Pervasive Game Design: a Case Study Using Social Interaction to Promote Physical Activity of Elderly People

by

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This work is dedicated to those who remain young at heart,
no matter how many times their hearts have beaten.


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Abstract

As populations age worldwide, different challenges emerge to promote quality of life of the elderly. Games have been proposed as a strategy to pursue those challenges, achieving varied levels of success. Nonetheless, there is an excessive focus on health benefits alone, with little concern for aspects such as player's sought experiences and motivations to play.

An emerging category of games that can be used to address this problem are *pervasive games*, which are electronic games that incorporate elements from the real world into the game world. Because pervasive games blend context (real world) and content (game world) elements, they can be especially appealing for people of all ages, but also particularly to the elderly. Thus, understanding how different design elements of pervasive games affect (elderly) players is essential. In this doctoral research, this issue is investigated, with two main contributions.

First, a tool was developed that allows designers to test variations on pervasive game design. An "experiment system" pervasive game – *i.e.*, a game designed not to solve a specific problem directly, but to understand it from a design perspective – was developed and evaluated. This innovation allows researchers and designers to evaluate specific design elements of pervasive games. While previous works evaluated game *vs* non-game or traditional approaches, the tool introduced in this research allows to evaluate variations in the same game.

In the second main contribution, the developed system was used to investigate the effect of a specific design element – social interaction – in different contexts. As a result of these investigations, new knowledge was acquired about the effects of social interaction as a strategy to promote active lifestyles among older adults. This design element was evaluated in different conditions, including cultures of Brazil and Japan. It was found that the presence of social interaction design elements in a pervasive game system had a significant positive effect on the levels of physical activity of elderly players. This new knowledge can foment future research and development of more effective strategies that explore social elements, it can help better understand motivation or generate data to model user behavior, among other applications.

Overall, this doctoral research further advances the idea that games, even serious games, should first be fun, and additional benefits come later as a natural consequence. By studying the

potentially very engaging category of pervasive games, it opens up a new front of investigation that could lead to more fun and effective health interventions in the future.

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1 Introduction

Populations are ageing worldwide. In 2005, Japan's became the first so-called "super aged" society [1] – *i.e.*, a society with at least a fifth of the population over 65 years old [2] – and over the years it was followed by many others [3]. Although this process is more prominent in developed countries, it is not exclusive to them, with all nations experiencing the phenomenon, albeit in different rates, as consequence of the natural demographic evolution [4].

As this process continues, several challenges emerge, affecting different domains, including, among others, *economy* [5], *culture* [6] and *social relations* [7]. All these challenges are part of the more general goal of promoting the quality of life of the elderly, which has become a growing social concern.

Different strategies have been employed over time with that objective in mind, but the last two decades saw special interest on games and gamification processes. *Playing*, in all its forms, is an inherent aspect of human nature [8]. Games, specifically, are an ingrained part of our existence – making and playing them is an intuitive behavior for people of any age. In that spirit, games have been used as tools to help elderly people for many years now, with varied levels of success [9]

Games for elderly fall into the broader category of *serious games*, *i.e.*, games with purposes other than just entertainment [10]. A recurring problem with these games, particularly common in those targeting the elderly, is that they are often *too serious*. Even though they part from

the premise that fun experiences can engage users and promote positive change, most of the studies in this field have an excessive or even exclusive focus on health benefits, often ignoring aspects such as what kind of experiences players seek, and if they are actually having fun while playing.

An emerging category of games that can be used to address this problem are *pervasive games*, which are electronic games that incorporate elements from the real world into the game world [11]. The basic idea is to use aspects of player's life as part of the game, promoting higher levels of immersion to create more fun experiences. The extremely popular Pokémon GO [12], for example, associates real locations with in-game hotspots and use geographic and climatic aspects of the player's current location to determine what kind of monsters will be seen. Innumerable aspects could be used by a game, though, such as physical objects, social connections, different available devices and resources, among many others.

Because pervasive games blend context (real world) and content (game world) elements, they can be both extrinsically (related to the environment) and intrinsically (related to self) appealing, which can be very engaging, according to current theories of human motivation [13].

When it comes to senior players, pervasive games can be especially beneficial, since they often promote physical activity and nurture social connections, and both effects are strongly correlated with higher quality of life among elderly adults [14, 15]. Additionally, due to their nature, pervasive games naturally promote more casual experiences, which is a very frequently sought experience by elderly players [16] and can smooth the introduction of new technologies to novice users [17].

In summary, pervasiveness could be a powerful approach to create more effective serious games, in particular for elderly players. That said, understanding pervasive games and how their different design elements affect (elderly) players is essential. In this doctoral research, this issue is investigated, with two main contributions.

First, a tool was developed that allows designers to test variations on pervasive game design. An "experiment system" pervasive game – *i.e.*, a game designed not to solve a specific problem directly, but to understand it from a design perspective – was developed and evaluated. This innovation allows researchers and designers to evaluate specific design elements of pervasive games. While previous works evaluated game *vs* non-game or traditional approaches, the tool introduced in this research allows to evaluate variations in the same game.

In the second main contribution, the developed system was used to investigate the effect

of a specific design element – social interaction – in different contexts. As a result of these investigations, new knowledge was acquired about the effects of social interaction as a strategy to promote active lifestyles among older adults. This design element was evaluated in different conditions, including cultures of Brazil and Japan. This new knowledge can foment future research and development of more effective strategies that explore social elements, it can help better understand motivation or generate data to model user behavior, among other applications.

The remaining chapters of this dissertation describe these contributions and their evaluation in detail, being structured as follows.

Chapters 2 and 3 both contain overviews about the basic topics of the research, namely, pervasive games and games for the elderly. Historical and theoretical backgrounds are included, as well as brief reports about the current research on these topics.

In Chapter 4, the notion of "experiment system" pervasive game is introduced, and the system proposed, implemented and evaluated in this doctoral research is described, in particular its design process and the ways in which it can be adapted to different contexts, allowing researchers to propose variations in game design and investigate how they affect players's behavior.

Chapter 5 illustrates the adaptability of the developed system in practice, by showing how it can be changed to a different cultural context while keeping its core elements and remaining an adequate test tool.

Two social interaction case studies are presented in Chapter 6, evaluating its effect as a design element in Brazilian and Japanese cultures. These experiments illustrate effectively how pervasive game design can be explored to promote effective interventions to help elderly people, while demonstrating that social factors are an essential element to their play experience.

Finally, Chapter 7 concludes the dissertation by summarizing the main findings and contributions of this doctoral research, as well as their impact for future research, open questions and possible strategies to investigate them.

2

Pervasive Games

In the early 90s, the acclaimed Xerox engineer, Mark Weiser, introduced the idea of *ubiquitous computing* [18] – computing "everywhere" –, which grew into a whole new field of Computer Science in the decades following the initial conceptualization, and later became known also as *pervasive computing* – computing that "spreads".

Regardless of the name used, core to this vision was the principle of *calm technology* [19], or technology that "doesn't get in the way". Weiser advocated that technology should not require constant attention from users, but instead ask for attention only when the system could be useful to fulfill some *intent*. In other words, users should need not worry about complicated details of how technology works, but concentrate only in their intended goals. At the same time, systems should constantly monitor the environment to detect situations in which they could provide useful information or automate tasks to make people's lives easier.

Given that description, it seems that electronic games are systems completely incompatible with the idea of pervasive computing: usually the main goal of a game, especially a particularly fun game, is to capture the attention of players.

In the following sections, we discover how it is possible to surpass this apparent contradiction and apply the concept of pervasiveness to electronic games.

2.1 Games that "Spread"

When one considers that *playing* is usually an end in itself, it comes as a natural consequence that the whole purpose of a game, when seen as a system, is to capture the attention of the user to the actual system. In other words, games are designed to engage users into the task of *using the system*.

In fact, one of the many possible definitions of a "fun" game is one that creates *flow* [20], or a state of deep immersion and concentration (Fig. 2.1), in which users feel a disconnection from the outside world, focusing only at the task at hand (in this case, playing).

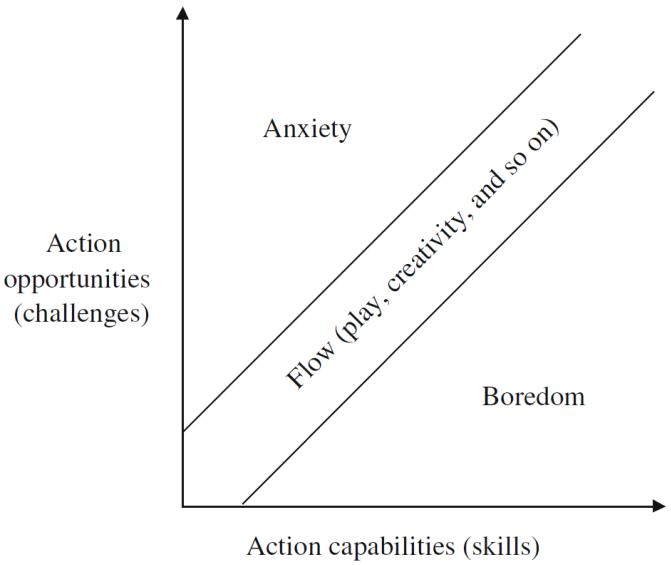


Figure 2.1: Flow (adapted from [20]).

In that sense, electronic games could never be seen as *pervasive* in the sense of *calm technology*, but they can still be designed as systems that *spread everywhere*, *i.e.*, they can be systems that monitor the player's environment and change the game experience based on given environment. That is the idea behind *pervasive games* [11, 21], which are electronic games that incorporates elements from the real world into the game world (Fig. 2.2), blurring the edges of the perceived boundaries of the play space, the so-called "magic circle" [22].

As an example, the extremely popular *Pokémon GO* [23] uses many different real world elements to engage players and nurture the community around the game (Fig. 2.3). Physical locations are associated to "pokéstops" and "gyms", and players have to walk to them to get

items and perform other game actions. The game uses augmented reality to create the illusion that pokémon are present in the real world, and there is an ongoing narrative that often involve real world aspects and can be influenced by social relations among players.

Pervasive games can also appeal to the senses. For instance, the mobile game *Zombies, Run!* [24] is targeted at runners and uses audio cues to simulate the experience of being chased by a

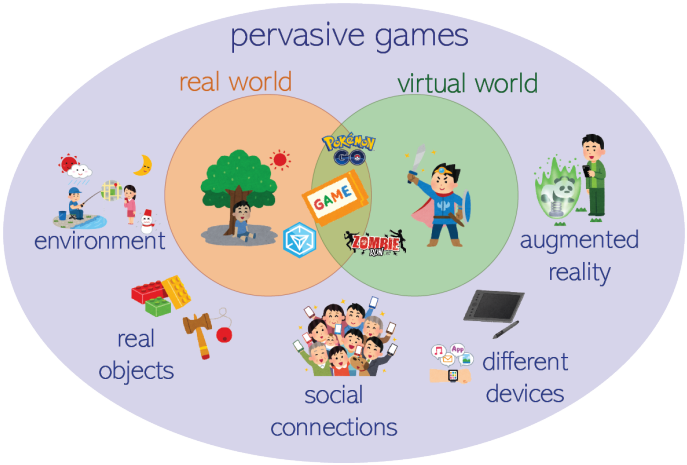
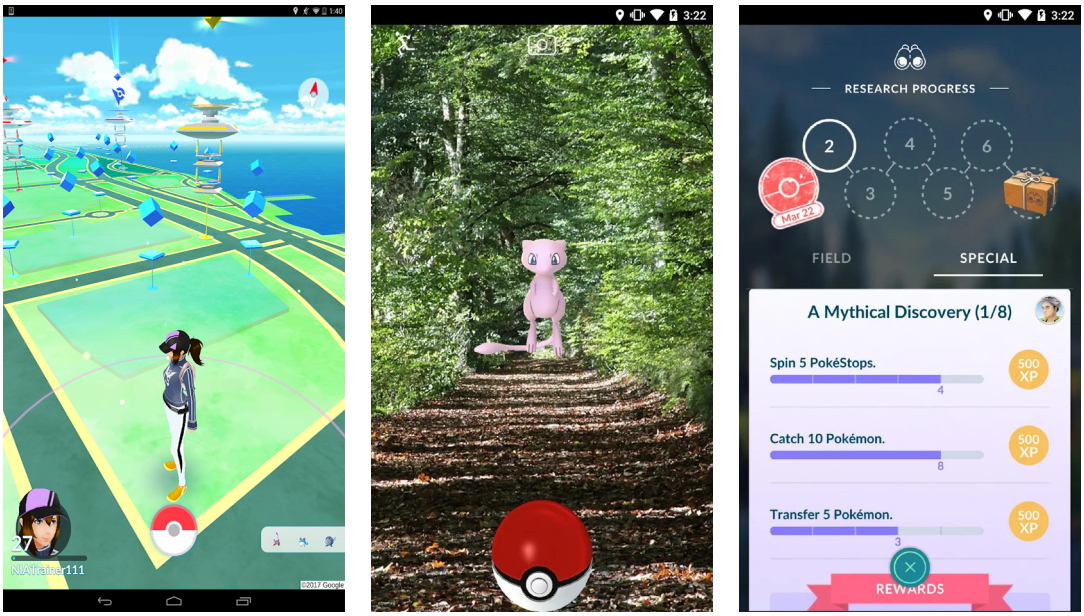


Figure 2.2: Pervasive games incorporate elements from the real world into the gameplay.



(a) real world locations **(b)** augmented reality **(c)** immersive narrative

Figure 2.3: Pokémon GO (adapted from [23]).

horde of zombies. The game generates a path based on information about existing public spaces and roads, and then uses audio instructions to tell the player which way to go when running from the "zombies".

Many other examples of commercial and academic pervasive games [11] explored this idea of using real world elements to promote immersion and create more fun experiences. However, even though the notion seems intuitive and these examples serve as anecdotal evidence, it is still necessary to study it in a more structured manner.

The next section defines a pervasive game from the perspective of *game design*, and analyzes how they shape experience to promote engagement.

2.2 A Game Design Perspective

Game design is design of player experience [25] and, as a discipline, it studies any kind of ludic contexts, not being limited to electronic media. Acclaimed designer Hebert Simon explains that "everyone designs who devises courses of actions" [26]. In that sense, it is possible to say that game designers devise courses of actions for players, aiming at particular experiences.

To understand pervasiveness from a game design perspective, it is necessary to analyze how changing game elements to integrate aspects of the real world finally shapes player experience. "Game elements" can mean many things, though, as a game can be seen in different ways, or "lenses" [25]. In this analysis, games are described using Schell's *elemental tetrad* (Fig. 2.4), which is a very useful way to break ludic systems down into their core elements.

This model describes a game in terms of four domains that affect each other and combine to create specific experiences to the player. They are:

- ***technology*** – any media, materials or interactions that make the game possible, not restricted to high-end devices, such as gamepads or computers, but also things such as pencil and paper, plastic pieces, *etc*;
- ***mechanics*** – all procedures, rules, conditions and restrictions of the game, *i.e.*, game goals, game components, player roles, allowed actions, *etc*;
- ***story*** – the sequence of events of the game, its characters and narratives;
- ***aesthetics*** – all aspects of the game that appeal to human senses, such as graphics and sounds, but also smells, tastes and tactile sensations.

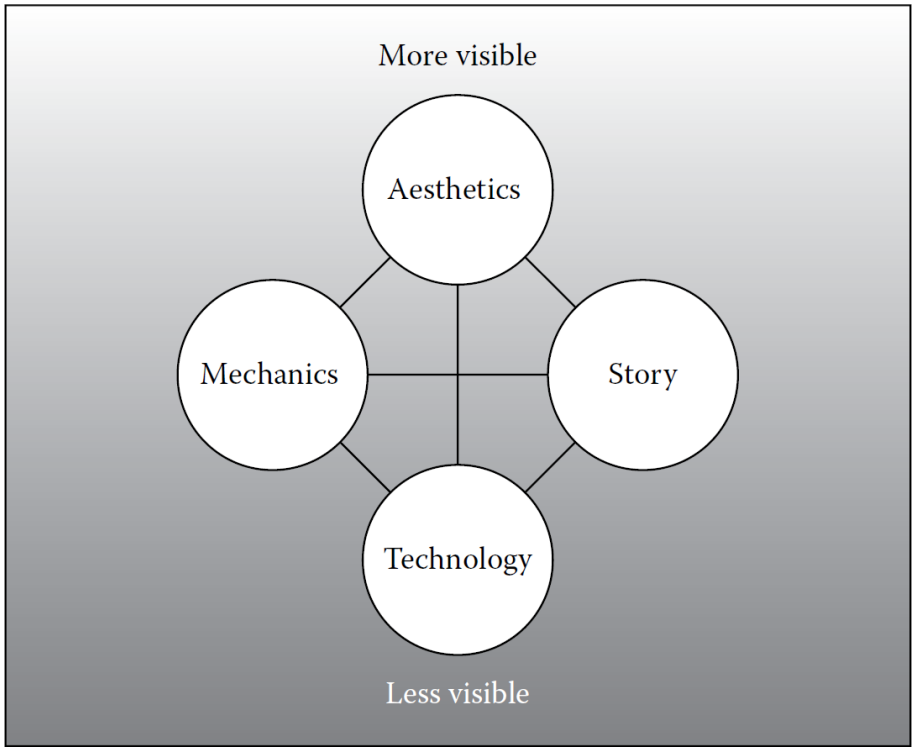


Figure 2.4: Schell's elemental tetrad [25].

Taking the tetrad as a reference, it is possible to say that a game is pervasive if it integrates elements from the real world into one or more of the basic domains. In other words, if it is a game that, based on the current *context of play*, may use different *technologies*, adapt its *mechanics* or change its *story* and/or *aesthetics* to create different experiences.

2.3 Pervasive Games and Engagement

Pervasive games have the inherent potential to be engaging. One way to understand why is by applying the Self-Determination Theory (SDT) [27], which is a psychological theory that explains human's needs and motivations. According to SDT, all humans have *basic psychological needs* (Fig. 2.5) that are equally important and influence one another:

- **autonomy** – a sense that one controls their own decisions.
- **competence** – the feeling that one can be effective and master some skill or task.
- **relatedness** – the need to feel connected to other people.

