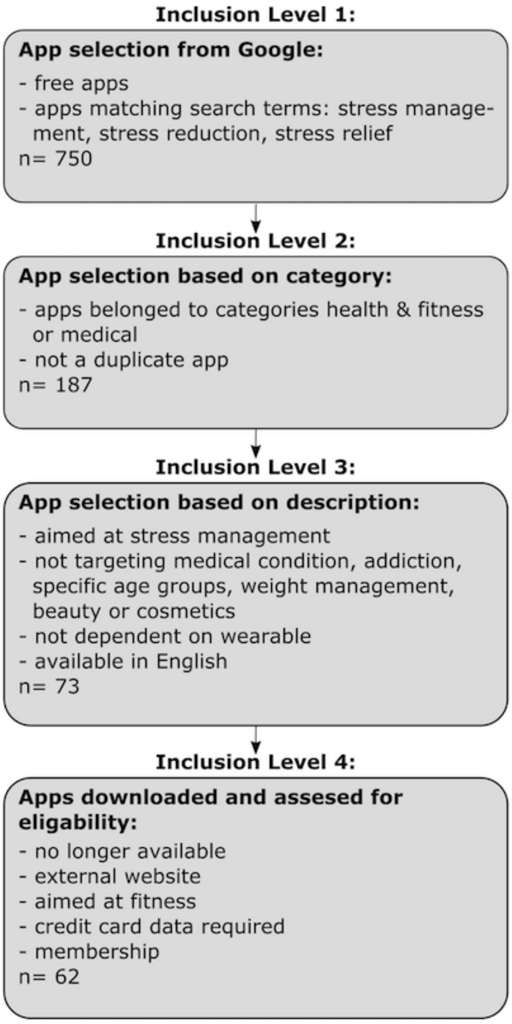
Each app received a score between 0 and 17, representing the number of gamification techniques included in the app. If the raters disagreed on the use of a technique, it was noted as included. Supplementary, it was noted whether an app needed an Internet connection to run, showed advertisements, required registration, had additional features available for payment, used links to external websites, and could be used with wearables (Table 2).

## Analysis

To make sure that the evaluation criteria were applied in a consistent manner by both raters, the interrater reliability was calculated according to Gwet's agreement coefficient (AC) [63]. This study applied Gwet's AC instead of the more often utilized Cohen kappa, because Cohen kappa is only reliable if the trait prevalence is approximately 50% [63,64]. However, this is not the case for this study (the prevalence is very low), making Gwet's AC more reliable in representing the gathered data. Results show a high interrater agreement of AC=.97.

Mean, standard deviation, and range were calculated for the sum of gamification techniques. To determine whether a linear relationship exists between the occurrence of the content from behavior theory and gamification techniques, correlational analyses were performed. For this, the Spearman correlation coefficient r and statistical significance *P* was calculated for the number of gamification techniques and the scores of behavior change techniques as well as for stress management methods in each app [54].

**Figure 1.** Levels and criteria for inclusion of identified apps.




## Results

### Evaluation of Gamification Techniques

The 62 stress management apps included an average of 0.5 (range 0-2) gamification techniques, with a standard deviation of 0.7. The sum score of gamification techniques for each app (presented in Multimedia Appendix 1) reveals that 8 out of 62 apps included a total of 2 techniques, and 12 apps included 1 technique, whereas 42 of the reviewed apps did not include any gamification techniques.

Regarding frequency of use, “feedback” (n=16) was implemented most often, followed by “parallel communication systems” (n=3). In contrast, the aspects “social pressure,” “real world prizes,” “teams,” “competition,” “marketplace and economies,” “ranks of achievement,” “narrative context,” “agents,” and “avatars” were never included (Figure 3). To summarize, the performance-oriented gamification techniques were found most frequently.

**Figure 2.** Outline of the overall study procedure.

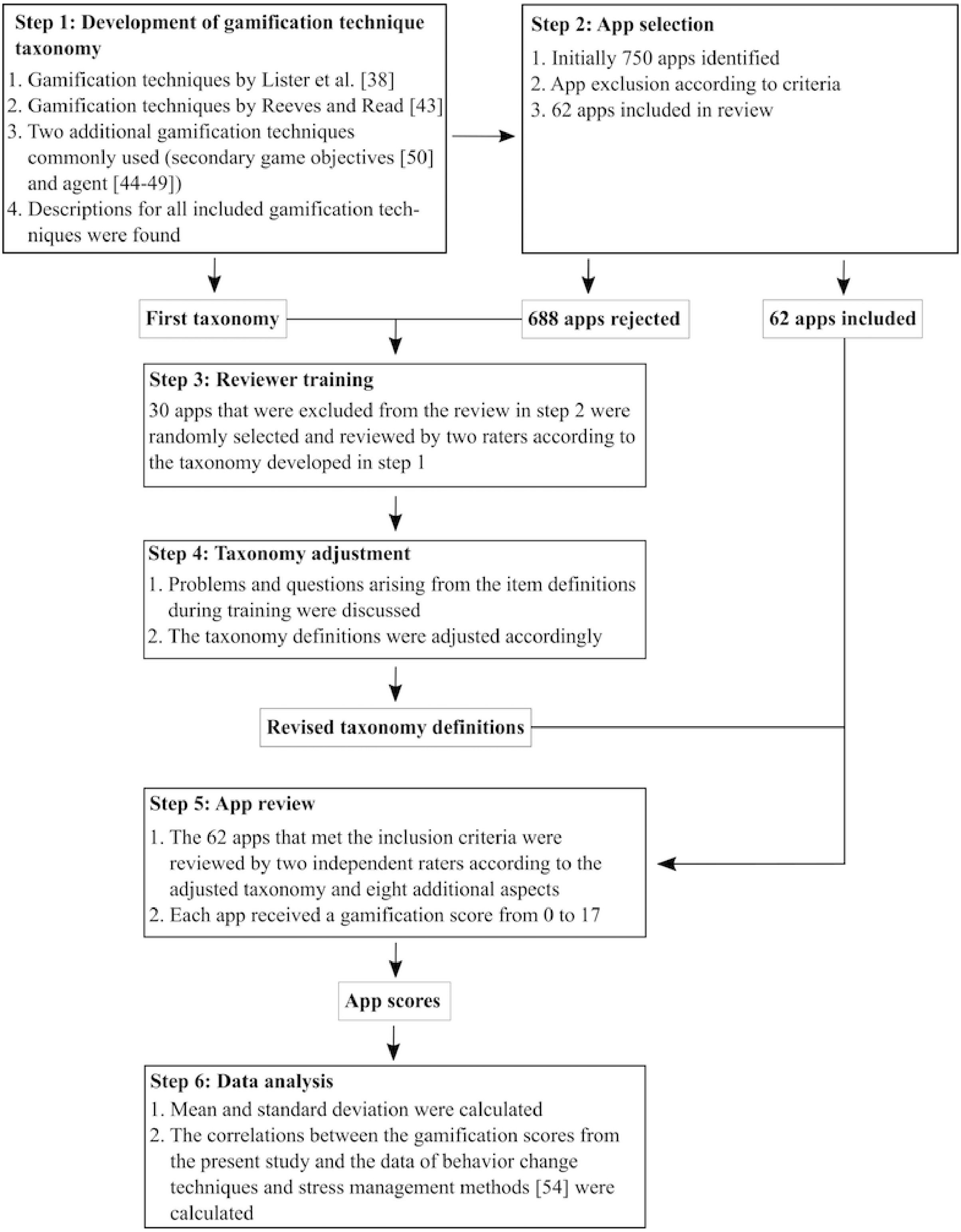
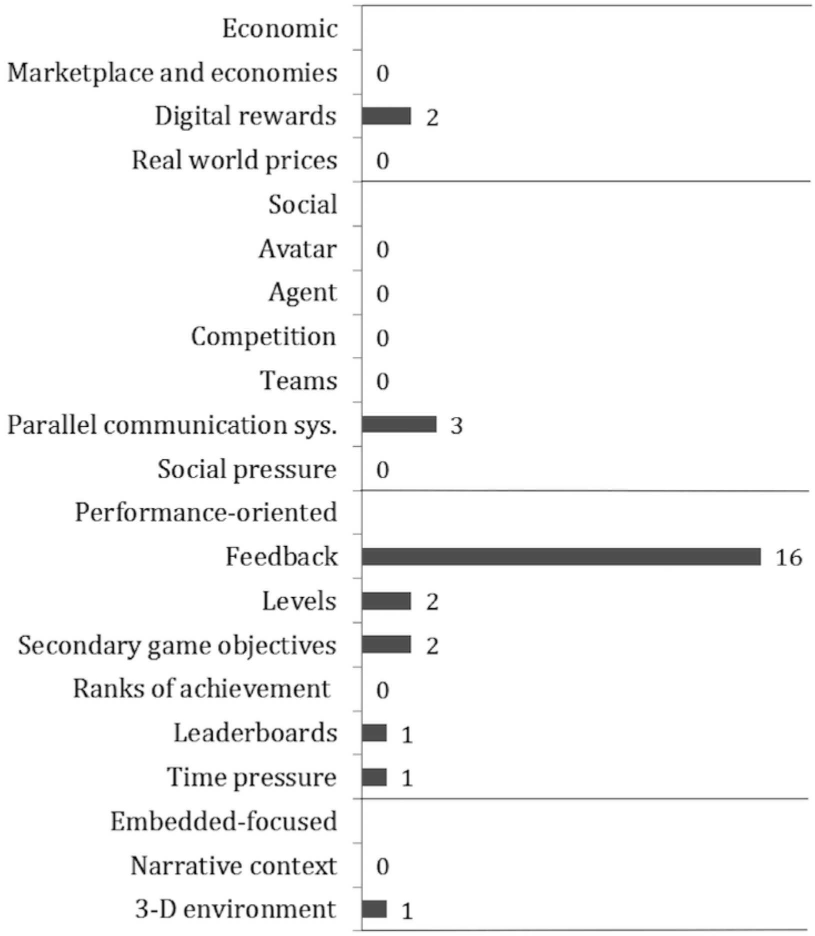


**Figure 3.** Frequencies of the 17 gamification techniques included in the apps. Techniques were scored according to the previously introduced taxonomy of gamification techniques (see Methods subsection Evaluation).



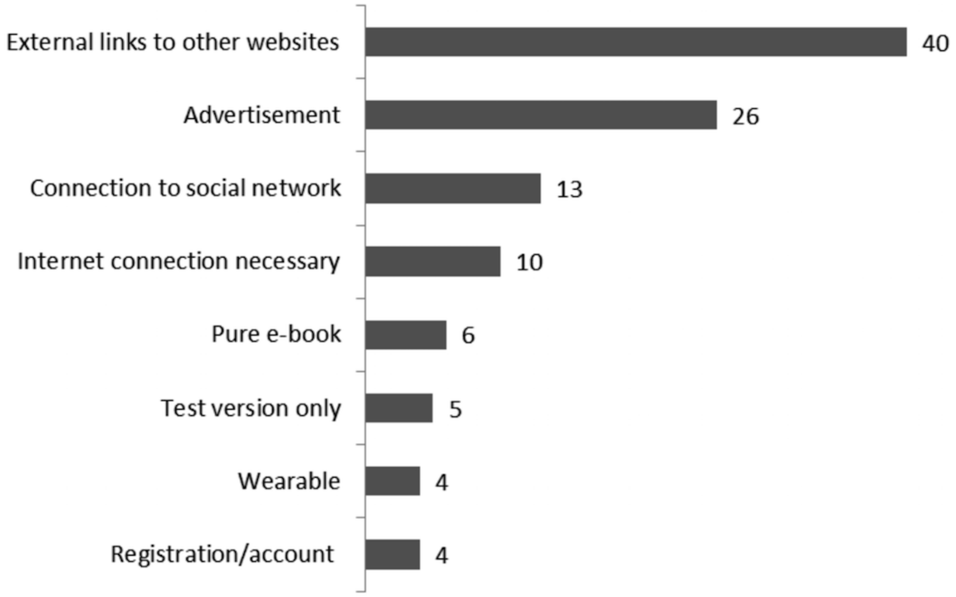

## Evaluation of Additional Aspects

Beside the use of gamification techniques, this study also considered several additional aspects regarding the selected apps. In this context, it has to be emphasized that a considerable number of apps included external links to other websites (n=40), thus utilizing additional sources for features and information. The display of advertisements was found in as many as 26 apps. Thirteen of all reviewed apps required Internet connection. Furthermore, 6 apps only included text content and were, therefore, rated as pure electronic book (e-book). The frequencies of all additional aspects investigated in this review are displayed in Figure 4.

## Correlation Analysis

Since the gamification data was positively skewed ($P \leq .01$), the Spearman correlation was applied to see whether an association existed between the use of gamification techniques and the use of the evidence-based content [54]. “Feedback” was excluded from this analysis as it is a gamification technique as well as a behavior change technique and was included in both taxonomies. The results for the correlation analysis revealed that no significant associations between gamification techniques and behavior change techniques ($r$=.17, $P$=.20) as well as gamification techniques and stress management methods ($r$=.14, $P$=.26) could be found.

**Figure 4.** Frequencies of 8 additional aspects included in apps. Additional aspects were scored according to the previously introduced taxonomy for additional aspects (see Methods subsection Evaluation) and are ranked by the most frequently ones included.




## *Discussion*

### Principal Findings

The goal of this study was to investigate the use of gamification techniques in apps that are aimed at stress management for healthy adults, available for free through Google Play. By conducting an expert review to investigate the use of gamification techniques in a quantitative manner, this study focused on the first level of the MDA framework [41]. The purpose of this approach was to find out whether designers of stress management apps are currently making use of gamification techniques in order to influence the user's behavior. The evaluation was based on a taxonomy of 17 gamification techniques, which expands the range used in previous reviews (eg, [37,38]). This extended taxonomy combines the gamification techniques used in an app review by Lister and Colleagues [38] and a more extensive list of game elements developed by Reeves and Read [43]. Moreover, the present taxonomy provides clear item definitions for the investigated gamification techniques to ensure interrater-reliability (AC=.97).

Results showed an average as low as 0.5 gamification techniques for the 62 tested apps. Although at least one technique was included in 32% (20/62) of the apps, no app included more than 2 techniques. In fact, as much as 68% (42/62) of the sample did not use any gamification technique at all. Thus, even though some app developers tried making use of gamification to some extent, these findings indicate little to no use of gamification techniques in the context of free stress management apps for Android. Therefore, it can be concluded that app designers have not been trying to impact user behavior through the implementation of gamification techniques.

These results contradict those presented by Payne et al [37], who found that their sample (52 physical activity game apps from the Apple Store) included all of the 10 investigated gamification techniques once, except "real world prizes." This high utilization of gamification techniques compared with the results of this study could be explained by the fact that their review focused on game apps. In a similar study, Lister and colleagues [38] investigated the use of 6 gamification techniques in 132 fitness and health apps from the Apple Store. Whereas their gamification scores were slightly larger than in this study, Lister and colleagues' conclusion confirms the implications of this review, namely, that there is a lack of use for gamification techniques.

Regarding frequency of use, "feedback" was the most often implemented technique. This is a positive result, as "feedback" is not only a gamification technique but also a common technique for promoting behavior change [14]. It has the potential to increase the effectiveness of an intervention, for example, by offering important information, providing social comparison, and helping the user to make decisions [65]. The second most often used technique proved to be "parallel communication systems." This technique can among others, be used in combination with teams. Both "parallel communication systems" and "teams" pose social aspects and can, therefore, provide an important means for social support [22].

These findings differ significantly from those of Lister and colleagues [38], who reported "social peer pressure," "digital rewards," and "competition or challenges" to be the gamification techniques most often used. These strong variations are most likely due to the difference in app genre.

Whereas some apps reviewed in this study made use of "digital rewards," "levels," and "secondary game objectives," this was only the case to a very small degree. These aspects were only found in 2 apps. Nonetheless, app designers should make more intensive use of these techniques. As rewards are a common feature in other gamified interventions, designers could provide points [53], a token system, or badges to ensure a more active use of the system [66]. "Secondary game objectives" should also be considered for implementation more often, although, designers should bear in mind that this technique is only effective when these objectives support the primary goal of the app [50]. “Levels” can be used to provide goals [62] and show progression but at the same time, they can promote competition, which might not be sought in the context of stress management.

The gamification techniques “3-D environments,” “leaderboards,” and “time pressure” were included only once. On the one hand, game designers should consider to make stronger use of “3-D environments,” as such environments may elicit an enhanced recovery from stress [67]. On the other hand, care should be taken when implementing “time pressure” and “leaderboards.” Whereas the use of these techniques surely makes sense in other contexts, for example, exercising, it might lead to excitement and tension in the user. As a result, the use of these 2 gamification techniques in stress management apps might counteract the overall aim of relaxation. Since the argument of causing stress for a user is also valid for the items “competition” between users and “social pressure,” it is favorable for the tested apps that these aspects were not detected by the investigators.

Other techniques that were never used included “marketplace and economies,” “real world prizes,” “narrative,” “avatar,” “agent,” “teams,” and “ranks of achievement,” App designers should consider a more extensive use of these techniques. As such, the implementation of a “marketplace and economy” (eg, through a currency) can help to quantify the value of rewards and objects [43]. It could also be combined with “real world prizes,” which could, for example, be implemented through a loyalty program. Even though “real world prizes” are especially useful to win over new users, designers should keep in mind that excessive use of this technique can habituate players [52]. The implementation of a “narrative” provides the user with information on what to do and thus helps to achieve goals [43], such as the change of a behavior. The use of an “avatar” personalizes the experience for the player and indicates his or her role in the narrative. This technique is most effective if the avatar resembles the person with whom it is interacting [43]. Moreover, the creation of an “agent” to represent another person can help the user to accomplish different goals and tasks. It can also have positive effects on their learning. A reason for this might be the ability of an “agent” to explain [46] and, thus, to guide the user through actions or words. These aspects can increase the general interactivity of apps and can cause the perception of social interaction. Another way to incite social interaction and provide interactivity is the use of “teams.” “Teams” cause a social relationship to form between users [43]. However, the use of “teams” could also cause social pressure, which designers may want to avoid in this context. The same might be true for “ranks of achievement” as these are often visible to other users and can be used to express a user’s status in relation to others. Whereas it might lessen the effectiveness of this technique, a way to avoid such a negative outcome could be to keep the rank invisible to other users [43].

The techniques reported to be used least often in this study differ from those by Lister et al [38] and Payne et al [37]. In contrast to the results of this study, Lister and colleagues found that 25% of their sample used “real world prizes,” 33% “leaderboards,” and 25% “ranks of achievement,” whereas Payne et al [37] reported 19% for the use of “rankings or standings” and 29% for “leaderboards.”

Considering that neither the use of evidence-based content, nor gamification techniques alone is sufficient to ensure both behavior change and app usage [19,20], the lack of gamification techniques discovered in the reviewed sample appears questionable. Furthermore, no association between gamification techniques and behavior change techniques, or between gamification techniques and stress management methods could be detected. This reveals that the reviewed apps did not use combinations of gamification and evidence-based content.

The lack of correlation found in this study does not match the results of Lister and colleagues [38], who reported a correlation between gamification techniques and specific motivational behavior change techniques. This disagreement between Lister et al and this study might be due to the difference in app genre targeted by the 2 studies. In addition, Lister and colleagues reviewed twice as many apps as compared with this study, which allows uncovering relations with smaller effect sizes. Opposed to this, Payne et al [37] reported that no correlation between gamification techniques and behavior change techniques existed for their sample. Their results support the findings of this study that app developers should pay more in-depth attention to the use of gamification techniques and their sensible combination with evidence-based content in apps aiming at behavior change.

Because the implementation of gamification techniques is directly influenced by app designers and can largely affect user behavior and reactions, designers should carefully consider the effects specific gamification techniques might have on the user. Correspondingly, designers should chose techniques with strong regard to the context of the app they are constructing. Hence, future studies should pay close attention to the levels of dynamics and aesthetics [41] and, thereby, to the functions and effects the applied gamification techniques have on the user’s behavior and reactions.

The need for improvement suggested by the gamification results also extends to the additional aspects that were investigated in this study. As such, a large portion of the apps included features that require an Internet connection. This approach reduces the time that is needed for installation as well as download and provides the opportunity for larger content. Nevertheless, this aspect might require optimization, since its use makes apps dependent on Internet connections, which may not be available at all times and in all places. This point is even more important for the 10 apps that ran only when an Internet connection was available. Another aspect that needs to be addressed in this context is the fact that as many as 6 out of 62 apps consisted of text only. Therefore, it is hard to see the advantage of such apps over self-support e-books and websites—consumers expect modern technology to be interactive. The user’s perception of the media’s interactivity has great influence on user loyalty [68]. As such, instead of text only, these apps could make use of social and community aspects [22], or react to the user in order to create flow experiences [29]. However, most apps did not make use of social community aspects either. Only 13 of the tested apps provided a connection to a social media network. This requires improvement, as previous findings suggest that users appreciate the opportunity to share data with designated individuals [35]. As some of the apps were trial versions, it is reasonable to assume that these apps might include more features in the paid version; yet this aspect only applied to 5 of the tested apps. The 4 apps that offered the additional use of a wearable device might also offer additional features, which were not covered by this study. Whereas registration and the need of a password for working with the app could make the use of apps with sensible data much more secure, this was not the case for the current sample. Furthermore, a considerable number of the sample included either permanent or pop-up advertisement. Both pose serious security risks, as they often use unsafe mechanisms [69] and should, therefore, be avoided. As this study, however, focused only on free apps, the large number of apps including advertisement might not be representative for paid apps. Regardless of this, the use and effects of aspects such as advertisement and the prerequisite of an Internet connection should be investigated in future studies.

### Limitations

In view of the MDA framework by Hunicke and colleagues [41], this study investigated the use of gamification on the level of gamification techniques. This level is visible to the user and can greatly influence his or her behavior and reactions. Moreover, in opposite to dynamics and aesthetics, this level of gamification techniques can be directly influenced by app designers. Thus, the aim of this study was to find out whether app designers are currently trying to influence the user's behavior through the implementation of gamification techniques. For this purpose, an expert review of the apps was conducted. However, as no randomized controlled trials were carried out in this study, it is impossible to make any affirmative conclusions about the effects of the investigated techniques. Future studies should, therefore, focus on the levels of dynamics and aesthetics to examine the effects that the use of the gamification techniques investigated in this study might have on the user's behavior and reactions.

Whereas this study investigated an important aspect with its focus on the quantitative analysis of gamification usage in the sample, it needs to be kept in mind that the integration of game elements alone is no guarantee for successful gamification [33]. Hence, future studies should also concentrate on a qualitative analysis of the gamification techniques used in stress management apps in order to supplement the data gained in this study. On one hand, such studies should focus on the way gamification techniques are implemented. Another area of investigation that should be focused on in future work is the general quality of the investigated apps. This includes aspects such as color, appearance, and design of the app; ease of use; as well as other usability aspects.

Regarding the implications of this study, one must keep in mind that the results of the correlational analysis are hard to interpret due to the low mean and the standard deviation of the number of gamification techniques in the sample. A possible reason for the low mean of gamification techniques in the current sample could be that this review only focused on free apps. This may have resulted in the exclusion of paid apps with a more extensive use of gamification. Nonetheless, according to AppBrain [70], 90% of available android apps in the category "health and fitness" and 86% in the category "medical" are available for free at this point. Thus, this study should be representative to some degree.

### Conclusions

The results of this study clearly reveal that the use of gamification techniques in stress management apps is not very common. This is the case for the implementation of gamification techniques as well as the association of those techniques with evidence-based content (use of behavior change techniques and stress management methods [54]). It, therefore, needs to be concluded that app designers are not trying to influence user behavior through the implementation of gamification at this point. In view of gamification's positive effect on motivation and engagement [21], app designers should, however, consider making more comprehensive use of gamification techniques in order to increase user compliance. In addition to this, developers should pay intense attention to the context and overall aim of the app when selecting techniques, as not all techniques appear suitable for every context. With this in mind, the cooperation of experts in the fields of gaming, behavior change theory, and stress management seems imperative to ensure a solid combination and effectiveness of techniques. If followed, this strategy has the potential to greatly enhance the effectiveness of apps aimed at stress management and other behavioral changes. Nonetheless, future studies should examine the effects of gamification techniques and their combination with behavior change techniques and stress management methods on the user in randomized controlled studies.

