A Pervasive Game to Evaluate the Effectiveness of Social Interaction to Increase Daily Activity of Older Adults

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概要：This paper describes the design of a pervasive game that uses social interaction aiming at increasing daily activity among older adults. We propose an experiment to analyze the game design with respect to how social interaction affects players' daily activity levels. In order to allow comparison between test and control groups, different variations of the game were designed: one version includes social interaction both in the virtual and real worlds, while the other offers no social interaction elements.

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1. Introduction

All countries in the world are experiencing the aging of their population [1], with a some of them – headed by Japan – already having a super aged population. This phenomenon presents several challenges for government and society, particularly with regards to health and quality of life of aged people.

Previous research has shown that higher levels of physical activity among older adults is associated with lower risks of cognitive impairment, Alzheimer disease, and dementia [2, 3]. Several studies have also shown that engaging into leisure activities can help prevent dementia [4] and that games can be used to reduce or prevent the loss of cognitive skills and to maintain the general health condition of aged people [5].

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Although studies have used games in general to promote health amongst ageing and aged people, the emerging field of pervasive games [6] has yet to be fully explored for this purpose. The category includes any game that takes elements from the real world – such as player's location, available devices and networks, environment properties, real objects, social relations, etc – and blends them with the virtual world.

These innovative mechanics can create experiences distinct from traditional games, using immersion to promote player engagement [7]. This is illustrated by the huge success achieved amongst people of all ages by some commercial titles such as Ingress[*1] and Pokmon GO[*2]. Because they can affect player engagement and, thus, influence the outcome of health focused interventions, broadening their scope and expanding their benefits, pervasive games are promising tools that must be further explored.

This research aims at investigating how pervasive games can be used effectively to promote health amongst older adults, and which elements of game design can change

[*1] https://www.ingress.com/ (accessed on 2017-07)
[*2] http://www.pokemongo.com/ (accessed on 2017-07)

the results. Since this topic is too broad, the daily level of physical activity is used as main outcome, given its deep impact on older adults' quality of life. On each step of the investigation, a different aspect of pervasive game design will be chosen based on previous results and literature, and then analyzed on how it affects the outcome.

In this paper, we focus on social interaction. We describe a pervasive game that uses social interaction, and a proposed experimental setting to evaluate its effects on activity levels of older adults. Different versions of the game were designed: one in which the players must fulfill challenges and achieve goals only by themselves, and another in which they can interact with other players and cooperate to obtain shared benefits. Since health promotion is a very broad topic, the game focuses specifically on increasing physical activity levels, an essential aspect for older adult's quality of life. This is achieved by inviting players to walk around and visit different points of interest.

The remaining of this document is organized as follows. Section 2 highlights selected works that are relevant for this research; Section 3 describes the game design; Section 4 presents the proposed experiment; and, finally, Section 5 presents the final discussion about this work and future steps.

2. Related Work

Several different studies have found that digital games exert a positive effect on the health of older adults [5, 8], with special focus on physical fitness [9] and cognitive [10] function. In fact, since there is strong evidence that physical activity has a clear positive impact on cognitive skills [11], many works have focused on that kind of intervention, in particular with *exergames* [12, 13].

Most publications, however, target mainly effects for health, giving little or no attention to aspects such as fun, player experience and motivation to play. Analyzing this matter, De Schutter and Abeele argue [14] that elderly people, like any other people, want to play mainly because it is fun, and that this should be the main goal of games, while health benefits will follow as a natural consequence.

Not only that, but it is necessary to investigate older players' needs, desires and motivations to play, and how design elements could affect them. A study on this specific topic [15] identified five player profiles, based on the main perceived value of the game – *pleasure* or *usefulness* – and the predominant factor sought in game experience – *content* or *context*. Even though all these factors play

Fig. 1: Examples of game cards.

(a) map (b) hotspot

Fig. 2: Screenshots from the game.

a role on motivation, they have different weights for different player profiles. Since pervasive games incorporate reality as part of game mechanics, it is possible to provide adaptability to different contexts and players, aiming at satisfying these different needs.

One design aspect that could have a significant impact on player engagement is social interaction. Several interventions targeting elderly people have found positive results on morale and loneliness prevention when social elements are introduced, specially if it involves existing friends or promotes group activities (including those with strangers) [16, 17]. Some games have also explored this aspect [18, 19], but there is little investigation (like, for example, comparative trials) on its specific effects on engagement.

3. Game

To evaluate how social interaction on a pervasive game could affect aged and ageing people's engagement into physical activity, a mobile game called *Shinpo* (神歩) was designed, with two variations: one with no social interaction and the other with social interaction both in the virtual and real worlds. The nature of the social interaction itself – if just inside the game or requiring that players actually meet in real life – could have different effects on people's experiences, or even on their willingness

to interact at all.

The game was designed to have simple and easy to understand rules, that allow for a simple user interface. This is important to minimize potential barriers on technology adoption sometimes found with aged and ageing people [20].

In Shinpo, the player must collect cards, each card having an associated animal and being of certain level (Fig.1). There are different animals, all belonging to Japanese fauna (or folklore) and 4 different levels. There is no hierarchy between animals, but levels vary from 1 to 4 and are represented by different colors, in order: green, red, silver and gold. The goal of the game is to obtain at least one gold card of each animal.

In order to stimulate players to walk around, any action inside the game requires that they first "enter" a *hotspot*, which are physical (real world) locations they must be close to. Major shrines in Kyoto city were chosen as hotspots. The main screen of the game shows a map of the (real) world, centered at the player's current location and with nearby hotspots indicated by icons (Fig.2(a)). When the player is close enough to a hotspot, she can enter it and access the hotspot screen (Fig.2(b)), where a list of her cards is shown and she can touch any card to perform further actions.