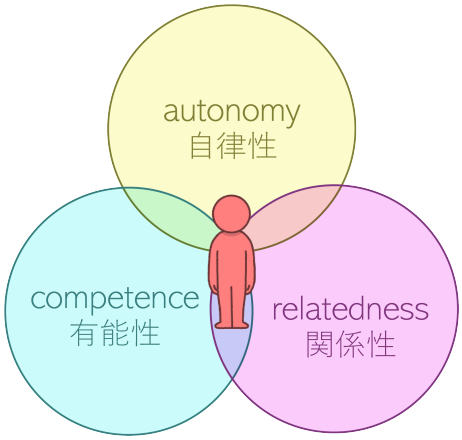


Figure 2.5: Basic human needs, according to the Self-Determination Theory.

These needs must all be satisfied to achieve maximum *wellness*. In the same sense that lack of food or water impairs physical health, thwarting of basic psychological needs impairs mental health. Analogously, satisfaction of these needs makes people thrive.

SDT states that human motivations can be *intrinsic* (related to self) or *extrinsic* (related to the environment), with a spectrum along this axis, driven mainly by the need of *autonomy* (Fig. 2.6). The higher the autonomy, the higher the power of the motivational factor to influence behavior.

By promoting experiences of *exploration and freedom*, pervasive games allow players to exercise their *autonomy*, exploring their environment and making choices to shape their game experience. By naturally focusing on *casual play sessions*, pervasive games can help players improve specific skills on their own pace, satisfying their need of *competence*. And, finally, if *social aspects* are explored, pervasive games can also serve as a way to increase user's social cognition skills, satisfying the need of *relatedness*.

This reasoning leads to believe that pervasive games have the potential to be very engaging. In the next and final section of this chapter, different works studying and/or exploring this potential are presented, with descriptions of the main findings and conclusions.

2.4 Research on Pervasive Games

Electronic games that incorporate real world elements have been studied for many years. Although the basic concept remains constant, several authors have proposed different definitions and classifications for such games, and many different games have been developed for research.

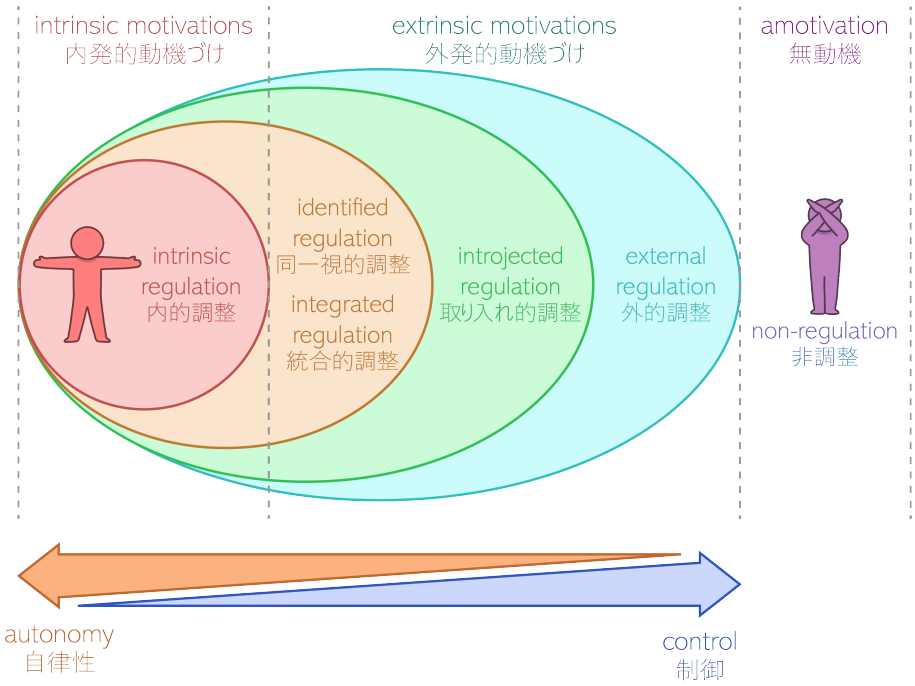


Figure 2.6: Human motivation, according to the Self-Determination Theory.

One of the first descriptions of the idea comes from Björk et al., who talk about *ubiquitous* games [28], studying them from the perspective that "participants on the ground and online participants share a common experience". The emphasis in their analysis was on the possibility of the same game existing not only in a virtual (online) world, but also in the real world. In their original work, though, the developed game had different representations of the player in each case, keeping the two worlds still separated.

Gutierrez et al. started to blur the line between different worlds, by taking a more psychological/design oriented position and exploring how games could create different realities, parallel to the real world, and allow players to experience these realities by alternating between them. They call this concept *trans-reality* games [29].

Bonsignore et al. further advanced the idea, talking about *mixed-reality* games [30], in which real and virtual environments are fully blended, and the real world becomes the landscape for a virtual experience. This category includes the genre of Augmented Reality (AR) games – when technology is projected over the real world to enhance user's experience –, and Alternate Reality games – when fictional narratives are built based on events in the real world, creating a new reality that exists only for the players.

A different work that came from the realm of ubiquitous computing focused more on technology, defining the broader category of *context-aware* games [31]. According to the authors, the term applies to any game that has the ability adapt to the environment. Many different elements could be used to give the player different experiences, such as location, weather, available resources, biometric measurements, *etc*.

Although Tutzschke and Zukunft used the term "pervasive games" [32], they focused specifically on Location Based Games (LBG), restricting the category to games that use player's location as main element of mechanics. Guo et al. give a more generic definition, arguing that pervasive games allow players to interact with the real world, providing and enhanced experience [33].

A few authors proposed classifications of pervasive games, based on different aspects. The TeMPS framework [33], for example, assigns different levels of pervasiveness to games using 4 domains:

- ***temporality*** – related to *when* the game happens, the more freedom the player has to choose when to play, the more pervasive the game;
- ***mobility*** – related to *where* the game can happen, games that can be played in more contexts are more pervasive;
- ***perceptibility*** – related to *how* the game interacts with the environment, with games that monitor and react to many different aspects being more pervasive;
- and ***sociality*** – related to *who* can play, if the game promotes social experiences in many different ways it is more pervasive.

McGonigal described [34] pervasive games in terms of their objectives of functions, identifying 3 non-exclusive main functions that can manifest in such games:

- ***colonization*** happens when the game serves as a means to introduce novice users to unfamiliar technology, increasing its acceptance;
- ***disruption*** happens when the game influences people's daily lives, affecting their reality, respected the player's freedom to choose when and how this happens;
- and ***activation*** happens when the game uses previously ignored aspects of the environment to grab user's attention and create ludic contexts.

Another classification, proposed by Valente et al., was based on the required characteristics that a game must have to be pervasive [35]. According to these authors, it is necessary that the game uses ***mobile technologies*** and that it has ***context awareness***, while being ***multiplayer*** and having ***remote communication*** are optional but relevant aspects.

Buzeto et al. defined a subset of pervasive games, called *reconfigurable games*, analyzing how much the game changes its elements of technology, mechanics, story and aesthetics *dynamically*, based on resources and devices available in the environment. The authors established 3 levels of reconfigurability:

- on *level 1*, the game changes ***technology*** only, using different devices based on their availability; a good example is "Battlefield 4" [37], that is normally a First-Person Shooter (FPS), but offers a Real-Time Strategy (RTS) mode when a tablet is synchronized with the game console;

- on *level 2*, the game also adapts ***mechanics*** and ***aesthetics*** to the capabilities of the available devices; "Forza Horizon" [38], for example, takes advantage of the specific characteristics of smartphones and tablets to turn these devices into portable GPS units reflecting the race data, when such devices are available.

- finally, on *level 3*, ***story*** is also changed, making all elements of the elemental tetrad dynamically adapted; the game "Dead Rising 3" [39], for example, changes the narrative if a smartphone is connected to the game, even simulating a phone call to the player to give them information and instructions.

These different classifications analyze pervasive games from varied points of view, being complementary to each other. As any topic related to (game) design, it is not possible to say that either of them is more correct than the others, but only that they emphasize different aspects, allowing designers to have many different views of the same game.

3

Games for Elderly

Electronic games have been a topic of research for many years, in their own field that became known as *serious games* – *i.e.*, games that have purposes other than just fun, such as education, training or health promotion [40, 41]. Games and gamification processes have been studied for their applicability as tools in areas as diverse as education [42], behavior change [43] and rehabilitation [44].

Older adults became a natural focus group for serious games research [9], since they have unique needs that increase in intensity and peculiarity with age, and games can be an engaging, often cheaper and more widely available approach to target elderly people in varied goals such as cognitive training [45], physical health stimulation [46] and prevention of loneliness [47].

From the very beginning, researchers already hypothesized that games could have a positive effect on elderly people [48]. Games can often provide different levels of mental and physical stimulus, self challenge and personal growth, as well as promote experiences of social connection and belonging. As explained by the Self-Determination Theory (Section 2.3), these experiences are essential to achieve adequate levels of quality of life and to maintain both physical and psychological wellness of human beings.

Although evidences of this fact would become a consolidated theory much later, when games for seniors first started being proposed, it already seemed clear that elderly people, especially those living under conditions that greatly thwarted these basic needs – such as people

living in nursing homes or in isolation – could potentially attain great benefits from playing electronic games.

The following sections present a deeper exploration of consolidated knowledge and previous work in the field of games for elderly, analyzing their requirements and opportunities, as well as characteristics commonly found in elderly players.

3.1 Requirements and Opportunities

The initial research focus was on the limitations and issues to be considered when designing games for this specific audience, which are consequences of the reduced physical and mental skills that come with the aging process. Different works investigated the challenges when developing games for seniors [49–51], summarizing the basic requirements and identifying possible opportunities, as follows.

Requirements

Aging causes several changes on human beings' physical and mental abilities [52]. In general, elderly people experience varied degrees of deterioration of their motor skills, with slower response times, difficulty in performing and maintaining movements and loss of balance and coordination. Because of this, games for elderly should avoid small targets and moving interface elements, as well as gestures or movements that are too fast.

Static and dynamic visual acuities also deteriorate with age, with loss of contrast and color sensitivity and reduced range of visual adaptation. This makes it difficult for older people to identify and differentiate small elements on the screen. Special care is required in choosing size, positioning and colors of game elements. Auditory acuity is also affected, in particular for higher frequencies. It is recommended to avoid synthetized speech and always provide redundant feedback to complement sound information.

Not only physical skills are impacted by the aging process, but also the cognitive function, with possible deficits on attention processes, working memory, reasoning skills and language comprehension. Games for elderly require especially intuitive interfaces, with controls that must be simple and easy to understand to reduce the cognitive load and allow users to focus on their experience and on achieving game goals.

Other types of challenges can come from contextual elements, such as cultural and generational aspects. For example, younger generations have the advantage of having grown up in continuous contact with recent technologies, media, and cultural phenomena, making it much easier for them to quickly become familiar with modern games.

In contrast, older adults must learn new concepts and interaction models with a much more limited experience from which they can draw analogies, and there could even be the case that they must unlearn previous knowledge, when familiar actions have changed meaning in new contexts. This means that games for older generations should consider established concepts and technologies as bridges to introduce game mechanisms, and focus on casual play sessions, allowing players to explore the game in their own pace.

This challenge could be mitigated sometimes, due to natural technology "domestication" that happens over time. For instance, because the first commercial electronic games became popular in the early 1970s [53], the next decade will witness the first generation of people 60 or older that had access to videogames for their whole life. Nonetheless, as technology and media evolve, a generational gap is always expected and should be considered.

Older generations might also hold different values than younger people and much more varied interests. Although any generalization that treats elderly people as a homogenous group is erroneous [54], it is possible to hypothesize, for example, that themes or topics that were particularly popular in the past might appeal for seniors in the present.

Also, not generally, but in many cases, something that might be engaging for younger players could often be unappealing and sometimes even considered inappropriate or offensive for a great part of older audiences. The mere idea of elderly people playing games might be seen as childish or inappropriate by part of society in some cultures [55], requiring game designers to pay special attention to elderly players' feelings about their social context, *i.e.*, if they are worried that this might be the case.

Opportunities

Physical and mental function deterioration that come with age is not only a challenge for game design, but also an opportunity. In fact, games that focus on preventing the loss of such functions or in promoting physical and/or mental training quickly became a major research topic [9, 56]. Elderly people often express their interest in training their body and mind, precisely to prevent or slow down the effects of aging [57] and there are examples of successful commercial

games with that specific appeal, such as the popular Brain Age series [58].

Similarly, the generational gap can also become an opportunity, as game designers not only have the chance to explore alternate themes and narratives not so mainstream among young people, but also to promote intergenerational connection and exchange of knowledge [59, 60].

Elderly people have immense life experience and knowledge about their culture in general and about specific topics in particular, even if they didn't have the chance to work in many different fields or travel to many different places. Younger generations can benefit from this knowledge, while most elderly deeply enjoy the chance to share their stories and help preserve their culture [61].

Previous studies have also proposed to use technology to help seniors with lots of experience that could either work in more flexible schedules or mentor younger workers [62]. Companies could explore games and gamification techniques as a way to engage more people into similar arrangements, that could benefit all parties.

Finally, older adults usually have much more time available for leisure and self-care, having more opportunities as a consequence to explore and invest effort into new games. It is important to notice, though, that there is a tendency among older players to prefer more casual game experiences [63]. This tendency might change in the future, as young gamers of today become older, and there is a higher ratio of players who seek more intense play sessions, but evidence suggest that simpler games that can be played in short sessions are preferable.

It is essential to also take into account that, even more than younger players, older people will easily disregard experiences that do not seem appealing, as they have much better established beliefs and personal tastes. In essence, not any game will serve, but a game that is easy to use, only requires an adequate level of time and effort, and deals with an interesting theme for this public.

3.2 Motivations to Play and Game Experience

Research using electronic games to help elderly people part from the premise that games can engage players because they are fun, however, many of these studies focus excessively or exclusively on health benefits, often ignoring aspects such as user's motivations and experiences while playing.

More recent research has started to analyze these elements more thoroughly [64], follow-

ing the principle that games, even serious games, should first be fun, and all additional benefits will come later as a natural consequence of playing [54].

For instance, some early works tried to better understand elderly player's preferences regarding content and/or genre of the games, primarily using surveys [65–67]. These authors found that varied factors motivate elderly people to play games, but primary ones included:

- focus on cognitive training or quality of life improvement;
- casual style of gameplay;
- appealing narratives;
- and ease of use.

These works also reported a preference for puzzle games over action games and a rejection of games with violent contents. When subjects could describe the main reasons why they felt attracted to particular games, there was a great emphasis on physical and mental training (Fig. 3.1).

Figure 3.1: Word cloud of the reasons for choosing games [66].

A study focusing specifically on casual games [16] found an overall enjoyment with all evaluated genre, but observed – in corroboration of similar studies – a preference for puzzle over simulation games, and for these two genre over action games.

A popular category used in many studies is that of "exergames", *i.e.*, games that use exercise as their main element. While studying this genre, researchers found that players enjoy such games and have an intrinsic motivation to play, based on perceived benefits for their health and increase in social confidence [68, 69].

Investigating the topic of motivation more deeply, De Schutter and Malliet performed an ethnographic study and combined the *Uses and Gratifications Theory* [70] and the *Self-Determination Theory* (Section 2.3 to propose five basic profiles of older players (Fig. 3.2)), generally observing a predominant individual adherence to one of the profiles, with aspects of the others appearing to a lower degree.

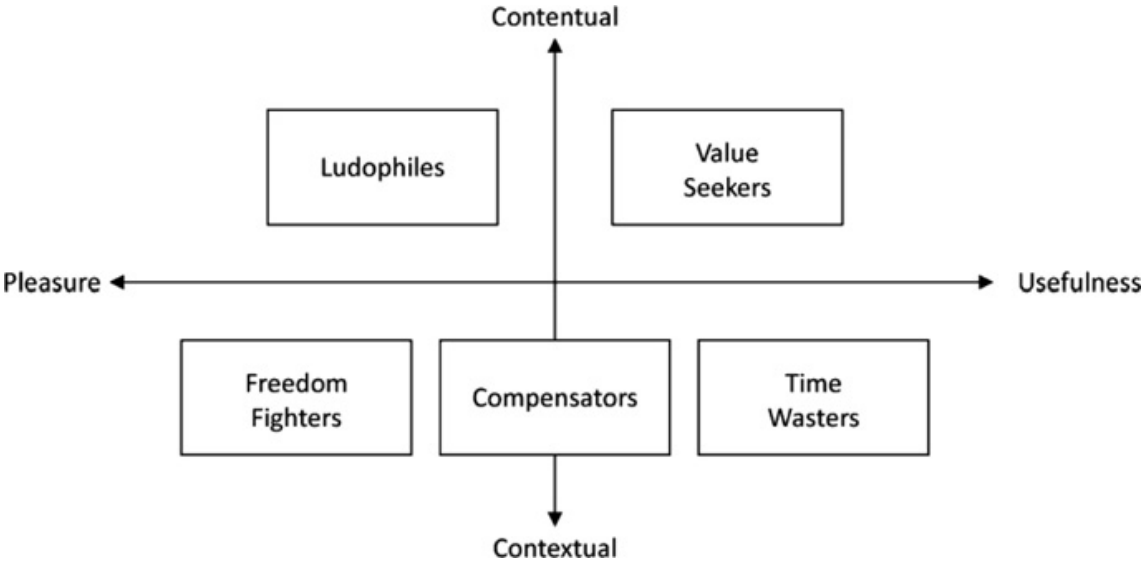


Figure 3.2: A classification of older players of digital games [57].