This study was the first to investigate the use of gamification techniques as well as the cooccurrence of gamification techniques and evidence-based content in stress management apps. Moreover, it provides an extended framework for the investigation of gamification usage in mHealth apps.

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## Authors' Contributions

AH, CAC, and GB contributed to the manuscript in its conception and writing. AH and CAC developed the app screening and evaluation methods. AH and SJB each evaluated the downloaded stress management apps. Data analysis was done by AH and

CAC. AH wrote the initial draft of the manuscript. All authors had full access to all of the data, and read and approved this initial draft and the revisions. No financial disclosures were reported by the authors of this paper.

## Conflicts of Interest

None declared.

## Multimedia Appendix 1

Gamification score for each reviewed stress management app from the Google Play Store.

[PDF File (Adobe PDF File), 149KB - games_v5i2e13_app1.pdf ]

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## Abbreviations

**3-D:** three-dimensional
**AC:** agreement coefficient
**e-book:** electronic book

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Original Paper

# Using Computer Simulations for Investigating a Sex Education Intervention: An Exploratory Study

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## Abstract

**Background:** Sexually transmitted infections (STIs) are ongoing concerns. The best method for preventing the transmission of these infections is the correct and consistent use of condoms. Few studies have explored the use of games in interventions for increasing condom use by challenging the false sense of security associated with judging the presence of an STI based on attractiveness.

**Objectives:** The primary purpose of this study was to explore the potential use of computer simulation as a serious game for sex education. Specific aims were to (1) study the influence of a newly designed serious game on self-rated confidence for assessing STI risk and (2) examine whether this varied by gender, age, and scores on sexuality-related personality trait measures.

**Methods:** This paper undertook a Web-based questionnaire study employing between and within subject analyses. A Web-based platform hosted in the United Kingdom was used to deliver male and female stimuli (facial photographs) and collect data. A convenience sample group of 66 participants (64%, 42/66) male, mean age 22.5 years) completed the *Term on the Tides*, a computer simulation developed for this study. Participants also completed questionnaires on demographics, sexual preferences, sexual risk evaluations, the Sexual Sensation Seeking Scale (SSS), and the Sexual Inhibition Subscale 2 (SIS2) of the *Sexual Inhibition/Sexual Excitation Scales-Short Form (SIS/SES - SF)*.

**Results:** The overall confidence of participants to evaluate sexual risks reduced after playing the game ($P<.005$). Age and personality trait measures did not predict the change in confidence of evaluating risk. Women demonstrated larger shifts in confidence than did men ($P=.03$).

**Conclusions:** This study extends the literature by investigating the potential of computer simulations as a serious game for sex education. Engaging in the *Term on the Tides* game had an impact on participants' confidence in evaluating sexual risks.

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**KEYWORDS**

sex education; personality; STI; gender; computer simulation

## Introduction

### Background

Sexually transmitted infections (STI), including human immunodeficiency virus (HIV) are ongoing concerns. Rates of new STI diagnoses are increasing in most countries of the world, particularly among young people [1]. The best method for preventing the spread of these infections is the correct and consistent use of condoms [2,3]. However, people continue to engage in risky sexual behaviors, such as having condomless sex [4] and using condoms incorrectly [5,6]. Given these threats to individual and public health, many strategies and intervention programs have been developed to encourage consistent and correct condom use; these interventions have met with varied levels of success [7].

There are several reasons for variation in the impact of interventions. First, a "one-size-fits-all" approach is unlikely to be effective with all the intended recipients, given that they will vary in age, sexual preferences, sexual experience, and sexual attitudes [8-10]. Kirby and Laris [9] noted that it is important for a sex education program to meet the needs of the audience, taking into account different backgrounds and community values. Recent research has shown that personality traits, as well as perceived attractiveness, can significantly affect the perception of sexual risk [11]. Henderson et al [12] demonstrated how individuals high in Sensation Seeking (SS), compared with those lower in SS, rate potential partners as more attractive and are more willing to have sex with those partners, but they feel that they are less likely to contract an STI. Results of a similar study showed that participants who were engaged in a wider range of potentially risky sexual behaviors were characterized by higher Sexual Sensation Seeking Scale (SSS) [13]. These results support the idea that sex education programs may benefit from the inclusion of components aimed at teaching young people to satisfy their preferences for SSS through sexual behaviors involving minimum risk.

In addition to SSS, another measure that might be relevant is Sexual Inhibition (SI), particularly a subscale from the *Sexual Inhibition/Sexual Excitation Scales (SIS/SES)*, which assesses sexual inhibition due to performance consequences (Sexual Inhibition Subscale 2, SIS2). In a sample of gay men, Bancroft et al [14] showed that condomless anal sex was more likely among those who scored lower on sexual inhibition due to the "threat of performance consequences" (eg, threat of an STI). In samples of both heterosexual men and women, research has supported the association between scores on SIS2 and sexual risk taking behavior [15,16].

Second, some people feel less vulnerable to STIs based on their belief that they can ascertain whether a potential partner is likely to be infected or not on the basis of the way that they look or some other superficial characteristic. It has been shown that men feel that they would be able to make judgments about other people's sexual health status based on perceived attractiveness [8,17]. In one study, participants believed that judgments of sexual unfaithfulness could be made of the face alone, without consideration of behavioral cues [18]. Hence, one main aim of sex education programs, but one that has been seldom addressed in interventions to date, should be to challenge this false sense of security.

Third, many sex education programs have been described, particularly by young people, as being "boring" or "irrelevant" to their needs [19]. Carswell et al [20] emphasized the importance of Web-based sex education interventions, pointing out how attractive they are for young people, as they offer a confidential and convenient medium for accessing health information, avoiding the embarrassment of discussions with teachers and health providers, and overcoming potential boredom by using an interesting game format. DeSmet et al [21] and D'Cruz et al [22] highlighted the importance of certain game design features that should be considered when developing a game for sex education, such as individual tailoring, goal-setting, narrative or story, audiovisual effects, interactivity, challenge on different levels, rewards, and immediate feedback.

Bearing in mind these three issues, one direction in which sexual health interventions could profitably develop involves the use of serious games. As young people are very familiar with computer and video game playing [23,24], they may find it easier and more motivating to engage with this format of sex education intervention [25,26]. Serious games could focus on increasing understanding of the risks and addressing misconceptions [27] in the complex area of STI transmission. This could happen if people are given the potential to engage with a simulated world of people and their sexual interactions, in order to see how easy it is for diseases to spread. In serious games, it is predominantly the players who direct events and are therefore actively involved in the learning process [28,29], in contrast to traditional sex education interventions, where learners are generally relatively passive [30,31].

There has been some previous research exploring the use of games for sex education. *The Source* [19] is an alternative reality game that was delivered over 5 weeks to young people aged between 13 and 18 years. Each week focused on a different topic (including sexual health) that was taught using various methods, such as puzzles, board games, digital media tasks, and scavenger hunts. No behavioral outcome data were reported. However, participants enjoyed the tasks and some of them reported that *The Source* reinforced their decisions to engage in safer sex, although many of them commented that they found the board games boring and not as interactive as the computerized tasks.

Verran et al [32] explored the idea of using a computer simulation called *SimZombie* for educational activities about the epidemiology of an infectious disease (albeit not a sexually transmitted one) carried out at the Manchester Science Festival 2011. *SimZombie* makes use of the fact that many young people show interest in zombies and therefore it helps them engage more than they would do with a "one-way" mode of communication, such as a leaflet explaining the epidemiology of diseases. In the activities designed by Verran and colleagues, 10 teams of 4-6 participants (predominantly families or teenagers) had to answer 3 rounds of questions about monsters, microbiology, and general scientific knowledge. After each round, their answers were marked by being inserted into the simulation. Enthusiastic feedback given by participants evidenced learning through these activities.

Shegog et al [33] developed a stand-alone Web-based game of 13 lessons, called *It's Your Game (IYG)*. IYG lessons, which target early adolescents, include activities like interactive 2D exercises, quizzes, animations, and peer video. An evaluation of this game [34] showed no significant difference in the delay of sexual activity between intervention and control students; however, there was a significant positive between-group difference on psychological variables related to STI and condom knowledge, perceived norms about sex and condom use self-efficacy.

Although previous studies have suggested potential positive benefits of serious games in health education, very little research has been carried out to investigate the influence of computer simulations for sex education specifically. As it is possible that the benefits of such games will vary according to age [35], gender [19], and sexual attitudes [8], it would be useful to investigate the possible impact of these variables.

### Aim of This Study

The primary purpose of this study was to explore the potential of computer simulation as a serious game for sex education and how the effects of a serious game might be moderated by personality traits, age, and gender. The research questions were (1) Do gender, age, and personality traits influence levels of confidence in evaluating sexual risk? (2) Does a simulation in the form of a serious game influence participants' confidence regarding the assessment of sexual risk? and (3) Do gender, age, and personality traits influence the impact of the serious game in altering participants' confidence in evaluating sexual risks?

## Methods

### Sample and Recruitment

Men and women in Southampton and surrounding areas were recruited via social media (Facebook, Twitter), posters at the University, and community advertisement boards. Potential participants were informed that data would be collected using an electronic quiz in order to investigate the use of a serious game in the form of a computer simulation for sex education. The posters contained the following information: "I would like to see how you will perform in a game we have developed for sex education." Inclusion criteria were 18-30 years of age and English speaking. A total of 42 men, 22 women, and 2 participants who chose "other" for the question on gender were screened and all met the inclusion criteria.

Data were collected in May 2016. In total, 22 participants completed the experiment online at home, with a further 44 doing so in the lab. All participants were provided with a study information sheet and indicated electronic informed consent. The study took approximately 25 min.

### Study Design

This was a Web-based questionnaire study (that used between and within subject analyses). The study employed a quiz to collect data. A draft quiz was initially trialed on 6 pilot study participants and was then refined on the basis of their feedback during individual "think aloud" sessions. "Think aloud" is a commonly used protocol for usability testing of an intervention [36].

### Measures

The final questionnaire comprised four sections: (1) demographic information, (2) the participant's sexual risk evaluations, (3 personality trait questionnaires (SSS [37] and SIS2 of the *SIS/SES – Short Form* [38]), and (4) the *Term on the Tides* quiz. The order of the 10 test questions in the quiz was fully randomized for each participant.

#### Demographics and Sexual Behavior

Participants were asked about their age, ethnicity, gender, and sexual orientation. Ethnicity options included white, black, Asian, mixed, and other. Gender options were "male," "female," "other," and "prefer not to say," and for sexual orientation (preference), "men," "women," "both," or "none."

#### Personality Traits Questionnaires

The SSS [37] assesses the tendency to seek out varied, novel, and complex sexual experiences and the desire to take personal, physical, and social risks in order to enhance sexual sensations. A sample item is "I am interested in trying out new sexual experiences." The SSS can be used with both men and women, and shows good construct validity and internal consistency (Cronbach alpha=.83 for men and Cronbach alpha=.81 for women) [37]. Questions were answered on a 4-point scale, ranging from 1 (*not at all like me*) to 4 (*very much like me*). The sums of the scores are calculated to produce a total score on SSS, with a higher score indicating higher levels of the trait.

The SIS2 assesses individual propensity to inhibit arousal because of threat of performance consequences (such as contracting an STI) [38]. This scale is one of three subscales of the *SIS/SES – SF*. A sample item is "If I realize there is a risk of catching a sexually transmitted disease, I am unlikely to stay sexually aroused." SIS/SES-SF can be used with both men and women, shows good construct validity and test-retest reliability [38]. Response options range from 1 (*strongly disagree*) to 4 (*strongly agree*); after suitable recoding, scores are summed to produce a total score, with a higher score indicating higher levels of inhibition.

#### Evaluation of Sexual Risk

Participants were asked to respond to the following statement: "Risks taken during unprotected sex are easy to evaluate." Response options ranged from 1 (*strongly agree*) to 5 (*strongly disagree*). This item was used as a measure of the participants' confidence in evaluating sexual risk.

Participants also rated their level of agreement with this statement: "The risk that someone takes when they have unprotected sex depends on the risk taking behavior of the other people in the sexual population." Response options ranged from 1 (*strongly agree*) to 5 (*strongly disagree*). This item was included to assess the extent to which participants felt that they were in control of potential risky situations.

Both items were completed before ($t_1$), and immediately after ($t_2$), completion of the *Term on the Tides* quiz.

#### Game Description: Term on the Tides

The quiz concerns a cruise called *Term on the Tides*, developed for this study, where the user of the game is asked to answer some questions about the sexual health status of people on the cruise, at different stages of the simulation (developed in Java).

The storyboard was introduced with the following: "You embarked on a singles love cruise sailing from Mykonos down to Ibiza. The ship is full of heterosexual single men and women who are looking for easy, no-strings attached sexual encounters with each other. Passengers have not been medically examined and therefore are unaware of whether are carrying a sexually transmitted disease or not. The journey time to your destination is 1 week. The ship is fully prepared for any lengthy journey and it is well-stocked with food and supplies including an inexhaustive supply of condoms. Due to the nature of the cruise, everyone is unconcerned with forming a relationship. So whether they will choose to have sex with someone, with or without a condom, is purely based on physical appearance." The main task of the participants was to give the right answer to 10 questions or scenarios regarding the sexual health status of certain people on the cruise.

The scenarios presented in the questions were based on the responses of male participants in a previous study [8], regarding their reported condom use intentions according to their perceptions of women's attractiveness. These responses were used in order to produce the profiles of the people in the simulation (Figure 1). Each person's profile had two characteristics: (1) how their condom use intentions and their judgments of STI likelihood varied with the attractiveness of a potential sexual partner, and (2) how the STI likelihood judgments of the person varied with the attractiveness of a potential sexual partner. For example, the Type A man shown in Figure 1 tends to use condoms less with women he finds more attractive (therefore he gets a "−" sign in the first box of his profile) and also believes that STI status is not associated with perceived attractiveness (therefore he gets a "=" in the second box of his profile). As nine different profiles could be created using combinations of the three symbols ("+," "−," "="), nine different types of men were created and several copies (clones, ie, people with similar behavior) of those were included in the simulation. The number of clones of each type used was proportional to the number of participants in the first study [8] who fitted those types, based on their responses. In total, there were 100 men in the simulation.

A summary of attractiveness ratings given by each man in the previous study to each woman was shown to the users throughout the game (Figure 2). The profiles of the women were chosen in a similar way to that described above for men, with the difference being that we constructed the female profiles based on how men rated female pictures in the first study [8]. Ten types of women were chosen and we tried to include as much variability in attractiveness and STI ratings as possible. Ten clones of each one of those profiles was included in the simulation, leading to a total of 100 simulated women.

**Figure 1.** Male profiles in the computer simulation. Each type has two symbols to describe his personality. For the top one, a "+" indicates that a person uses condoms more with women that they find attractive, a "−" indicates that a person uses condoms less with women that they find attractive, and an "=" indicates that condom use is not affected by attractiveness. The bottom symbol represents the belief of a person with regards to the relationship between sexually transmitted infection (STI) risk and attractiveness: "+" means the person believes that attractive women are more likely to have an STI, "−" means that they believe attractive women are less likely to have an STI, and "=" means that the person believes that attractiveness is not related to STI.

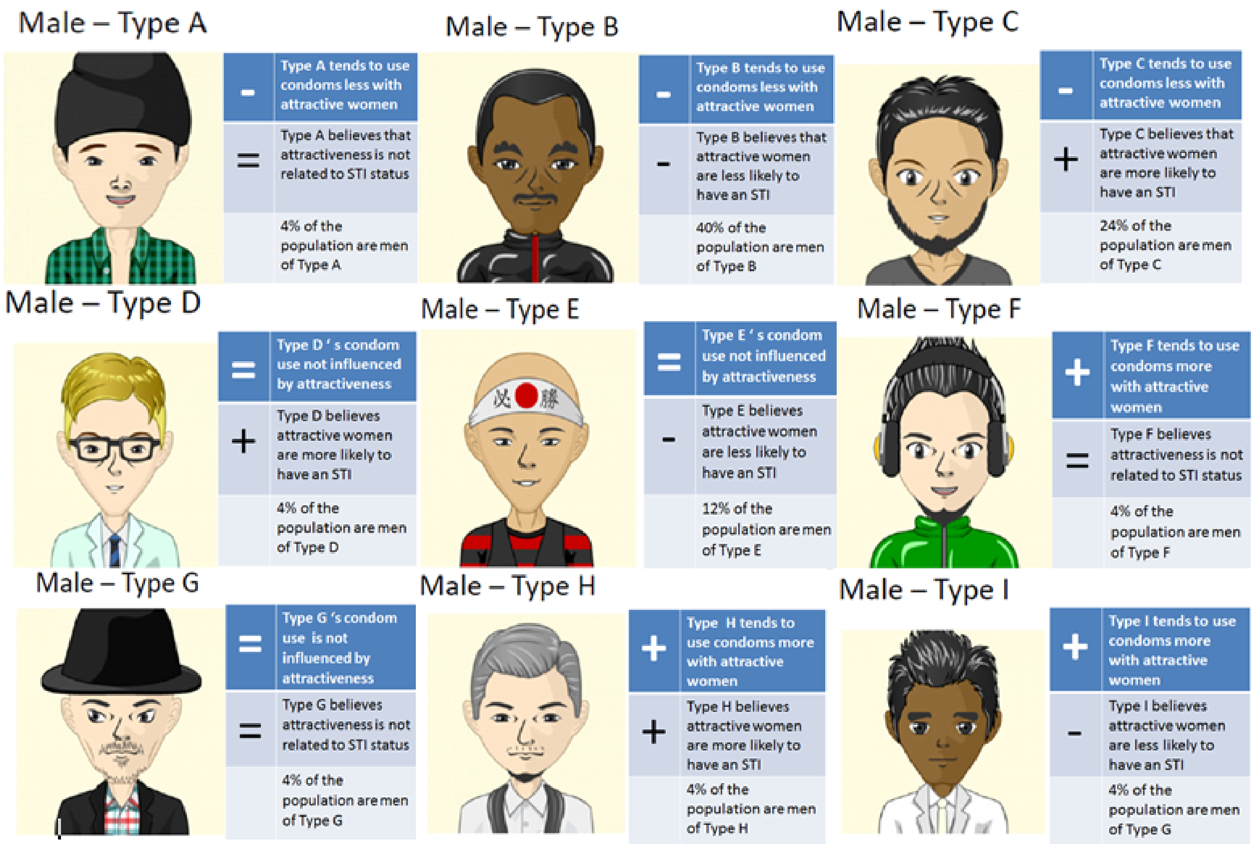


**Figure 2.** Attractiveness table. A “+” indicates that the specified man is attracted to the specified woman, a “−” indicates that the man specified is not attracted to the specified woman, and an “=” means that the man does not find the woman either attractive or unattractive.

| | Men Types | Type A | Type B | Type C | Type D | Type E | Type F | Type G | Type H | Type I |
|---|---|---|---|---|---|---|---|---|---|---|
| | Number of men | 4 | 40 | 24 | 4 | 12 | 4 | 4 | 4 | 4 |
| Women Types | Number of women | | | | | | | | | |
| Type 1 | 10 | - | - | - | - | - | - | - | - | = |
| Type 2 | 10 | = | - | - | - | = | - | - | = | - |
| Type 3 | 10 | - | + | + | + | + | = | - | = | + |
| Type 4 | 10 | = | + | = | = | + | - | - | + | + |
| Type 5 | 10 | + | = | = | + | + | + | - | - | + |
| Type 6 | 10 | + | = | = | = | + | - | - | - | = |
| Type 7 | 10 | + | - | = | + | = | + | - | = | + |
| Type 8 | 10 | + | = | = | - | = | + | - | - | = |
| Type 9 | 10 | = | - | = | = | = | - | - | = | - |
| Type 10 | 10 | + | - | = | - | = | = | - | + | = |

There were various different framings used and each one of them clearly specified the precise situation of the people in the simulation. For example, in one, the user is asked to predict the outcome of an encounter between a man of Type A and a Type 4 woman versus an encounter between a man of Type A and a Type 7 woman (see Figure 3). When participants were able to correctly judge which sexual interaction was most risky, they were awarded 1 point. Ten scenarios were presented; therefore, the score for someone who did not make any correct estimates would be 0 and for someone who accurately answered all scenarios would be 10.

The final stage of the game was the feedback provided to the users. Users watched a series of encounters between men and women in the simulated population, and they received information on how well they managed to estimate risk in each scenario, by receiving an overall score for the quiz and appropriate feedback to each question (see Figure 4).

In order to determine the correct answers to the questions, the computer simulation makes use of the attractiveness and condom use intentions of each person on the cruise. At the beginning of each simulation, infections are allocated to the population at random. People have the chance to meet each other and decide (1) whether to have sex or not, and, if they decide to have sex, (2) whether to have sex with or without a condom, based on the variables of attractiveness and condom use intentions specified for their type. There is a very high chance of an STI transmission when someone has condomless sex with another person who carries an infection. An average over 100 simulations was used for this quiz.

In order to account for possible biases stemming from the appearance of the images used for each type of person in the game, a random selection of pictures was allocated at the beginning of the game, from a selection of three different versions (white, black, and Asian faces).

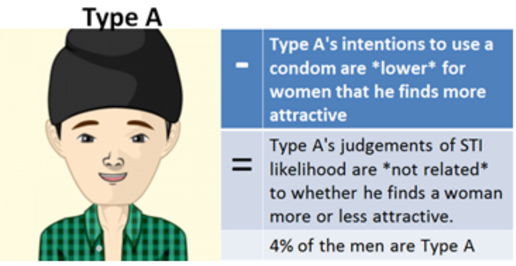
## Procedure

After providing informed consent, each participant completed the self-administered questionnaires followed by the quiz. A £100 Amazon voucher was offered as an incentive to the person with the highest score on the quiz. The Ethics Committee of the University of Southampton approved the study.

## Data Analysis

To identify factors influencing the confidence ratings and the levels of change of confidence of evaluating sexual risk, a series of bivariate associations (Pearson correlation coefficients) and independent *t* test were conducted between the main variables examined (age, gender, personality traits, quiz score, and confidence of evaluating sexual risk before and after the game). Matched pairs *t* test was used to test whether participants' confidence in evaluating STI risk changed from $t_1$ to $t_2$, that is, before and after the simulation.

**Figure 3.** Example question: Is a type A man more likely to get an infection from a Type 4 woman or a Type 7 woman?




**Attractiveness Table**

| | Men Types | Type A | Type B | Type C | Type D | Type E | Type F | Type G | Type H | Type I |
|---|---|---|---|---|---|---|---|---|---|---|
| | Number of men | 4 | 40 | 24 | 4 | 12 | 4 | 4 | 4 | 4 |
| Women Types | Number of women | | | | | | | | | |
| Type 1 | 10 | - | - | - | - | - | - | - | - | = |
| Type 2 | 10 | = | - | - | - | = | - | - | = | - |
| Type 3 | 10 | - | + | + | + | + | = | - | = | + |
| Type 4 | 10 | = | + | = | = | + | - | - | + | + |
| Type 5 | 10 | + | = | = | + | + | + | - | - | + |
| Type 6 | 10 | + | = | = | = | + | - | - | - | = |
| Type 7 | 10 | + | - | = | + | = | + | - | = | + |
| Type 8 | 10 | + | = | = | - | = | + | - | - | = |
| Type 9 | 10 | = | - | = | = | = | - | - | = | - |
| Type 10 | 10 | + | - | = | - | = | = | - | + | = |

**Figure 4.** Feedback given to the participants.

| | Men Types | Type A | Type B | Type C | Type D | Type E | Type F | Type G | Type H | Type I | Female Infections |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number of men | 4 | 40 | 24 | 4 | 12 | 4 | 4 | 4 | 4 | ○ means woman infected by man |
| Women Types | Number of women | | | | | | | | | | |
| Type 1 | 10 | - | ○ - | - | - | - | - | - | - | = | 1 |
| Type 2 | 10 | = | - | ○ - | - | = | - | - | = | - | 1 |
| Type 3 | 10 | - | + | + | ● + | + | = | - | = | + | |
| Type 4 | 10 | = | ○ + | = | = | + | ● - | - | + | + | 1 |
| Type 5 | 10 | + | = | ○ = | + | + | + | - | - | + | 1 |
| Type 6 | 10 | + | = | = | = | + ● | - | - | - | = | |
| Type 7 | 10 | + ● | ○ - | = | + | = | + | - | = | + ● | 1 |
| Type 8 | 10 | + ● | = | = | - | = | + | - | - | = | |
| Type 9 | 10 | = | - | ○ = | = | = | - | - | ● = | - | 1 |
| Type 10 | 10 | + | - | = | ○ - | = | = | - | ● + | = | 1 |
| Male Infections Summary ● means man infected by woman | | 2 | | | 1 | 1 | 1 | | 2 | 1 | |

## Results

### Descriptive Statistics

#### *Demographics*

A total of 66 participants (42 men, 22 women, and 2 "other") had a mean age of 22.5 years (SD 3.3, min 18, max 29). The majority of participants were identified as white (80%, 53/66) and as heterosexual (approximately 88% [58/66]; see Table 1).

