Tamagotchi++: A Serious, Personalized Game to Encourage Healthy Behavior

Bruce Ferwerda
Department of Computer Science and Informatics
Jönköping University
Jönköping, Sweden
bruce.ferwerda@ju.se

Michael J. Lee
Department of Informatics
New Jersey Institute of Technology
Newark, New Jersey, USA
mjlee@njit.edu

ABSTRACT

With life expectancy steadily increasing, healthy aging is becoming more important. Especially at a later age, the susceptibility to complications, such as morbidity, increases. Engaging in sufficient physical activities throughout a lifespan lowers the chances on such complications and contributes to an increased quality of life. However, the vast majority of the world's population does not engage enough in any form of physical activity. In this position paper we propose a serious game solution to promote physical activities based on the popular Tamagotchi from the 90's. We propose the virtual character of which the user needs to take care of to be a reflection of oneself. Thereby, any (in)activities of the user is directly reflected through the emotional and physical state of the character. Through the character, we hope to increase engagement in physical activities and facilitate long term behavioral change. Furthermore, we propose additional features and open research questions.

CCS CONCEPTS

• **Applied computing** → **Consumer health**; *Computer games*; • **Human-centered computing** → *User models.*

KEYWORDS

Serious Games; Personalization; Health; Tamagotchi

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1 INTRODUCTION

Physical inactivity is known to be one of the leading risk factors for death worldwide. Engaging in physical activities (PA) [1] has shown to have many beneficial effects, such as maintaining weight, improving mental health, and lowering the risk of noncommunicable diseases (e.g., diabetes, certain types of cancer, and cardiovascular diseases) [23]. For people facing impairments, PA can help to improve their quality of life by improving the ability to do activities of daily living [21]. However, estimations of the World Health Organization (WHO) show that more than 80% of the world's adolescent population and more than 23% of the adults worldwide engage insufficiently in any form of PA despite the policies that are in place to address insufficient PA [49].

The lack of engaging in bodily movements and energy expenditure are in part due to inaction during leisure time, sedentary behaviors (i.e., during work and at home), and the increased quality of public services (e.g., the availability of passive modes of transportation). These factors are often related to demographic factors, such as a high or rising wealth of a country [49]. With countries becoming wealthier, the availability of technologies in people's lives become more prevalent as well. As a result, technologies are becoming increasingly pervasive and ubiquitous. Estimates show that currently almost 70% of the population owns some kind of smart device (e.g., smart phone, smart watch, tablet), with up to 90% in the more advanced markets [32]. The widespread adoption of technologies allow for the creation of technical solutions to support the aims of promoting PA.

In addition to demographic factors, PA is influenced by intrapersonal determinants, such as perceived behavioral control, self-efficacy, and self-motivation (see for an overview [46]). Therefore, physical inactivity on an individual level is often caused by psychological barriers. The consequential risks of inactivity may cause a negative vicious cycle, which leads to further limitation of bodily movements and energy expenditure and may further increase health complications [37]. Although interventions that involve multiple in-person coaching sessions is a possibility, they are costly and labor-intensive. Exploiting the widespread adoption of technologies to support and promote PA may be a better alternative.

With the increasing prevalence of smart devices and the abundance of sensors that these devices consist of, it is now possible to gain accurate activity data of individuals passively, in real-time. In conjunction with the increased capabilities of devices, an increased number of applications promoting PA are available (see for an overview [4]). However, Bardus et al. [4] pointed out in their overview that PA applications miss experimental validation on the efficacy of features on PA, are found to be ineffective in increasing PA over time, and mostly adhere to a one-size-fits-all approach.

To increase the effectiveness of PA applications, researchers have proposed numerous solutions, especially in the form of gamification (see for an overview [35]). These applications utilize gaming elements to encourage people into certain PA by increasing engagement through entertainment. However, one of the hidden dangers of entertainment games is that the extrinsic motivations (e.g., winning) may become more important than the intrinsic motivations

[1] PA does not only entail conventional exercises (e.g., aerobics, strength training, and flexibility workouts), but include *any* type of bodily movement that results in energy expenditure, including activities during leisure time, such as walking and travelling [49].

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(e.g., healthier lifestyle) [8]. As the extrinsic motivations may gain the upper hand, the educational aspect may diminish. An alternative to games for entertainment is serious games. Serious games are used with the intention to educate or train people [31]. Training differs from educating in that the former focuses on the development of specific identified skills (i.e., for a specific purpose), whereas the latter contributes to the more general levels of understanding (e.g., areas of applications) [44].