According to this model, players motivations can be understood in terms of 2 axes: *pleasure – usefulness* and *content – context*. The first axis determines if the immediate motivation to play is based more on fun or on perceived benefits of the game. The second axis is related to the conditions of the play activity – whether it is mainly driven by the content of the game (intrinsic motivations) or by the context in which the player is inserted (extrinsic motivations). The proposed profiles are:

- ***ludophiles*** – typical "hardcore" players who are mainly driven by content, *i.e.*, by the game itself; they are highly interested in games and have usually played throughout their whole lives; even though players in this group play just for fun, they don't necessarily

consider playing a useless activity, often talking about games as important social-cultural phenomena, and an important part of their lives;

- ***value seekers*** – players in this group are strongly motivated by content, but are also driven by perceived benefits of the game; they play because they believe they can learn something from the game, exercise some passion or experience some cultural element;

- ***time wasters*** – these players are driven by context, playing only when they have some free time to spend; they are interested in spending such time in a useful activity, focusing on games that can provide some benefit, such as cognitive training;

- ***compensators*** – players in this group are motivated by context, with a mix of pleasure and usefulness factors; they use games as a way to escape long periods of undesired unpleasant experiences, such as solitude or boredom; they often see games as a meaningful source of entertainment, but also as a problematic activity, because they would prefer engaging into more relevant endeavors;

- ***freedom fighters*** – this group is also driven by context, but with more focus on pleasure; they play mainly to relieve themselves from daily obligations or unpleasant activities, while believing that games have an intrinsic positive effect in their lives.

This scheme illustrates that elderly players do not form an homogenous group, but seek many different experiences and are driven by many different motivations. The "ludophiles", in particular, could be seen as a very special case, since they represent people who played for their whole lives and, thus, have a much deeper connection to games, which is not the case for most elderly people. In fact, the authors reported that subjects classified with this profile represented the youngest group among all participants.

Although it is not possible to make a definitive claim that would apply to all senior players, when all studies are considered, some trends could be observed. With regards to context, there is a general preference for casual games, which aligns with the idea that games could be used as a way to introduce unfamiliar technologies to novice players [34]. When it comes to content, it's noticeable a general interest in physical and mental training.

3.3 Pervasive Games

Two of the real-world elements most commonly used in pervasive games are *physical location* and *social connections*. These elements, in particular, can be especially beneficial to senior players.

When elderly people are invited to walk around and visit places in the real world, they are stimulated to have regular physical activity; when they interact with other people via the social mechanics of the game, it may be possible to reduce or prevent social isolation. Both effects are strongly correlated with higher quality of life among elderly adults and a lower incidence of age-related diseases [14, 15, 56, 71, 72].

Naturally, the set of real world elements that could be used to design pervasive experiences is not limited to these options, and, in fact, it is possible to argue that pervasive games, *in general*, can be especially engaging to elderly players (Fig. 3.3).

Because they mix the *context* of playing with the *content* of the game, pervasive games can potentially create both extrinsic and intrinsic motivations. Additionally, the integration into player's life naturally creates more casual game experiences, which, as seen in Section 3.2, is a natural preference for most elderly people.

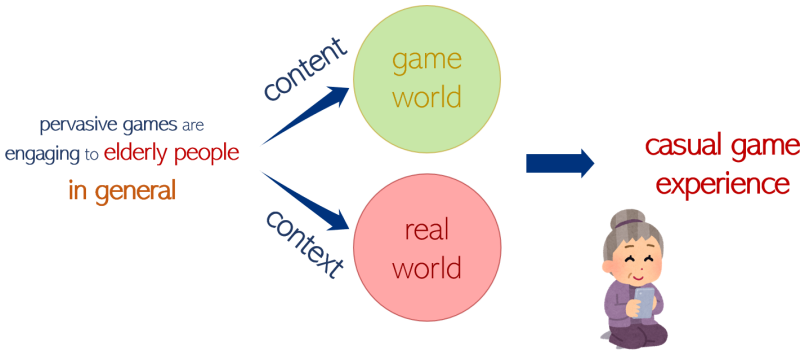


Figure 3.3: Pervasive games create casual experiences.

Since pervasive games themselves are a relatively recent idea, research on pervasive games for older adults is also very recent, but a few studies have already employed either games or gamified apps with pervasive elements.

For instance, Gamberini et al. created a mixed-reality game (Fig. 3.4) to promote cognitive training for elderly people [73]. The game integrates physical objects into its mechanics, creating a more familiar experience for elderly players.

Figure 3.4: A mixed-reality tabletop game for elderly [73].

Brox et al. focused specifically on exergames, evaluating different games and providing a narrative review [74] arguing that social factors are an essential element of persuasion. In a similar fashion, Paul et al. also focused on physical activity, evaluating a gamified app [75] that used group incentives to stimulate people to walk.

Due to its immense success, several works studied Pokémon GO specifically, analyzing its effects on levels of physical activity. For instance, when analyzing the motivations of players (not restricted to the elderly) to play the game, Marquet et al. found that seeking to increase physical activity was one of the main reasons, and observed a stronger correlation between playing the game and the number of daily steps in this group [76]. Althoff et al. found similar results, with a strong effect of the game on the levels of activity on the first 30 days after starting playing [77]. In a similar study, Hino et al. evaluated long term effects, while focusing on middle-aged and elderly adults, observing positive effects of the game for up to 10 months.

Although there are only a few works studying the effect of pervasive games on seniors, the initial results are very promising and show evidence that pervasive games can become a powerful tool to help the elderly.

4

Shinpo - an Adaptable Pervasive Game

In this chapter, the concept of systems that are created to evaluate design, the "experiment systems", is introduced. Then, the design and evaluation of such a system, developed specifically to study pervasive game design, is presented.

4.1 Experiment Systems

Hebert Simon, in his famous work "The Sciences of the Artificial" [26], describes the design process as "problem solving without a goal". He claims that design problems are "ill-defined" or "ill-structured" tasks, because it is not possible to completely understand the problem beforehand, and the processes of understanding and solving the problem happen simultaneously.

Tackling these "wicked problems" [79] requires an iterative process (Fig. 4.1), each iteration bringing a better understanding of the problem, and a more adequate solution. As the elements of design change, so do the user's possible *courses of actions*, and so does the designer's understanding of how to devise desired courses of action.

Useful tools that can be used in this process are the so-called "experiment systems", *i.e.*, system used to perform experiments on design. In contrast to regular systems, that are developed to solve specific problems, *experiment* systems are created to *understand* problems.

In the context of *game* design, the iterative process is the same, with the additional con-

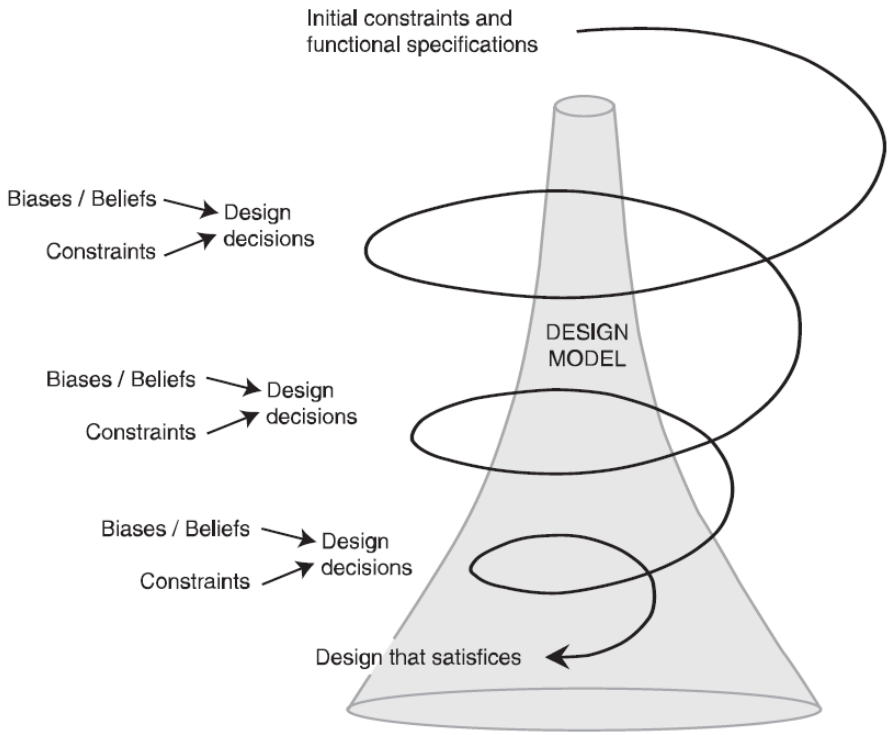


Figure 4.1: The iterative design process [80].

straint that game designers devise courses of action to create particular experiences (Section 2.2). To evaluate how different design elements of pervasive games affect players, it is necessary to have an "experiment system" game that allows for changes in pervasive elements of the game.

An adequate experiment system that could be used to test hypotheses about game design should be adaptable enough to allow for variations in its different elements, while at the same time never changing so much that the evaluation of those variations would be meaningless. To achieve that end, a core immutable set of **design principles** were defined, allowing for variations of specific instantiations of those principles.

4.2 Design Principles

The principles proposed in this research were defined after an iterative design process that analyzed existing (pervasive) games and took the input of specialists from varied fields and from

final users. Table 4.1 presents the principles, describing how each of them affects adaptability of one or more of the domains in the elemental tetrad.

Table 4.1: Design principles of *Shinpo*.

Principle	Possible Adaptations
The main goal is collection of items. **Rationale:** this is simple play element present in almost every culture and appreciated by players of varied ages, backgrounds and motivations; additionally, since the main point is the *abstraction* of collecting items, the nature of the items can be easily changed.	• *aesthetics* – different representations and visual styles; • *story* – different meanings of the items in the game narrative; • *technology* – different media, such as virtual or physical items;
Items are collected by walking to specific locations. **Rationale:** this serves the research goal of promoting physical activity, but also allows for flexibility.	• *mechanics* – varied constraints of navigation and access to places; • *story* – different meanings and roles of places in the game narrative; • *technology* – different types and arrangements of places, as well as levels of scale (*e.g.*, within a room, a building, a city);
Collaboration over competition. **Rationale:** players can interact in different ways, and even though interaction in the form of player *vs* player competition is enjoyed by some people, collaboration can be enjoyed by any person.	• *mechanics*, *technology* – direct *vs* virtual, static *vs* dynamic, acquaintance *vs* strangers, groups *vs* individuals, *etc*...; • *story* – different roles of people in the game narrative.

4.3 Game Design

Based on the established design principles, a concrete game concept was proposed, implemented and evaluated for its feasibility.

The game, called *Shinpo* – from Japanese, 神歩, which could be translated as "sacred steps" – targets Japanese elderly people in Kyoto city. It was designed as a location-based mobile game that invites players to collect virtual cards by walking to temples and shrines around the city, taking advantage of the fact that there is a unusually high concentration of such places in Kyoto.

Each card of the game has an associated animal and a level, indicated by its color (Fig. 4.2). All animals were chosen from Japanese fauna (or folklore) and there is no hierarchy between animals, but levels vary from 1 to 4 and are represented in order by the colors green, red, silver and gold. The goal of the game is to obtain at least one gold card of each animal.

Figure 4.2: Examples of game cards.

Google Places API[1] was used to automatically identify major temples and shrines in Kyoto city and add them to the game database. The main screen of the game (Fig. 4.3a) shows a map of the (real) world, centered at the player's current location, and nearby "hotspots" – *i.e.*, recognized temples and shrines – are indicated by red *torii* icons.

When the player is close enough to a hotspot, it becomes possible to "enter" it and access the hotspot screen (Fig. 4.3b), where a list of owned cards is shown and any card can be touched to perform further actions. Game actions can only be executed in this situation – *i.e.*, when the player is physically close to a hotspot – not only to stimulate players to physically walk to different places, but also to prevent safety hazards, since walking while looking at the screen would be dangerous.

When a player enters a hotspot for the first time in the game, a few random cards of the initial level are given. After that, a few random cards are given periodically, the amount and the levels depending on the total number of steps walked and the total number of hotspots visited on the previous period. To measure the number of steps, the game uses *Moves App*[2], which is an external application that implements a pedometer and allows connected apps to access that information.

While inside a hotspot, the player can trade 5 cards of one level for 1 card of the next level. Because there are 4 levels, it takes a long time to achieve the game's goal and, by design, players with higher levels of physical activity can win the game faster.

[1] Google Inc. https://developers.google.com/places/web-service/intro (Jun/2019)
[2] ProtoGeo Oy, 2012. http://web.archive.org/web/20180625120716/http://moves-app.com/.

(a) world map **(b)** inside a hotspot

Figure 4.3: Screenshots from the game.

Shinpo was developed with *social interaction* in mind as a design element to be tested later, since that is the purpose of the research. To allow control of this element, all social interaction mechanics were designed to be complementary to the main goal of card collection, in such a way that the core elements of gameplay would be kept for both single-player (no social interaction) and multi-player (social interaction) variations of the game. Thus, social interaction rules were added to form a superset of the basic game rules, always respecting the design principles of focusing on cooperation between players.

The additional mechanics are:

- players can create profiles with a simple avatar 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 an owned card (except golden ones) at any visited hotspot; 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.

The theme of the game and the use of temples and 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 かるた (*karuta*).

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.

For instance, other abstractions could be used (*e.g.*, zodiac signs instead of animals or coins instead of cards); different rules and interaction strategies (*e.g.*cooperation in combination with competition, challenges, hierarchies); different visual styles (*e.g.*, traditional, cute, cartoonish); and different technologies (*e.g.*, physical objects, *IoT* devices). These adaptations, when limited within a closed context, could also be presented to different groups of players to evaluate their specific experience. As an example, the color schemes or the illustration style could be changed and evaluated for their appeal to different audiences.

4.4 Feasibility Evaluation

This section describes the evaluation of Shinpo for its feasibility as an experiment system, which was made in a study with volunteer community dwelling senior citizens from Kyoto city. The study was approved by the Kyoto University Hospital Ethical Committee (Japan Medical Association Clinical Trial Registration Number JMA-IIA00314).

Participants

Participants were recruited from a group of people who attended a program run by Kyoto University Hospital, offering weekly sessions of exercise-based cognitive training at a local community center. The inclusion criteria consisted of healthy people having 50 or more years of age, with independent ambulation and no physical or mental limitation that could prevent them from walking short distances or understanding the game rules.

The age range of 50 years or more was chosen because this research is inserted in the context of preventive health interventions and thus it focused on the wider group of middle-aged and *older adults*, not being restricted to the group of "strictly" *elderly*, which are usually represented by the age range of 60 years or more.

Protocol

A 3-week protocol was used (Fig. 4.4).

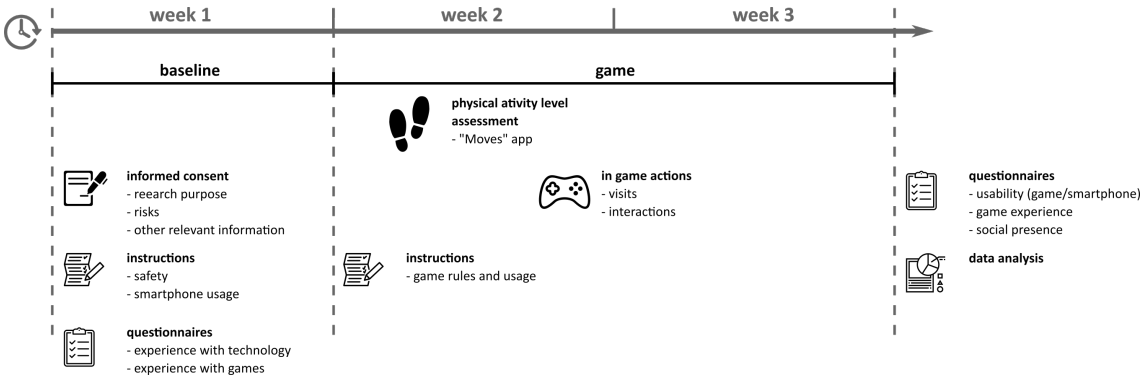


Figure 4.4: Feasibility study protocol.

At the beginning of the study, participants answered 2 questionnaires to assess their previous experience with technology (Section A.1) and games (Section A.2), but no previous experi-

ence was required to join the experiment. After signing the informed consent term and answering the questionnaires, participants received a smartphone pre-configured to run the game and a manual with explanations about the basic smartphone operation and the game rules. They then received an oral explanation about the basic usage of the smartphone and about how to play.

During the first week, participants' levels of physical activity (step-count) was monitored to be used as a baseline for comparison. On the remaining two weeks, participants could play the game freely while their physical activity were still monitored, as well as their in-game actions, such as visits to hotspots and interactions with other players.

Step counts were monitored using the Moves app [81]. Participants were instructed to carry the smartphone with them as much as possible whenever they left home. The same instructions were also present at the smartphone's wallpaper and lock screen images, so they would be visible whenever the user unlocked the screen.

At the end of the study, volunteers were asked to answer questionnaires to assess the usability of the game (Section A.3), and to report their experience while playing (Section A.4), including their sense of social presence (Section A.5). The questions were based and/or adapted from the Game Experience Questionnaire (GEQ) [82] and from the System Usability Scale (SUS) [83]. All questions had a 5-level Likert scale of one of two types: agreement level (0=strongly disagree, 4=strongly agree) and frequency (0=never, 4=always).

Results

Basic demographic data about the participants and their previous experience with games and technology are presented in Table 4.2.

It is possible to notice that most participants have some experience using the PC, while only about half of them had some experience with smartphones. For both electronic and non-electronic games, the majority of participants had no previous experience, while more people had experience with non-electronic games than with electronic ones.

The average scores of the usability, game experience and social presence evaluation are presented in Table 4.3, while Table 4.4 shows the total occurrences of specific game actions for all participants during the 2 weeks of intervention after baseline.

The data suggested that the game theme and overall design was adequate, since categories such as visual style, enjoyment and engagement had positive evaluations on average. It also

Table 4.2: Participants' demographic data and previous experience with technology and games.

Demographics	
Average age (σ)	74.6 (3.3)
Number of participants	12
Female	9 (75%)
Dropouts	3 (F=2)
Experience with PCs	
Frequency of usage	
Everyday	1 (8%)
2+ times/week	5 (42%)
1- times/week	1 (8%)
Never	5 (42%)
Skills	
Internet, email	1 (8%)
Social networks	3 (25%)
Experience with smartphones	
Never used	5 (42%)
Make calls	6 (50%)
Internet, e-mail	6 (50%)
Social networks	3 (20%)
Install apps	3 (20%)

Non-electronic games	
Doesn't play	9 (75%)
Everyday	0 (0%)
2+ times/week	2 (17%)
1- times/week	1 (8%)
Electronic games	
Frequency of play	
Doesn't play	9 (75%)
Everyday	1 (8%)
2+ times/week	1 (8%)
1- times/week	1 (8%)
Partners	
(% of those who play)	
Alone	3 (100%)
Family (adults)	1 (33%)
Family (children)	0 (0%)
Friends	0 (0%)
Strangers	0 (0%)

Table 4.3: Usability, game experience, and social presence average scores.