#### *Personality Variables*

On the SSS, the mean score for men was 23.1 and for women was 22.5. Higher scores indicated greater sexual sensation seeking. There was no significant gender difference in this measure ($t_{62}$=0.42, not significant [ns]).

**Table 1.** Sample demographics.

| Variable | | n |
|---|---|---|
| **Ethnicity** | | |
| | White | 53 |
| | Black | 3 |
| | Asian | 7 |
| | Mixed | 1 |
| | Other | 2 |
| **Gender** | | |
| | Men | 42 |
| | Women | 22 |
| | Prefer not to say | 2 |
| **Age (in years)** | | |
| | 18-24 | 46 |
| | 25-30 | 20 |

On the SIS2, the higher a participant scored, the higher the propensity for sexual arousal to be reduced in the face of threats of performance consequences. The mean SIS2 score for women (12.9) was significantly higher than that for men (11.2) ($t_{62}$=3.05, *P*<.005).

### Research Question 1: Do Gender, Age, and Personality Traits Influence Levels of Confidence in Evaluating Sexual Risk?

At $t_1$, women believed that risk was easier to assess than did men, with the mean ratings 3.82 and 3.25, respectively ($t_{62}$=1.99, *P*=.05); however, the belief that risk depends on the other people did not differ between men and women ($t_{62}$=0.19, ns).

Age showed no significant correlations with participants' confidence in evaluating risk (*r*=.11, n=66, ns) or their belief that risk depends on others in the population (*r*=−.05, n=66, ns).

At $t_1$, no significant correlations between SSS or SIS2 and participants' confidence in evaluating sexual risk (*r*=.15 and *r*=.10, respectively, n=66, ns) or in believing that the sexual risk depends on others in the population (*r*=.15 and *r*=.13, respectively, n=66, ns) were found.

### Research Question 2: Does a Simulation in the Form of a Serious Game Influence Participants' Confidence Regarding the Assessment of Sexual Risk?

In response to the statement "Risks taken during unprotected sex are easy to evaluate," the mean score before the game was 3.47, and after the game it was 2.98. A matched pairs *t* test showed that the change in confidence was significant ($t_{63}$=5.81, *P*<.001). Before the intervention, 56% agreed that it was easy to evaluate risk, whereas only 44% did so after the intervention. Similarly, 24% disagreed before the game compared with 38% after the game.

In response to the statement "The risk that someone takes when they have unprotected sex depends on the risk taking behavior of the other people in the sexual population," the mean score before the game was 3.74, and after the game it was 3.77. A matched pairs *t* test revealed that the difference between these mean scores was not significant ($t_{65}$=0.27, ns).

### Research Question 3: Do Gender, Age, and Personality Traits Influence the Impact of the Serious Game in Altering Participants' Confidence in Evaluating Sexual Risks?

There was a significant gender difference in the impact of the game on confidence ratings; women had a greater reduction in confidence regarding their perceived ability to evaluate sexual risk than did men (mean change scores for men 0.30 and 0.82 for women; $t_{60}$=3.11, *P*<.005). There were no gender differences in change scores for believing that risk depends on other people (mean change scores for men 0.05 and −0.18 for women; $t_{62}$=0.92, ns). Age did not correlate with either of the risk measures (for easy, *r*=.12, n=64, ns, and for risk depends on others, *r*=−.18, n=60, ns).

Similarly, there was no correlation between the changes in confidence ratings concerning assessment of sexual risk before and after the game, and scores on SSS or SIS2 (*r*=−.06, n=64, ns and *r*=.11, n=64, ns, respectively). Finally, there was also no correlation between the changes in confidence ratings concerning sexual risk depending on others before and after the game, and scores on SSS or SIS2 (*r*=.20, n=66, ns, and *r*=−.03, n=66, ns, respectively).

### Additional Results on Quiz Scores

The average score on the quiz across the 66 participants was 5 out of 10 (min=2, max=8; the mean for men was 5.1, and 4.8 for women; $t_{62}$=0.79, ns). There were no differences in scores according to age (*r*=−.13, n=66, ns) or whether participants completed the study at home or in the laboratory (*r*=.20, n=66, ns). Anecdotal reports after the study indicated that many participants found the game very interesting and thought provoking, but also quite challenging.

No significant correlation was found between scores on the quiz and confidence in evaluating sexual risk at $t_1$ ($r$=−.06, n=66, ns and $r$=−.07, n=66, ns, for risk for self and risk for others, respectively), or the change in confidence regarding risk-assessment between $t_1$ and $t_2$ ($r$=−.01, n=64, ns and $r$=−.06, n=66, ns, respectively).

## Discussion

### Principal Findings

This study sheds some light on the use of computer simulations as a serious game for sex education. There was a significant change in participants' confidence in evaluating sexual risk in the *Term on the Tides* game. Before they played the game, the majority of the participants believed that it was easy to evaluate the risks of unprotected sex. The serious game challenged individuals' confidence to evaluate risks and, as a result of this, approximately 40% of participants reported lower confidence after playing the game than they did at the $t_1$ baseline. The fact that overall confidence in evaluating risks reduced after the participants had engaged with the game illustrates a potentially positive public health outcome. It would be expected that lower confidence in evaluating sexual risks would lead to greater caution in sexual encounters.

Age and the personality trait variables—SSS and SIS2—were not correlated with the confidence of evaluating risk or with the level of change in confidence before and after the game. Gender, however, did have an effect, as women demonstrated a bigger shift in confidence of evaluating sexual risk than men. This finding agrees with a previous study on *The Source*, an alternative reality game [19], which suggested that women were influenced more by engaging in the game than men. Brüll et al [39] argued that males prefer the use of more explicit terminology to describe sexual activity in a game than females.

Previous studies have shown that the difficulty of a game is a major determinant of the influence that it has on users, mainly because users get discouraged if the game is very difficult or they get bored if it is too easy [40,41]. Although in this case participants were not asked directly to comment on the difficulty of the game, we observed that many reflected on the experience and discussed with the researcher what they had learned from the game. Most of them found it "challenging," and may have been motivated to continue because the person with the highest score would win an Amazon voucher.

Future research should investigate the effect of age on the influence of a sex education game using a bigger sample, as there were not enough older participants in this study to report findings regarding this variable with confidence. Additionally, the relationship status and relationship power of the participants should be investigated, as this might significantly change the way they associate with the characters of the game and therefore their evaluation of sexual risk [42]. Moreover, different ways to enhance immersion in the game should be examined, in order to keep the interest of the users high and keep them engaged with the educational activity for as long as possible; for example, by using a virtual reality (360) simulation, which will challenge the users' sexual health knowledge and attitudes on various difficulty levels using a somewhat less artificial and sterile environment or characters [43]. Sexual arousal during the sex education game could also be investigated as it is a factor that influences condom use in real-life contexts [44].

This study is a step toward the design of tailored and relevant sex education interventions, as called for by DeSmet [21] and D'Cruz [22]. Although this study includes several features recommended by these authors, for example, goal-setting, narrative, and so on, it might be profitable to explore greater interactivity and the use of audiovisual stimuli.

### Strengths and Limitations

Some limitations of the study need to be acknowledged. Participants were not asked systematically about the difficulty of the game and therefore we only have anecdotal information about this variable. Also, we used a relatively small convenience sample and no behavioral outcomes or behavioral theory were assessed. Notwithstanding these limitations, this study is the first to explore the influence of computer simulations in the form of a serious game for sex education in relation to risk perception, and to investigate the impact that individual difference variables (age, gender, and personality) may have on the outcome. The results would be particularly useful for serious games designers for sex education as they provide some limited but promising insight into which aspects of games-tailoring could be beneficial and worth investigating further.

### Conclusions

Computer simulations, presented in the form of a serious game, had an impact on participants' confidence in evaluating sexual risk, especially for women. This suggests that serious games developed for use in this setting should be further investigated and perhaps gender-tailored. Working toward these goals might contribute to a reduction in STI rates. Personality traits and age were not related to the change in participants' confidence in evaluating sexual risks before and after engaging in the game.

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### Authors' Contributions

AE led the study design, game development, conducted the research, and prepared early drafts of the article. SB, CG, and RI helped with the design of the study and the game development. RI and AE carried out the analyses. All authors read and commented on drafts of the article, and approved the final version.

## Conflicts of Interest

None declared.

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## Abbreviations

**HIV:** human immunodeficiency virus
**IYG:** It’s Your Game
**SES:** Sexual Excitation Scale
**SI:** Sexual Inhibition

**SIS2:** Sexual Inhibition Subscale 2
**SS:** Sensation Seeking
**SSS:** Sexual Sensation Seeking Scale
**STI:** sexually transmitted infection

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Original Paper

# What Older People Like to Play: Genre Preferences and Acceptance of Casual Games

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## *Abstract*

**Background:** In recent computerized cognitive training studies, video games have emerged as a promising tool that can benefit cognitive function and well-being. Whereas most video game training studies have used first-person shooter (FPS) action video games, subsequent studies found that older adults dislike this type of game and generally prefer casual video games (CVGs), which are a subtype of video games that are easy to learn and use simple rules and interfaces. Like other video games, CVGs are organized into genres (eg, puzzle games) based on the rule-directed interaction with the game. Importantly, game genre not only influences the ease of interaction and cognitive abilities CVGs demand, but also affects whether older adults are willing to play any particular genre. To date, studies looking at how different CVG genres resonate with older adults are lacking.

**Objective:** The aim of this study was to investigate how much older adults enjoy different CVG genres and how favorably their CVG characteristics are rated.

**Methods:** A total of 16 healthy adults aged 65 years and above playtested 7 CVGs from 4 genres: casual action, puzzle, simulation, and strategy video games. Thereafter, they rated casual game preference and acceptance of casual game characteristics using 4 scales from the Core Elements of the Gaming Experience Questionnaire (CEGEQ). For this, participants rated how much they liked the game (enjoyment), understood the rules of the game (game-play), learned to manipulate the game (control), and make the game their own (ownership).

**Results:** Overall, enjoyment and acceptance of casual game characteristics was high and significantly above the midpoint of the rating scale for all CVG genres. Mixed model analyses revealed that ratings of enjoyment and casual game characteristics were significantly influenced by CVG genre. Participants' mean enjoyment of casual puzzle games (mean 0.95 out of 1.00) was significantly higher than that for casual simulation games (mean 0.75 and 0.73). For casual game characteristics, casual puzzle and simulation games were given significantly higher game-play ratings than casual action games. Similarly, participants' control ratings for casual puzzle games were significantly higher than that for casual action and simulation games. Finally, ownership was rated significantly higher for casual puzzle and strategy games than for casual action games.

**Conclusions:** The findings of this study show that CVGs have characteristics that are suitable and enjoyable for older adults. In addition, genre was found to influence enjoyment and ratings of CVG characteristics, indicating that puzzle games are particularly easy to understand, learn, and play, and are enjoyable. Future studies should continue exploring the potential of CVG interventions for older adults in improving cognitive function, everyday functioning, and well-being. We see particular potential for CVGs in people suffering from cognitive impairment due to dementia or brain injury.

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**KEYWORDS**

games, recreational; genre preference; mobile applications; aged; core elements of the gaming experience

## Introduction

### Video Game Training

Commercial video games are designed to be enjoyable, challenging, and capable of fostering sustained player engagement [1]. Video games are further subdivided into "hardcore" and "casual" video games (CVGs). Hardcore video games are complex, require high commitment, and are played for longer periods of time, whereas CVGs are simple, require low commitment, and have short play sessions [2]. Traditionally, video games are not designed for specific improvement of cognitive domains. An exception to this are cognitive exercises, or brain-trainers, that use gamification of cognitive training, where neuropsychological tests are combined with video games elements such as scorekeeping and leaderboards [3]. Cognitive benefits from playing video games can therefore be considered more of an unintentional by-product [1].

To date, most video game training studies have used hardcore action video games (especially first-person shooter [FPS]) to demonstrate how video games can improve perceptual and cognitive abilities, notably those that are also subject to age-associated decline [4,5]. Although action video games are mainly targeted at younger audiences, these kinds of games present barriers to older adults. First, learning to play and interact with fast-paced action video games can be very difficult and demotivating for older adults. Second, questionnaire and playtest studies have found that older adults generally dislike action video games, especially when featuring violent content [4,6-8]. Together, this leads to a situation where older adults, despite promising cognitive benefits, are less willing and motivated to play action video games, and thus less likely to follow through with action video game interventions [4,8,9].

In order to offer older adults and even patients more attractive forms of video game interventions, we suggest tapping the potential of CVGs as an enjoyable activity to improve cognitive functions and emotional well-being. By better understanding the types of CVGs older adults enjoy playing and the specific game characteristics they find appealing, we hope to identify CVG genres and game characteristics that might raise the motivation of participants in future video game interventions.

### The Case for Causal Video Games

What makes CVGs an excellent choice for an older adult population is their promise to "eliminate any possible barrier to someone enjoying the game" [10]. Unlike hardcore video games, CVGs are intended as games for everyone that are easy to use and play, do not require high commitment or special skills, and can be completed in short play sessions [11,12].

To reach this goal, CVGs follow four casual game design values: "Acceptability" refers to the appeal for a wider, heterogeneous group of players. To this end, CVGs borrow themes familiar to the social context of the player that are nonviolent and foster positive emotions and growth. "Accessibility" makes sure that players with different cognitive and physical skill levels can quickly learn to play the game. "Simplicity" aims to lower the cognitive load on the player through simple and minimized game elements as well as easy rules and goals. Finally, "flexibility" assures that CVGs adapt to players and integrate into their everyday life. For this, CVGs are designed to be error-forgiving, adapt the difficulty level to the player, and can be easily stopped and replayed [11,13,14].

Interestingly, CVGs further try to provide players with positive outcomes outside of the game such as mental exercise, relaxation, social and playful activity [11]. This touches a recently published "gerontoludic" manifesto [9] that suggests focusing more on whether video games create an enjoyable experience and consider the preferences of older adults (ie, the "playfulness" aspect) rather than pragmatically insisting on improvement of cognitive abilities (ie, the "usefulness" aspect) [9] and age-related barriers to interact with video games (ie, the "accessibility" aspect). Given that recent studies suggest that CVGs have a potential in improving cognitive function and promoting emotional well-being [3], this study aims to look at whether different CVG genres are suitable and fun to play for older adults.

### Casual Video Game Genres

The notion of video game genre that allows organizing games into categories is crucial in connection with CVGs for three reasons: Whereas it is agreed that CVGs, as a whole, reduce usability barriers and are the most enjoyed and motivating type of video games, research into preferences for CVG subgenres among older adults is lacking [15]. This is reflected even among active older gamers that were shown to predominantly play card or board game-like video games, whereas other genres are rarely played [16]. Second, recent studies have shown that different CVG genres engage different perceptual and cognitive functions, allowing the selection of specific game genres to improve specific cognitive skills [17-19]. From a pragmatic point of view, this is crucial as video game-based interventions will not benefit cognitive abilities unless the game is known to engage specific cognitive skills [4]. By better understanding game genre preferences of older adults, future game interventions could offer them different CVG genres that they are both willing to play and that improve specific cognitive abilities [4,20]. Third, the concept of genre closely relates to usability. As the pattern of interactions and rules of the games represent the most commonly used video game genre classification scheme [21], examining how older adults learn, control, and understand games from different genres can help addressing usability problems pertaining to each video game genre [22].

Although several recent studies have addressed usability barriers and used survey methods to assess game preferences in older adults [4,16,23,24], playtest studies using a wider range of CVG genres to study game interests and preferences of older adults are lacking [4].

### Research Questions

In this study, we wanted to identify CVG genres that older adults enjoy and are willing to play most, and how favorably their CVG design values are rated. Given the explorative nature of this study, the following research questions rather than hypotheses were formulated. Do the CVGs provide enjoyment and is there a preference for specific CVG genres? Do the CVGs meet the casual game design values (easy rules and story, clear goals and actions, easy to control, and make their own) and are they suitable for older adults?

## Methods

### Participants

In total, 16 healthy older adults (5 females, 11 males) aged between 65 and 84 years (mean 71.94 years, SD 6.34) participated in this study. Participants were recruited from the Seniors University of Bern, Switzerland. All participants had normal or corrected-to-normal vision. Exclusion criteria were a diagnosis of dementia or mild cognitive impairment and fine motor skill impairments leading to inability to handle a tablet computer. All participants provided signed informed consent in accordance with the latest version of the Declaration of Helsinki and were rewarded with two cinema tickets for their participation. The cantonal ethics committee of Bern, Switzerland (Kantonale Ethikkommision) granted the ethics approval.

### Selected Casual Video Games

For this study, we selected 7 single-player, tablet-based CVGs (Figure 1) available on the Web on app stores for mobile phones and tablet computers (iTunes App store, Apple Inc). The CVGs were selected by a professional game designer to conform to accepted casual game design values [11,13]. These include familiar, cheerful, and nonviolent game topics (“acceptability”), games that are simple to play and learn with easy rules and goals (“simplicity”), allow players to quickly reach proficiency (“accessibility”), and provide a flexible and error-forgiving game experience (“flexibility”).

For genre-specific comparisons, we selected casual games from 4 casual game genres (casual action, casual puzzle, casual simulation, and casual strategy games), following video game genre classifications based on both the cognitive skills they involve [25] and the pattern of interactions and rules of the games [21]. Casual action games require the player to perform a series of actions to meet specific objectives and usually involve eye-hand coordination and fast reaction [25,26]. Casual puzzle games refer to games with the goal to solve enigmas via manipulation of game objects and require reasoning and problem-solving skills [21,25]. Casual simulation games recreate real-world activities (eg, sports, driving, and city building) and require domain-specific and procedural knowledge about the system, coordination of cognition, information processing, as well as movement control [19,21,25,27]. Finally, casual strategy games require planning, decision making, and execution and adjustments of actions to achieve a desired outcome in the system and require executive control [25].

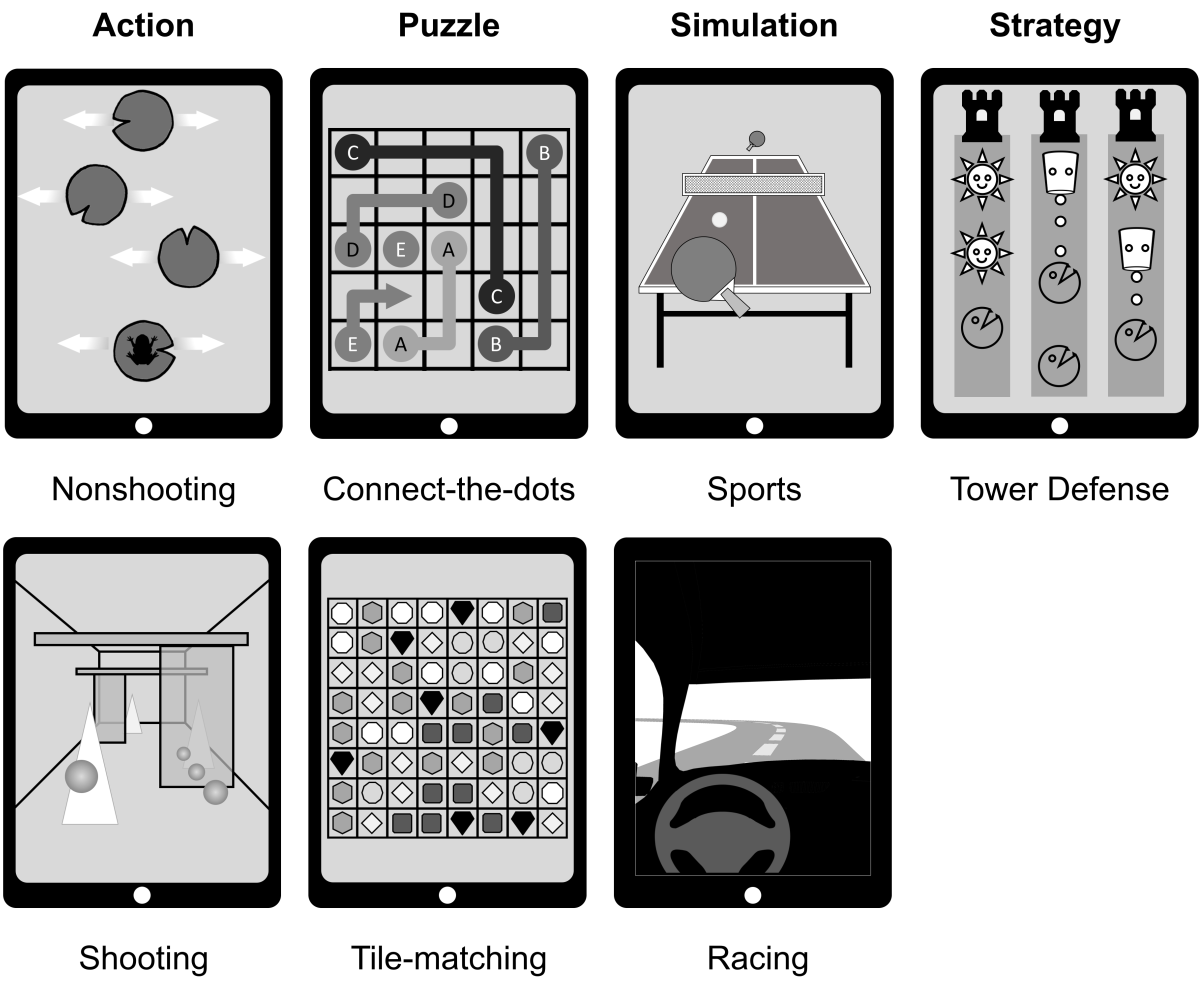
For the casual action games (Figure 1, first row from left), we chose an FPS and a nonshooting game. In the no shooting action game Pocket Frog Splash Sliders (Nimblebit), players must hop a frog across lily pads that move back and forth by tapping the touchscreen in time. Missing the lily pad will subtract 1 life from the player’s lives, whereas extra lives could be earned by skipping lily pads during a jump. The shooting action game Smash Hit (Mediocre AB), played in training mode, combines an infinite runner and FPS game elements. The goal is to move ahead as far as possible by collecting bullets and hitting glass obstacles by tapping the touchscreen to aim and shoot.

For the puzzle genre (Figure 1, second row from left), we chose 2 grid-based puzzles differing in interaction with the game. Flow Free (Big Duck Games LLC) is a logic puzzle game in which players must connect pairs of same-colored dots, using tap and drag movements. To solve the puzzle, the entire grid should be filled with nonoverlapping connections to cover the entire grid using a minimal number of moves [28,29]. Bejeweled (PopCap Games), played in infinite mode, is a tile-matching puzzle game played on an 8×8 grid covered with jewels in 7 different colors and shapes. The player must swap two adjacent gems (ie, 1 of the 4 cardinal neighbors) to create an alignment (vertical or horizontal) of 3 or more identical gems. Matched gems are removed and newly generated gems fall in their place [30].