The scope of serious games within the domains of health and welfare is limited. Wattanasoontorn et al. [48] surveyed the use of serious games and found that they have mainly been used to either train people (e.g., improving balance or cognitive functioning) or to educate people (e.g., educate about healthier lifestyles), but rarely both at the same time. Creating games in isolation of these aspects may cause limitations: only covering the training aspect may limit awareness (e.g., the effects of the skill on health and the breadth of the area in which the acquired skill can be applied to), whereas only focusing on the education may limit the effectiveness as there is no proper training of a skill. Therefore, to maximize the potential of serious games to promote PA, a game should not only try to train users with a certain skill, but also educate them about the effects of the training on physical and mental health, and how the acquired skill can be incorporated in different contexts of daily living.

In this position paper we propose a serious game that facilitates both training *and* educational aspects of health interventions. By incorporating both aspects into one system, we hope to be able to facilitate long-term behavioral change.

2 RELATED WORK

2.1 Physical Inactivity

The process of aging increases the chances of health complications, such as morbidity. Morbidity has shown to be closely associated with functional decline, which consequently can increase progression towards developing greater impairment [30]. PA has shown that it can play an important role in healthy aging [43] as well as improving the quality of life of those facing impairments [21] through improved functioning. Although physical inactivity has more direct consequences for older adults due to the combination of natural physical and mental decline over time, it is important to adhere to enough PA throughout a lifespan to mitigate the chances on complications later on in life.

There are many underlying factors of physical inactivity, such as environmental, demographic, psychological, and cognitive factors (see for an overview [46]). Aside from the environmental factors, these PA barriers are often grounded in misconceptions and beliefs of people's own functioning in relation to PA. There are several opportunities to support the determinants of PA, such as through the (combined) use of persuasive technologies, serious games, personalization, and adaptation.

2.2 Persuasive Technologies

An abundance of applications have been developed to promote PA (see for an overview [4]). Although numerous applications exist, they in general lack persuasive strategies to keep users engaged and motivated in their behavioral change. To increase the effectiveness of applications, knowledge can be drawn from behavioral theories (see for an overview of the behavioral theories that have been used [34]) to develop persuasive solutions. Lin et al. [29] used positive and negative reinforcement to facilitate motivation and efficacy. They showed that anticipated negative reinforcement can have negative effects on motivation to engage in an activity. However, Midden and Ham [33] showed that it is especially the negative social feedback that contributes to the encouragement of an activity. Hence, negative social feedback seems to be especially useful to encourage people to go the extra mile but loses its value when used to motivate people to engage in an activity.

Others have used social influencing mechanisms (e.g., social sharing, support, and comparison) to motivate users in a behavioral change (e.g., [28, 50]). Young [50] used Twitter to facilitate real-time information sharing in order to modify behaviors. Lim et al. [28] developed a shoe accessory that glows brighter as the wearer increases their physical activity.

Another strategy that has been frequently adhered to is the use of persuasive messages, such as in reminders (e.g., [47]) and alerts (e.g., [6]). Tsai et al. [47] developed a mobile application geared towards diabetic patients for self-monitoring their daily caloric balance (i.e., consumption and energy expenditure) by providing reminder prompts on their current status. Chatterjee et al. [6] used sensor data to provide alerts to diabetic patients on their activity and physiological parameters to promote behavioral change.

2.3 Serious Games

Persuasive technologies on its own follows the assumption that behavioral change is mainly achieved through raising awareness and changing attitudes. However, prior studies have shown that a raised awareness [51] or a change of attitude [52] do not necessarily precede a behavioral change, but may have been influenced by other factors. Learning on the other hand have been identified as a key component for behavioral change [3].

One way to effectively educate is with the use of serious games through engagement. Serious games are games that are used for the purpose other than just entertainment. These kind of games use game elements of entertainment to train and/or educate its users. Serious games have been used to teach science and technology, for example in learning about biology through protein folding [7] and learning coding through solving puzzles [24, 26]. The use of serious games within the health domain mainly focuses on either training or educational aspects (see for an overview [48]). For example, research focusing on older adults have mainly used serious games to train them with a certain skill [5]. One of the determinants of PA that has received considerable attention among older adults is the fear of falling. Levy et al. [27] mitigated the fear of falling by combining virtual reality therapy with serious games. Silva et al. [41] created a multiplayer game for senior care centers to train older adults in balancing and muscle strength to prevent falling with including social aspects at the same time.

Serious games depicting educational aspects mainly focus on lifestyle and dietary purposes. Peng [36] used a serious game design to educate players about how their food choices influences physical attributes (e.g., weight and their current goal). Amaro et al. [2]

created a game named "Kalèdo" for middle school children (age 11-14) that provided nutritional information about food to influence their dietary behaviors.