Category	**Score** $[0, 4]$
Usability	
Controls	1.50
Learn curve	1.90
Feedback	2.25
Game rules	2.06
Game experience	
Theme and visual style	2.45
Originality	2.17
Feeling of Immersion	2.02
Feeling of Enjoyment	2.40
Feeling of Engagement	2.21
Feeling of Freedom/Ability to explore	1.78
Feeling of (positive) Challenge	2.11
Social presence	0.48

Table 4.4: Game actions.

Action	Amount
Visit a hotspot	140
Leave a copy of a card	22
Meet another player	16
Join a challenge	2
Finish a challenge	0

seemed that participants could understand the game rules and the feedback to player actions provided by the game. However, aspects such as game controls were negatively evaluated, and, in particular, the category of social presence received a very low score.

The results of the evaluation of social elements were also corroborated by game action data, since the actions related to social interaction were very rarely used. In particular, the challenge mechanics was not used at all. Based on the data and on informal reports from users, it was hypothesized that people could not understand the challenge mechanics. At the same time, the "leave a copy" mechanics was very ineffective if only a few people were playing or if players were too far apart, since they could not interact.

Step count data are presented at Table 4.5. In this stage of the development, only the feasibility of the system as a test tool was evaluated, with no deeper analysis of the effect on the levels of physical activity. Nonetheless, a slight positive effect in comparison to the baseline was already observed.

Table 4.5: Number of steps of the whole group during the study.

Week	Mean (σ)	Effect (relative to σ)
1	22567.2 (16347.8)	–
2	24272.9 (16995.3)	+1705.7 (7.6%)
3	24393.3 (14203.8)	+1826.1 (8.1%)

4.5 Improvements

To address the issues found during the feasibility evaluation as well as to improve other technical aspects of the game, adjustments were made on the system, as follows.

Social Interaction

The evaluation indicated that the "leave a copy" mechanics was not effective if only a few players were playing or if people were too far apart. To address this issue, it was changed so hotspots would now connected as groups, and when a player leaves a copy of a card in a member of the group, all members would also have it available (Fig. 4.5).

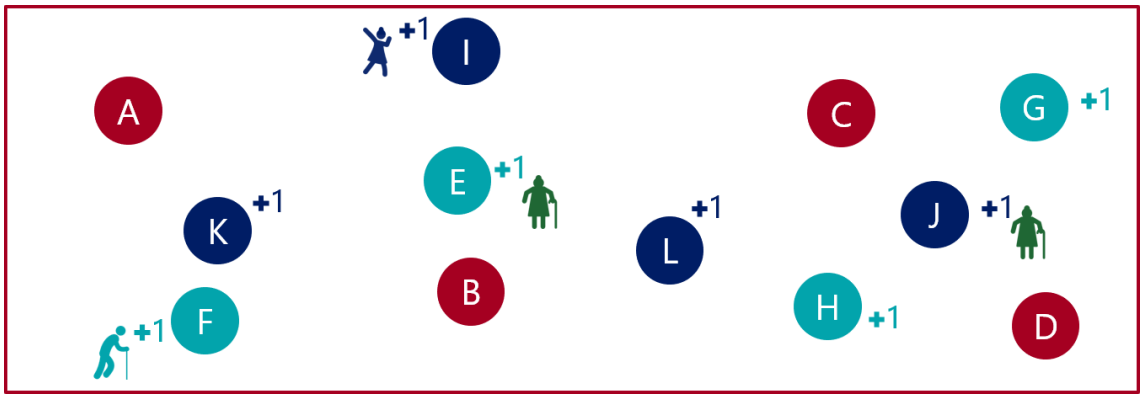


Figure 4.5: Connecting hotspots – if a player leaves a copy in a hotspot (*e.g.*, the blue players), the card will be also available in all hotspot in its group.

Additionally, it seemed that participants could not understand the challenge mechanics and did not use it. In the improved version, challenges are automatically generated daily. Players are randomly assigned to groups, and when any member of the group visits a hotspot, all members receive a card (Fig. Fig. 4.6). Players are aware of the challenge and can see the members of their group and their respective contribution (Fig. 4.7l).

Color, Infrastructure and Measurements

The color palette of the game was also adjusted to increase the readability and visual comfort of the interface. Red was chosen as the main color, since it is strongly associated with Japanese shrines and with Japan itself. The remaining of the palette was determined using color theory [84].

Card colors were also changed accordingly. Purple was chosen for the highest level, since in Japanese culture this color is associated with valuable items. The remaining colors were chosen to establish a hue gradient, with special care to use tones that would have high contrast with the user interface.

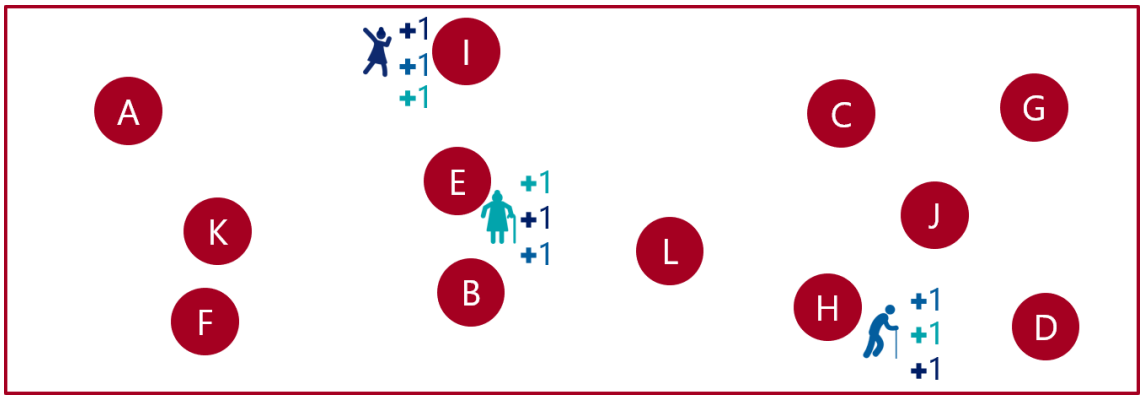


Figure 4.6: New challenge mechanics – players are automatically assigned a group daily, and when a member visits a hotspot, all members get a card.

A few participants had some problems of slow response time, which could be aggravated by unreliable mobile networks connections. To reduce the data requirements of the game and increase response time, the backend infrastructure was reimplemented from scratch, improving performance significantly.

As a final adjustment, the step count measurement strategy was also changed. Shortly after the end of the feasibility study, development of the Moves app was discontinued, which prevented it from being used in future experiments. To solve that problem, the measurement was migrated to the game itself, using a background service that operated whenever the smartphone was turned on. This service used Google Android's Sensor API, which is the same library used by Google Fit, an application previously shown to have accuracy equivalent to or better than that of wearable devices [85]. This strategy had the added benefit of simplifying the game installation process, as it no longer required the user to connect the game to an external app and give the appropriate permission to access their data.

Special Adaptations for the Elderly

Besides the choice of theme and colors that was made specifically to appeal to Japanese elderly players, additional care was also taken to adjust the system to fulfill the basic requirements of games for elderly listed in Section 3.1.

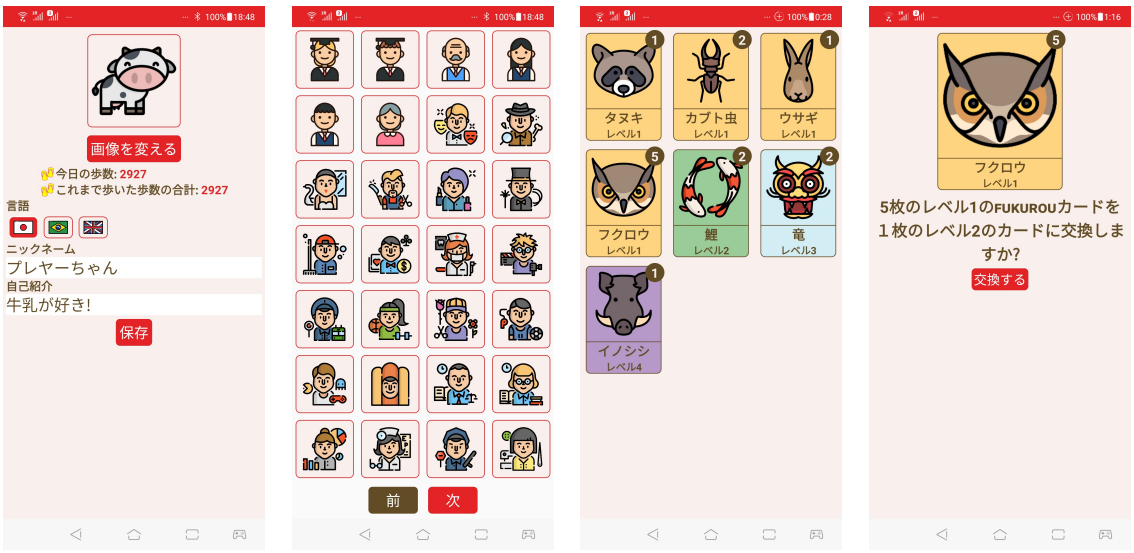
From the beginning, game rules were designed to be simple and straightforward, without unnecessarily complex elements or relationships, but instead single goals that could be immediately understood.

The game font and icons were increased to be easily visible on most modern smartphones, and the level of contrast was maximized within the basic palette of the game to make elements easier to read. Also, only a small set of 5 basic color were used, with a few additional variations for borders and highlight.

The interface was simplified as much as possible, with any action taking at most 3 screens to be completed.

4.6 Final version

The final version of the game kept the core elements of the initial design, while providing better social interaction mechanics and an overall better experience to players, as will be discussed in the remaining chapters of this dissertation. In Fig. 4.7, a few screenshots of this final version are presented, followed by brief descriptions of the main aspects of the mechanics.



(a) players have public avatars that identify them to other players

(b) they can choose the avatar icons from a set of available options

(c) there are cards with different animal icons, and different levels indicated by color

(d) players can 5 cards of one level for 1 card of the next level, and their goal is to get the maximum level card for all animals

Figure 4.7: Screenshots of the game.

(e) players must walk to nearby hotspots (shrines and temples) to collect cards

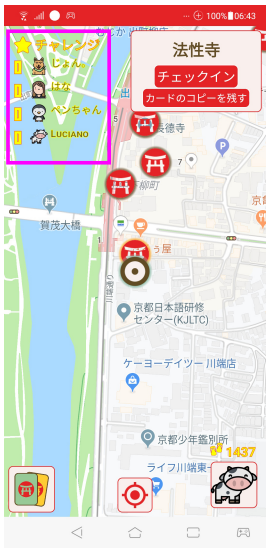
(f) they are warned not to walk while keeping the game screen open

(g) they get cards constantly, based on how much they walk

(h) and also when they check in

(i) players can leave copies of their cards at the hotspots they visit

(j) other players will see a mark on such hotspots, and, when they visit them, both players get cards



(k) everyday players are assigned to a challenge group

(l) and when a member of the group visits a hotspot, all members receive a card

Figure 4.7: Screenshots of the game (cont.).

5

Adapting to a Different Cultural Context

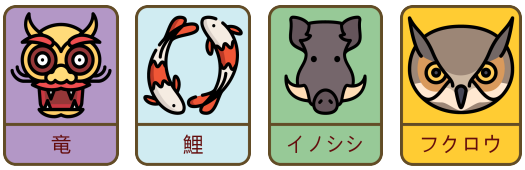
After the basic design of Shinpo was finished, a new evaluation was necessary to test if the new mechanics would be more effective. At the same, it was necessary to further investigate the adaptability of the game. For instance, to be an effective test tool that would enable evaluation of pervasive game design and general findings, Shinpo should be adaptable not only for specific elements but also for varied contexts, including different cultures.

Thus, as part its evaluation, the game was adapted to be used in Brazil, a country with a very different culture than Japan. The following sections describe the adaptation process and the evaluation of the adapted version for its impact on the effectiveness of the game as an experiment system.

5.1 Development of the Brazilian Version

The first change made into the game was a translation to Brazilian Portuguese. One special consideration was made about the title of the game. Even though 'Shinpo' is a made-up name that could potentially be used in any language without major problems, it was also carries a semantic value that is culturally relevant and, if possible, should also be transported to the new context. For that reason, after a few iterations, the game was finally named "Trilhas" in Portuguese, which translates into *trails*, including the nuance of *paths to be followed*.

The choice of collectible items was kept, since cards are also a popular item for collection in Brazil. It was also unnecessary to make any changes on the colors of the cards, since the previously chosen hues also have positive or neutral associations in Brazilian culture. The animals, although chosen for their connection to Japan, were also generic and popular enough to be also easily recognized by Brazilian people, so they were kept, and other animals from Brazilian fauna were added (Fig. 5.1b).



(a) Japan

(b) Brazil

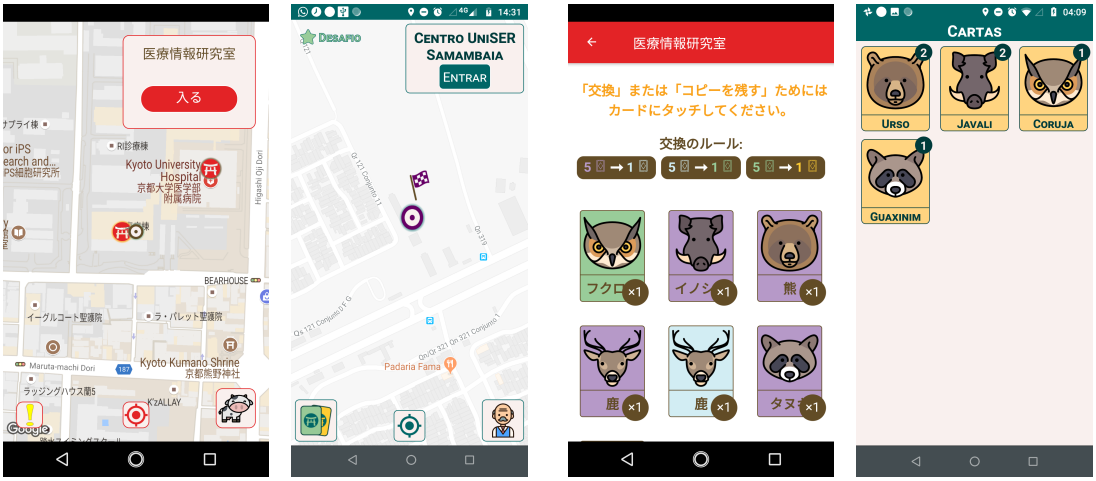
Figure 5.1: A few cards of the Brazilian version.

The color palette of the interface was changed. For the Japanese version, red was chosen as the main color – since it has a strong positive association in Japan. In Brazil, however, this color can have negative connotations, often being considered aggressive or associated with violence. So, the main color of the game was changed to green, which has a very positive connotation in Brazil, the remaining colors being adapted accordingly (Fig. 5.2).

For the choice of places to be visited, Buddhist temples and Shinto shrines are almost nonexistent and have no cultural significance in Brazil, so new types of locations would have to be used. The change, however, wasn't as easy as simply using sacred places that would be locally relevant instead.

In Japan, due to tradition and/or cultural appreciation, both religious and not religious people hold a positive – or, at least, neutral – association with temples and shrines. In Brazil, however, religious buildings are relevant mainly to religious people alone, and a few non-religious people might hold a negative association to them. The country is mainly Christian, so churches were included as options, but also bakeries, cafés, banks, supermarkets, government buildings, schools, etc.

The game icons were adapted to reflect the new palette and the new choice of target places, to represent a more generic meaning of "goal", since the previous icons were heavily specific to Japanese culture (Fig. 5.3).



(a) map **(b)** cards menu

Figure 5.2: Changing the color palette.

(a) **(b)** **(c)** **(d)**

Figure 5.3: Examples of adaptation of game icons (Brazilian version on the right): (a) - logo, (b) - hotspot marker, (c) - cards icon, (d) - nearby players indicator.

5.2 Evaluation

To evaluate the adapted game, a trial was performed with a group of volunteer community dwelling senior citizens who attend an exercise program run by Federal University of Pelotas (UFPel), in the southern region of Brazil. The protocol was similar to the one used at the feasibility study (Fig. 4.4), however, with 3 weeks of intervention after the baseline, instead of 2.

As in the feasibility evaluation, participants answered questionnaires at the beginning of the study, regarding their previous experience with technology and with games, as well as ques-

tionnaires about their game experience at the end. In essence, the same questionnaires were used, but they were translated to Portuguese and the format of certain items was adapted to make then easier to understand (Appendix B).

For qualitative data, both informal conversations during the meetings and written answers to the open fields at the questionnaires were registered.

This experiment was approved by the Ethical Committee of Federal University of Pelotas.

Results

In Table 5.1, demographic data about the participants is presented, including a comparison with the participants of the previous study in Kyoto. Table 5.2 shows the results of the game experience evaluation.

Metric	Kyoto	Pelotas
Demographics		
Average (STD)	74.6 (3.3)	70.7 (4.9)
Participants	12	15
Female	9 (75%)	14 (93%)
Dropouts	3 (F=2)	2 (F=2)
Experience with PCs		
Frequency of usage		
Everyday	1 (8%)	0 (0%)
2+ times/week	5 (42%)	4 (27%)
1- times/week	1 (8%)	2 (13%)
Never	5 (42%)	9 (60%)
Skills		
Internet, email	1 (8%)	0 (0%)
Social networks	3 (25%)	3 (20%)
Experience with smartphones		
Never used	5 (42%)	2 (13%)
Make calls	6 (50%)	12 (93%)
Internet, e-mail	6 (50%)	8 (53%)
Social networks	3 (20%)	10 (67%)
Install apps	3 (20%)	4 (27%)

Metric	Kyoto	Pelotas
Non-electronic games		
Doesn't play	9 (75%)	5 (33%)
Everyday	0 (0%)	
2+ times/week	2 (17%)	10 (67%)
1- times/week	1 (8%)	
Electronic games		
Frequency of play		
Doesn't play	9 (75%)	11 (73%)
Everyday	1 (8%)	2 (13%)
2+ times/week	1 (8%)	0 (0%)
1- times/week	1 (8%)	2 (13%)
Partners*		
Alone	3 (100%)	4 (100%)
Family (adult)	1 (33%)	0 (0%)
Family (young)	0 (0%)	0 (0%)
Friends	0 (0%)	0 (0%)
Strangers	0 (0%)	0 (0%)

*percentages are relative to respondents that said they play electronic games

Table 5.1: Participants' demographic data and previous experience technology and games.