For the casual simulation (Figure 1, third row from left), we chose a racing and sports simulation game. Real Racing 3 (Firemonkeys Studios) is a realistic racing game with different racing events. The goal of the game is to win the race and steer the car by tilting the tablet left to turn left and right to turn right. The car accelerates and decelerates automatically. For this study, we selected a beginner-level race (Circuit de Spa-Francorchamps). Virtual Table Tennis HD (SenseDevil Games) is a realistic sports simulation game that emulates table tennis in the game world. The game is played against a computer opponent by moving the ping-pong paddle along the touchscreen using drag movements. For this study, we selected a game from the beginner level.

For the casual strategy game genre (Figure 1, fourth row from left), we selected the Plants vs Zombies (PopCap Games) tower defense (TD) game, a subgenre of real-time strategy games. Due to time constraints and restraint from military-themes and games that require prolonged commitment, we chose one casual strategy game only. The goal of TD games is to collect resources (suns) and place defensive units (plants) along paths on a map to prevent enemies (zombies) attacking on parallel lanes from reaching the player’s base. The game is lost when the enemy reaches the player’s home base; the game is won when waves of attacking enemies are successfully defended [31].

**Figure 1.** Casual video game genres (illustrations based on video games used in the study).




## Questionnaire

The players' casual game experience was measured using the Core Elements of the Gaming Experience Questionnaire (CEGEQ) after completion of each game [32]. The CEGEQ is based on the assumption that enjoyment of a game emerges from the player's perception of the video game and their interactions with it. Here, the player's perception of the game (ie, video game) is assumed to be formed by the environment (eg, graphics and sounds) and game-play (eg, rules and scenario) that are both thought to produce enjoyment. The player's interaction with the game ("puppetry") is believed to reflect ownership, which is achieved through manipulation of the game ("control") or can be produced by "facilitators" that can compensate lacking control over the game [32]. The CEGE questionnaire contains 10 scales representing the latent constructs (enjoyment, frustration, CEGE, puppetry, video game, control, facilitators, ownership, game-play, and environment) measured with 38 items. The reliability of the CEGEQ is sufficiently high (Cronbach alpha=.794) [33].

For this study, we selected 5 scales of the CEGE (enjoyment, game-play, control, ownership, and environment). Casual game genre preference was measured using the enjoyment scale (3 items) reflecting the extent to which each game was enjoyed and encouraged replayability. Three scales were used to examine to what extent the selected casual games met the casual game values [11,13,34] as rated by the participants. The game-play scale (6 items) reflects how the rules and underlying story or scenario of the game are judged. Control (8 items) refers to how the player learns to control the game and make it his own, and measures whether the general goal and actions of the game are clear, how easy the controllers (input device) are to use, how they are mapped to the actions, and whether everything was visible on the interface. The scale ownership (6 items) was used to determine how the player uses the actions to complete the goal of the game, creates a strategy and personal goals, uses rewards, and takes ownership over the game. Finally, environment (6 items), the way the player perceives the game via graphics and sounds, was measured. This was done to rule out effects attributable artistic style and visual aesthetics that are inherent to video game genre, but not of interest to our study.

## Procedure

This study used playtesting sessions that combine questionnaires with the opportunity of hands-on playing of video games to quantify the player's attitudes, opinions, and perception of different CVG genres. This approach is well suited for persons with no previous game experience and also far more informative than mere interviews and surveys in active gamers [35]. For the informal playtesting session (lasting about 120 min), participants were tested individually and were seated at a desk next to the experimenter in a small laboratory room. All casual games and video clips were administered on a tablet computer with touch interface and a 9.7 screen (iPad Air 2, Apple Inc). For the playtesting session, participants were first asked to fill out questionnaires regarding demographics, game, and computer experience. After that, participants were informed about the procedures of the playtesting study and a written consent was obtained. For each of the 7 CVGs, participants first watched a short video clip of a person playing the game (observational session, 3-5 min). After that, the experimenter read the instructions to the participant to ensure that they understood the rules. Then, the participants were invited to play the game for a limited amount of time or levels (game-play session, about 5 min). Following that, participants were asked to evaluate their game experience with the CVG by answering the 39 items of the CEGEQ on a closed 5-point Likert-type scale, ranging from 1 (completely disagree) to 5 (completely agree), which lasted between 5 and 10 min.

### Statistical Analysis

The participant's evaluation of the game experience with the casual games was assessed with 39 closed-response questions that participants answered using a closed 5-point Likert-type scale. The 10 negatively worded items were reverse-coded by subtracting the value from 6. Scores for each of the 10 scales of the CEGEQ were then calculated by averaging the item ratings corresponding to each scale and dividing them by 5. We removed item 24 ("I felt guilty for the actions in the game") from the CEGEQ as we specifically selected nonviolent video games.

First, separate repeated measures one-way Analyses of Variance (rmANOVA) with casual game genre as a within-subject factor were performed by using SPSS for Windows (version 24.0, SPSS Inc) to test whether the video game genre had a significant effect on each of the 5 CEGEQ scales of interest (enjoyment, game-play, control, ownership, and environment). An alpha value of .05 was used to determine significance.

Second, linear mixed effect models (LMEM), fit by restricted maximum likelihood estimation (REML) were performed (using R version 3.3.1 (R Foundation for Statistical Computing, Vienna, Austria ) and the package lme4 [36]) for each CEGE scale (enjoyment, game-play, control, and ownership) to examine the effects of environment ratings, game experience, age, and level of education on CVG genre. To this purpose, we fitted an LMEM with the respective CEGE scale as dependent variable, a random intercept per subject as random effect, and video game genre, environment ratings, game experience, age, and education as fixed effects. Gender was not included as a fixed parameter due to the small number of female participants. The global effect of the factor video game genre was tested using the conditional *F* test, whereas all other fixed-effect parameters were tested using a conditional *t* test. Pairwise comparisons of the estimated marginal means were performed between the different video game genres using Bonferroni-Holm correction for multiple testing.

## Results

### Demographics

All 16 participants reported having access to and using desktop or laptop computers on a daily or weekly basis, whereas only 5 (5/16, 27.8%) participants (2 females, 3 males) reported having ever played, and that they are currently playing computer video games. All 5 participants reported playing games preinstalled on Desktop PC computers (eg, Free Cell, Patience, and Mahjong) on a daily to monthly basis. None of the participants reported having ever played video games on tablet-computers.

### Ranking of the Casual Games on the Enjoyment Scale

The results of this study indicate that the mean participant's ratings of the casual games were above average (ie, >0.5—the midpoint of the item rating range) across all CEGE scales considered in the analysis. The order of casual game enjoyment or genre preference from the most enjoyed to the least enjoyed was as follows (Table 1, total): casual puzzle games (Flow Free followed by Bejeweled); the casual action no shooting game (Pocket Frog Splash); the casual action shooting (Smash Hit); and casual strategy game (Plants vs Zombies) that showed identical ratings, and, finally, the casual simulation games (Virtual Table Tennis followed by Real Racing).

**Table 1.** Means and CIs (95%) of the selected CEGE scales for all casual games played grouped by gender (females: n=5; males: n=11; and total: N=16).

| Genre | Gender | Enjoyment | Game-play | Control | Ownership | Environment |
|---|---|---|---|---|---|---|
| **Casual action video games** | | | | | | |
| No shooting | Total | 0.85 (0.79-0.92) | 0.61 (0.53-0.69) | 0.72 (0.67-0.78) | 0.64 (0.58-0.70) | 0.72 (0.66-0.78) |
| | Female | 0.87 (0.77-0.96) | 0.55 (0.45-0.64) | 0.71 (0.68-0.74) | 0.56 (0.52-0.59) | 0.73 (0.67-0.79) |
| | Male | 0.85 (0.78-0.92) | 0.64 (0.56-0.74) | 0.73 (0.65-0.79) | 0.68 (0.62-0.74) | 0.72 (0.65-0.79) |
| Shooting | Total | 0.83 (0.71-0.94) | 0.66 (0.59-0.73) | 0.72 (0.68-0.77) | 0.70 (0.63-0.77) | 0.76 (0.71-0.81) |
| | Female | 0.79 (0.49-1.00) | 0.57 (0.51-0.63) | 0.70 (0.64-0.78) | 0.70 (0.63-0.82) | 0.75 (0.68-0.81) |
| | Male | 0.85 (0.75-0.93) | 0.70 (0.62-0.78) | 0.74 (0.69-0.79) | 0.69 (0.62-0.77) | 0.76 (0.70-0.83) |
| **Casual puzzle video games** | | | | | | |
| Connect-the-dots | Total | 0.95 (0.91-0.99) | 0.65 (0.60-0.71) | 0.85 (0.80-0.90) | 0.77 (0.71-0.83) | 0.78 (0.73-0.84) |
| | Female | 0.93 (0.85-1.00) | 0.64 (0.55-0.73) | 0.84 (0.76-0.92) | 0.78 (0.73-0.83) | 0.75 (0.68-0.81) |
| | Male | 0.95 (0.91-0.99) | 0.66 (0.61-0.72) | 0.86 (0.8-0.92) | 0.76 (0.68-0.84) | 0.80 (0.74-0.86) |
| Tile-match | Total | 0.85 (0.78-0.92) | 0.70 (0.62-0.78) | 0.79 (0.74-0.84) | 0.70 (0.65-0.75) | 0.75 (0.68-0.81) |
| | Female | 0.87 (0.81-0.93) | 0.67 (0.57-0.77) | 0.78 (0.69-0.88) | 0.69 (0.59-0.82) | 0.69 (0.56-0.79) |
| | Male | 0.84 (0.75-0.93) | 0.71 (0.62-0.82) | 0.80 (0.75-0.85) | 0.70 (0.66-0.74) | 0.78 (0.72-0.85) |
| **Casual simulation video games** | | | | | | |
| Racing | Total | 0.75 (0.61-0.88) | 0.72 (0.65-0.78) | 0.71 (0.65-0.77) | 0.69 (0.62-0.76) | 0.79 (0.73-0.85) |
| | Female | 0.61 (0.36-0.84) | 0.63 (0.56-0.71) | 0.65 (0.60-0.72) | 0.62 (0.50-0.72) | 0.74 (0.69-0.81) |
| | Male | 0.81 (0.67-0.92) | 0.75 (0.69-0.82) | 0.74 (0.67-0.80) | 0.72 (0.66-0.79) | 0.81 (0.75-0.88) |
| Sports | Total | 0.73 (0.59-0.86) | 0.69 (0.62-0.76) | 0.71 (0.66-0.75) | 0.69 (0.61-0.77) | 0.73 (0.69-0.77) |
| | Female | 0.75 (0.52-0.92) | 0.65 (0.53-0.76) | 0.74 (0.70-0.79) | 0.70 (0.57-0.85) | 0.72 (0.68-0.76) |
| | Male | 0.72 (0.56-0.85) | 0.71 (0.65-0.79) | 0.70 (0.65-0.75) | 0.68 (0.60-0.76) | 0.73 (0.68-0.78) |
| **Casual strategy video games** | | | | | | |

| Genre | Gender | Enjoyment | Game-play | Control | Ownership | Environment |
|---|---|---|---|---|---|---|
| Tower defense | Total | 0.82 (0.72-0.92) | 0.68 (0.62-0.74) | 0.78 (0.74-0.82) | 0.76 (0.69-0.82) | 0.74 (0.69-0.80) |
| | Female | 0.87 (0.79-0.95) | 0.65 (0.54-0.76) | 0.76 (0.70-0.79) | 0.74 (0.67-0.81) | 0.76 (0.69-0.82) |
| | Male | 0.80 (0.67-0.90) | 0.69 (0.64-0.76) | 0.79 (0.74-0.84) | 0.76 (0.69-0.83) | 0.74 (0.68-0.81) |

### Effect Analyses for CEGE Scales

As hypothesized, there was a significant main effect for CVG genre on enjoyment ($F_{1,\ 2.977}$=4.794, *P*=.005, η ²=.220); game-play ($F_{1,6}$=4.698, *P*=.004, η ²=.227); control ($F_{1,6}$=8.704, *P*=.001, η ²=.339); and ownership ($F_{1,6}$=3.615, *P*=.003, η ²=.184) ratings. There was, however, no significant difference in environment ratings ($F_{1,6}$=3.615, *P*=.07, η ²=.114) across CVG genres. To adjust the effects of video game genre for the potentially confounding effect of the graphics and audio of the video games ("environment"), the effect of video game genre and environment were analyzed within a LMEM for each CEGE scale. In addition, the effects of personal background variables (age, education, and prior game experience) were included in the LMEMs (Table 2). The LMEM analysis revealed a significant global effect of video game genre (*P*<.001) and a trend for positive effects of environment ratings (*P*=.05). For game-play ratings, there was a significant global effect of video game genre (*P*<.001) and a significant negative effect of game experience (*P*=.01). For control ratings, there was only a significant global effect of video game genre (*P*<.001), whereas there was a significant global effect of video game genre (*P*=.01) and a significant positive effect of environment ratings (*P*=.03) on ownership ratings. The linear mixed-effects model was further used to perform all 21 pairwise comparisons between the 7 CVGs for each CEGE scale showing significant global effects of the factor video game genre. Pairwise comparison of the estimated marginal means for enjoyment indicate that the casual puzzle video game (Flow Free) was significantly more enjoyed than casual simulation racing ($t_{89}$=−3.74, *P*=.01) and sports ($t_{89}$=−3.61, *P*=.01) video game. Game-play ratings of casual action no shooting video game scored significantly lower than those for the casual puzzle video game (Bejeweled; $t_{89}$=3.47, *P*=.02), and the casual simulation racing ($t_{89}$=3.74, *P*=.01) and sports ($t_{89}$=3.32, *P*=.03) video game. Pairwise comparisons further indicated that control ratings for the casual puzzle video game (Flow Free) were significantly better than those for both the casual action no shooting ($t_{89}$=4.58, *P*<.001) and shooting ($t_{89}$=4.68, *P*<.001) video game as well as for the casual simulation racing ($t_{89}$=−5.39, *P*<.001) and sports ($t_{89}$=−5.02, *P*<.001) video game. Furthermore, the second casual puzzle video game (Bejeweled) was rated better in terms of control than the casual simulation racing video game ($t_{89}$=−3.28, *P*=.03). Finally, pairwise comparisons on the effect of video game genre on ownership revealed that both the casual puzzle video game (Flow Free; $t_{89}$=3.46, *P*=.02) and casual strategy video game (Plants vs Zombies; $t_{89}$=3.39, *P*=.02) were rated better than the casual action no shooting video game.

**Table 2.** Tests for fixed effects within the linear mixed effects models (LMEM) for each CEGE scale.

| Variable | Enjoyment | Game-play | Control | Ownership |
|---|---|---|---|---|
| Video game genre | $F_{6,\ 89}$=3.54[a] | $F_{6,\ 89}$=3.89[a] | $F_{6,\ 89}$=8.03[b] | $F_{6,\ 89}$=3.24[a] |
| Environment rating | $t_{89}$=1.96 | $t_{89}$=1.73 | $t_{89}$=0.94 | $t_{89}$=2.22[a] |
| Game experience | $t_{12}$=1.94 | $t_{12}$=−3.23[a] | $t_{12}$=−1.86 | $t_{12}$=0.13 |
| Age | $t_{12}$=−1.06 | $t_{12}$=0.66 | $t_{12}$=0.73 | $t_{12}$=0.56 |
| Education | $t_{12}$=−0.26 | $t_{12}$=0.32 | $t_{12}$=−0.87 | $t_{12}$=0.24 |

[a]Significant at the .001 level.

[b]Significant at the .05 level (two-sided).

## Discussion

### Principal Findings

In this study, we examined casual game enjoyment and game characteristics ratings across a range of 4 genres in healthy older adults. The results of the playtest study revealed that tablet-based casual games are generally enjoyed by older adults with an effect of CVG genre on enjoyment, independent of environment ratings and personal background variables. In addition, the constituent elements of casual games resonated well with healthy older adults. There was an independent effect of CVG genre on gameplay, control, and ownership ratings. Moreover, environment ratings had an effect on enjoyment and ownership, but not on control and gameplay, when controlling for all other fixed effects. Prior game experience positively influenced enjoyment and negatively influenced game-play ratings. Finally, there were no independent effects of age and education on any of the CEGE scales.

## Comparison With Prior Work

The genre effect on enjoyment indicates a preference for the casual puzzle (Flow Free) over the casual simulation games (Real Racing and Virtual Table Tennis). Nevertheless, all CVGs were given good enjoyment and replayability ratings. This finding is strongly in line with findings from previous survey studies in active older gamers [16,24,37] and 2 playtest studies using similar puzzle games [15], reporting that casual games are generally the most liked type of video games among older adults. This further reflects the preference of older adults for slower-paced games with an intellectual challenge over fast-paced games (eg, action, sports, and strategy games) and relates to the notion that older adults prefer to play games that are similar to the games they used to play when they were younger (eg, card, board, and paper-based puzzle games) [15].

However, we did not find evidence to support a general dislike for the action game genre (no shooting and shooting) reported in other studies [7], as this represents the second most liked casual game genre in our study. It has been argued that the strong visual, attentional, and processing speed demands, which are known to decline with age, make action games less enjoyable for older players [38]. Although the casual action games in this study relied heavily on fast reaction and hand-eye coordination, it is our belief that their nonviolent and joyful themes contributed to an enjoyable experience in our study. This again, is in line with the findings of McKay and Maki [7], showing that older adults did enjoy and were willing to play a cartoonish FPS game, whereas they disliked and were unwilling to play a realistic FPS game with violent content. To sum up, the higher ratings for puzzle than action games replicate the findings of a recent playtest study [15] comparing an action with a puzzle game, that were similar in terms of the cognitive abilities they engage, and found that the puzzle game was deemed more motivating by older adults.

As for the third most liked casual strategy game genre (Plants vs Zombies), we were not able to relate this finding to survey and other playtest study findings; as, to the best of our knowledge, there have been no studies on enjoyment and usability using strategy games in older adults. However, strategy games have successfully been used in 1 video game training study with older adults [39]. Finally, we found that casual simulation (sports and racing) games were least liked by the participants in this study. This again is reflected in survey findings reporting that even among active older game players, only 20% reported playing racing and sports games [16].

Taken together, these findings indicate a positive overall attitude of older adults toward tablet-based casual games, and that they are very open and willing to try out new technology when given an opportunity to play. Of note, environment (ie, graphics and sounds) ratings remained a contributor to enjoyment when controlling for all other effects. Whereas environment ratings did not differ across genres, the visual presentation of a CVG seems to contribute to overall enjoyment of CVGs.

We also find hands-on evidence to support the notion that casual games provide a set of game characteristics that are suitable for a senior audience in terms of usability [34]. Overall, the casual game characteristics were well-perceived by the older adult players in terms game-play, control, and ownership.

The gameplay ratings, that is, how participants judged the rules and underlying story (scenario) of the games were satisfactory, with the casual simulation and puzzle video games being easier to understand than the casual action (no shooting game) video game. The fact that the least liked games were rated easiest to understand is hardly surprising, as simulation games make use of real-world concepts and rules already known to the player and thus, at least in terms of rules of the game, are particularly suitable for an older audience with little or no game experience [34]. In terms of control ratings, that is, whether the goal and actions of the game were clear and the controllers of the game were easy to use, the casual puzzle video game (Flow Free) was rated better than all casual simulation and action video games. Finally, regarding ownership ratings, that is the extent to which player sees the actions in the game as a result of his own efforts, the casual puzzle (Flow Free) and the casual strategy video games (Plants vs Zombies) were rated better than the casual action no shooting game (Pocket Frog Splash).

The latter two findings reflect the above-mentioned notion that action games are not as much appreciated due to the speed of movement and intense interaction, which is reflected in the lower control and ownership ratings [15]. These findings underscore previous reports that puzzle games are the preferred game genre of older adults and the easiest to interact with [40].

Of note, the least enjoyed casual simulation (sports and racing) video games differed inherently from the others in how players had to control the game. Other than using single tapping or sliding movements as game input, these games were unique in that they required players to perform tilting (to steer the car in the racing game) or continuous drag movements (to move the ping-pong paddle in the sports game). This additional load on the interaction with the game should be considered when comparing ratings of enjoyment and interaction with the game.

## Limitations

This study is not without known methodological limitations regarding problems in obtaining a representative sample of older adult players [6]. Of note, there is great heterogeneity in older people regarding their cognitive and physical abilities and their preferred leisure activities that were not addressed in this study. Although our participants were healthy, highly motivated older adults interested in research with little or no prior game experience and were generally unfamiliar with video game genre jargon, it remains unclear whether our findings can be generalized to less-motivated and even cognitively impaired persons.

Although special attention was paid to gender-inclusivity during the selection of the casual games, we did not include gender as a factor in the analysis of genre preference and interaction with the game, owing to the smaller number of female participants.

In addition, playing time for each video game was limited to around 5 min, allowing us to collect first impressions and ease of interaction, rather than long-term experiences with the video games. It therefore remains unclear whether the CVG genre preferences persist over extended experience with the game (eg, during a game-based intervention).

## Conclusions

The goal of this study was to find out how well different CVG genres met casual game characteristics and how this led to game enjoyment in a population of older adults. We argue that our findings can be matched with a recent position De Schutter and Abeele [9] take in their "gerontoludic" manifesto. Here, the authors criticize that video game-based aging interventions focus too much on improving cognitive function and usability, while fun aspects are often forgotten.

To address this issue, the manifesto states that video games should primarily provide older adults with a meaningful and playful activity. We were able to confirm this with the general finding that casual games were well-enjoyed and participants were willing to play them. This is closely related to their second claim that video games should focus on challenge and personal growth and rather than simply combatting age-related cognitive decline. Although we did not address this, we believe that this claim is easily met by the positive themes CVGs are characterized by and that these games use difficulty adjustments to optimally challenge the player. Finally, in their third claim the authors propose that video games should offer a diversity to accommodate the heterogeneity of older adults in their cognitive and physical skill levels, backgrounds, and preferences. Again, it is our understanding that it is in the very nature of CVGs to satisfy this demand.

In line with recent findings, this study confirms a special preference of older adults for the puzzle game genre. It would be interesting for future studies to capitalize on this in future video game interventions for older adults. It also appears worthwhile to conduct video game interventions using multiple game genres, as only few studies have looked at the training benefits of different game genres in older adults [30]. We therefore welcome future studies to continue exploring the potential of CVG interventions and investigate possible effects on cognition, everyday functioning, and well-being. Finally, we see particular clinical potential for CVGs in people suffering from cognitive impairment due to dementive and depressive disorders or brain injury.

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## Authors' Contributions

AC developed the practical design of the study, tested the participants, carried out the analysis, and wrote the manuscript. PW conducted the LMEM analyses and helped with the interpretation of the results. RMM and UPM contributed to the design of the study and provided feedback on the introduction and discussion section of the manuscript. TN jointly developed the study design, was instrumental in the interpretation and discussion of the results, and supervised and coordinated the study. All authors jointly contributed in correcting and approving the final manuscript.

## Conflicts of Interest

None declared.

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## Abbreviations

**ANOVA:** analysis of variance
**CEGEQ:** Core Elements of the Gaming Experience Questionnaire
**CVG:** casual video game
**FPS:** first person shooter
**LMEM:** linear mixed effects model


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Original Paper

# A Blended Web-Based Gaming Intervention on Changes in Physical Activity for Overweight and Obese Employees: Influence and Usage in an Experimental Pilot Study

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## *Abstract*

**Background:** Addressing the obesity epidemic requires the development of effective interventions aimed at increasing physical activity (PA). eHealth interventions with the use of accelerometers and gaming elements, such as rewarding or social bonding, seem promising. These eHealth elements, blended with face-to-face contacts, have the potential to help people adopt and maintain a physically active lifestyle.

**Objective:** The aim of this study was to assess the influence and usage of a blended Web-based gaming intervention on PA, body mass index (BMI), and waist circumference among overweight and obese employees.