When a player enters a hotspot for the first time in the game, she receives a few random cards of the initial level. After that, she will receive a few random cards periodically, and the amount and the levels of the new cards depend on the total distance walked and the total number of hotspots visited on the previous period. The larger these amounts are, the more cards she receives and the higher their level is.

The player can trade 5 cards of one level (up to silver) for 1 card of the next level. Because there are 4 levels, it takes a long time to achieve the game's goal. By design, players with higher levels of physical activity can win the game faster.

On the social interaction version of the game, additional rules were created to stimulate cooperation between players:

- players can create profiles with a simple animal icon, a nickname and a brief self-introduction, this profile is accessible to other players and is associated with any public actions performed by the owner;
- once per day, each player can leave a copy of a card she owns (except golden ones) at a hotspot of her preference; the copy of the card remains on that hotspot for the rest of the day and other players will see a notification icon during that time; any player that visits the hotspot will receive a copy; as players get copies of the card, the owner herself also receives random cards of same level, depending on the number of total copies distributed; players can give a "like" when they receive a card this way, and the owner of the original card is notified;
- if two players are in hotspots close to each other (including the case in which they are both on the same hotspot) they may receive a challenge to fulfill together; each player is notified of the challenge and of their challenge partner and, if both accept it, each will receive a list of one or more hotspots to visit before the end of the day; if they successfully complete the challenge, they receive random cards of level 2 or 3 as a prize;
- if there is any other player nearby, the player will see a notification icon and, if two players meet and scan each other's phones, each of them receives a random card; the more people a player meets during one day, the higher the level of the random card is.

This last item was designed to require direct personal interaction between players, in such a way that it is possible to test variations of the game including it or not. Another possibility is to always include such kind of interaction and analyze how it changes when the data is controlled for additional variables, such as sex and player profile (as referenced on Section 2).

The theme of the game and the use of shrines as hotspots, referencing traditional elements of Japanese culture, were used to create a neutral yet appealing motif for Japanese people, specially older adults. Card collection was used as the principal gameplay element because of the simplicity and flexibility if offers, associated to the familiarity of Japanese seniors with this kind of mechanics: there are many games in Japan that involve collecting items – or even animals, such as the case of insects – or that use cards in general – like Karuta (かるた).

These particular cultural elements contextualize the game aiming at further promoting user engagement, however, the flexibility of card based and collection based mechanics allows for easy adaptation to other cultures.

Besides that, even though this game was designed to be deliberately simple and provide an adequate controlled environment for investigation, it can be also easily adapted in the future to include new narrative and new mechanics in order to evaluate different aspects of game design.

4. Experiment Proposal

In order to test the hypothesis that pervasive games with social interaction will have a positive effect on levels of physical activity amongst older adults when compared to the standard version of the game, a controlled trial is proposed.

For this experiment, community dwelling volunteers (50+) will be recruited. This research focuses on preventive care and, thus, the target population will include only healthy people, with sufficient cognitive capacity and physical fitness to complete the game tasks without risk.

Each person's level of physical activity will be assessed before the intervention using the Japanese version of the PASE (Physical Activity Scale for the Elderly) [21] as well as the total number of steps and the distance walked for a 7 day period. As a secondary outcome, cognitive function will be measured using the TMT-A (Trail Making Test, part A) [22] and the VFT (Verbal Fluency Test) [23].

Complementary to these objective measurements, each person will answer a questionnaire to collect basic demographic information and evaluate their previous experience with technology and digital games, including if and what kind of device they own and use, and how often; and if, how often and what kind of games (including non-electronic) they play, and what kind of experience they seek while playing (based on the player profile classification referenced in Section 2).

Subjects will be randomly assigned to one of two groups: test and control. People in the control group will play the simpler version of the game, without social interaction; while the test group will play the full version of the game. The level of physical activity will be measured during the intervention using the number of steps and distance walked and cognitive function will be assessed once more at the end of the intervention.

It is expected that the primary outcome will have a statistically significant higher average increase on the test group when compared with the control group, and an increase overall within each group. Secondary outcomes will also be analyzed for each group, such as the cognitive level variation as measured before and after the intervention, the average number of game cards obtained, the average number of hotspots visited, the average number of game actions performed, and, for the test group, the average number of personal and in-game social interactions.

A final questionnaire will be answered to evaluate the self reported level of fun. Semi-structured interviews will be performed with randomly select players (willing to do so) in other to further comprehend their experience, emotions and expectations while playing the game.

Final results will be additionally analyzed when controlled for sex, level of physical activity before the intervention and previous experience with technology and games.

5. Conclusion

This paper described a mobile, pervasive, social interaction focused game to promote physical activity amongst older adults.

The game was designed to take contextual elements and player's motivation into consideration, but had also to be simple enough to create a controlled environment where the effects of different design aspects could be investigated.

Based on the hypothesis that, in this context, social interaction affects player engagement, different versions of the game were designed, either including or excluding such elements, and a controlled trial was proposed to test that hypothesis.

In the next steps of this research, the proposed experiment will be executed and the results will be used to foment further investigations on this topic. Possible paths include, among others, testing variations on different game elements, such as theme, story, interaction media, etc; proposing and testing other variations of social interaction; comparing different categories of pervasive games; attempting to replicate the results and/or adapt the game to different cultural contexts.

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