Category	Score $[0, 4]$	
	Kyoto	**Pelotas**
Usability		
Controls	1.50	3.07
Learn curve	1.90	3.23
Feedback	2.25	2.46
Game rules	2.06	2.65
Game experience		
Theme and visual style	2.45	2.76
Originality	2.17	3.06
Feeling of Immersion	2.02	2.84
Feeling of Enjoyment	2.40	3.03
Feeling of Engagement	2.21	2.90
Feeling of Freedom/Ability to explore	1.78	2.92
Feeling of (positive) Challenge	2.11	2.64
Social presence	0.48	2.04

Table 5.2: Usability, game experience, and social presence.

In the questionnaires, the most often cited non-electronic games were crosswords, puzzles, checkers, and card games. For electronic games, solitaire and memory games were cited frequently.

When making comments and suggestions about the game, 3 participants reported concerns about safety, since, overall it is dangerous to walk around carrying a smartphone in Brazil. Two of the participants said they enjoyed the chance to use technology to improve their health, and one person said they liked the chance to user a smartphone for the first time.

Additionally, on informal conversations during the follow-up meetings, participants reported enjoying the experience of discovering new places in their neighborhood, and that they often met other participants in specific locations.

Discussion

The main focus of this evaluation was assessing if Shinpo would still be an adequate test tool when adapted to Brazil, and if the improved social interaction mechanics would be more effec-

tive.

The usability and game experience scores were equally good or better than the previous version of the game. However, since the game was changed in non-trivial ways between the feasibility study in Kyoto and the new evaluation in Pelotas, the comparison at this stage was not completely fair. Nonetheless, as explained in Chapter 6, this initial results were confirmed when a fair follow-up study was made in Japan.

Considering that the design process employed to adapt the game to a new culture was performed in a way as to only make minimal changes necessary to ensure suitability to the new environment, without changing the design principles and core mechanics, this leads to believe that the new social interaction mechanics were more effective and engaging, and the overall design of the game was improved. These results are also backed up by the feedback from users in conversations and in the open fields of the questionnaires.

Additionally, this study also illustrated some key differences between Japanese and Brazilian environments. First of all, elderly people in Brazil seem to be much more familiarized with smartphones than their Japanese counterparts. This result was expected, since the wide popularity of social networks such as Facebook and WhatsApp among people of all ages in Brazil would also imply such knowledge among the elderly.

When it comes to general comments about the game, it is noticeable that Brazilian people were especially concerned with safety, since Brazil is notoriously a country much more dangerous than Japan.

Finally, researchers' observation of people's interactions during the meetings resulted in the impression that Brazilian people tend to talk to each other in much more spontaneous ways, even with strangers, while Japanese elderly tend to talk more freely with acquaintances only.

6

Evaluating Social Interaction as a Design Element

Once evaluated as an adequate experiment system, Shinpo was used in controlled trials as a tool to tested social interaction as a pervasive design element. As explained in previous chapters, social interaction was chosen due to previous results showing its relevance as a factor affecting elderly people's quality of life. Analogously, promotion of physical activity was used as target because higher levels of physical activity are strongly correlated with the health of older adults.

The experiments described in this chapter were approved by the Kyoto University Hospital Ethical Committee (Japan Medical Association Clinical Trial Registration Number JMA-IIA00314), by the Ethical Committee of University of Brasília's Ceilândia Faculty and by the Ethical Committee of Federal University of Pelotas.

6.1 Trial in Brazil

The first evaluation of social interaction as a design element using Shinpo was performed in collaboration with University of Brasília, in Brazil. Due to the nature of the intervention, it was not possible to blindly assign individual participants to different experimental groups, as players would be aware of the assignment if they talked with other participants playing a different

version of the game. Thus, two isolated groups were chosen, each playing one variation of the game, no social interaction (NSI) *vs* social interaction (SI), in a quasi-experimental design.

Participants

Participants were recruited among students who attended classes in a community project that targeted older adults and that was run by the university. Students in that project did not incur any financial cost to join it, and no educational background was required, except for being able to read and write. Classes were offered at sites in different regions of the city. While students at different sites did not have contact with each other, students at the same site attended classes together. Two different sites were chosen to recruit students and form the intervention groups: one group played the NSI variation of the game, and the other group played the SI variation. There were no identifiable differences among sites regarding participants' social, educational or economic backgrounds.

Similarly to the previous experiments, the inclusion criteria for this intervention comprised of healthy people having 50 years or more, with independent ambulation and no cognitive or physical impairment that prevented them from understanding the instructions of the game or making short walks.

Protocol

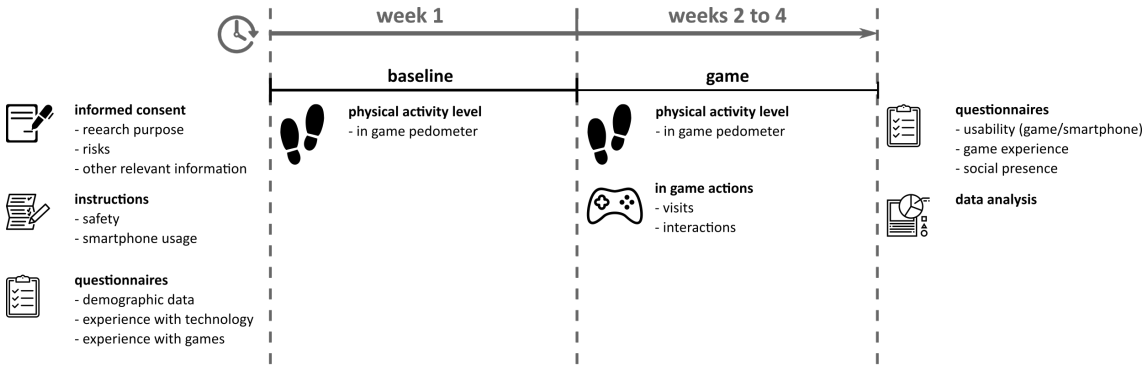


Figure 6.1: Controlled trial protocol.

Participants played Trilhas – the Brazilian version of Shinpo described in Chapter 5 – following a 4-week protocol similar to the previous experiments (Fig. 6.1). Participants' levels of physical activity were measured by the game, as previously described in Section 4.5, and the

average number of steps per week was considered as the main outcome to be observed. As in previous interventions, during the first week participants did not play the game, but only their step-count was monitored to be used as baseline. After that, they played the game for 3 more weeks.

To evaluate how much participants played the game, the weekly average number of visits to hotspots was also observed. Within a single day, this observation represents the number of unique hotspots visited by the player, while within a week, it is the sum of the visits in each day of the week (i.e., the same hotspot is not counted twice for the same day, but it can be counted twice for a week). This measurement was used because players are directed to not keep the game open while walking, so play time is not a good measurement of how much a person played.

Just like in previous interventions, participants were asked to answer questionnaires at the beginning and at the end of the study, to assess, respectively, their previous experience with games and technology, and their game experience. The same questionnaires from the cultural adaptation evaluation (Appendix B) were used.

Results

Information about participants' previous experience with technology and games is reported in Table 6.1. These data include answers collected at the beginning of the study from all participants.

Most participants used their own devices. For the NSI group, 3 devices were lent, while 2 were lent for the SI group. One person borrowed a device because they did not own a smartphone, while all others borrowed devices because their own device was incompatible (different OS or unsuitable OS version). Only 1 person who borrowed a device dropped out (from the NSI group), and all other participants who borrowed devices stayed until the end.

To evaluate the effect of the game version in each group, the change in average step-count each week, when compared to the baseline week, was considered, i.e., $\Delta_i = w_i - b$, where w_i is the number of steps on the i-th week, and b is the number of steps during the baseline week. The relative change was also considered, i.e., Δ_i/b. This data is shown in Table 6.2 for participants who remained until the end of the experiment. The baseline column shows the average number of steps during the first week for each group. The remaining columns show the mean change for the following weeks.

Data about hotspot visits are shown in Table 6.3 for participants who remained until the

Table 6.1: Participants' demographic data and previous experience with technology and games (Brasília).

	NSI	SI
Demographics		
Participants (*F*)	15 (11)	17 (14)
Average age (σ)	64.3 (6.0)	61.1 (7.4)
Dropouts	8 (53%)	6 (35%)
PC experience		
Usage frequency		
Everyday	6 (40%)	5 (29%)
2 or more times/week	4 (27%)	4 (24%)
Up to once/week	4 (27%)	6 (35%)
Never 1	(6%)	3 (12%)
Able to...		
check e-mail	14 (93%)	12 (71%)
do web searches	14 (93%)	12 (71%)
read news online	12 (80%)	13 (76%)
use social networks	14 (93%)	13 (76%)
install applications	7 (47%)	4 (24%)
Smartphone experience		
Never used before	1 (7%)	1 (6%)
Able to...		
make calls	14 (93%)	13 (76%)
check e-mail	13 (87%)	13 (76%)
browse the web	14 (93%)	12 (71%)
use social networks	13 (87%)	16 (94%)
install applications	6 (40%)	8 (47%)

	NSI	SI
Games experience		
Play frequency		
Everyday	1 (7%)	3 (18%)
2 or more times/week	3 (20%)	0 (0%)
Up to once/week	1 (7%)	0 (0%)
Very rarely	1 (7%)	2 (12%)
Never plays	9 (60%)	12 (71%)
Devices used[a-c]		
Computer	3 (50%)	2 (40%)
Console[d]	0 (0%)	3 (60%)
Smartphone	3 (50%)	4 (80%)
Handheld[e]	0 (0%)	2 (40%)
Play partners[a-c]		
Alone	4 (67%)	4 (80%)
Friends	0 (0%)	1 (20%)
Family (adult)	1 (17%)	2 (40%)
Family (young)	1 (17%)	3 (60%)
Strangers	1 (17%)	0 (0%)

[a] Respondents could indicate more than one item.
[b] Some people reported playing but did not indicate any option on this item.
[c] Percentages are relative to the number of people who reported any play activity.
[d] *PlayStation*, *Xbox*, *Nintendo Switch*, *etc*
[e] *Nintendo 3DS*, *Sony PSP*, *etc*

Table 6.2: Average number of steps at baseline and variation in subsequent weeks (Brasília).

		Baseline (SE)	Δ_2 (SE)	Δ_3 (SE)	Δ_4 (SE)
NSI	Absolute	17099.4 (3906.5)	383.8 (563.8)	435.9 (574.5)	-106.1 (979.9)
	Relative	–	1.1% (4.3%)	2.2% (4.6%)	-2.6% (8.1%)
SI	Absolute	17981.9 (2171.1)	3841.9 (1425.4)	2270.6 (947.1)	2443.4 (982.6)
	Relative	–	21.7% (5.1%)	16.5% (4.4%)	17.9% (4.7%)

end of the experiment. Each column shows the average number of weekly visits to hotspots for each group, with v_i indicating the value for the i-th week of intervention. Standard errors are shown in parentheses for all values.

Table 6.3: Average number of visits (Brasília).

	v_2 **(SE)**	v_3 **(SE)**	v_4 **(SE)**
NSI	8.4 (2.1)	8.9 (1.7)	5.1 (3.0)
SI	14.2 (1.9)	9.5 (2.0)	12.8 (3.4)

The scores for the usability and game experience questionnaire are summarized in Table 6.4. The values indicate the average agreement level (0 –- not at all, 4 –- extremely) for the category if it is a positive item. When the item is negative, the scale was inverted to attribute values. In this scheme, an evaluation of more than 2 indicates a positive opinion. The data included only those of participants who stayed until the last week.

Table 6.4: Game experience questionnaire results.

	NSI	**SI**
Usability		
Controls	2.2	2.7
Learn curve	2.2	2.6
Game rules	1.9	2.2
Game experience		
Theme and visual style	2.3	2.5
Feeling of immersion	2.4	2.2
Feeling of enjoyment	2.4	2.9
Feeling of engagement	1.6	2.3
Feeling of freedom/ability to explore	1.5	2.9
Feeling of (positive) challenge	1.4	2.1

The questionnaire also included an open-response item in which participants could freely write down suggestions and comments.

For the NSI group, one participant reported that they often played competitive online games and that "Trilhas" could benefit from a competitive factor. Two participants said they could not play often but wished to have helped more in the research. One participant said the game was boring.

For the SI group, many participants said they enjoyed the chance to make more exercise. A few participants said they liked the look of the game, finding it "cute". During the follow-up meetings, many participants commented on the fact they received cards from other participants at specific locations. One participant reported concern about other people knowing their whereabouts.

Analysis

In the statistical model, the change for each week after baseline was considered to be a repeated measure, and an analysis of variance (ANOVA) was performed, with group and week as factors, for participants who remained until the end of the experiment. Because the experimental setting did not allow for the balancing of data, a Type-III strategy was used to account for unbalanced data. The relationship between the change in the step-count and the number of hotspot visits was evaluated using Pearson's correlation coefficient.

Considering the absolute change, the analysis of the effect of group as factors resulted in $p = .01$ ($\eta^2 = .19$). No relevant relationship was found with week as a factor ($p = .65$). For relative change, taking group as a factor resulted in $p = .009$ ($\eta^2 = .27$), while taking week as a factor resulted in $p = .54$. The correlation factor (Pearson) between the absolute change in the number of steps and the number of visits was $r = .21$, with a 95% CI of $[-.06, .45]$. When relative change is considered, the factor was $r = .34$, with a 95% CI of $[.08, 0.56]$.

There was more variation in the main outcome for the control group, probably due to the higher dropout rate by the end of the third week in that group. The statistical analysis with respect to the absolute change indicating a medium to high effect size suggests that there was a higher positive effect on the SI group. A higher number of visits in this group suggests that participants played more, although correlation data were inconclusive: a medium correlation was found for relative change, but only a small correlation was found for absolute change. This finding leads to the belief that social interaction mechanics had some effect on player engagement, but other factors might have also influenced it. One other possible explanation could be that players might tend to visit the same nearby places often, thus increasing their physical activity to some extent but not in a linear relationship with the number of visits.

The complementary evaluation of usability and game experience indicated an overall positive evaluation for system usability and game experience, as most items had values > 2. The average evaluation for the SI group was higher for all items, but the difference between groups

was small for most items, preventing any solid conclusions. Players in both groups gave positive feedback for the "visual style" of the game and feelings of "immersion" and "enjoyment"; however, there was a larger difference between groups for the categories of "engagement", "exploration" and "challenge". One possible explanation is that the NSI group might have had an inferior experience in these categories because the version of the game they played had a subset of the rules of the SI group, which could be perceived as less challenging. The usability evaluation for "game rules" was lower in the NSI group; however, because the rules in the NSI version were a subset of those in the SI version, this finding might also be explained by an inferior game experience. Another possible explanation is that some players might not have understood these rules, although players'comments did not indicate such a case.

The subjective evaluation considering the open-response comments seems to indicate that players in the SI group had more fun and felt more engaged in the game, specifically enjoying the card exchange mechanics, although they also felt motivated by the chance of being stimulated to do more exercise. One participant from the NSI group complained about the lack of competition, which is a modality of social interaction, leading to the belief that the social factor is relevant for some players.

6.2 Trial in Japan

A confirmatory trial was performed in Kyoto, following the same 4-week protocol used in Brazil. For this trial, participants were recruited at the general public, using flyers. A ¥10,000 voucher was offered as reward for joining the experiment.

At the end of the initial baseline week, participants were randomly assigned to either NSI or SI groups, ensuring equal proportion for gender, age and previous experience with games and technology. The same outcomes were measured and the same data analysis strategies were used for this trial.

Results

Information about participants' previous experience with technology and games is reported in Table 6.5. These data include answers collected at the beginning of the study from all participants.

Table 6.6 shows step count data for both Brasília and Kyoto, considering absolute and

Table 6.5: Participants' demographic data and previous experience with technology and games (Kyoto).

	NSI	SI
Demographics		
Participants (*F*)	9 (7)	9 (7)
Average age (σ)	64.6 (8.9)	62.2 (8.4)
Dropouts	2 (22%)	2 (22%)
PC experience		
Usage frequency		
Everyday	4 (45%)	2 (22%)
2 or more times/week	1 (11%)	2 (22%)
Up to once/week	1 (11%)	3 (34%)
Never	3 (33%)	2 (22%)
Does...		
check e-mail	6 (67%)	4 (44%)
browse the web	4 (44%)	5 (56%)
do web searches	4 (44%)	5 (56%)
read news online	4 (44%)	4 (44%)
use social networks	3 (33%)	2 (22%)
edit photos	4 (44%)	4 (44%)
use word processor	5 (56%)	5 (56%)
Smartphone experience		
Never used before	1 (11%)	0 (0%)
Able to...		
make calls	8 (89%)	9 (100%)
check e-mail	8 (89%)	9 (100%)
browse the web	6 (67%)	8 (89%)
use social networks	6 (67%)	9 (100%)
install applications	6 (67%)	9 (100%)

	NSI	SI
Games experience		
Play frequency		
Everyday	3 (22%)	2 (22%)
2 or more times/week	0 (0%)	2 (22%)
Up to once/week	0 (67%)	0 (0%)
Rarely	5 (56%)	2 (22%)
Never plays	1 (11%)	3 (34%)
Devices used[a-c]		
Computer	3 (38%)	1 (17%)
Handheld[e]	1 (13%)	1 (17%)
Console[d]	0 (0%)	0 (0%)
Smartphone	5 (63%)	5 (83%)
Play partners[a-c]		
Alone	8 (100%)	6 (100%)
Family (young)	1 (13%)	0 (0%)
Family (adult)	0 (0%)	0 (0%)
Friends	1 (13%)	0 (0%)
Strangers	0 (0%)	0 (0%)

[a] Respondents could indicate more than one item.
[b] Some people reported playing but did not indicate any option on this item.
[c] Percentages are relative to the number of people who reported any play activity.
[d] *PlayStation*, *Xbox*, *Nintendo Switch*, *etc*
[e] *Nintendo 3 DS*, *Sony PSP*, *etc*

proportional values, for comparison. The baseline column shows the average number of steps during the first week for each group. The remaining columns show the mean change for the following weeks.