**Methods:** In an uncontrolled before-after study, we observed 52 health care employees with BMI more than 25 kg/m$^2$, who were recruited via the company's intranet and who voluntarily participated in a 23-week Web-based gaming intervention, supplemented (blended) with non-eHealth components. These non-eHealth components were an individual session with an occupational health physician involving motivational interviewing and 5 multidisciplinary group sessions. The game was played by teams in 5 time periods, aiming to gain points by being physically active, as measured by an accelerometer. Data were collected in 2014 and 2015. Primary outcome was PA, defined as length of time at MET (metabolic equivalent task) ≥3, as measured by the accelerometer during the game. Secondary outcomes were reductions in BMI and waist circumference, measured at baseline and 10 and 23 weeks after the start of the program. Gaming elements such as "compliance" with the game (ie, days of accelerometer wear), "engagement" with the game (ie, frequency of reaching a personal monthly target), and "eHealth teams" (ie, social influence of eHealth teams) were measured as potential determinants of the outcomes. Linear mixed models were used to evaluate the effects on all outcome measures.

**Results:** The mean age of participants was 48.1 years; most participants were female (42/51, 82%). The mean PA was 86 minutes per day, ranging from 6.5 to 223 minutes, which was on average 26.2 minutes per day more than self-reported PA at baseline and remained fairly constant during the game. Mean BMI was reduced by 1.87 kg/m$^2$ (5.6%) and waist circumference by 5.6 cm

(4.8%). The univariable model showed that compliance, engagement, and eHealth team were significantly associated with more PA, which remained significant for eHealth team in the multivariable model.

**Conclusions:** This blended Web-based gaming intervention was beneficial for overweight workers in becoming physically active above the recommended activity levels during the entire intervention period, and a favorable influence on BMI and waist circumference was observed. Promising components in the intervention, and thus targets for upscaling, are eHealth teams and engagement with the game. Broader implementation and long-term follow-up can provide insights into the sustainable effects on PA and weight loss and into who benefits the most from this approach.

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**KEYWORDS**

eHealth; gamification; physical activity; fitness tracker; body mass index; engagement; social support; blended care

## Introduction

Worldwide, 2.1 billion individuals are overweight or obese and the prevalence keeps increasing [1]. This a major burden for not only individual health but also health care and societal costs [2]. Physical activity is important to enhance weight loss and for the prevention of weight gain, reducing the risks of serious health problems such as cardiovascular disease, cancer, diabetes, osteoarthritis, and depression [3,4]. Adherence to physical activity recommendations among obese individuals is poor [5,6], creating an urgent need for a scalable, effective, and sustainable approach to enhance physical activity in the prevention and treatment of obesity. Although eHealth has this potential, attrition rates in eHealth programs are high [7,8], which means that sustainable behavior change may require a more intense approach [9]. The most promising approach for promoting healthy behavior in an efficient manner seems to be the combined use of successful eHealth components and non-eHealth components [10].

The eHealth components that have been shown to be promising elements of a successful Web-based health intervention are use of accelerometer or activity tracker [11] and gamification [12]. Accelerometers monitor the level of physical activity, which plays a critical role in reducing health risks and improving body composition [13-16] and is essential for long-term weight management in overweight and obese individuals [17]. There is a growing availability of such “quantified self” devices, which objectively measure an individual’s level of physical activity by means of the total amount, intensity, duration, and frequency of physical activities. In addition to objective registration of the level of physical activity, using an accelerometer can raise the individual’s awareness of his or her activity level [18] and consequently increase the level of physical activity [19,20]. Gamification is an emerging field and has shown to be promising, achieving its effectiveness by rewarding, social bonding, and making the health intervention fun to engage in [12], which is in common with proven health behavior change approaches [21,22]. Despite the advantages of a broad reach and easy accessibility [23], eHealth-only approaches tend to suffer from high attrition and dropout rates [8], which should be prevented if aiming for a sustainable lifestyle change.

Apart from eHealth, direct human contact by way of counseling can be an important component in lifestyle behavior programs. Motivational interviewing is a suitable counseling technique to improve exercise adherence [24] and weight loss [25,26], taking into account a patient’s readiness to make lifestyle changes as well as for planning and goal setting. A recent review suggested that direct human contact may help intensify the effect of eHealth technologies [10]. There is a lack of evidence on the effectiveness and usage of programs in which eHealth and non-eHealth components are blended for optimal effectiveness, reach, adherence, and costs.

Aiming for a both effective and efficient intervention with blended usage of eHealth components and non-eHealth components, we developed our program and implemented it in a pilot setting. The results of this pilot study will inform us whether broader implementation with longer follow-up is useful for this target population. Therefore, the aims of this study were to analyze the sustainability of physical activity during the game and to assess changes in body mass index (BMI) and waist circumference. In addition, we aimed to assess the influence of compliance, engagement, and eHealth teams on these outcomes.

## Methods

### Study Design and Population

This uncontrolled, before-after pilot study evaluates a blended Web-based gaming intervention for overweight and obese employees to become more physically active and adopt a healthy diet in a way that suits their personal preferences and abilities and, ultimately, to lose weight. The program was developed and implemented by the occupational health center of the Erasmus MC, University Medical Center in Rotterdam to improve the vitality and well-being of its overweight and obese employees. The main idea was developed and tested in 2010 and upgraded to the current version in 2013, which was tested by a test group before implementation in our study population. Key objectives of this program are to encourage overweight employees to become more physically active and adopt a healthy diet in a way that suits their personal preferences and abilities and, ultimately, to lose weight. The program consists of a face-to-face individual session with an occupational health physician, 5 group sessions, and a 20-week movement game that is played in real life, using accelerometers to measure physical activity.

Participants were recruited by memos on the company’s intranet in December 2013 and in September 2014 and were selected based on being overweight or obese (BMI ≥25 kg/m$^2$) or having a large waist circumference (≥102 cm for men and ≥88 cm for women) and being motivated to change their lifestyle. Because of the Web-based approach, affinity with computers was desirable, but only computer accessibility was required. Excluded from participation were employees who (1) were using medication with weight gain being a side effect, (2) were unable to be physically active, (3) were currently pregnant or breastfeeding, or had the wish to be pregnant within 23 weeks, (4) did not speak Dutch, or (5) needed an intervention for an additional problem (alcohol intervention, thyroid regulation). Selection for the program took place during a 30-minute individual session with the occupational health physician.

Participation in the program was voluntary and no individual information was shared with anyone, especially not with the employer or direct supervisor. The program was free of charge for the first 24 applicants because this was covered by a grant. When the program was offered half a year later to an additional 28 applicants, the program content remained identical, but a participation fee of €450 was introduced to cover the workshop and the accelerometer. The study protocol was approved by the Medical Ethics Committee of the Erasmus University Medical Center (registration numbers MEC-2015-134 for overweight participants and MEC-2012-257 for obese participants), and signed informed consent forms were obtained from all participants. Although this is not a randomized controlled trial, reporting of the study was performed according to the CONSORT-EHEALTH (Consolidated Standards of Reporting Trials of Electronic and Mobile Health Applications and Online Telehealth) standards where applicable [27]. See Multimedia Appendix 1 for the CONSORT-EHEALTH checklist.

## Intervention

Gaming components of social bonding, rewarding, and competition are included throughout the program, which is offered in a combination of eHealth and face-to-face care (non-eHealth), that is, a blended intervention.

### *Non-eHealth*

#### Session With Occupational Health Physician

During this session, motivational interviewing was used to determine motivation to make lifestyle changes and to start individual planning and goal setting [28]. After being selected, participants received a confirmation letter stating the start date of the program and instruction on how to purchase the obligatory accelerometer.

#### Group Sessions

Group sessions took place in the 1st, 2nd, 3rd, 4th, and 12th week of the program and lasted 2.5 to 3 hours each. Each group consisted of a maximum of 20 participants. Because obesity requires a multidisciplinary approach [29], the sessions were alternately given by a physician, a dietician, a physical therapist, and a psychologist. During the group sessions, participants (1) were educated on the health risks of obesity and the benefits of a healthy lifestyle, including physical activity, diet, alcohol consumption, and relaxation; (2) were guided in individual goal setting and planning and challenged to makes choices that would be sustainable in regard to personal preferences and social context, with the aim to increase physical activity and lower caloric intake; and (3) received explanation on the movement game and on the use of the accelerometer. Social networking with fellow group members was stimulated during all sessions.

### *eHealth: Movement Game*

The movement game is a Web-based tour around the world, which is played by being physically active in the "real world." Touring the world takes 20 weeks, and every 4 weeks the tour crosses another continent (Europe, North America, Asia, Australia, Africa). The game was played by 2 competing teams aiming to win the continent by scoring the most "movement points." An independent "game coach" randomly divided the participants of one program into 2 eHealth teams, which he announced during the third group session along with the rules of the game. Every team member strove to reach his or her personal target, which was set before the first continent by the physical therapist. Movement points were granted according to the duration and intensity of physical activity, which was registered by an accelerometer. Players were asked to upload the accelerometer data into the Web-based movement game via a USB connection at least once a week and were educated on the Dutch norm of physical activity, which is being physically active at least 5 times a week for 30 minutes (21.4 minutes/day) at MET (metabolic equivalent task) 3 or higher, and on the "fit norm," which is physical activity at least 3 times a week for 20 minutes (8.6 minutes/day) at MET 6 or higher [30]. If a personal target was reached within a continent, a written advice for raising the target for the next continent appeared on the personal webpage. Participants could visually monitor their progression toward their individual targets and against the other team at any time, both on a desktop computer and on a mobile phone. Figure 1 shows a screenshot of the gaming intervention. Multimedia Appendix 2 provides additional screenshots of the movement game, illustrating the competition.

Registration of physical activity was performed by the Activ8 system (Remedy Distribution Limited, Valkenswaard, The Netherlands), which is a small triaxial accelerometer that is worn in the pocket of any pants or with a leg strap on the upper leg [31]. The Activ8 output was tested against video analysis, and sensitivity scores of postures and movements ranged from 81% to 98%. The game coach handed out instructions for installing the Activ8 software on the computer and assisted if necessary. A critical requirement for sufficient valid functioning is wearing the device in the correct position and without (excessive) tilting; this was specifically instructed by the game coach in our study. During the game, the Activ8 device needed to be worn at all times, except during swimming and sleeping. Because swimming was not registered by the Activ8 device, the number of swim minutes could be filled out manually on the game's webpage.

Every 2 weeks an automatic email was sent to the participants, providing general information on multiple lifestyle aspects related to the upcoming continent. If participants failed to log on to the game's website for more than 2 weeks, an email reminder was sent by the game coach. An online social network was provided by the game by means of a digital forum page. Written messages, as well as responses to these messages, could be posted by the participants or the game coach. The game coach could be consulted every working day at the occupational health center and was the same person throughout the program.

Awards could be won both individually and as teams. Virtual bronze, silver, and gold medals would appear for every individual achieving 80%, 90%, or 100% of their individual target within a continent. In addition, after completion of a 4-week continent, 1 individual player and all members of the winning team received tangible gifts related to a healthy lifestyle, such as a sports towel or a water bottle. The individual winner was selected by the game coach based on having collected the most movement points, having made the most progress, or showing the best team spirit on the forum. The game coach announced the continent winners by a message on the Web-based forum and granted the awards personally.

Although uploading of movement points by the accelerometer could only be done using a desktop computer, all other aspects of the game were accessible by mobile phone as well. Confidentiality of users was ensured by using only first names in the game. To ensure security of content and users, the game used password-protected accounts, encrypted password storage, encrypted log-in details, and secure external servers. During the program, no interfering bug fixing was needed.

**Figure 1.** Screenshot of the movement-game.


## Measurements

Collection of baseline characteristics (age, sex, level of education, shift work, working hours per week) was done during the individual selection session with the company's occupational health physician (TK), between February 2014 and July 2015. Educational level was categorized into 2 categories (low or medium and high) according to the Dutch educational system.

Participants with BMI ≥30 kg/m$^2$ were additionally seen by the specialist for internal diseases and endocrinology (EvR) of the Obesity Center CGG ("Centrum Gezond Gewicht") of the Erasmus Medical Center of Rotterdam to ensure appropriate treatment of underlying or complicating diseases. Costs were covered by the health insurance company, with the exception of an individual's deductible. Because participants with BMI ≥30 kg/m$^2$ were remeasured at 10 weeks by this specialist, we added this 10-week measurement to participants with BMI 25-30 kg/m$^2$ in groups 3 and 4 in order for the measurements to be identical for all BMI categories.

### Primary Outcome: Average Physical Activity per Day (Average MVPA)

The Activ8 accelerometer provided information on the number of seconds spent at a certain MET level, which was collected by the supportive information and technology company (ICT) at the end of the 20-week movement game. We categorized physical activity into time spent in moderate physical activity (MPA) and time spent in vigorous physical activity (VPA), expressed in MET-hours. The cutoff energy levels used for this study were ≥3 to 6 METs for MPA and ≥6 METs for VPA. The cutoffs are based on the Dutch recommendations for healthy behavior [30]. Moderate to vigorous physical activity (MVPA) was the sum of MPA and VPA, also expressed in MET-hours. The accelerometer had to register ≥10 hours per day of activity at >1 MET to count as a "valid day." We registered a "nonvalid day" when no more than 10 hours of activity was registered or when there was no registration at all because the battery ran out, because we interpreted this as nonusage of the device. We calculated the average MVPA in MET-hours by dividing MVPA during the game by the number of valid days.

### Secondary Outcomes: Body Mass Index and Waist Circumference

For weight measurements, the occupational health physician used the scale that was available for daily practice (Inventum PW705BG (Arnhem, The Netherlands)), which is calibrated once a year and remained the same throughout the study period. For calculating BMI in kg/m$^2$, body height was self-reported at baseline, which differed less than 1% from objective measures at 10 and 23 weeks, and the value was kept the same in all BMI calculations. Waist circumference was always measured by the same occupational health physician and was measured halfway between the lower rib and the iliac crest, as is advised by the Dutch obesity recommendations for general practitioners [32]. Both measurements were done at baseline and 10 and 23 weeks after baseline. Delta BMI and delta waist circumference were used as outcome parameters, which were the measurements at baseline minus those at 10 and 23 weeks.

### Determinants: Compliance, Engagement, eHealth Team, and Other

#### *Compliance*

A program-specific demand was used as behavioral measure of compliance, which was the percentage of days with more than 10 hours of accelerometer wear during the 20-week game (ie, accelerometer wear).

#### *Engagement*

Engagement was measured as the number of times at least 100% of the personal target level was reached (ranging from 0 to 5) and categorized into ≤3 times and 4 or 5 times.

#### *eHealth Teams*

All participants were randomly assigned to an eHealth team (8 teams in total) for social influencing. For the purpose of analyses, we categorized teams into dummy numbers 1 to 8.

#### *Other Measures of Usage*

To further assess usage of the game, we measured the number of log-ins on the game website and the number of messages posted on the forum.

### Data Analysis

Descriptive statistics were used to present the baseline characteristics of the study population. We excluded data of 1 participant because of pregnancy. The primary outcome measure was average MVPA (time-weighted area under the curve of the MET level) during the 20-week period of the game. Secondary outcomes were reductions in BMI and waist circumference versus baseline. Determinants were compliance to and engagement with the game and team effects.

In univariable linear regression analyses we investigated the association between age, sex, educational level, BMI at baseline, working hours per week, shift work, eHealth team, compliance (accelerometer wear), engagement (number of times the target level was reached), and other measures of usage (number of log-ins and messages on the forum) as independent variables and the average amount of MVPA per day as the dependent variable. To compare eHealth teams, we chose the team with the lowest average MVPA as the reference category. We log-transformed MVPA to create an approximately normal distribution of our outcome variable.

Univariable and multivariable analyses were performed using linear mixed models to account for the within-subject correlations due to intrateam effects and, in the case of BMI and waist circumference, for repeated measurements. The average amount of MVPA per day was used as outcome measure of the multivariable analyses, and the reductions in BMI and waist circumference at 10 and 23 weeks versus baseline were outcome measures of both univariable and multivariable analyses. We evaluated multiple models by combining different determinants in each model, aiming to get insight into the (combination of) independent variables with the most effect on the outcomes. The independent variables in separate and combined models were accelerometer wear as a measure of compliance and the number of times the individual target was reached as a measure of engagement; in the linear mixed models for the change in BMI and waist circumference during the intervention, we added the average amount of MVPA during the game and changes in time (10 and 23 weeks). All models were further adjusted for sex, age, and BMI at baseline. The variances between eHealth teams were included as random effects. A random intercept was included to account for the within-subject correlations. Collinearity between independent variables was assessed by calculation of the variance inflation factors. We considered including interaction effects between each independent variable and time, but this was not necessary because tests showed no significant interaction effects.

All statistical tests were two-sided and used a significance level of .05. All statistical analyses were performed using IBM SPSS version 22 (IBM Corporation).

## Results

In total, 52 employees participated in this program, of whom 1 participant was excluded from analyses because of pregnancy. Figure 2 shows the flow of participants in the program, including the number of participants, the grouping, and the program flow over time. Of the participants with BMI ≥30 kg/m$^2$, 3 were not additionally screened at study inclusion by the specialist for internal diseases and endocrinology because of personal choices.

Baseline characteristics for all study participants are provided in Table 1. The mean age of the participants was 48.1 years, ranging from 29 to 65 years, and 69% received higher education. The majority of participants were female (42/51, 82%).

**Table 1.** Baseline characteristics of participants (n=51).

| Characteristics | n (%) | Mean (SD) |
| --- | --- | --- |
| **Sex** | | |
| Men | 9 (18) | |
| Women | 42 (82) | |
| Age, years | | 48.1 (9.2) |
| **Educational level** (n=45) | | |
| Low or medium | 14 (31) | |
| High | 31 (69) | |
| Insufficient physical activity[a] (n=42) | 31 (74) | |
| Weight, kg | | 96.3 (16.9) |
| **Waist circumference, cm** | | |
| Men | | 124.3 (14.59) |
| Women | | 109.7 (10.8) |
| **Body mass index, kg/m$^2$** | | 32.7 (5.1) |
| 25-30 | 15 (29) | 27.2 (0.9) |
| ≥30 | 36 (71) | 35 (4.4) |
| **Work** | | |
| Hours/week | | 30.8 (7.1) |
| Shift work[b] | 10 (20) | |

[a]Defined as no adherence to the Dutch guideline at baseline.

[b]Evening or night shifts.

Figure 3 shows that the average MVPA remained fairly constant during the entire game and that the Dutch norm of physical activity was met by every individual in each continent, which is high as opposed to 26% at baseline based on self-reported data. The “fit norm” was not met by 90% of the participants (data not shown). The average MVPA during the game was 7.08 MET-hours, ranging from 0.5 to 18.89 MET-hours.

Table 2 shows that sex, age, level of education, BMI, and waist circumference at baseline as well as work parameters were not significantly associated with the average MVPA. Several elements of the game seem to be associated with a higher level of MVPA. After inversion of the log-transformed MVPA, the eHealth teams showed a 7.9-fold difference in increase in average MVPA (95% CI 4.2-14.8), illustrating the large variability in improvement in MVPA across teams. The average MVPA of teams ranged from 1.9 to 13.3 MET-hours per day. More compliance was also significantly associated with an increase in average MVPA. For example, 20 more days of wear would mean an increase of 35% of MVPA (95% CI 2%-79%) on the days the accelerometer was worn. On average, the accelerometer was worn for more than 10 hours per day on 89% of the available days, ranging from 44% to 100%. This percentage was above 80% in all 5 continents of the game. Compared with low engagement during the game (ie, infrequently reaching individual targets), there is an absolute gain in MVPA of 2.8-fold relative increase (95% CI 1.7-4.6) when being highly engaged. The individual target of physical activity was reached at the most 3 times by 32 (63%) participants and more than 3 times by 19 participants (37%).

**Table 2.** Association between baseline characteristics and program usage and physical activity (n=51): univariable linear regression analyses.

| Characteristics | | Moderate to vigorous physical activity[a] | |
|---|---|---|---|
| | | B (95% CI) | *P* value[b] |
| **Sex** | | | |
| | Women | Reference | |
| | Men | 0.38 (−0.35 to 1.10) | .30 |
| Age, years | | 0.01 (−0.03 to 0.04) | .76 |
| **Educational level** | | | |
| | Low or medium | Reference | |
| | High | 0.44 (−0.20 to 1.08) | .18 |
| Body mass index, kg/m$^2$ | | −0.02 (−0.07 to 0.04) | .53 |
| Waist circumference, cm | | 0.10 (−0.01 to 0.03) | .36 |
| Work, hours/week | | −0.02 (−0.07 to 0.02) | .26 |
| **Shift work** | | | |
| | Yes | Reference | |
| | No | 0.23 (−0.50 to 0.96) | .53 |
| **Characteristics of program usage** | | | |
| eHealth team (1-8) | | | |
| | Team 1 | 2.06 (1.43 to 2.70) | <.001 |
| | Team 2 | 2.04 (1.37 to 2.72) | <.001 |
| | Team 3 | 2.06 (1.46 to 2.66) | <.001 |
| | Team 4 | 1.72 (1.14 to 2.29) | <.001 |
| | Team 5 | 1.01 (0.43 to 1.59) | .001 |
| | Team 6 | 0.09 (−0.48 to 0.67) | .75 |
| | Team 7 | 0.45 (−0.13 to 1.02) | .13 |
| | Team 8 | Reference | |
| Compliance: accelerometer wear[c] | | 0.02 (0.00 to 0.04) | .04 |
| Engagement | | | |
| | ≤3 times target reached | Reference | |
| | 4 or 5 times target reached | 1.03 (0.52 to 1.53) | <.001 |
| Number of log-ins | | −0.00 (−0.01 to 0.01) | .74 |
| Number of messages | | 0.01 (0.00 to 0.02) | .04 |

[a]Log-transformed average moderate to vigorous physical activity (metabolic equivalent task or MET>3), in MET hours.

[b]Statistical significance was defined as *P*<.05.

[c]Percentage of days with >10 hours of physical activity registration.

The attrition curve in Figure 4 shows a decrease in compliance and engagement and other measures of usage toward the end of the game, although the average MVPA remained fairly constant. A total of 4 participants showed no accelerometer wear in the last continent. Reasons for no uploads were vacation abroad for 2 participants, a lost device for 1 participant, and a lack of motivation for another participant. We note that some teams switched to alternative social media in the last continent, which may explain the decrease in messages on our forum.

Table 3 suggests that team membership has a fairly robust effect on average MVPA, because the standard deviation of the random effect of eHealth team remains similar in models 3 through 6 and because 0.45 (0.99 in model 2 minus 0.54 in model 3) of the variance between participants was explained by eHealth team. The heterogeneity between eHealth teams is presented as the standard deviation of the normally distributed random effects of eHealth teams for the log-transformed MVPA value. The value of 0.88 for this standard deviation in model 3 implies a 3.7-fold relative difference in average MVPA between two teams randomly chosen from the population, thus suggesting large differences between teams that could not be explained by age, sex, or BMI at baseline, nor were they additionally affected by compliance or engagement. The variance inflation factor did not exceed 1.5 for any independent variable, which indicates that there was no multicollinearity problem.