2.4 Personalization & Adaptation

Personalization and adaption is a common practice in fields as recommender systems (e.g., [11, 13, 25]). Especially, theory-based personalization strategies are receiving increased interest next to more data-driven approaches. These strategies are often based on higher level characteristics, such as cultural values (e.g., [12, 17, 39, 40, 42]) or lower level characteristics, such as personality traits (e.g., [10, 14–16, 18, 45]). However, prior studies within health using serious games or persuasive technologies usually adhere to a one-size-fits-all approach (e.g., assigning a fixed goal to all participants). Especially within the health domain, this one-size-fits-all approach is not suitable for everybody and can even result in harmful behaviors. Hence, tailoring solutions to users' behaviors, preferences, and needs through personalization and adaptation is necessary. The works that adhered to some kind of personalization or adaptation have shown positive results in increasing the effectiveness of the intended purpose of the serious game and/or intervention. For example, Adams et al. [1] showed to be effective in promoting PA by using the 60^{th} percentile as a future goal setting based on the performance of the last week. Gerber et al. [20] used personalized text messages that included tips on healthy eating and physical activity, as well as reminders and expressions of encouragement.

With the abundance of sensors available through the pervasiveness of smart devices, smart interventions can be created to further support the PA determinants. For example, connected to a mobile application, Hurling et al. [22] used an accelerometer to automatically capture exercise data, whereas Fukuoka et al. [19] used digital pedometers to collect step data to track activity and create interventions. Although these solutions are focused on automatic capturing of activities, sensors can also be used to map the surroundings of people to suggest more suitable PA alternatives. For example, sensors can be used to detect local weather or GPS can be used to track useful facilities in the proximity of people.

3 PROPOSAL

We propose a game that adopts many of the gameplay elements of a popular standalone device from the past called Tamagotchi. A Tamagotchi is an egg-shaped handheld digital pet, created in Japan in 1996 (see Figure 1), which sparked a craze of popularity upon its release. The goal of the Tamagotchi game is for the user to take care of an amorphous blob to have it grow and mature. Caring for the Tamagotchi involves monitoring its happiness. The happiness of the Tamagotchi is influenced by the amount of attention given to it by its user. For example, feeding and playing with the Tamagotchi has a positive influence on its happiness. However, overfeeding can cause sickness and will require medicine. Ignoring your Tamagotchi for extended amounts of time, not feeding it enough, or not providing medicine when it becomes sick may cause it to die. Therefore, caring for a Tamagotchi stimulates the creation of an emotional attachment and awareness of how to take proper care of a pet. The game taps into our basic psychological need of relatedness [38], which includes taking on responsibility

Figure 1: A Tamagotchi unit (from www.bandai.com)

through nurturing, caring, and enjoyment of interacting with a pet [9]. In this position paper we propose a personalized serious game to promote PA that is inspired by the Tamagotchi concept. By additionally incorporating both educational and training aspects on PA we hope to facilitate long term behavioral change.

3.1 Features

Our game adopts the Tamagotchi concept of caring in the form of a mobile application. However, instead of caring for a virtual pet, we propose to personalize the virtual character by letting it be a reflection of oneself (i.e., the user) by customizing the game character with a cartoon avatar of the user (see Figure 2). Consequently, the (in)actions taken by the user will educate them directly on the anticipated health effects as it will be reflected in the condition of the character, such as changes in the emotional and physical state. Furthermore, PA and other recommended behaviors will be promoted through training (e.g., providing suggestions for certain activities and how to execute them) as well as through education by educating users on the health benefits of engagement (which will then also be visually reflected through the virtual character). For example, the game would require the character to hydrate throughout the day, take a minimum number of steps, eat (healthy) food, and raise the heartbeat to a particular range for a specific amount of time. Strategies to convey the persuasion to engage in the PA can be personalized to maximize its effect (e.g., based on cultural values and/or personality traits).

Data of activities can unobtrusively be captured through sensors of smart devices (e.g., smartphones, wearable technologies). For example, smartphones nowadays have an abundance of sensors available that can accurately capture the movements of its user. Also, the increased adoptation of wearable technologies provide opportunities to gain information about the activities and the physical condition of the user. For those activities we cannot obtain data of (e.g., drinking liquids) and for those who opt not to use these built-in sensors in their devices, we can have an option for user to input their own data. Although this introduces the ability for potential cheating, we believe that long-term and serious players would not exploit this privilege as the gameplay would be similar