Table 6.6: Average number of steps at baseline and variation in subsequent weeks (comparative).

		BL (SE)	Δ_2 (SE)	Δ_3 (SE)	Δ_4 (SE)
Brasília	**NSI**	17099.4 (3906.5)	383.8 (563.8)	435.9 (574.5)	-106.1 (979.9)
	SI	17981.9 (2171.1)	3841.9 (1425.4)	2270.6 (947.1)	2443.4 (982.6)
Kyoto	**NSI**	46897.2 (7905.4)	1583.3 (3108.3)	591.5 (2414.5)	-1041.8 (1992.7)
	SI	45967.3 (8260.7)	11520.0 (3941.5)	9576.3 (2631.5)	7648.7 (3900.9)

		Δ_2 (SE)	Δ_3 (SE)	Δ_4 (SE)
Brasília	**NSI**	1.1% (4.3%)	2.2% (4.6%)	-2.6% (8.1%)
	SI	21.7% (5.1%)	16.5% (4.4%)	17.9% (4.7%)
Kyoto	**NSI**	4.6% (7.2%)	2.4% (4.7%)	0.6% (4.4%)
	SI	28.0% (8.7%)	23.0% (5.1%)	13.9% (8.0%)

Data about hotspot visits are shown in Table 6.7 for participants who remained until the end of the experiment, for both Brasília and Kyoto. Each column shows the average number of weekly visits to hotspots for each group, with v_i indicating the value for the i-th week of intervention. Standard errors are shown in parentheses for all values.

Table 6.7: Average number of visits (comparative).

		v_2 (SE)	v_3 (SE)	v_4 (SE)
Brasília	**NSI**	8.4 (2.1)	8.9 (1.7)	5.1 (3.0)
	SI	14.2 (1.9)	9.5 (2.0)	12.8 (3.4)
Kyoto	**NSI**	42.8 (15.8)	89.7 (24.5)	96.2 (35.2)
	SI	169.0 (63.9)	115.0 (40.0)	140.0 (57.6)

On Table 6.8, the scores for the Game Experience Questionnaire (including the Social

Presence module) and the System Usability Scale are presented. The results of the experiments in Brasília and Kyoto are shown side by side for comparison, however, the results for Brasília were based on fewer items.

While in Kyoto the full set of questions of the GEQ was used, in the previous experiments only a subset of those questions were used. Thus, when the individual items from the questionnaire used in Brasília were regrouped to form the categories of GEQ, some categories could not be calculated, and all of them are composed of fewer items than the original setting. For this reason, it is not possible to draw strong conclusions from this comparison, or perform any valid comparative statistic analysis.

Table 6.8: Game Experience and Usability questionnaires' comparative results.

	Brasília*		**Kyoto**	
	NSI (SE)	**SI (SE)**	**NSI (SE)**	**SI (SE)**
GEQ - Core				
Competence	–	–	1.6 (0.1)	2.1 (0.2)
Sensory and Imaginative Immersion	1.8 (0.4)	2.8 (0.2)	1.7 (0.2)	2.3 (0.1)
Flow	–	–	1.4 (0.2)	1.6 (0.1)
Tension	1.8 (0.3)	0.9 (0.3)	0.5 (0.1)	1.1 (0.2)
Challenge	1.6 (0.4)	2.0 (0.2)	1.3 (0.2)	1.5 (0.1)
Negative affect	1.3 (0.3)	1.6 (0.3)	0.7 (0.2)	1.0 (0.1)
Positive affect	1.3 (0.2)	2.3 (0.3)	2.6 (0.2)	3.0 (0.1)
GEQ - Social Presence				
Psych. Involvement - Empathy	1.3 (0.5)	1.9 (0.4)	0.8 (0.1)	2.0 (0.2)
Psych. Involvement - Negative Feelings	–	–	0.5 (0.1)	1.0 (0.2)
Behavioral Involvement	1.2 (0.8)	1.0 (0.4)	0.5 (0.1)	1.5 (0.2)
System Usability Scale	2.0 (0.3)	2.4 (0.2)	2.6 (0.1)	2.8 (0.1)

* Based on fewer items.

Analysis

In the same manner as the previous experiment, weeks after baseline were treated as repeated measures, and an analysis of variance (ANOVA) was performed, with group and week as factors, for participants who remained until the end of the experiment. The relationship between the change in the step-count and the number of hotspot visits was evaluated using Pearson's correlation coefficient.

Considering the absolute change, the analysis of the effect of group as factors resulted in $p = .04$ ($\eta^2 = .31$). No relevant relationship was found with week as a factor ($p = .19$). For relative change, taking group as a factor resulted in $p = .02$ ($\eta^2 = .30$), while taking week as a factor resulted in $p = .17$. The correlation factor between the absolute change in the number of steps and the number of visits was $r = .58$, with a 95% CI of $[.32, .77]$. When relative change is considered, the factor was $r = .39$, with a 95% CI of $[.08, .64]$.

6.3 Discussion

In terms of statistically significant positive effect, the results of the experiment in Kyoto were similar to the results found in Brasília, corroborating the data from that experiment. In fact, the experiment in Kyoto yielded more powerful effects and higher correlation between play activity and measured effect.

However, differences between the two experiments could also be observed. The demographic data doesn't suggest any significant discrepancy between groups in these two cities, although elderly people in Brazil seem to use the smartphone more often, while elderly people in Japan report more experience playing games.

The first striking difference rests on the fact that the baseline levels of physical activity in Japan were more than twice those observed in Brazil. Several explanations are possible for this observation.

First of all, many participants in both studies attended programs promoted by local universities targeting the elderly. However, some participants in Kyoto attended a program specifically focused on exercise, which might have introduced a bias towards more physical activity in this group.

An aspect that is also relevant is the characteristics of each city. While Brasília is a city with many distant locations that are mainly accessed by car and, to a lesser degree, by public transportation, in Kyoto it is especially common for citizens to walk between destinations on their daily lives. A third possible explanation could be that Japanese people, in general, have higher baseline levels of physical activity, when compared to Brazilian people [86, 87].

Another observed discrepancy rested in the number of game interactions in each experiment, with values in Japan reaching as much as 10 times those observed in Brazil. This difference is more striking, since there are not significant variations in the game design between sites that

could justify this observation. The two most probable causes could be:

1. That there were many more sites available for players in Kyoto, even though specific measures were taken to provide many hotspots for the experiment in Brazil. This could have happened due to the fact that basic searches for shrines and temples in Kyoto can easily return dozens of results for any given part of the city, while in Brazil the searches had to be done with many different keywords, due to the specific context of each case.

2. That in Japan elderly people felt more motivated to visit many places, due to a deeper connection with the topic of shrines and temples for these participants than Brazilian participants would feel with the more generic categories used in their case.

The game experience and usability scale results are the ones that require most care for analysis. No comparison is possible between experiments, since the metric was different in each case. The break down of the Social Presence module of GEQ into subcategories gave more accurate results for the experiment in Kyoto. While the category of "Empathy" resulted in a positive evaluation for the SI group, "Behavioral Involvement" was not satisfactory for both cases.

It is interesting to notice that the results were larger for the SI group for all categories, suggesting more social interaction in that group, both positive and negative. For the core items of GEQ, the SI group had better results than NSI group for "Positive Affect", "Competence" and "Sensory and Imaginative Immersion", but "Challenge", "Negative Affect" and "Tension" were also higher, although not over 2, which would be a bad result overall. This is in conformity with the hypothesis that people in this group had a more intense game experience.

Despite these differences, the results of both experiments line up to give stronger evidence that social interaction is an important motivational factor into promoting physical activity of elderly people using pervasive games.

Limitations

The trials described in this chapter contributed new important data about social interaction, but, naturally, there were limitations.

The sample size was small, which reduces the possibility of observing stronger (or weaker) effects, and gathering more insights about the experience of players. In the case of the Brazilian experiment, participants were also recruited in the context of a university-run community project with no relation to the study; however, because participants attended classes together in

each group, this may have introduced biases and affected the results, since participants would meet often and could stimulate one another to play the game (or not play it) more than in the case of strangers.

In that experiment it was also not possible to blindly assign participants and control for previous experience with technology and games or other possible socioeconomic differences that might have affected the results, although questionnaire data suggest that the NSI group had a slightly higher ratio of proficiency to technology, which could have made participants in that group more prone to using the game, in opposition to the observed effect.

The main outcome was measured using smartphone software. The methodology has been evaluated in previous studies, and the authors of those studies concluded that it is adequate; however, future interventions might test similar settings with a different device, such as external pedometers, and compare the results. In both cases, because the data are not collected in a controlled environment but rather in a user-dependent context, participant compliance with carrying the device affects the results.

Step-count was observed in a continuous state, considering any daily activity of participants. Because the baseline week used these same criteria and the analysis considered the observed change, the results are still relevant. Nonetheless, further interventions might also separate in-game counts explicitly and analyze if there is any difference.

Although this research is inserted in the more general field of interventions to improve the quality of life of older adults, it focuses specifically on increasing physical activity based on previous results that show a strong correlation between these variables. Future interventions could measure these two variables explicitly and evaluate their relationship in the context of pervasive games.

7 Conclusion

In this doctoral research, the emerging genre of pervasive games was explored from a design perspective, and social interaction was used as a study case to understand how this genre could be used to stimulate specific behaviors.

The following sections summarize the main contributions, discuss their impact and propose possible paths of investigation for future research.

7.1 Main Contributions

This research was focused on understanding how design elements of pervasive games can create engaging experiences and affect players. In that realm, two main contributions were made.

The first one was the design, implementation and evaluation of an "experiment system" pervasive game. This system allow designers to propose variations on aspects of the game, while maintaining a core set of gameplay elements, in order to study how these variations affect player behavior.

With such system, other designers and researchers can further advance the study of pervasive games, and test other design elements and other modalities within each of these elements, observing how these aspects shape player's experiences and influence their behavior, attitudes and motivation, among others. This contribution is innovative because it allows for evaluation

of specific design elements within the same game, while previous works focus on comparison of game *vs* non-game or traditional approaches. The developed system was tested both in Brazil and Japan, and different variations of mechanics were proposed, with evaluations of these cases resulting in satisfactory results concerning its adequacy as a design test tool.

The other main contribution of this research was the evaluation of the effects of social interaction in the context of pervasive games. The results of this evaluation indicate that social factors are an important motivational aspect to promote physical activity among elderly people using pervasive games. This aspect was analyzed via two different controlled trials, one in Brazil and one in Japan. The first evaluation resulted in significant evidence for the positive effect of the game in the intervention group, but the correlation between playing and having more physical activity was inconclusive. In the follow-up evaluation, the initial results were corroborated with similar effects and the correlation between playing and having more physical activity could be clearly observed. This contribution is innovative because there was no previous result regarding social factors in this new context of pervasive game design.

This new evidence strengthens the previous body of research indicating that social connections are an essential element to promote quality of life of human beings, and of elderly people in particular. Based on this findings, it is possible to elaborate new interventions that could be more effective into engaging elderly people and helping them lead more active lifestyles. This new data could also be used to create models of player behavior, studying walk patterns and game engagement over time, for example.

7.2 Limitations

As long as there is enough coffee and enough time, research can always wander indefinitely through many paths. Even though this PhD candidate could never complain about lack of coffee, the same could not be said of available time. The consequence is that the scope of the research creates limitations, that must be addressed properly.

This doctoral research used social interaction and physical activity as study cases, and elderly people as target audience, however, design of pervasive game can include innumerable aspects and audiences. The findings serve as evidence of the general ideas defended in this thesis, but further investigations are necessary to make definitive claims. Since game design is a very broad discipline and much more Art than Science, it is also natural that this topic will never be

completely extinguished.

In terms of social interaction, specifically, there was a deliberate focus on collaboration, based on previous evidence that this element would be appealing to players in general and to the target audience in particular. However, many studies have also focused on competition and combinations of collaboration and competition to motivate people. These other possibilities must also be considered, as well as many other modalities of social interaction, such as dynamic *vs* static, direct *vs* remote, with acquaintances *vs* with strangers, among many others.

From a social-cultural perspective, it is important to consider that even the most engaging experiences could fail due to lack of an adequate context to make them available to the general public. Hugely popular games such as Pokémon GO, for example, often rely on the popularity of previous versions of the game or on a well established franchise. In that case, players already familiar with the game will engage because they have an inherent interest, and can then serve as evangelizers to attract new players.

In the context of application, increasing physical activity was used as a target behavior change because many previous work indicate a strong correlation between it and quality of life of the elderly. Naturally, indicators of wellness and quality of life could also be directly measured and analyzed for their relationship with this metric.

In a more general sense, many other elements of design could be tested, such as narrative, physical objects, different scales of locations, climatic and geographic elements, dynamic social connections – for example, open or spontaneous social gaming experiences –, among others.

7.3 Impact

As this new horizon of pervasive design as a strategy to create engaging serious games opens up, different aspects could be investigated, and the results of this doctoral research could have an important role into future explorations.

For instance, an important aspect that could not be fully investigated due to the necessary limitations in scope is whether the modality of social interaction affect player behavior. In other words, "social interaction" is a broad term, and it is useful to investigate how different kinds of interaction could affect players, and to what degree.

In that ground, the developed tool could be used to create new variations on the pervasive game design to test different modalities of social interaction. Challenge groups could be fixed

for specific periods, such as weekly, and mechanics that explore collaboration (inter-groups) and competition (intra-groups) simultaneously could be introduced, as well as additional elements, such as rank systems. Different real world social roles could be reflected as different game world experiences, such as allowing family members, friends and acquaintances to influence the target players' game experience by assuming auxiliary roles in the game narrative presented to them. Also, *spontaneous collaborative play sessions* could be introduced, *i.e.*, depending on the context, players near each other could start a task together, such as "conquer a specific shrine" and this form of highly contextual play could be compared to the more traditional daily life immersive play.

In the time perspective, a widely open question in engagement research as a whole is how to promote long term engagement. As explained in Chapters 2 and 3, a few works have already started to explore this question, but the evidence for the power of long term engagement of pervasive games is still infant and inconclusive.

The game proposed in this research was designed to have a long lifetime, but the focus of the evaluation was for the short term effect of a specific design element. Nonetheless, it is possible to introduce changes on the card system, such as card ranks and more complex evolution of cards to evaluate the system for longer times. The feedback from players indicate a will of at least some of them to continue playing even the unmodified version for longer periods, so the reasons that motivate such players could also be further investigated via qualitative analysis, such systematic semi-structured interviews with players throughout the evaluation.

From a psychological point of view, the argument was made (Chapter 2) that pervasive games are engaging because they explore both context and content of gameplay at the same time, potentially fulfilling all basic psychological needs. Although this argument stands, it is important to notice that other authors also identified the aspect of pleasure *vs* usefulness (Chapter 3), in particular when related to elderly players. So one possible additional investigation is if this other perspective could also be addressed by pervasive games. Are players mainly driven by one of these two factor more motivated? Can pervasive games more effectively influence one of these aspects of even both at the same time, when compared to other strategies?

The developed system and experimental settings proposed in this research, or further variations of it, could be used to also study this issue. For instance, participants of the experiment could be classified into the 5 profiles [57] identified by De Schutter and Malliet, or just simply interrogated using questionnaires and/or semi-structured interviews about the main reasons

they (want to/accepted to) play (electronic) games, and the correlation between profiles and observed effect could be analyzed. The same evaluation could be naturally performed with other pervasive games and comparisons of the results could be made.

In a broader socio-cultural sense, a popular idea is engaging different generations for mutual benefit. Pervasive games are potentially engaging to people of all ages, but how is possible to create effective intergenerational games?

The results of this research could be applied in the investigation of this aspect as well. The findings about social context suggest a strong relevance of group incentives in the engagement process, as evidenced by the observed effect on the social interaction groups and subjective report from players. On the other hand, the comparison of experiments in Brazil and Japan led to the hypothesis that elements with strong cultural importance can be a significant aspect of player experience (such as temples and shrines in Japan). These two observations could be combined to propose a game variation in which players of different ages work together to build a narrative, taking different roles inside the game.

For instance, player age could be an element of the real world incorporated into the game that gives them comparative advantages and disadvantages that stimulate players of different ages to work together. In only one of infinitely possible examples, younger players could have a stronger ability to introduce variations into the narrative, while older players could have the ability to create new main story lines by sharing the knowledge and experience. Both types of players would then benefit by gaining points when they work together and enjoy a richer experience.

Overall, this doctoral thesis advances the idea that games, even serious games, should first be fun, and additional benefits come later as a natural consequence. By studying the potentially very engaging category of pervasive games, it opens up a new front of investigation that could lead to more fun and effective health interventions in the future.