**Table 3.** Multivariable association between baseline characteristics and program usage and physical activity (n=51): separate models using linear mixed models.

| Characteristics of program usage: models | | | Moderate to vigorous physical activity[a] | | |
|---|---|---|---|---|---|
| | | | Sources of variance, SD[b] (95% CI) | | B (95% CI) |
| Model: description | Independent variables (additional) | Categories | Between eHealth teams | Between participants | |
| Model 1: raw | | | N/A[c] | 0.98 (0.80 to 1.19) | N/A |
| Model 2: baseline characteristics | | | N/A | 0.99 (0.81 to 1.22) | |
| | Age | | | | 0.01 (−0.03 to 0.04) |
| | Sex | Women | | | Reference |
| | | Men | | | 0.43 (−0.33 to 1.19) |
| | BMI[d] at baseline | | | | −0.02 (−0.08 to 0.04) |
| Model 3: model 2 + eHealth team | | | 0.88 (0.51 to 1.55) | 0.54 (0.43 to 0.67) | |
| Model 4: model 3 + compliance | | | 0.86 (0.49 to 1.52) | 0.55 (0.44 to 0.69) | |
| | Compliance[e] | <85% | | | Reference |
| | | 85%-95% | | | 0.15 (−0.34 to 0.65) |
| | | ≥95% | | | 0.17 (−0.31 to 0.64) |
| Model 5: model 3 + engagement | | | 0.83 (0.46 to 1.50) | 0.54 (0.43 to 0.68) | |
| | Engagement[f] | ≤3 | | | Reference |
| | | 4 or 5 | | | 0.19 (−0.25 to 0.64) |
| Model 6: model 3 + compliance + engagement | | | 0.82 (0.45 to 1.48) | 0.56 (0.44 to 0.70) | |
| | Compliance | <85% | | | Reference |
| | | 85%-95% | | | 0.17 (−0.34 to 0.67) |
| | | ≥95% | | | 0.06 (−0.50 to 0.62) |
| | Engagement | ≤3 | | | Reference |
| | | 4 or 5 | | | 0.17 (−0.32 to 0.66) |

[a]Log-transformed average moderate to vigorous physical activity (metabolic equivalent task or MET>3), in MET hours.
[b]SD is the standard deviation of the random effect between teams or between participants.
[c]N/A: not applicable.
[d]BMI: body mass index.
[e]Compliance is expressed as percentage of days with >10 hours of physical activity registration (accelerometer wear).
[f]Engagement is expressed as the number of times at least 100% of the target was reached (1-5).

Figure 5 shows the categories of reductions in BMI and waist circumference after 23 weeks. The mean BMI was reduced by 1.87 kg/m$^2$ (range -8.7 to 2.4 kg/m$^2$) during the program, corresponding to 5.6% (range -20.2% to 7.6%), and the mean waist circumference was reduced by 5.6 cm (range −4.5 to 23 cm). Univariable analysis showed significantly more reductions in BMI and waist circumference (BMI: B 0.12, 95% CI 0.04-0.20; waist circumference: B 0.22, 95% CI 0.09-0.36) when BMI and waist circumference values were higher at the start of the program (Multimedia Appendix 3).

Model 5 in Table 4 shows that more engagement was the only component associated with reductions in BMI (B 1.23, 95% CI 0.17-2.29) and waist circumference (Multimedia Appendix 4; B 4.44, 95% CI 0.84-8.03) even with adjustment for the effect of the eHealth team. Thus, reaching a relatively high personal level of physical activity seems more important than aiming for the absolute highest level of physical activity of a group. Addition of more elements to the models (models 6 and 7) attenuated the effects of engagement. The frequency of accelerometer wear (compliance) affected neither BMI nor waist circumference significantly (model 4). The value 0.53 for the standard deviation of the random effect of eHealth team in model 3 shows a maximum difference of 2 kg/m$^2$ between teams in reduction of BMI (1.96x2x0.53 kg/m$^2$) and the value 1.79 shows a maximum difference of 7 cm in reduction of waist circumference (1.96x2x1.79 cm). Although this exceeds the average reduction in BMI (1.87 kg/m$^2$) and in waist circumference (5.6 cm), the variance between participants of eHealth teams hardly changes by adding eHealth team to the model, implying no effect of eHealth team on the reduction in BMI and waist circumference.

**Table 4.** Determinants of reductions in body mass index, at 10 and 23 weeks versus baseline, combined in models using linear mixed models.

| Characteristics of program usage: models | | | Δ BMI[a,b], kg/m² | | |
|---|---|---|---|---|---|
| | | | Sources of variance, SD (95% CI) | | B (95% CI) |
| Model: description | Independent variables (additional) | Categories | Between teams | Between participants | |
| Model 1: raw | | | N/A[c] | 1.38 (0.97 to 1.96) | N/A |
| Model 2: baseline characteristics | | | N/A | N/A | |
| | Age | | | | −0.001 (−0.06 to 0.06) |
| | Sex | Women | | | Reference |
| | | Men | | | −0.28 (−1.61 to 1.04) |
| | BMI at baseline | | | | 0.11 (0.01 to 0.21)[h] |
| Model 3: model 2 + eHealth team | | | 0.53 (0.10 to 2.73) | 1.36 (0.95 to 1.94) | |
| Model 4: model 3 + compliance | | | 0.39 (0.001 to 0.59) | 1.08 (0.65 to 1.78) | |
| | Compliance[d] | <85% | | | Reference |
| | | 85%-95% | | | -0.14 (-1.41 to 1.13) |
| | | ≥95% | | | 0.60 (-0.57 to 1.77) |
| Model 5: model 3 + engagement | | | 0.43 (0.001 to 0.60) | 1.26 (0.86 to 1.84) | |
| | Engagement[e] | ≤3 | | | Reference |
| | | 4 or 5 | | | 1.23 (0.17 to 2.29) |
| Model 6: model 3 + MVPA[f] | | | 0.44 (0.001 to 0.60) | 1.06 (0.65 to 1.74) | |
| | MVPA | | | | 0.16 (−0.39 to 0.70) |
| Model 7: model 3 + compliance + engagement + MVPA | | | 0.50 (−0.00 to 0.64) | 1.04 (0.62 to 1.75) | |
| | Compliance | <85% | | | Reference |
| | | 85%-95% | | | −0.09 (−1.37 to 1.19) |
| | | ≥95% | | | 0.13 (−1.22 to 1.47) |
| | Engagement | ≤3 | | | Reference |
| | | 4 or 5 | | | 1.01 (−0.13 to 2.15) |
| | MVPA | | | | −0.05 (−0.64 to 0.55) |
| | Time | 0-10 weeks | | | Reference |
| | | 0-23 weeks | | | 0.99 (0.35 to 1.62)[g] |

[a]BMI: body mass index.

[b]Δ of outcome = reduction in outcome calculated by measurement at baseline minus measurement at follow-up.

[c]N/A: not applicable.

[d]Compliance is expressed as percentage of days with >10 hours of physical activity registration (accelerometer wear).

[e]Engagement is expressed as the number of times at least 100% of the target was reached (1-5).

[f]MVPA: moderate to vigorous physical activity.

[g]Statistically significant at *P*<.05.

**Figure 2.** Flow of participants. BMI: body mass index; OP: occupational health physician; PA: physical activity.

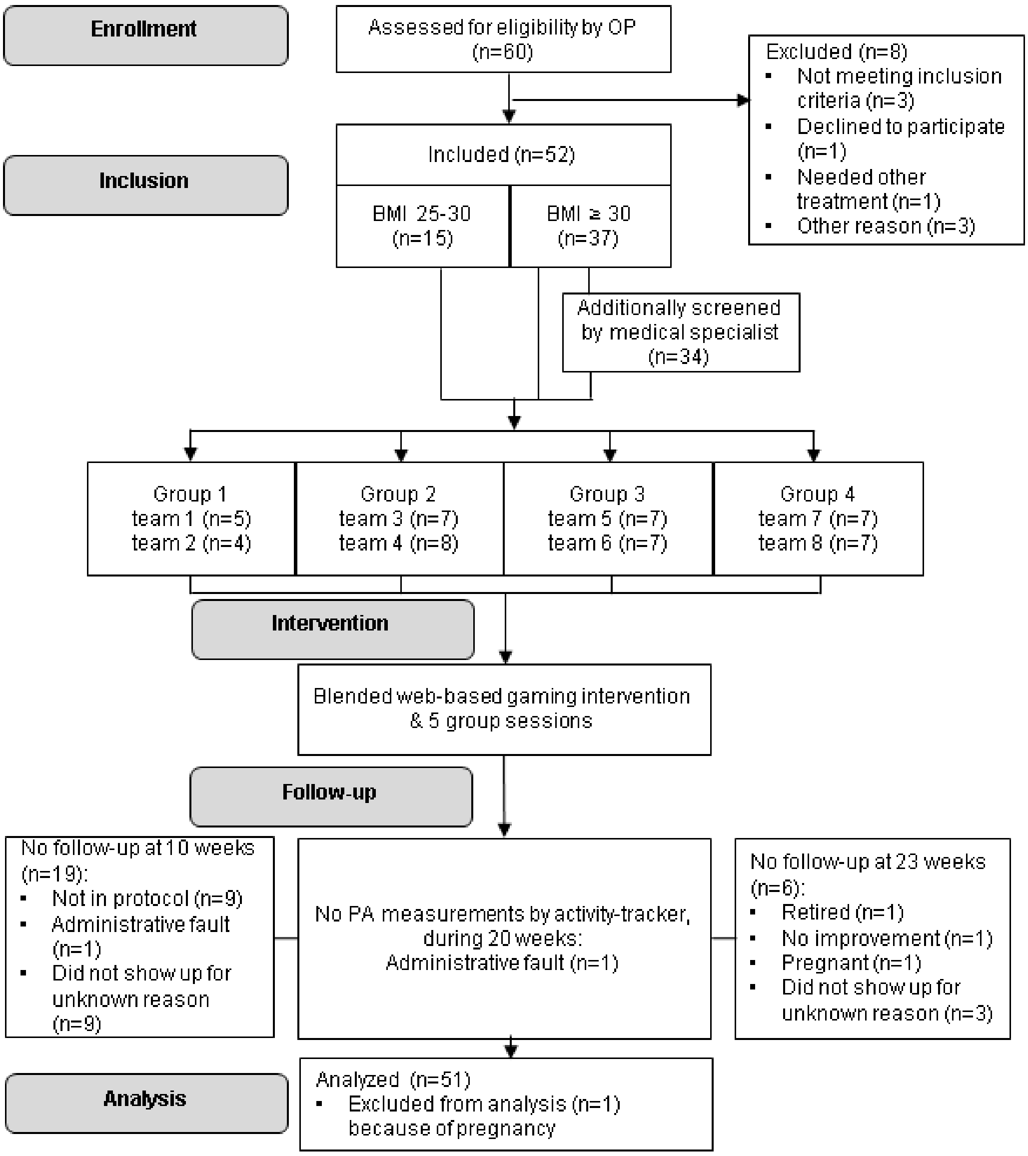


**Figure 3.** Box plot showing moderate to vigorous physical activity in minutes per day in all 5 continents of the game. The dashed line marks physical activity (PA; metabolic equivalent task or MET≥3) for 30 minutes at least 5 times a week (=150 minutes per week, which is on average 21.4 minutes per day). The top and bottom borders of the box mark the 75th and 25th percentiles; the horizontal line in the middle indicates the median. The whiskers mark the lowest and highest scores.

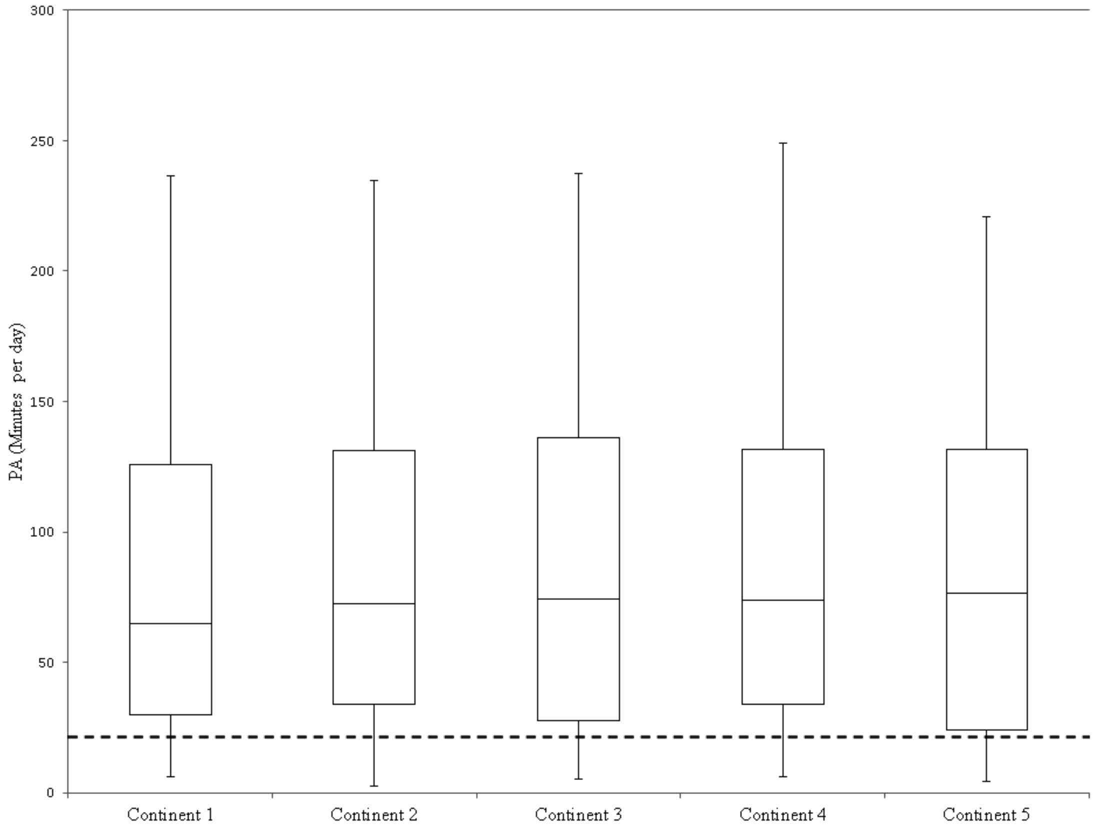



**Figure 4.** Attrition curve: program usage in the continents of the movement game. Compliance (accelerometer wear) is expressed as the average number of days with at least 10 hours of physical activity registration at >1 MET (metabolic equivalent task). Engagement (target reached) is expressed as physical activity registered by the accelerometer divided by the individual target level of physical activity within a certain continent. Log-ins to the program are expressed as the number of online log-ins within a certain continent divided by the number of online log-ins during the entire game. Messages posted are expressed as the number of messages posted on the Web-based forum within a certain continent divided by the number of messages posted during the entire game.

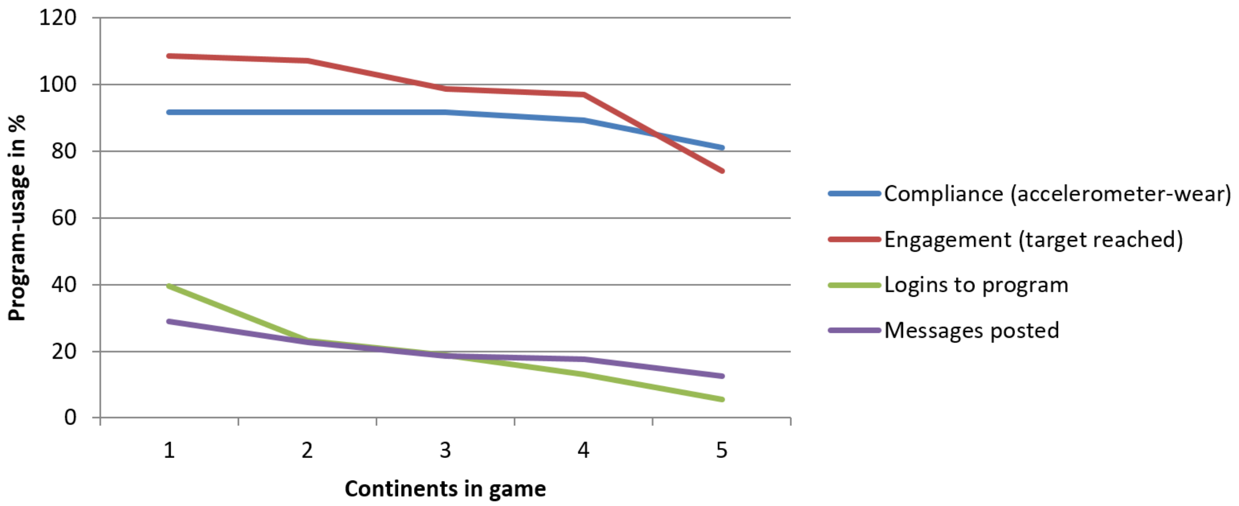
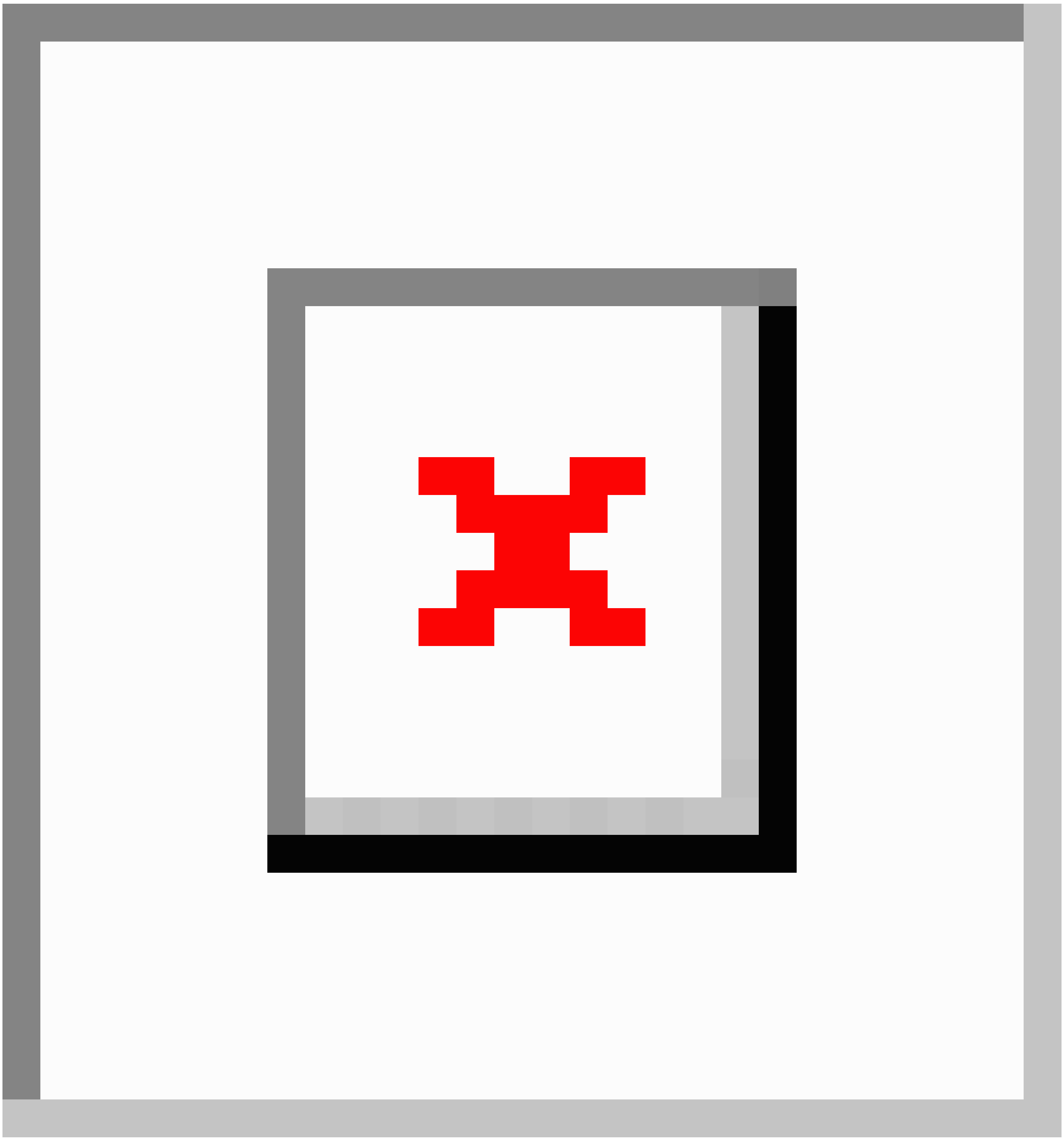


**Figure 5.** Reduction in weight and waist circumference of eHealth program participants, at 23 weeks versus baseline, in categories. BMI: body mass index.



## Discussion

### Principal Findings

In this clinical pilot study in an overweight or obese working population, we evaluated the levels of physical activity during a Web-based gaming intervention using a triaxial accelerometer and we assessed changes in BMI and waist circumference versus baseline. In addition, we evaluated individual characteristics and characteristics of program usage as determinants of our outcomes. We found that levels of physical activity remained high during our intervention and, in addition, reductions in BMI and waist circumference were achieved. Key components for success were social interaction by eHealth teams and the level of engagement. These results indicate that broader implementation of a Web-based gaming intervention with focus on eHealth teams and engagement will be beneficial for overweight and obese individuals, and long-term effects should be studied.

Accelerometer measurements showed a mean MVPA of 86 minutes per day at moderate or vigorous level in our participants, which was high in comparison with an average of 35.5 minutes of MVPA per day in men and 32 minutes in women reported by Hallal et al [33]. The authors reviewed studies with the same wear time criteria of at least 10 hours/day, but subjects were healthy instead of overweight or obese and were observed for a short period of time instead of involved in an active intervention. Our mean MVPA is also high considering that adherence to physical activity guidelines among obese individuals is reported to be even poorer than among healthy weight individuals [5]. When we compare our results with the general Dutch population, we note that a relatively large proportion of our participants met the recommendation of MPA (100% vs 65%) but relatively few met the recommendation of VPA (10% vs 20%). This lack of sufficient vigorous activity was also reported in a systematic review on active video gaming, showing physical activity hardly exceeding 3 METs [34]. The international recommendation to promote and maintain health recommends any person to be moderately active for at least 30 minutes at least 5 days per week, or vigorously active for at least 20 minutes at least 3 days per week, but advises more physical activity for more health benefits [35,36]. The required time and energy expenditure for weight loss is still unclear [37]. MPA, such as walking, is a common, accessible, and inexpensive form of physical activity, which has shown multiple health effects including reduction in BMI [38]. Nevertheless, physical activity at vigorous level is advised for additional health benefits in the WHO (World Health Organization) Global Recommendations on Physical Activity for Health [36], which also requires less time. Therefore, we could debate whether innovative approaches toward Web-based games should also be aimed at increasing the percentage of VPA for further improvement of weight parameters.

Our finding that more accelerometer wear was not associated with more MVPA in multivariable models supports the finding of previous research that just wearing an accelerometer is not sufficient to promote more MVPA [39,40]. There are more benefits of accelerometer wear than just behavioral, though, which extend to objective measurement and providing personalized feedback based on measurements. Objective measurements by body-worn monitors are preferred over self-reported physical activity [41,42], because self-reported information on physical activity is known to be overestimated compared with the actual amount [43], with an even greater inconsistency between self-reported physical activity and that measured using accelerometers among obese individuals [44]. On the other hand, data by accelerometer wear only provide information on the time the device was worn, in contrast to self-reported information, which gives a more general idea of physical activity. Average of 89% days with valid wear time was high in comparison with 73% in another study among workers [18], which could be due to our selection criteria of overweight or obese and highly motivated participants. Other challenges to the use of accelerometers include the loss of the device and incorrect placement of the device [45]. Nevertheless, we will keep considering usage of an accelerometer as a key element of a Web-based gaming intervention for the purpose of accurate registration needed in individual target setting and in competition with others.

Our finding of a mean reduction of 1.87 kg/m$^2$ in BMI during the program is high, considering the reported effectiveness of exercise programs among adults who are overweight or obese with a pooled reduction between 0.3 and 0.7 kg/m$^2$ [46]. Our results are within the range 0.6 to 4 kg/m$^2$ that they reported when a diet was added. BMI was reduced by more than 5%, which means a reduction of obesity-related health risks [47] and a potential gain of psychosocial benefits, such as a decrease in stress and depression [48] and less sick leave at work [49]. Because primarily Web-based interventions are likely to be more cost-effective and have a wider reach, our intervention may be interesting for policy makers and health professionals.