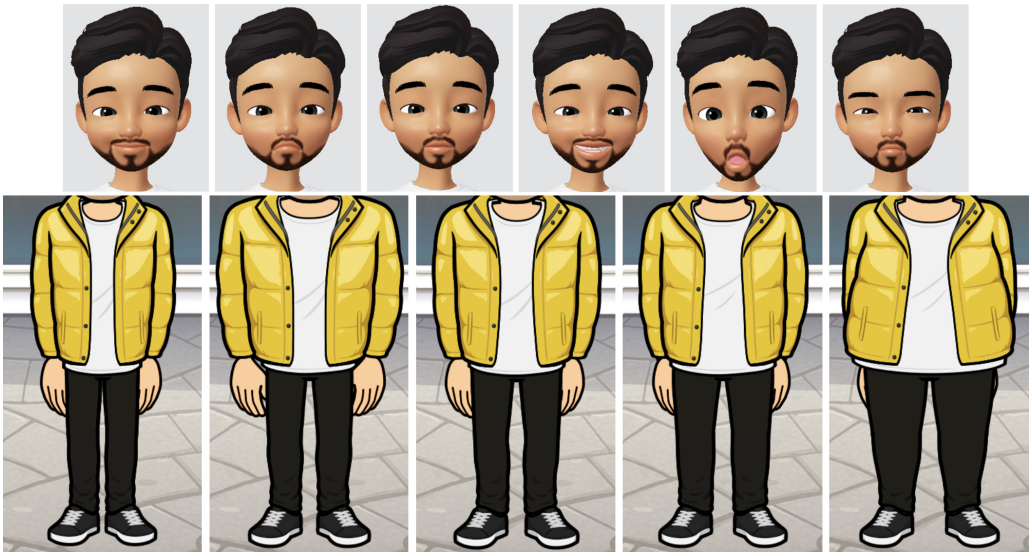

Figure 2: Examples of different emotional (top) and physical (bottom) states of the virtual character

to that of the original Tamagotchi in this case. One well-known aspect of the Tamagotchi is its constant need for attention and its tendency to notify/signal its owner (and those in the vicinity) with beeping sounds at inopportune moments (e.g., in a meeting, during class, while sleeping). The Tamagotchi device itself is quite simple (with three buttons, a speaker, and a low-resolution LCD screen) and does not include any sensors. There is an option to turn off the speakers, but doing so could possibly result in negative consequences for the Tamagotchi since the owner cannot be signaled to take care of its needs immediately. We plan to address this interruption issue by integrating with the users' data (e.g., a user should not be interrupted during all or certain types of calendar event), sensors (e.g., a user should not be interrupted if the device is face down on a flat surface), and customizable preferences (e.g., the user can always be interrupted when connected to a specific WiFi network, but not when they are within the boundaries of a GPS geo-fence or connected to their vehicle's bluetooth speakers).

Contextual data (e.g., location data, WiFi connectivity, local weather reports, and calendar events) can also be used to determine the context of the user so that the game could suggest location-relevant and/or location-appropriate activities, and thereby lowering the threshold of engagement. For example, it could suggest and give examples of stretching activities to a user in their office, suggest speeding up their pace when they are walking in a large open space outside to increase their heart rate, recommend a longer jogging route, or provide alternative activities based on local weather (e.g., suggest indoor activities when it detects bad weather).

By aggregating the data mentioned above, we can use machine learning techniques to recognize behavioral patterns and predict future whereabouts. These predictions can further support the adaptation of interventions in users' everyday life by customizing the recommended activities. For example, if a user did not follow the advised activities throughout the day and the prediction models determine that there is only one activity window left in the user's day, the game could recommend a more intense activity program (within the user's capabilities and context) to reach or approximate the initial activity goal.

4 OPEN RESEARCH QUESTIONS

The proposed serious game opens up new research opportunities that can provide new insights on how to effectively promote PA through different kinds of activities and sensors.

One avenue to explore is how the representation of self may influence one's behavior and interaction with the application. For example, if the game character is an avatar of a user, will the user be more willing to take care of their own body so that it takes care of their digital self? What about social connections - will a user feel more obligated to take care of their body if they know other people can see their avatar's fitness status? Will providing explanations and transparency on why certain activities are recommended increase the engagement of users?

There are also open questions about the data sources and sensors (and different combinations of these) informing the game, and how that might affect gameplay and users' motivation. This is important as different devices might only have certain sensors or data sources available. For example, how would users react to a game that only uses a step tracker, or just a heart rate monitor? Depending on how many sensors are informing the game may lead to different experiences, expectations, and usage by users.

We can test these ideas through a controlled experiment, comparing differences in usage. For example, for the first three questions mentioned above, we can run experiments manipulating a combination of the following: the avatar's visualization (self or generic image), connection to social networks (show or do not show character on social network), and the effect of providing activity interventions with and without explanations and transparency.

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