A

Questionnaires for the Feasibility Study

A.1 Previous Experience with Technology

アンケート・Ａ１

端末ＩＤ			
性別	女 ・ 男	年齢	

1) あなたはスマートフォンまたはタブレット端末を使用しますか？「b) いいえ」を選択された方は、次の２への回答は不要です。

a) はい、使用します

b) いいえ、使用しません

2) スマートフォンまたはタブレット端末で行えることを全て選択してください。

☐ 電話をかける

☐ メール、ウェブブラウザを使用する

☐ ＳＮＳ（LINE、Facebook、Twitterなど）を使用する

☐ アプリをインストールして使用する

3) あなたはパソコンを使用しますか？「b) いいえ」を選択された方は、次の４と５への回答は不要です。

a) はい、使用します

b) いいえ、使用しません

4) パソコンで行えることを全て選択してください。

☐ メール、ウェブブラウザを使用する

☐ 写真を管理する

☐ ゲームをする

☐ Ｗｏｒｄ、パワーポイント、エクセルの作成や編集をする

5) あなたはパソコンをどのぐらい使用しますか？

a) 毎日

b) １週間に２～３回程度

c) １週間に１回程度

d) その他：＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

A.2 Previous Experience with Games

アンケート・Ａ２

1) あなたはゲームをしますか？ 最近（１ヶ月）したゲームをすべて選択してください。

（※電子ゲーム、ソーシャルゲームは別途項目を設けています。）

（※何も選択しなかった場合は、次の２への回答は不要です。）

☐ ボードゲーム（囲碁、将棋、麻雀、チェッカー、バックギャモンなど）

☐ カードゲーム（トランプ、かるた、花札など）

☐ パズル（数独、クロスワードなど）

☐ ギャンブル（パチンコ、競馬など）

☐ その他：＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

2) １のゲームをする頻度はどのぐらいですか？

（※最も頻度の高いゲームに関して回答してください）

a) 毎日

b) １週間に２～３回程度

c) １週間に１回程度

d) その他：＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

3）あなたは電子ゲーム（ニンテンドー３ＤＳ、Ｗｉｉ、パソコン、スマートフォン、タブレットなど）をしますか？ 最近（１ヶ月）したゲームをすべて選択してください。もしゲームのタイトルがわかれば、記入してください。

（※何も選択しなかった場合は、次の４～７への回答は不要です。）

☐ 学習ゲーム（脳トレ、漢字検定アプリ、英語学習アプリなど）

タイトル：＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

☐ パズルゲーム（数独、クロスワード、論理パズルなど）

タイトル：＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

☐ カードゲームやボードゲーム（ソリティア、ポーカー、囲碁、将棋、麻雀など）

タイトル：＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

☐ 運動ゲーム（Ｗｉｉ Ｆｉｔなど）

タイトル：＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

☐ スポーツゲーム（野球、サッカーなど）

タイトル：＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

☐ レースゲーム（マリオカートなど）

タイトル：＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

☐ アウトドアゲーム（ポケモンＧＯなど）

タイトル：＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

☐ アクションゲーム（マリオ、ドンキーコング、カービィなど）

タイトル：＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

☐ ロールプレイングゲーム（ドラゴンクエスト、ファイナルファンタジー、ポケモンなど）

タイトル：＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

☐ シミュレーションゲーム（シムシティなど）

タイトル：＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

☐ その他：

＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

4) ３のゲームをする頻度はどのぐらいですか？

（※最も頻度の高いゲームに関して回答してください。）

a) 毎日

b) １週間に２～３回程度

c) １週間に１回程度

d) その他：＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

5) ゲームする際にどの機器を使用しますか？ 機器の使用頻度順に ＿ に数字を入れてください。最も使用する機器を「１」としてください。使用しない機器は空欄のままにしてください。

＿ パソコン

＿ 携帯型ゲーム機（ニンテンドー３ＤＳ、ＰＳＰなど）

＿ ゲーム機（ニンテンドーSwitch、Ｗｉｉ、PlayStation、Ｘｂｏｘなど）

＿ スマートフォン

＿ タブレット

＿ その他：＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

6) 他の人と電子ゲームをすることはありますか？当てはまるものを全て選択してください。

☐ 孫と電子ゲームをします。

☐ 他の家族と電子ゲームをします。

☐ 友達と電子ゲームをします。

☐ 他人とオンラインゲームをします。

☐ 他人とソーシャルゲーム（ポケモンＧＯなど）をします。

☐ その他：＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

7) 電子ゲームの経験年数はどのぐらいですか？

a) １年以下

b) １～３年

c) ３～１０年

d) １０年以上

※ アンケートの終わり ※

A.3 Usability

アンケート・A４

今回のゲームのプレイ中にどのように感じたかお答えください。このアンケートは匿名ですので、安心して正直にお答えください。

1. 外出する際にスマートフォンを身に付けていた。 #D490
   - ☐ 全くなかった
   - ☐ 滅多になかった
   - ☐ 時々あった
   - ☐ よくあった
   - ☐ とても頻繁にあった
2. スマートフォンを忘れたことがあった。 #73D5
   - ☐ 全くなかった
   - ☐ 滅多になかった
   - ☐ 時々あった
   - ☐ よくあった
   - ☐ とても頻繁にあった
3. スマートフォンの基本的な操作ができるようになった（電源を入れる、画面のロックを解除する、ゲームを起動する、前の画面に戻る、ホーム画面に戻る）。 #4820
   - ☐ 全く同意できない
   - ☐ 同意できない
   - ☐ どちらともいえない
   - ☐ 同意できる
   - ☐ 非常に同意できる
4. 夜にスマートフォンを充電することを覚えていた。 #113C
   - ☐ 全くなかった
   - ☐ 滅多になかった
   - ☐ 時々あった
   - ☐ よくあった
   - ☐ とても頻繁にあった

5. スマートフォンの使い方について難しかったことや改善点があれば自由にお書き下さい。 #90B7

6. ゲームで目的を達成するためにどうすればよいか理解できた。 #E62B

☐ 全く同意できない
☐ 同意できない
☐ どちらともいえない
☐ 同意できる
☐ 非常に同意できる

7. ゲームで何をすべきかわからなかった。 #A2F2

☐ 全くなかった
☐ 滅多になかった
☐ 時々あった
☐ よくあった
☐ とても頻繁にあった

8. ゲームの見た目が好きだ。 #62BA

☐ 全く同意できない
☐ 同意できない
☐ どちらともいえない
☐ 同意できる
☐ 非常に同意できる

9. 操作に対する反応が悪かった。 #CBB9

☐ 全くなかった
☐ 滅多になかった
☐ 時々あった
☐ よくあった
☐ とても頻繁にあった

10. まだゲームのやり方がわからない。 #5FDD

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

11. ゲームのやり方を理解するためにマニュアルを見る必要があった。 #DA1B

- ☐ 全くなかった
- ☐ 滅多になかった
- ☐ 時々あった
- ☐ よくあった
- ☐ とても頻繁にあった

12. ゲームの見た目は、このゲームに合っていない。 #5FFC

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

13. ゲームの音楽が好きだ。 #7BDD

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

14. 次に何をすれば良いかわからなくなることがあった。 #5BE7

- ☐ 全くなかった
- ☐ 滅多になかった
- ☐ 時々あった
- ☐ よくあった
- ☐ とても頻繁にあった

15. ゲームのやり方は理解しやすかった。 #9C73

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

16. **ゲームの操作に自信がある。** #31B7

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

17. **ゲームの中で、したいことをどのようにすればできる**のかわからなかった。 #5873

- ☐ 全くなかった
- ☐ 滅多になかった
- ☐ 時々あった
- ☐ よくあった
- ☐ とても頻繁にあった

18. **ゲームのやり方に慣れた。** #B8A6

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

19. **画面上の情報はあまり意味が無かった。** #3140

- ☐ 全くなかった
- ☐ 滅多になかった
- ☐ 時々あった
- ☐ よくあった
- ☐ とても頻繁にあった

20. **思い通りにゲームできた。** #43BF

- ☐ 全くなかった
- ☐ 滅多になかった
- ☐ 時々あった
- ☐ よくあった
- ☐ とても頻繁にあった

21. **目的を達成するために必要となる情報は与えられていた。** #4DBF

- ☐ 全くなかった
- ☐ 滅多になかった
- ☐ 時々あった
- ☐ よくあった
- ☐ とても頻繁にあった

22. **ゲームのルールを理解した。** #E0BD

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

23. **ゲームの音楽が煩わしいと感じた。** #CC9A

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

24. **ゲームについて困ったことや改善点があれば自由にお書き下さい。** #DD04

25. **このゲームで良かった点があれば自由にお書き下さい。** #7978

A.4 Game Experience

アンケート・A５

今回のゲームのプレイ中にどのように感じたかお答えください。このアンケートは匿名ですので、安心して正直にお答えください。

1. ゲームをしている間、拘束されているように感じた。 #FB67
   - ☐ 全く同意できない
   - ☐ 同意できない
   - ☐ どちらともいえない
   - ☐ 同意できる
   - ☐ 非常に同意できる
2. 神社をゲームの題材にすることは不適切と感じた。 #7189
   - ☐ 全く同意できない
   - ☐ 同意できない
   - ☐ どちらともいえない
   - ☐ 同意できる
   - ☐ 非常に同意できる
3. やる気が出るのを感じた。 #00B3
   - ☐ 全く同意できない
   - ☐ 同意できない
   - ☐ どちらともいえない
   - ☐ 同意できる
   - ☐ 非常に同意できる
4. 神社をゲームの題材にすることに面白さを感じた。 #8B6D
   - ☐ 全く同意できない
   - ☐ 同意できない
   - ☐ どちらともいえない
   - ☐ 同意できる
   - ☐ 非常に同意できる
5. ゲームから何かを学んでいると感じた。 #F446
   - ☐ 全く同意できない
   - ☐ 同意できない
   - ☐ どちらともいえない
   - ☐ 同意できる
   - ☐ 非常に同意できる

6. **ゲームをすることに価値があると思った。** #09BF

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

7. **ゲームで求められていないことでも、自分自身で色々とチャレンジしようとした。** #8A68

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

8. **ゲームのプレイ中、時間を忘れていた。** #56AE

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

9. **何をすべきかわからず混乱した。** #E764

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

10. **ゲームをしなければ、もっと他に有用なことができたと感じた。** #D5FD

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

11. **簡単すぎた。** #A080

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

12. **後悔した。** #B79F

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

13. **時間の無駄であると感じた。** #69A1

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

14. **ゲームが印象的だとは感じなかった。** #E8BA

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

15. **ゲームの見た目は好ましくなかった。** #84EA

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

16. **想像力がかき立てられるのを感じた。** #8CFE

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

17. ゲームを楽しめた。 #685E

☐ 全く同意できない
☐ 同意できない
☐ どちらともいえない
☐ 同意できる
☐ 非常に同意できる

18. ゲーム中に何もしていない時間があった。 #B064

☐ 全く同意できない
☐ 同意できない
☐ どちらともいえない
☐ 同意できる
☐ 非常に同意できる

19. 難しいと感じた。 #C05B

☐ 全く同意できない
☐ 同意できない
☐ どちらともいえない
☐ 同意できる
☐ 非常に同意できる

20. 自分で独自のルールを設定して遊んだ。 #124D

☐ 全く同意できない
☐ 同意できない
☐ どちらともいえない
☐ 同意できる
☐ 非常に同意できる

21. 今回のゲームをもう一度やりたいと思わない。 #9672

☐ 全く同意できない
☐ 同意できない
☐ どちらともいえない
☐ 同意できる
☐ 非常に同意できる

22. 今回のゲームは独創的だと思う。 #088B

☐ 全く同意できない
☐ 同意できない
☐ どちらともいえない
☐ 同意できる
☐ 非常に同意できる

23. **ゲームは退屈だった。** #9AE6

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

24. **このような種類のゲームは好きではない。** #6176

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

25. **ゲームの見た目は好ましかった。** #F9BD

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

26. **ゲームの見た目がゲームの世界観に合っていた。** #AE41

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

27. **ゲームを進めていくにつれてやりたいという気持ちが強くなっていった。** #545C

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

28. **ゲームの見た目がゲームの世界観を表すには不適切だった。** #B6F6

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

29. **刺激を受けた。** #84F8

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

30. **アバター画像を自分の画像として簡単に設定できなかった。** #5167

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

31. **ゲームのプレイ中、周囲が気になってゲームに集中できなかった。** #0F6E

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

32. **ゲームをやめたときはいつでも、またすぐにゲームをはじめたいと思った。** #3D67

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

33. **上手にゲームができた。** #07D6

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

34. **やりがいがあると感じた。** #7D06

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

35. **ゲームにおいて可能な限り色々やりたいと思った。** #9EF8

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

36. **ゲーム内で色々と試すことができると感じた。** #5A1E

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

37. **不満を感じた。** #5DEB

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

38. **良い経験であると感じた。** #1747

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

39. **ゲームのアバター画像は好ましかった。** #9F92

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

40. **ゲームのプレイ中、ゲームに集中していた。** #A6D2

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

41. 時々、ゲームの存在を忘れていた。 #162F

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

42. 自由にできることが無かった。 #0A51

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

43. 面倒だと感じた。 #411D

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

44. ストレスを感じた。 #2C92

- ☐ 全く同意できない
- ☐ 同意できない
- ☐ どちらともいえない
- ☐ 同意できる
- ☐ 非常に同意できる

A.5 Social Presence

アンケート・A６

今回のゲームのプレイ中にどのように感じたかお答えください。このアンケートは匿名ですので、安心して正直にお答えください。

1. **他のユーザの気分に影響を与えた。** #38D8
   - ☐ 全くなかった
   - ☐ 滅多になかった
   - ☐ 時々あった
   - ☐ よくあった
   - ☐ とても頻繁にあった
2. **他のユーザの行動は自分の行動に依存していた。** #CCFD
   - ☐ 全くなかった
   - ☐ 滅多になかった
   - ☐ 時々あった
   - ☐ よくあった
   - ☐ とても頻繁にあった
3. **他のユーザと一緒にいるのが楽しいと感じた。** #E994
   - ☐ 全くなかった
   - ☐ 滅多になかった
   - ☐ 時々あった
   - ☐ よくあった
   - ☐ とても頻繁にあった
4. **復讐したい気持ちになった。** #E949
   - ☐ 全くなかった
   - ☐ 滅多になかった
   - ☐ 時々あった
   - ☐ よくあった
   - ☐ とても頻繁にあった
5. **他のユーザの気分から影響を受けた。** #9028
   - ☐ 全くなかった
   - ☐ 滅多になかった
   - ☐ 時々あった
   - ☐ よくあった
   - ☐ とても頻繁にあった

6. **自分の行動は他のユーザの行動に依存していた。** #7857
   - ☐ 全くなかった
   - ☐ 滅多になかった
   - ☐ 時々あった
   - ☐ よくあった
   - ☐ とても頻繁にあった

7. **自分が他のユーザに注意を払っていると感じた。** #14B9
   - ☐ 全くなかった
   - ☐ 滅多になかった
   - ☐ 時々あった
   - ☐ よくあった
   - ☐ とても頻繁にあった

8. **他のユーザに嫉妬を感じた。** #5ACF
   - ☐ 全くなかった
   - ☐ 滅多になかった
   - ☐ 時々あった
   - ☐ よくあった
   - ☐ とても頻繁にあった

9. **他のユーザの行動が自分の行動に影響を与えた。** #41FA
   - ☐ 全くなかった
   - ☐ 滅多になかった
   - ☐ 時々あった
   - ☐ よくあった
   - ☐ とても頻繁にあった

10. **自分が嬉しかったとき、他のユーザも嬉しいと思っていると感じた。** #4092
    - ☐ 全くなかった
    - ☐ 滅多になかった
    - ☐ 時々あった
    - ☐ よくあった
    - ☐ とても頻繁にあった

11. **他のユーザが自分の操作に注意を払っていると感じた。** #F295
    - ☐ 全くなかった
    - ☐ 滅多になかった
    - ☐ 時々あった
    - ☐ よくあった
    - ☐ とても頻繁にあった

12. **他のユーザと共感した。** #62D9

- ☐ 全くなかった
- ☐ 滅多になかった
- ☐ 時々あった
- ☐ よくあった
- ☐ とても頻繁にあった

13. **他のユーザを称賛した。** #775A

- ☐ 全くなかった
- ☐ 滅多になかった
- ☐ 時々あった
- ☐ よくあった
- ☐ とても頻繁にあった

14. **自分の行動が他のユーザの行動に影響を与えた。** #AD07

- ☐ 全くなかった
- ☐ 滅多になかった
- ☐ 時々あった
- ☐ よくあった
- ☐ とても頻繁にあった

15. **他のユーザとつながりがあると感じた。** #976A

- ☐ 全くなかった
- ☐ 滅多になかった
- ☐ 時々あった
- ☐ よくあった
- ☐ とても頻繁にあった

16. **他のユーザが失敗したときに嬉しい気持ちになった。** #2A27

- ☐ 全くなかった
- ☐ 滅多になかった
- ☐ 時々あった
- ☐ よくあった
- ☐ とても頻繁にあった

17. **他のユーザが嬉しいと思っていると感じたとき、自分も嬉しかった。** #3B75

- ☐ 全くなかった
- ☐ 滅多になかった
- ☐ 時々あった
- ☐ よくあった
- ☐ とても頻繁にあった

B

Questionnaires for the Trials in Brazil

B.1 Previous Experience with Technology and Games

QUESTIONÁRIO I

Usuário: (deixar em branco)	
Idade:	Sexo: ☐ F ☐ M

1. Qual a sua experiência com smartphones (celulares que rodam aplicativos)? Marque todas as opções que se aplicarem:
   - ☐ nunca usei *smartphone* antes
   - ☐ consigo fazer ligações
   - ☐ consigo ver meu e-mail
   - ☐ consigo navegar na internet
   - ☐ consigo usar redes sociais (WhatsApp, Facebook, etc...)
   - ☐ consigo instalar aplicativos
2. Com que frequência você usa o computador?
   - ☐ nunca usei o computador
   - ☐ uso até uma vez por semana
   - ☐ uso mais de uma vez por semana, mas não todo dia
   - ☐ uso diariamente
3. Qual a sua experiência com computadores? Marque todas as opções que se aplicarem:
   - ☐ consigo ver meu e-mail
   - ☐ consigo fazer pesquisas
   - ☐ consigo ler notícias
   - ☐ consigo usar redes sociais (WhatsApp, Facebook, etc...)
   - ☐ consigo instalar programas

4. Você joga algum jogo não eletrônico ou passatempo (xadrez, damas, gamão, jogos de cartas, jogos de tabuleiro, quebra-cabeças, palavras cruzadas, etc...)? Em caso positivo, por favor escreva abaixo o(s) nome(s) do(s) jogo(s); em caso negativo, deixe em branco.