Two important gaming components in our Web-based program were eHealth teams, as a measure of social bonding, and individual engagement, by way of target setting including virtual rewards. Although eHealth team was not associated with the reduction in BMI or waist circumference, both elements showed beneficial effects on the level of physical activity. This is in line with other studies that reported social support to be associated with obesity-specific health-related quality of life [50], with positive health behavior, such us more physical activity and fruit and vegetable intake [51], and with adherence to treatment [52,53]. Kreps and Neuhauser [54] describe how using eHealth for social bonding can really make a difference in enhancing the quality of health care and health promotion effects. A recent study by Zuckerman and Gal-Oz [40] reported no differences in physical activity by adding gaming elements to daily physical activity registration with feedback on progress. The contradiction between these findings and our study could be explained by their short follow-up of several days and thus the novelty effect. A systematic review by Maher et al [55] on the effectiveness of online social networks on changes in diet and weight or physical activity found evidence that online social networks may be effective in changing health behavior. They noted that integrating social networks in gamification is promising and that the user interface of online social networks should be selected carefully so that it is accessible, interactive, contextually tailored, and can be delivered to larger audiences. Online social interaction during our intervention took place on the Web-based forum of the game within and between teams. We suspect an underestimation of the number of Web-based contacts because several teams also communicated through other social media forums. Unclear is why certain teams ended up choosing other social media than that provided by the game, but they may have foreseen that our website would not be accessible anymore after the 23rd week of the game. Although social influence by eHealth teams seems a strong component, the differences between teams were large, and more research is needed to find out how and by whom social support should be delivered and to predict for whom this could work.

Personal targets were set by the individual and reaching targets appeared to be an important gaming component, which can be explained by comparing it to the theory of *flow*, which is popular among video game designers and was described by Eysenbach as one of the popular gamification tactics [12,56]. By setting targets, people become absorbed and engaged in an activity when they are doing something where their skill level is perfectly matched to the challenge level [12]. Nevertheless, maintaining high levels of activity seems challenging because high attrition rates are commonly seen and considered a disadvantage of eHealth [8]. In our game, the average MVPA did not drop despite the common decrease in usage. We suspect that the embedding of target setting in eHealth teams enhanced sustainability of the level of MVPA. Thus, the two gaming components in our Web-based program, that is, eHealth teams and individual engagement, seem to have positively influenced each other.

Blending components of gamification with face-to-face elements may have attributed to our results, although the study design did not allow quantification. A commonly identified benefit of Web-based interventions is their ability to reach a broad population, but Xu et al [57] showed that interventions successful for groups may not always translate to successful behavior change at the individual level. Offering additional face-to-face coaching to individuals with readiness to change behavior may increase intrinsic behavior for personal lifestyle changes by addressing intrinsic motivation [28], thus aiming for behavior changes to be sustained beyond the gaming period.

### Limitations

First, this clinical pilot study was performed among a small number of individuals without preintervention measurements of physical activity and without a control group, leading to a lack of power in some analyses and to the inability to accurately assess the strength of the effects of multiple blended elements [58]. Nevertheless, this compact setting and the increase in physical activity in comparison with self-reported baseline physical activity provided enough information to suggest broader implementation along with a follow-up study including more individuals in a randomized controlled setting.

Second, gaming elements in our intervention were mainly focused on physical activity. Dietary behavior was only addressed during the non-eHealth sessions. Because the focus was on physical activity, the effects on body composition might have been greater than on only BMI and waist circumference, which is beneficial in reducing cardiovascular risk [59]. Although there is sufficient evidence that physical activity in the absence of a dietary intervention can produce weight loss [37,60], these effects could be increased by including healthy diet in the game [29,46]. The mode of delivery should be carefully chosen because the effects differ among technologies and features [10], and the effect on diet should be measured by a food frequency questionnaire.

Finally, the follow-up time of half a year is insufficient to determine the effectiveness of weight loss maintenance and to ignore potential seasonal variations [61].

### Strengths

This study is unique in combining strong and proven effective elements of eHealth with a personalized non-eHealth approach while keeping it fun to engage in. This blended approach is in line with the US guidelines for primary care physicians, advising an initial evaluation by a physician before entering a lifestyle program to increase the chances of long-term success [62,63], and was also advised by Hutchesson et al [10].

The second strength is that we are targeting a high-risk population (selective prevention). Slootmaker et al [18] showed that eHealth interventions are not suitable for all individuals and should be aimed at individuals with risk factors.

Finally, our Web-based program aims at developing, adopting, and maintaining a healthy lifestyle. When proven effective, the prototype can be easily adapted to other target groups such as obese adolescents [64] and children [15], the elderly [20,65], and those in oncology rehabilitation [66].

### Conclusions

This blended Web-based gaming intervention was beneficial in helping participants become physically active above the general recommendation of 30 minutes 5 days per week during the entire intervention period, and a favorable effect on BMI and waist circumference was seen. Promising components in the intervention are teams effects and engagement with the game. Game development should focus on strengthening these elements while keeping the fun factor. Broader implementation and long-term follow-up can provide insights into the sustainable effects on physical activity and weight loss and into who benefits the most from this approach.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## Conflicts of Interest

The author TK is the developer of the movement game.

## Multimedia Appendix 1

CONSORT checklist.

[PDF File (Adobe PDF File), 1MB - games_v5i2e6_app1.pdf ]

## Multimedia Appendix 2

Screenshots of the movement-game.

[PPTX File, 1MB - games_v5i2e6_app2.pptx ]

## Multimedia Appendix 3

Univariable association between baseline characteristics and program-usage, and reductions in body mass index and waist circumference (n=51), at 10 and 23 weeks versus baseline, using a linear mixed model.

[PDF File (Adobe PDF File), 50KB - games_v5i2e6_app3.pdf ]

## Multimedia Appendix 4

Determinants of reductions in waist circumference, at 10 and 23 weeks versus baseline, combined in models using linear mixed models.

[PDF File (Adobe PDF File), 41KB - games_v5i2e6_app4.pdf ]

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## Abbreviations

**BMI:** body mass index
**CONSORT-EHEALTH:** Consolidated Standards of Reporting Trials of Electronic and Mobile Health Applications and Online Telehealth
**MET:** metabolic equivalent task
**MPA:** moderate physical activity
**MVPA:** moderate to vigorous physical activity
**VPA:** vigorous physical activity

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Original Paper

# Who Is Still Playing Pokémon Go? A Web-Based Survey

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## *Abstract*

**Background:** Poor physical activity is one of the major health care problems in Western civilizations. Various digital gadgets aiming to increase physical activity, such as activity trackers or fitness apps, have been introduced over recent years. The newest products are serious games that incorporate real-life physical activity into their game concept. Recent studies have shown that such games increase the physical activity of their users over the short term.

**Objective:** In this study, we investigated the motivational effects of the digital game "Pokémon Go" leading to continued use or abandonment of the game. The aim of the study was to determine aspects that motivate individuals to play augmented reality exergames and how this motivation can be used to strengthen the initial interest in physical activity.

**Methods:** A total of 199 participants completed an open self-selected Web-based survey. On the basis of their self-indicated assignment to one of three predefined user groups (active, former, and nonuser of Pokémon Go), participants answered various questions regarding game experience, physical activity, motivation, and personality as measured by the Big Five Inventory.

**Results:** In total, 81 active, 56 former, and 62 nonusers of Pokémon Go were recruited. When asked about the times they perform physical activity, active users stated that they were less physically active in general than former and nonusers. However, based on a subjective rating, active users were more motivated to be physically active due to playing Pokémon Go. Motivational aspects differed for active and former users, whereas fan status was the same within both groups. Active users are more motivated by features directly related to Pokémon, such as catching all possible Pokémon and reaching higher levels, whereas former users stress the importance of general game quality, such as better augmented reality and more challenges in the game. Personality did not affect whether a person started to play Pokémon Go nor their abandonment of the game.

**Conclusions:** The results show various motivating elements that should be incorporated into augmented reality exergames based on the game Pokémon Go. We identified different user types for whom different features of the game contribute to maintained motivation or abandonment. Our results show aspects that augmented reality exergame designers should keep in mind to encourage individuals to start playing their game and facilitate long-term user engagement, resulting in a greater interest in physical activity.

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**KEYWORDS**

games; recreational; mobile apps; cell phones; Pokémon Go

## *Introduction*

Daily physical activity is one of the leading strategies for fighting global mortality [1]. Although organizations such as the World Health Organization constantly promote the value of physical activity, the trend is the opposite [1]. In Germany, physical activity is continually decreasing within the population. This trend is present in all age groups. In 2016, more than half of the entire German population performed an inadequate amount of physical activity per day [2]. As a result, health care costs rise, and the probability of secondary diseases such as high blood pressure rises, too. Thus, solutions for motivating individuals to perform physical activity on a daily basis are more essential than ever.

Recent attempts to encourage individuals to perform physical activity include activity trackers and fitness apps, which have turned mobile phones into a personal measuring instrument to document daily physical activity [3]. By documenting and defining a certain daily goal in this manner, the user is encouraged to reconsider his or her lifestyle and incorporate more physical activity into their everyday life [4,5]. Further, elements such as challenges, badges, or rank lists with family, friends, or a community are used to motivate the users of an activity tracker to perform a healthy amount of daily physical activity [6-8]. Recently, an additional trend occurred in augmented reality exergames, also referred to as urban exergames [9], which incorporate real-life physical activity into their game concept. Urban exergames are characterized by a set of criteria: the player is required to be physically active, the game is played in an urban environment, it runs on mobile phones, and makes use of the built-in mobile phone sensors [9]. Medical and public health communities have discussed the potential of these games with regard to their influence on higher levels of sustainable physical activity to achieve health benefits [10].

The most successful game in this category in 2016 was Pokémon Go. It is an augmented reality game for iOS and Android released in July 2016. The game is based on fictional creatures called Pokémon (ref. to Pocket Monsters), which first came on the scene in the 1990s and were merchandized in video games, card games, movies, television series, comic books, toys, etc. The aim of Pokémon Go is to seek, hunt, and collect a variety of different Pokémon as in previous video games. However, instead of launching just another video game, Niantic, the developer of Pokémon Go, combined the geocaching concept with augmented reality mechanics. This augmented reality feature embeds two-dimensionally animated Pokémon in real-world images captured by the mobile phone camera. Users have to explore their real-world neighborhood to search for and hunt Pokémon. The individual Pokédex of every user provides an overview of which Pokémon have already been found and caught. The central element of the game is to catch and collect all the different Pokémon. Other features include training Pokémon and fighting against the Pokémon of other users in battle arenas. By performing various physical activities in Pokémon Go, the users gain experience points that are required to reach higher levels.

The launch of Pokémon Go led to hype all over the world. Large numbers of users met on streets and in public places [11]. Despite the relatively short time since its release, there is initial research on Pokémon Go. Current studies have mainly investigated the effect of Pokémon Go on physical activity [12,13]. Althoff et al showed that persons who are more interested in Pokémon Go, measured by search queries, are more active than those who are less interested [13]. Similar research also exists for other video games requiring physical activity, such as Wii Fit or Kinect Sports [14]. Going beyond objectively measured physical activity, it is, however, also relevant to consider the effects of playing Pokémon Go on further domains, such as social cognitive factors including the users' self-perception, behavioral intentions, and motivational aspects. Social and game-related correlates such as attitudes toward gaming and habits have been shown to influence active gaming among adolescents [15]. One study reported benefits and negative effects for children playing Pokémon Go [16]. Pokémon Go is a good research object due to its high number of users. Additionally, Pokémon Go includes several of the popular gamification tactics as described by Cugelman [8]. The game offers a clear theme by integrating Pokémon into the real world. The story is also quite easy to tell, with the overall goal being to collect all Pokémon and become the best Pokémon trainer [16]. Furthermore, the game offers clear goals (catch 'em all), challenges (hatch an egg), levels (experience levels), and allocation points (Pokéstops and arenas), and it shows the progress of the user, provides feedback, and rewards experience points. A badge is awarded each time an egg hatches, and the game leaders are shown at the top of each arena they are actually the best in.

To the best of our knowledge, we are the first to investigate the aspects of the motivation to start and continue playing an augmented reality exergame like Pokémon Go in the general population.

In this study, we investigated the influence of personality and various game functions on physical activity and motivation to start playing Pokémon Go as well as on motivation to continue playing the game or quitting. We performed a Web-based survey questioning motivation to start, continue, and quit, as well as personality based on the Big Five Inventory [17,18].

In summary, our main research questions are

1. How long do users play Pokémon Go?
2. What are the aspects motivating people to start playing Pokémon Go?
3. What are the aspects motivating users to continue playing Pokémon Go?
4. What are the aspects motivating users to quit playing Pokémon Go?
5. Are there any subjectively perceived effects of playing this augmented reality exergame on physical activity?
6. Which type of users engages with Pokémon Go?
7. How can these effects be transferred to other augmented reality exergames?

Our study provides guidance on how to initially get individuals engaged in augmented reality exergames and how to facilitate long-term user engagement.

## Methods

### Design

An open, self-selected, Web-based survey was designed to investigate the aforementioned research questions. The survey was designed in German and provided for German-speaking internet users. A Web-based survey was used as it is a suitable way to reach individuals with particular characteristics or interests, that is, the group of potential game users, in a short period of time without any limitations on physical space [19-21].

On the basis of the research questions, the main purpose of the survey was to collect data about three different user groups that we would like to compare. The three predefined user groups we wanted to identify and compare were individuals who actively play Pokémon Go, individuals who had played it, and others who had never played Pokémon Go before. To identify these three groups, users were asked to state in an initial question to which of these three groups they belong. On the basis of their answer, further thematic blocks were questioned, including physical activity and motivational aspects.

To differentiate between active and former users of Pokémon Go, more detailed questions about the duration of use and level reached were asked.

### *Measuring Physical Activity*

On the basis of the idea of Godin and Shephard, physical activity was examined subjectively in one question asking how many times per week a person spends at least 30 min performing physical activity that causes sweat [22]. Due to the idea that individuals who do not regularly perform physical activity might also respond to our survey, we also included the answers "several times per month," "once a month," "rarely," and "never" [23]. Active and former users also answered questions on whether playing Pokémon Go affects their subjective interest in physical activity and whether they think they perform more physical activity as a result of playing Pokémon Go.

### *Measuring Motivation*

Active and former users answered questions about motivational aspects. These referred to the initial motivation to start playing Pokémon Go, the motivation to continue playing, and to missing functions in the game. Former users were also asked for the reasons they stopped playing and about additional features they would like to see incorporated into the game. All of these questions included an open-ended text field. In this context, we also investigated possible motivating effects by peers and co-users and possible interdependencies of playing the game with the user's personal network.

### *Measuring Personality*

To determine which type of user engages with Pokémon Go, the Big Five Inventory was applied. The concept of the Big Five Inventory is quite old but nevertheless it is a practical tool in characterizing individuals. The Big Five dimensions of personality are calculated based on 10 questions rated on a 5-point Likert scale (1="not correct," 5="fully correct") [17,18]. The Big Five dimensions are extraversion, agreeableness, conscientiousness, neuroticism, and openness. In this study, we used the Big Five Inventory to investigate whether the five dimensions of personality can be used to differentiate types of Pokémon Go users as well as persons with no intention of playing this game. If there are differences, game designers could bear this in mind and cater their games to certain personalities.

## Data Collection

Data were collected between October 26 and November 20, 2016. The questionnaire was programmed and made available on a website hosted using the Unipark software [24]. The survey was introduced as a study examining the effects of modern digital games on health care systems (see Multimedia Appendix 1).

All participants were informed about the duration of the survey, data storage, and the leading investigator. Each participant decided to take part in this survey voluntarily by following the designated link to the survey. No incentives were offered for participation.

The survey was tested properly by 2 independent examiners with regard to wording and technical functionality. The survey included 42 items for all 3 investigated user groups, distributed over 7 different pages. Participants were able to review their entries per page before moving on.

## Recruitment

The survey was addressed to the general population with access to the Internet in Germany. No exclusion criteria or screening questionnaires were applied.

We applied different channels of recruitment to reach a broad range of potential participants for this open survey. The sampling procedure was nonprobabilistic and respondents were selected based on their voluntary willingness to participate [19]. The Web-based survey was promoted by a Facebook advertisement targeting persons aged between 14 and 99 years, who had indicated on Facebook that they were interested in physical activity and well-being, entertainment electronics, or Pokémon Go. This method of recruitment was chosen because the probability that the participants are younger and familiar with social media is quite high. Furthermore, this open Web-based survey is an observational study targeting participants who play or have played Pokémon Go. Recruitment via social media, therefore, seems to be a suitable approach [20].

The advertisement itself used text similar to the text presented on the introduction page for the Web-based survey (see Multimedia Appendix 1). In addition, the weblink to the Web-based survey was posted in one private Facebook group ("RWTH Aachen University") and on a Facebook fan page called "Pokémon Go Deutschland." The former group is frequently used by students of RWTH Aachen University and consists of 17,221 members at the time of recruitment. The Facebook fan page "Pokémon Go Deutschland" was followed by about Pokémon Go fans at the time of recruitment. In total, 12,516 individuals saw the link to our survey presented in their newsfeed or group on Facebook. The weblink to the survey was also posted in the German Web community "Pokémon Go Forum," which has 2456 members. Finally, the link to our open Web-based survey was distributed in a mailing list for students at the University of Cologne, Germany. In all cases, the recruitment was based on the same text as shown in Multimedia Appendix 1.

In total, n=345 unique individuals visited the website of our Web-based survey. The identification of different individuals was performed using the Unipark software based on Internet Protocol (IP) address and cookie function. N=88 of these 345 visitors never started the survey. N=58 discontinued completing the survey. In total, 199 visitors finally participated in the survey and completed the whole questionnaire. Of those, 53 were recruited through Facebook, 62 via the Pokémon Go forum, and 12 via email. For 72 participants, the channel of recruitment was unknown. The participation rate was thus 74.4% and the completion rate 60.9%. The average duration of completing the survey was 10 min 52.96 s with a median of 9 min 2 s.

### Statistical Analysis

Data were analyzed using the SPSS statistics software, version SPSS 22 (IBM). Several one-way analyses of variance (ANOVA) and multivariate analyses of variance (MANOVA) were conducted at a significance level of .05. To compare active and former users, we also calculated *t* tests for independent samples and chi-square statistics both at a significance level of .05.

### Ethics Statement

The Ethics Committee at RWTH Aachen Faculty of Medicine authorized this study and its ethical and legal implications in its statement EK236/16 in mid-2016.

## Results

### Participants

Depending on the answers to the first question in the survey, participants were divided into three groups (Table 1): active users of Pokémon Go (n=81), former users of Pokémon Go (n=56), and nonusers of Pokémon Go (n=62).

**Table 1.** Participant demographics by user group.

| Demography | | Participants: Pokémon Go users | | |
|---|---|---|---|---|
| | | Active (n=81) | Former (n=56) | Non (n=62) |
| **Age (in years)** | | | | |
| | Minimum | 19 | 15 | 15 |
| | Maximum | 60 | 66 | 85 |
| | Mean (SD) | 34.9 (9.8) | 25.6 (8.4) | 38.8 (19.6) |
| **Gender** | | | | |
| | Male | 54 | 34 | 32 |
| | Female | 27 | 22 | 30 |
| **Education** | | | | |
| | School pupil | 0 | 3 | 3 |
| | Low level | 4 | 0 | 0 |
| | Average level | 16 | 1 | 6 |
| | High level | 55 | 51 | 51 |
| | Other | 6 | 1 | 2 |
| **Environment** | | | | |
| | Urban area | 59 | 47 | 52 |
| | Rural area | 22 | 9 | 10 |
| **Household** | | | | |
| | Partner | 22 | 19 | 15 |
| | Family | 39 | 15 | 24 |
| | Shared flat | 8 | 14 | 4 |
| | Single | 13 | 9 | 17 |
| Duration of use (in months), Mean (SD) | | 3.9 (0.8) | 1.6 (1.3) | -[a] |
| Level, Mean (SD) | | 27.0 (3.9) | 14.9 (7.1) | -[a] |

[a]No data available for nonusers.

## Physical Activity

Figure 1 shows the results for the question about self-rated physical activity for all participants. A descriptive analysis reveals that former as well as nonusers of Pokémon Go tend to perform physical activity “several times a week,” whereas the group of active users is spread over the whole range of performing physical activity “several times per week” to “never.” A univariate analysis of variance revealed significant differences in the physical activity behavior between the three groups ($F_{2,196}$=14.359, $P$<.001).

Participants were asked about whether they believed Pokémon Go increased their interest in performing physical activity. As Figure 2 shows, active users had the impression that Pokémon Go increased their interest in physical activity. Former users did not believe that Pokémon Go increased their interest in performing physical activity. A univariate analysis of variance revealed significant differences in interest between active and former users ($F_{1,135}$ = 33.818, $P$<.001).

Participants were also asked whether they had the impression that they were performing more or less physical activity since playing Pokémon Go.

The majority of active Pokémon Go users (47/81, 58%) stated that they performed more physical activity than before playing this game. Answers among the former Pokémon Go users were more divergent, as shown in Figure 3. A one-way analysis of variance with “user group” as the between-subject factor revealed a significant difference between the two groups ($F_{1,135}$ = 48.833, $P$<.001).

**Figure 1.** Self-evaluation on how often physical activity is performed.

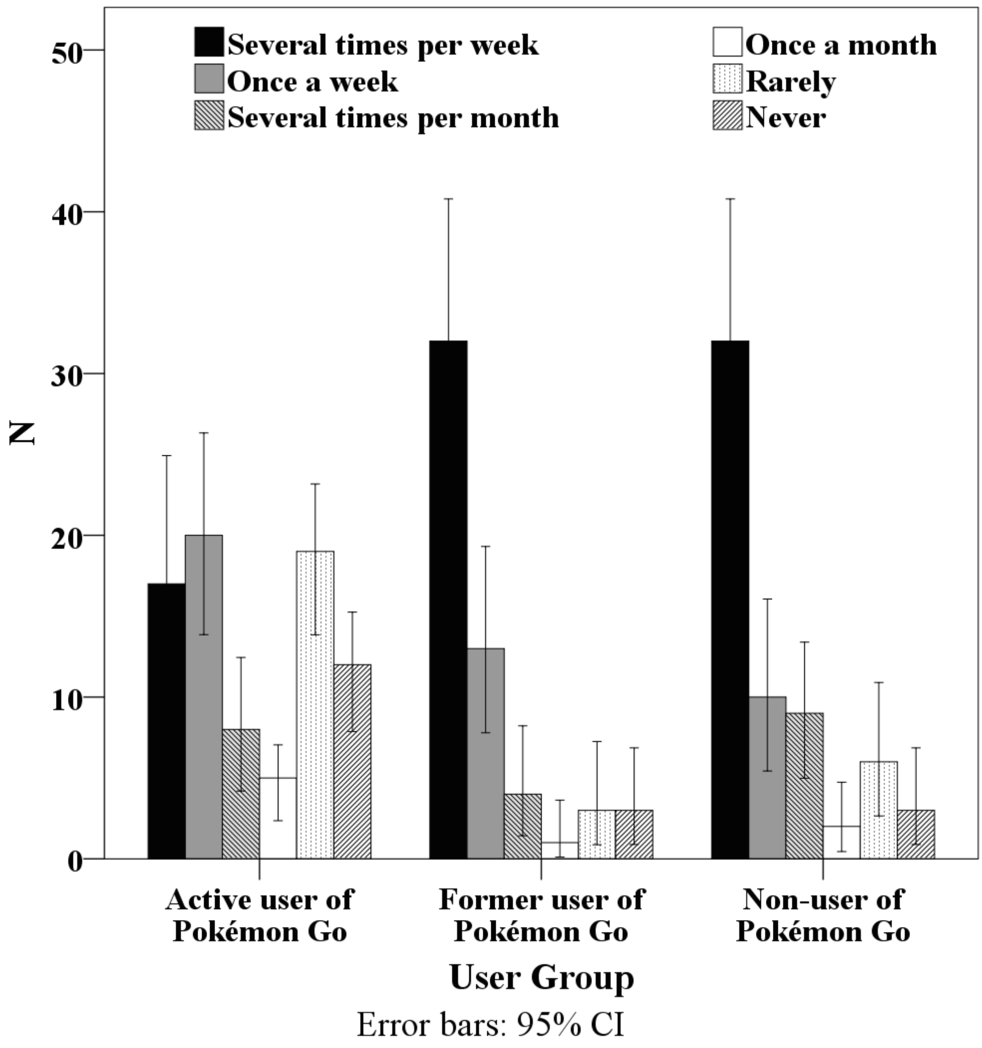


**Figure 2.** Subjective impression of whether Pokémon Go influenced users' interest in performing physical activity.

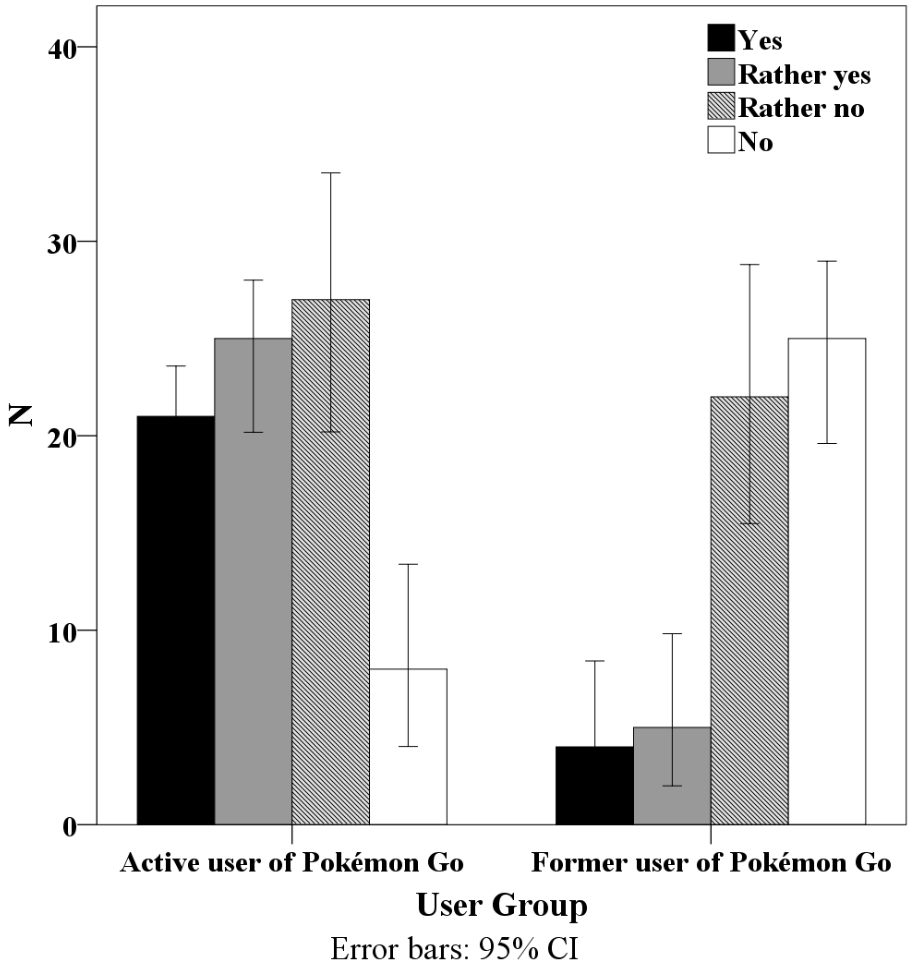
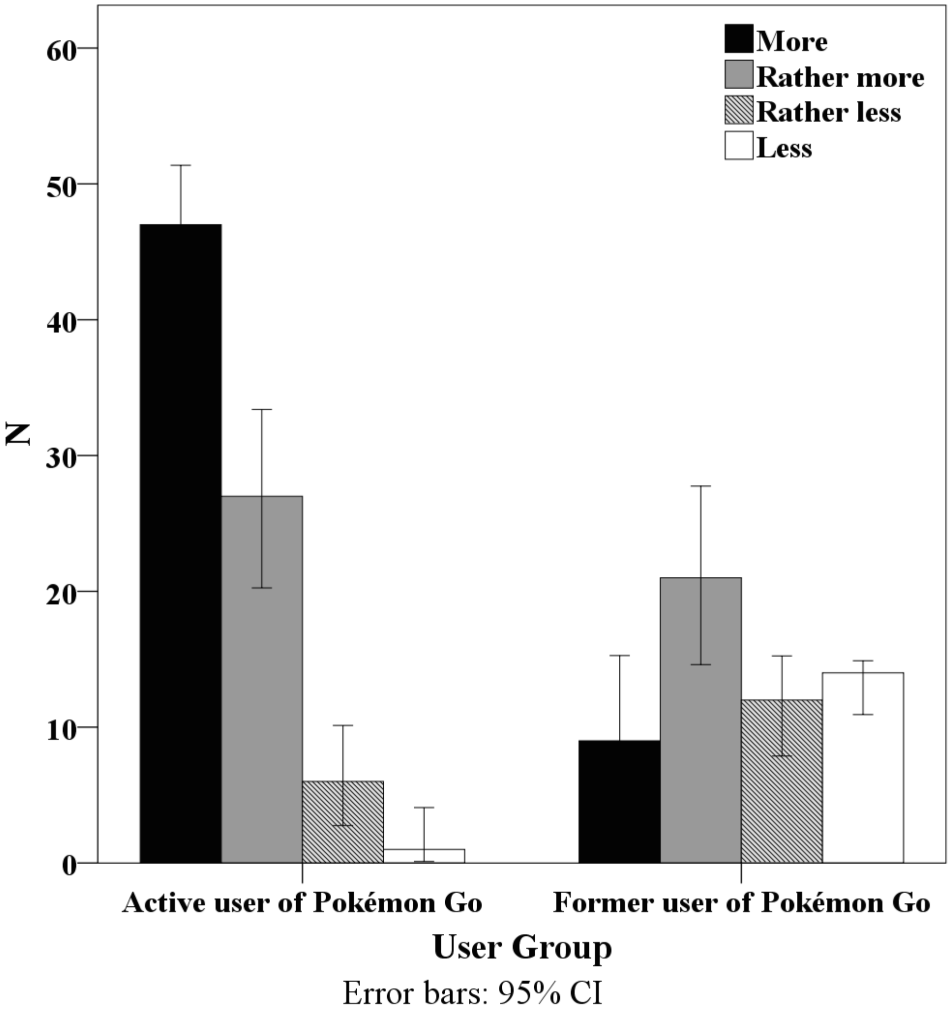


**Figure 3.** Subjective impression of whether more physical activity was performed than usual due to playing Pokémon Go.




## Motivation

The following section reports the findings related to motivational aspects. We focus especially on the motivation to start, continue playing, and quit the game.

### *Motivation to Start Playing the Game*

On average, active and former users reported two reasons to start playing Pokémon Go ($M_{active}$ 1.9 (SD 1.1), $M_{former}$ 2.0 (SD 1.1)). There was no difference in the number of reasons given by the two groups ($t_{135}$ = −0.53, *P*=.60). Table 2 provides an overview of the different aspects of motivation to start playing. Both groups mentioned curiosity most frequently. Being a POKÉMON fan, media reports, and reports from friends were also important sources of motivation for both groups (see Table 2). The only significant difference between active and former users of Pokémon Go occurred for the item “Being fascinated by the augmented reality function”; former users reported this reason more often than active users ($\chi^2_1$ = 5.8, *P*=.02).

**Table 2.** Motivation to start playing Pokémon Go (multiple answers allowed).

| Motivation to start playing | Pokémon Go users | | Significance | *P* value |
|---|---|---|---|---|
| | Active (n=81) | Former (n=56) | | |
| Mean of number of reasons (SD) | 1.9 (1.1) | 2.0 (1.1) | $t_{135}$=−0.53 | .60 |
| Curiosity, n (%) | 55 (68) | 36 (64) | $\chi^2_1$=0.2 | .66 |
| Being a Pokémon fan, n (%) | 32 (40) | 21 (38) | $\chi^2_1$=0.1 | .81 |
| Media reports, n (%) | 23 (28) | 15 (27) | $\chi^2_1$=0.0 | .83 |
| Reports from friends, n (%) | 22 (27) | 22 (39) | $\chi^2_1$=2.2 | .13 |
| Everybody around me plays it, n (%) | 11 (14) | 5 (9) | $\chi^2_1$=0.7 | .41 |
| Being fascinated by the augmented reality function, n (%) | 5 (6) | 11 (20) | $\chi^2_1$=5.8 | .02 |
| Combining fun and physical activity[a], n (%) | 3 (4) | 0 (0) | $\chi^2_1$=2.1 | .15 |
| Game for traveling[a], n (%) | 2 (3) | 0 (0) | $\chi^2_1$=1.4 | .24 |
| Nostalgia[a], n (%) | 1 (1) | 2 (4) | $\chi^2_1$=0.8 | .36 |

[a]Answers to open-ended questions; coded for analysis.

### *Motivation to Continue Playing the Game*

Participants were asked whether reaching the next level motivated them to continue playing (10-point scale: 1=did not motivate at all, 10 = highly motivated). The mean value for the group of active users was 7.1 points (SD 2.1); the mean value for the group of former users was 5.4 points (SD 2.6). The two groups differ significantly ($t_{101}$= 4.07, *P*<.001). In open-ended questions, participants were able to indicate which other aspects of the game besides reaching the next level motivated them to continue playing. Table 3 reports the reasons given. Active users were more motivated by the aim of completing the Pokédex ($\chi^2_1$=26.9, *P*<.001) and reported more fun and curiosity while playing ($\chi^2_1$=4.6, *P*=.03). There was no significant difference for any other reason given, but active users reported more reasons on average ($t_{131}$=4.65, *P*<.001; see Table 3).

**Table 3.** Motivation to continue playing the game (multiple answers allowed).

| Motivation to continue playing | Pokémon Go users | | Significance | *P* value |
|---|---|---|---|---|
| | Active (n=81) | Former (n=56) | | |
| Mean of number of reasons (SD) | 1.1 (0.8) | 0.5 (0.7) | $t_{131}$=4.65 | <.001 |
| Completing the Pokédex[a], n (%) | 33 (41) | 1 (2) | $\chi^2_1$=26.9 | <.001 |
| Fun or curiosity or recreation[a], n (%) | 12 (15) | 3 (4) | $\chi^2_1$=4.6 | .03 |
| Finding new or rare Pokémon[a], n (%) | 9 (11) | 4 (7) | $\chi^2_1$=0.6 | .44 |
| Catching strong Pokémon or being the best[a], n (%) | 8 (10) | 10 (18) | $\chi^2_1$=1.9 | .17 |
| Joint activities with family and friends[a], n (%) | 5 (6) | 3 (5) | $\chi^2_1$=0.0 | .84 |
| Being active or outside[a], n (%) | 5 (6) | 2 (4) | $\chi^2_1$=0.5 | .50 |
| Updates or new generations[a], n (%) | 4 (5) | 0 (0) | $\chi^2_1$=2.9 | .09 |
| Higher levels[a], n (%) | 3 (4) | 1 (2) | $\chi^2_1$=0.4 | .51 |
| Incubating eggs[a], n (%) | 2 (3) | 1 (2) | $\chi^2_1$=0.1 | .79 |
| Fighting in arenas[a], n (%) | 2 (3) | 0 (0) | $\chi^2_1$=1.4 | .24 |
| Nostalgia[a], n (%) | 2 (3) | 0 (0) | $\chi^2_1$=1.4 | .24 |

[a]Answers to open-ended questions; coded for analysis.

Beyond motivational aspects directly related to the game, we also analyzed whether there is motivation due to social interaction. On the basis of active and former users' self-reports, social contacts did not grow or decline through playing Pokémon Go. In total, 90% (73/81) of active users and 95% (53/56) of former users reported that their group of friends remained constant. There was no difference between the two groups ($\chi^2_1$=0.9, *P*=.34). We found significant differences between active and former users for the question about how often Pokémon Go is a relevant topic in conversations in meetings with friends and family. In all, 50% (28/56) of former users never talk about Pokémon Go, and a further 39% (22/56) seldom talk about it; 11% (6/56) indicated that they talk about it often. For the active users, 11% (9/81) never, 56% (45/81) seldom, 20% (16/81) often, 5% (4/81) almost always, and 9% (7/81) always talk about Pokémon Go when meeting friends ($\chi^2_4$=29.6, *P*<.001). We also asked users to rate the probability of recommending the game to others on a scale from 1 to 10. Active users would recommend the game more often than former users ($M_{active}$ 7.43 (SD 2.2); $M_{former}$ 4.21 (SD 2.3), $t_{135}$=8.39, *P*<.001).

To examine aspects that motivate users to continue playing as a whole, we also asked about missing functions in the game. The missing functions differ for active and former users. For active users, a higher number of Pokéstops and more arenas are more important. Former users mention the possibility of exchanging Pokémon and better augmented-reality functions significantly more often than active users (see Table 4). For both groups, more Pokémon in the neighborhood and the possibility of exchanging Pokémon are further important features that are currently missing in Pokémon Go. Only 4% (3/81) of active and 4% (2/56) of former users said that there are no missing functions. On average, 2.8 missing functions were mentioned in both groups (SD 1.6 and 1.5).

**Table 4.** Missing functions in Pokémon Go (multiple answers allowed).

| Missing functions | Pokémon Go users | | Significance | *P* value |
|---|---|---|---|---|
| | Active (n=81) | Former (n=56) | | |
| Mean of number of functions (SD) | 2.8 (1.6) | 2.8 (1.5) | $t_{135}$=0.084 | .93 |
| No missing functions, n (%) | 3 (4) | 2 (4) | $\chi^2_1$=0.0 | .97 |
| More Pokémon in my neighborhood, n (%) | 47 (58) | 35 (63) | $\chi^2_1$=0.3 | .60 |
| Exchanging Pokémon, n (%) | 45 (56) | 42 (75) | $\chi^2_1$=5.4 | .02 |
| Direct fights against others, n (%) | 44 (54) | 38 (68) | $\chi^2_1$=2.5 | .11 |
| More Pokéstops, n (%) | 36 (44) | 12 (21) | $\chi^2_1$=7.7 | .01 |
| More updates, n (%) | 31 (38) | 14 (25) | $\chi^2_1$=2.6 | .10 |
| More arenas, n (%) | 21 (26) | 6 (11) | $\chi^2_1$=4.8 | .03 |
| Better augmented reality, n (%) | 2 (3) | 8 (14) | $\chi^2_1$=6.8 | .01 |

**Table 5.** Participants' personality dimensions by user group.

| Big five dimensions | Pokémon Go users | | |
|---|---|---|---|
| | Active<br>Mean (SD) | Former<br>Mean (SD) | Non<br>Mean (SD) |
| Extraversion (points) | 3.2 ( 1.0) | 3.5 (1.0) | 3.4 (1.0) |
| Agreeableness (points) | 2.9 (0.8) | 3.0 (0.7) | 3.1 (0.8) |
| Conscientiousness (points) | 3.4 (0.8) | 3.4 (1.0) | 3.7 (1.0) |
| Neuroticism (points) | 2.8 (1.0) | 3.0 (1.0) | 2.7 (0.8) |
| Openness (points) | 3.5 (1.0) | 3.5 (1.1) | 3.5 (1.0) |

Former users were also asked for reasons that would make them start playing again. The most frequently reported reasons were an increase in the range of functions (12/56, 21%) and options for interaction with other users (18/56, 32%). Further answers related to technical features such as more stable servers and a lower battery consumption (7/56, 13%) and rendering the game more interesting by incorporating new challenges and more tactical game elements (6/56, 11%).

### *Motivation to Quit*

Individuals who were categorized as former users of Pokémon Go were asked for their reasons for quitting the game. The most frequently reported reasons were boredom (32/56, 57%), being disappointed (13/56, 23%), difficulties in reaching higher levels (16/56, 29%), and technical problems (10/56, 18%). Other points of criticism were related to missing components in the game itself, such as too few Pokémon (10/56, 18%), Pokéstops (5/56, 9%), and arenas (3/56, 5%) or a lack of co-users (4/56, 7%). Some former users also said that their general interest in the game had waned (6/56, 11%) or that they did not have the time to play (5/56, 9%). On average, 1.93 reasons were mentioned (SD 1.2).

### Personality

Mean values for the five personality dimensions within the different user groups are shown in Table 5.

A MANOVA was performed to investigate the effect of the between-subject factor “user group” on the different factors of the Big Five Inventory. Using Pillai’s trace, there was no significant effect of “user group” on the five factors of the Big Five Inventory ($V$=.059, $F_{10,386}$=1.165, $P$=0.31). Also, separate univariate ANOVAs revealed no significant effects of the between-subject factor “user group” for the separate factors of the Big Five Inventory (.17< $P$<.99).

## Discussion

### Principal Findings

The potential of mobile phone apps to increase physical activity and thereby contribute to better health is intensively being discussed these days [25]. Going beyond classical fitness apps and wearable devices such as activity trackers, initial studies investigating the effects of augmented reality exergames such as Pokémon Go on physical activity are available [8,9]. The focus of this study lies on the motivation for starting to play, continuing to play, and quitting this game.

This study presents results of an open Web-based survey. The sample is divided into three groups (active (N=81), former (N=56), and nonusers of Pokémon Go (N=62)). An investigation of self-reported physical activity showed that the percentage of persons who rarely or never perform physical activity with a duration of at least 30 min while perspiring is higher in the group of active users than in the group of former or nonusers. Examining motivation to start this game showed that curiosity and being a fan of Pokémon were the most frequently mentioned aspects. It is interesting that the group of former users mentioned interest in the augmented reality technology significantly more often as motivation to start playing Pokémon Go.

Regarding the motivation to continue playing, this study revealed that the group of active users is motivated by aspects directly related to the aim of completing the Pokédex and reaching higher levels in the game. The group of former users was significantly less motivated to continue playing by aspects such as reaching the next level. Their efforts were much more competitive. They were motivated by catching strong Pokémon and becoming the best. Aspects relating to social interaction such as having fun, being outside, and spending time with family and friends while playing the game also motivated them to continue.

Former users were asked about aspects that motivated them to quit the game. The most frequently mentioned aspects were boredom and disappointment. Besides these aspects, missing social interaction was also mentioned again, such as, for example, exchanging Pokémon or fighting directly against each other. This was also highlighted by active users as a missing function in the game. Finally, the augmented reality function was criticized as being not realistic enough. However, if this issue were resolved, former users would be willing to give the game a second chance.

Our investigation regarding differences in personality within the different groups studied revealed no results. The use of this game is independent of personality.

### Gamification

The augmented reality exergame Pokémon Go employs a range of gamification elements. The effectiveness of gamification has been discussed in different areas of application as well, for example, to support the self-management of chronic diseases [26]. The crucial question in this context is whether gamification can contribute to long-term user engagement since only then is it reasonable to assume positive effects on physical activity and health as described in other works [8,9]. In our survey, we found that by no means was everyone who started to use the game motivated to continue playing in the long term. This phenomenon has also been shown for other apps triggering healthy behavior [27] and for the use of activity trackers [28]. However, using and quitting the use of mobile technologies and wearables is a complex process and not only caused by mere dissatisfaction [29]. In the following section, the gamification elements are discussed in detail with regard to their contribution to motivation according to the three main topics: starting to play, continuing to play, and quitting playing.

#### *Motivation to Start Playing the Game*

Curiosity, being a Pokémon fan, and the augmented reality function were the most frequently mentioned reasons to start playing Pokémon Go. Media and download reports also showed that telling the right story or theme in combination with a new technology, in this case the little-known augmented reality function, could motivate thousands to start playing the game [16]. Other games in this context also need to find the right triggers to create curiosity and get people to start playing. The use of cartoon characters generally seems to be a promising approach that has also been shown to affect children’s food preferences when placed on food packaging [30]. The augmented reality function was a motivating factor, especially for the former players. This leads to the conclusion that new functions or technologies could encourage the start of use, but it takes more to facilitate long-term use.

#### *Motivation to Continue Playing the Game*

In previous studies, rewards, competitions, and fun elements have been judged as important elements leading to enjoyable experiences in game-playing [7,26]. App design and specific app features are also crucial for the users’ long-term engagement [31]. These factors have also been shown in the present study. With regard to the motivation to continue playing, we found differences related to the classical concept of levels [32]. Active users were motivated by reaching the next level, whereas former users reported being more motivated by catching strong or rare Pokémon. Social interaction in real life regarding Pokémon Go, such as spending time with family and friends, was also much more motivating for former users than for active ones. It is therefore of great importance for user's long-term engagement to consider individualized preferences. It furthermore seems important to integrate the game as far as possible into the users' real lives, especially if an augmented reality function is used. Motivation for continuing playing the game could thus be strengthened.

### *Motivation to Quit*

We should not ignore the fact that fairly high numbers of users have quit playing the game after a short period of use. One of the reasons mentioned was boredom. Within our study, the duration of playing Pokémon Go is even shorter than the average time of use for activity trackers, as reported in Ledger and McCaffrey [28]. Our results show that a strong interest in the theme of the game (in this case Pokémon Go) could prevent people from quitting it. In the event of such interest, reaching the next level was also experienced as motivating for users.

Missing social interaction functions within the game was a further reason for quitting the game. Social interaction and support were already important features demanded by users in earlier active games designed for the Nintendo Wii or Microsoft Xbox Kinect [33]. Tateno et al stated that Pokémon Go could be useful for increasing social contact outside the game itself [34]. Our study indicates that no social interaction outside the game arises as a result of just playing the game. Therefore, it is essential to include social interaction within the gameplay and the topic of the game. In the case of the investigated game, Pokémon Go, desired social interactions embedded in the game included direct fighting against each other without visiting an arena and swapping Pokémon among each other. Both aspects relate to highly realistic gameplay as Pokémon trainers could exchange Pokémon and fight against each other in the Pokémon books.

### *Personality*

Analysis using the Big Five Inventory among users revealed no indication of significant differences among users playing Pokémon Go or quitting it once it was played. The comparison of the Big Five Inventory with participants indicating no interest in playing Pokémon Go showed no differences.

## Transfer of Knowledge

All in all, the design and the incorporated gamification functions of Pokémon Go are suitable for different types of users. Although the initial motivation to start was the same for active as well as former users, the motivation to continue playing was mainly linked to social interaction. Social interaction was the main function identified as missing in this game and, furthermore, it was identified as the function motivating long-term use. If a user is not fully immersed in the theme, social interaction and especially social rewards are the elements motivating users less interested in the theme of the game to continue playing. This is independent of a certain personality or user type. Therefore, augmented reality exergames should incorporate functions that support social interaction among users as well as between users and their friends and family.

## Limitations

This study has several limitations related to its methodological design as well as the reported results. The open Web-based study was not representative due to regional recruiting via Facebook. Although the users of Facebook are adequate in terms of representative population characteristics, a bias is still possible [21]. A bias in recruitment might lead to differences for the groups in the Big Five Inventory as well as in age and education. We also included only self-reports and no objective measures for physical activity. In terms of distinguishing individuals with high physical activity from those with medium or low physical activity, this is still a limitation [23]. Furthermore, this study was conducted 14 weeks after the initial start of Pokémon Go in Germany. Therefore, our study could only reveal initial motivational aspects for active and former users due to the lack of a long-term perspective. Nevertheless, we were able to show that users already existed who had quit playing the game after quite a short duration of use. To examine the motivational structures in more detail, longitudinal studies are needed to obtain a deeper insight into the mechanisms, as conducted, for example, in the context of activity trackers [6,28]. A qualitative follow-up could also be useful to track motivation over time.

Due to the open Web-based recruitment, no inferences can be made about the usage rated and sociodemographical distribution of the general user group of Pokémon Go, especially as this Web-based survey was conducted in German. Finally, it must be noted that we are unable to answer the question about how much time has passed since former users quit playing the game. Although we know how long the average duration of use is, it might be interesting to determine whether a former user was an early adopter or late adopter of this game.

## Conclusions

In an exploratory approach, we ascertained motivational structures in the context of serious mobile games that can serve as the basis for future work. To the best of our knowledge, this is the first study explicitly investigating the motivation of active and former Pokémon Go users to use and stop using the game. We were able to determine aspects motivating users to start playing Pokémon Go as well as reasons to quit the game. Further insights into how to maintain long-term user engagement have been revealed and compared with recent studies in the field of serious games and activity trackers.

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## Conflicts of Interest

None declared.

## Multimedia Appendix 1

Introduction text of survey (German/English).

[PDF File (Adobe PDF File), 197KB - games_v5i2e7_app1.pdf ]

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## Abbreviations

**ANOVA:** one-way analyses of variance
**MANOVA:** multivariate analyses of variance


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