5. Você joga algum jogo eletrônico, por exemplo, no celular, videogame ou computador? Em caso positivo, por favor escreva abaixo o(s) nome(s) do(s) jogo(s); **em caso negativo, deixe em branco e ignore o restante deste questionário.**

6. Com que frequência você joga (considerando todos os jogos listados)?
   - ☐ jogo muito raramente
   - ☐ jogo até uma vez por semana
   - ☐ jogo mais de uma vez por semana, mas não todo dia
   - ☐ jogo diariamente

7. Quando você joga, quais dos dispositivos a seguir você utiliza? Preencha os espaços com o seguinte código: 1 – *nunca utilizei;* 2 – *utilizo raramente;* 3 – *utilizo frequentemente.*

   _ computador

   _ *smartphone*

   _ videogame portátil (3DS, PSP, etc...)

   _ videogame convencional (Xbox, PlayStation, etc...)

8. Você costuma jogar com outras pessoas? Marque todas as opções que se aplicarem:

   ☐ jogo apenas sozinho

   ☐ jogo com meus amigos

   ☐ jogo com familiares adultos (irmãos, filhos, etc...)

   ☐ jogo com familiares jovens e crianças (netos, sobrinhos, etc...)

   ☐ jogo com desconhecidos na internet

B.2 Usability and Game Experience

QUESTIONÁRIO II

Usuário:
(conta do google usada no jogo)

Em cada uma das perguntas abaixo, por favor, circule a opção que melhor indica como você se sentiu sobre o jogo, de acordo com a seguinte escala:

0	1	2	3	4
nem um pouco	levemente	moderadamente	bastante	extremamente

1. **Eu me diverti**

   nem um pouco - 0 | 1 | 2 | 3 | 4 - extremamente

2. **Eu achei o jogo cansativo**

   nem um pouco - 0 | 1 | 2 | 3 | 4 - extremamente

3. **Eu achei o jogo difícil**

   nem um pouco - 0 | 1 | 2 | 3 | 4 - extremamente

4. **Eu achei o jogo esteticamente agradável**

   nem um pouco - 0 | 1 | 2 | 3 | 4 - extremamente

5. **Eu me senti entediado(a)**

   nem um pouco - 0 | 1 | 2 | 3 | 4 - extremamente

6. **Eu senti que poderia explorar meus arredores**

   nem um pouco - 0 | 1 | 2 | 3 | 4 - extremamente

7. **Eu me senti irritado(a)**

   nem um pouco - 0 | 1 | 2 | 3 | 4 - extremamente

8. Eu me senti distraído(a)

nem um pouco - 0 | 1 | 2 | 3 | 4 - extremamente

9. Eu me senti estimulado(a)

nem um pouco - 0 | 1 | 2 | 3 | 4 - extremamente

10. Eu me senti desafiado(a)

nem um pouco - 0 | 1 | 2 | 3 | 4 - extremamente

11. Eu me senti frustrado(a)

nem um pouco - 0 | 1 | 2 | 3 | 4 - extremamente

12. Eu senti que jogar foi uma experiência rica

nem um pouco - 0 | 1 | 2 | 3 | 4 - extremamente

13. Eu tive que me esforçar bastante

nem um pouco - 0 | 1 | 2 | 3 | 4 - extremamente

14. Eu acho que gostaria de jogar esse jogo com frequência

nem um pouco - 0 | 1 | 2 | 3 | 4 - extremamente

15. Eu achei o jogo mais complexo do que o necessário

nem um pouco - 0 | 1 | 2 | 3 | 4 - extremamente

16. Eu achei o jogo fácil de usar

nem um pouco - 0 | 1 | 2 | 3 | 4 - extremamente

17. Eu achei que esse jogo tinha muitas inconsistências

nem um pouco - 0 | 1 | 2 | 3 | 4 - extremamente

18. Eu acho que a maioria das pessoas aprenderia rapidamente a jogar

nem um pouco - 0 | 1 | 2 | 3 | 4 - extremamente

19. Eu achei o jogo muito complicado de usar

nem um pouco - 0 | 1 | 2 | 3 | 4 - extremamente

20. Eu me senti muito confiante ao usar o jogo

nem um pouco - 0 | 1 | 2 | 3 | 4 - extremamente

21. Eu senti empatia pelos outros jogadores

nem um pouco - 0 | 1 | 2 | 3 | 4 - extremamente

22. Eu me senti conectado aos outros jogadores

nem um pouco - 0 | 1 | 2 | 3 | 4 - extremamente

23. Eu senti que minhas ações afetavam outros jogadores

nem um pouco - 0 | 1 | 2 | 3 | 4 - extremamente

24. Eu senti que as ações de outros jogadores me afetavam

nem um pouco - 0 | 1 | 2 | 3 | 4 - extremamente

Você tem algum comentário, crítica ou sugestão sobre o jogo?

C

Questionnaires for the Trials in Japan

C.1 Previous Experience with Technology and Games

アンケート：技術とゲーム経験

Google アカウント： ※ゲームで使用する Google アカウント（メールアドレス）を入れてください	
年齢：	性別：　　男　　女

1. スマートフォンで行うことをすべて選択してください。
   - □　電話をかける
   - □　メールを使用する
   - □　ウェブブラウザを使用する
   - □　ＳＮＳ（LINE、Facebook、Twitter、Instagram など）を使用する
   - □　アプリをインストールして使用する

2. あなたはパソコンをどのぐらい使用しますか？
   - □　使用しない
   - □　１週間に１回程度
   - □　毎日ではないが、１週間に２回以上
   - □　毎日

3. パソコンで行うことをすべて選択してください。
   - □　メールを使用する
   - □　ウェブブラウザを使用する
   - □　ウェブ検索をする
   - □　ニュースを読む
   - □　ＳＮＳ（LINE、Facebook、Twitter、Instagram など）を使用する
   - □　写真を管理する
   - □　Ｗｏｒｄ、パワーポイント、エクセルの作成や編集をする

4. あなたは非電子ゲーム（囲碁、将棋、トランプ、パズルなど）をしますか？
   最近（3 ヶ月）したゲームを書いてください。
   （※電子ゲーム、ソーシャルゲームは別途項目を設けています。）
   （※ゲームのタイトルを忘れた場合は、ゲームの内容を簡単に説明してください。）
   （※何も書かなかった場合は、次の 5 への回答は不要です。）

5. 非電子ゲームをどのぐらいしますか？
   □　めったにしない
   □　１週間に１回程度
   □　毎日ではないが、１週間に２回以上
   □　毎日

6. あなたは電子ゲーム（ニンテンドー３ＤＳ、Ｗｉｉ、パソコン、スマートフォン、タブレットなど）をしますか？最近（3 ヶ月）したゲームを書いてください。
   （※ゲームのタイトルを忘れた場合は、ゲームの内容を簡単に説明してください。）
   （※何も書かなかった場合は、次の 7～9 への回答は不要です。）

7. 電子ゲームをどのぐらいしますか？
   □　めったにしない
   □　１週間に１回程度
   □　毎日ではないが、１週間に２回以上
   □　毎日

8. 電子ゲームする際にどの機器を使用しますか？

パソコン	しない	時々	よく
携帯型ゲーム機 （ニンテンドー３ＤＳ、ＰＳＰなど）	しない	時々	よく
ゲーム機 （ニンテンドーWii、PlayStation など）	しない	時々	よく
スマートフォン、タブレット	しない	時々	よく
その他：	しない	時々	よく

9. 他の人と電子ゲームをすることはありますか？当てはまるものを全て選択してください。

□ 家族（子供）と電子ゲームをする
□ 家族（大人）と電子ゲームをする
□ 友達と電子ゲームをする
□ 他人とオンラインゲームをする

□ その他：_____

C.2 Usability and Game Experience

アンケート：ゲーム体験

Google アカウント： ※ゲームで使用する Google アカウント（メールアドレス）を入れてください

1. ゲームをしている際に、それぞれの質問についてどのように感じたか、以下の数値で示してください。

0	1	2	3	4
少しも 感じなかった	少し 感じた	そこそこ 感じた	とても 感じた	非常に強く 感じた

少し違和感のある質問や似た質問もありますが、全ての質問に答えていただくようお願いします。

a. 嬉しかった

0	1	2	3	4

b. 自分がゲームをするのが上手だと感じた

0	1	2	3	4

c. ゲームの題材（神社）は面白かった

0	1	2	3	4

d. 笑うことができた

0	1	2	3	4

e. 夢中になった

0	1	2	3	4

f. 喜んだ

0	1	2	3	4

g. 緊張した

0	1	2	3	4

h. ゲームから何かを学んでいると感じた

0	1	2	3	4

i. 落ち着かなくなった

0	1	2	3	4

j. 他のことについて考えていた

0	1	2	3	4

k. ゲームが面倒だった

0	1	2	3	4

l. ゲームが難しいと感じた

0	1	2	3	4

m. ゲームが芸術的で美しいと感じた

0	1	2	3	4

n. 自分の周りのすべてを忘れた

0	1	2	3	4

o. 気持ちが良かった

0	1	2	3	4

p. 上手にゲームができた

0	1	2	3	4

q. 退屈した

0	1	2	3	4

r. 成功したと感じた

0	1	2	3	4

s. 自分の想像力が豊かに感じた

0	1	2	3	4

t. 物事を探検できると感じた

0	1	2	3	4

u. 楽しんだ

0	1	2	3	4

v. ゲームの目標を達成するのが早かった

0	1	2	3	4

w. いらいらした

0	1	2	3	4

x. 気が散った

0	1	2	3	4

y. 刺激を受けた

0	1	2	3	4

z. 気が立った

0	1	2	3	4

aa.時間を見失った

0	1	2	3	4

bb. ゲームはチャレンジングだった

0	1	2	3	4

cc.ゲームは不可能に感じた

0	1	2	3	4

dd. ゲームに深く集中していた

0	1	2	3	4

ee.欲求不満を感じた

0	1	2	3	4

ff. 豊富な経験をしているように感じた

0	1	2	3	4

gg.外界とのつながりを失ったと感じた

0	1	2	3	4

hh. ゲームの題材に飽きたと感じた

0	1	2	3	4

ii. とても努力しなければならなかった

0	1	2	3	4

jj. 自分が有能だと感じた

0	1	2	3	4

kk.他のプレイヤーと共感した

0	1	2	3	4

ll. 私の行動が他のプレイヤーの行動に依存していると感じた

0	1	2	3	4

mm. 他のプレイヤーの行動が私の行動に依存していると感じた

0	1	2	3	4

nn. 他のプレイヤーとつながりを感じた

0	1	2	3	4

oo.他のプレイヤーが私に対して細心の注意を払っていると感じた

0	1	2	3	4

pp. 他のプレイヤーに細心の注意を払っていると感じた

0	1	2	3	4

qq. 他のプレイヤーに対して嫉妬を感じた

0	1	2	3	4

rr. 他のプレイヤーとゲームをすることが楽しいと感じた

0	1	2	3	4

ss.私が幸せな時は他のプレイヤーも幸せであると感じた。

0	1	2	3	4

tt. 他のプレイヤーが幸せな時は私も幸せであると感じた。

0	1	2	3	4

uu. 私は他のプレイヤーの気分に影響を与えていると感じた。

0	1	2	3	4

vv.私は他のプレイヤーの気分に影響を受けていると感じた。

0	1	2	3	4

ww. 私は他のプレイヤーのことが羨ましいと感じた。

0	1	2	3	4

xx.他のプレイヤーが私のすることに影響を及ぼしていると感じた

0	1	2	3	4

yy. 私がしたことが他のプレイヤーがすることに影響を及ぼしていると感じた

0	1	2	3	4

zz. 私は他のプレイヤーに対してやり返したいと感じた

0	1	2	3	4

aaa. 私は他のプレイヤーの失敗に対して嬉しいと感じた

0	1	2	3	4

2. ゲームをしている際に、それぞれの質問についてどのように思ったか、以下の数値で示してください。

0	1	2	3	4
全く同意できない	同意できない	どちらともいえない	同意できる	非常に同意できる

a. このゲームをしばしば使いたいと思った

0	1	2	3	4

b. このゲームは不必要に複雑であると思った

0	1	2	3	4

c. このゲームは簡単に使えると思った

0	1	2	3	4

d. このゲームを使うのに専門家による技術的なサポートが必要だと思った

0	1	2	3	4

e. このゲームにあるさまざまな機能はよくまとまっていると思った

0	1	2	3	4

f. このゲームでは一貫性のないところが多くあると思った

0	1	2	3	4

g. ほとんどのプレイヤーはこのゲームのやり方をすぐに理解できると思った

0	1	2	3	4

h. このゲームはとても扱いにくいと思った

0	1	2	3	4

i. 信を持ってこのゲームを使えていると思った

0	1	2	3	4

j. このゲームを使い始める前に多くのことを理解する必要があった

0	1	2	3	4

3. 外出する際にスマートフォンをどのくらい持ち歩きましたか？

a. 毎回、持ち歩いた

b. よく、持ち歩いた

c. 時々、持ち歩いた

d. ほとんど、持ち歩かなかった

e. 全く、持ち歩かなかった

4. ゲームについてのコメントや提案がある場合は、自由に書いてください。

References

[1] *Result of Population Estimates*. Statistics Bureau of Japan. 2019. URL: http://www.stat.go.jp/english/data/jinsui/2.html (visited on 06/2019).

[2] *The Wisdom of Years*. United Nations University. 2014. URL: https://web.archive.org/web/20161216145658/http://wisdom.unu.edu/en/ageing-societies (visited on 06/2019).

[3] *World will have 13 'super-aged' nations by 2020*. Financial Times. 2014. URL: https://www.ft.com/content/f356f8a0-1d8c-11e4-8f0c-00144feabdc0 (visited on 06/2019).

[4] United Nations. *World Population Ageing*. Tech. rep. United Nations, Department of Economic and Social Affairs, Population Division, 2017.

[5] Rp Hagemann and Giuseppe Nicoletti. "Population Ageing: Economic Effects and Some Policy Implications for Financing Public Pensions". In: *OECD Economic Studies* (1989).

[6] Atsushi Hiyama, Masatomo Kobayashi, Hironobu Takagi, and Michitaka Hirose. "Mosaic: collaborative ways for older adults to use their expertise through information technologies". In: *ACM SIGACCESS Accessibility and Computing* 110 (Sept. 2014), pp. 26–33. ISSN: 15582337.

[7] S. H. Chang and M. S. Yang. "The relationships between the elderly loneliness and its factors of personal attributes, perceived health status and social support". In: *Kaohsiung J Med Sci* 15.6 (June 1999), pp. 337–47. ISSN: 1607-551X (PRINT) 1607-551X (LINKING).

[8] Johan Huizinga. *Homo Ludens: A Study of Play-element in Culture*. Beacon Press, 1971. ISBN: 9780807046814.

[9] Chris M Bleakley, Darryl Charles, Alison Porter-Armstrong, Michael D J McNeill, Suzanne M McDonough, and Brendan McCormack. "Gaming for health: a systematic review of the physical and cognitive effects of interactive computer games in older adults". In: *Journal of Applied Gerontology* 34.3 (Apr. 2015), NP166–NP189. ISSN: 0733-4648.

[10] Tarja Susi, Mikael Johannesson, and Per Backlund. *Serious Games - An Overview*. Tech. rep. University of Skövde, Sweden, 2007.

[11] Fabricio N Buzeto, Ana H O R Castillo, Carla D Castanho, and Ricardo P Jacobi. "What is going on with ubicomp games". In: *Brazilian Symposium on Games and Digital Entertainment*. Universidade de Brasília. Brasília, DF, Brazil: SBC, 2012, pp. 1–7.

[12] Labs Niantic. *Pokemon GO*. 2016.

[13] Richard M. Ryan and Edward L. Deci. "Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions". In: *Contemporary Educational Psychology* 25.1 (Jan. 2000), pp. 54–67. ISSN: 0361476X.

[14] Gislaine C Vagetti, Valter C. Barbosa Filho, Natália B. Moreira, Valdomiro de Oliveira, Oldemar Mazzardo, and Wagner de Campos. "Association between physical activity and quality of life in the elderly: a systematic review, 2000-2012". In: *Revista Brasileira de Psiquiatria* 36.1 (Jan. 2014), pp. 76–88. ISSN: 1809-452X.

[15] Joe Tomaka, Sharon Thompson, and Rebecca Palacios. "The Relation of Social Isolation, Loneliness, and Social Support to Disease Outcomes Among the Elderly". In: *Journal of Aging and Health* 18.3 (June 2006), pp. 359–384. ISSN: 0898-2643.

[16] Alvin Chesham, Patric Wyss, René Martin Müri, Urs Peter Mosimann, and Tobias Nef. "What Older People Like to Play: Genre Preferences and Acceptance of Casual Games." In: *JMIR serious games* 5.2 (Apr. 2017), e8. ISSN: 2291-9279.

[17] Jane McGonigal. *Reality is Broken: Why Games Make Us Better and How They Can Change the World*. Penguin Group, The, 2011, p. 402. ISBN: 9781101475492.

[18] Mark Weiser. "The computer for the 21st century". In: *Scientific american* 3.3 (1991), pp. 66–75.

[19] Mark Weiser and JS John Seely Brown. "Designing Calm Technology". In: *POWERGRID JOURNAL* 1 (1996), pp. 1–5.

[20] Jeanne Nakamura and Mihaly Csikszentmihalyi. “The Concept of Flow”. In: *Flow and the Foundations of Positive Psychology*. Dordrecht: Springer Netherlands, 2014, pp. 239–263.

[21] Vlasios Kasapakis and Damianos Gavalas. “Pervasive gaming: Status, trends and design principles”. In: *Journal of Network and Computer Applications* 55 (Sept. 2015), pp. 213–236. ISSN: 10848045.

[22] Markus Montola. “Exploring the edge of the magic circle: Defining pervasive games”. In: *Proceedings of DAC* 1966 (2005), pp. 16–19.

[23] *Pokémon GO*. Niantic Labs. 2016. URL: https://play.google.com/store/apps/details?id=com.nianticlabs.pokemongo (visited on 06/2019).

[24] *Zombies, Run!* Six to Start and Naomi Alderman. 2016. URL: https://zombiesrungame.com (visited on 06/2019).

[25] Jesse Schell. *The Art of Game Design: A Book of Lenses*. 2nd. Natick, MA, USA: A. K. Peters, Ltd., 2014. ISBN: 1466598646, 9781466598645.

[26] Herbert A. Simon. *The Sciences of the Artificial*. 1st. Vol. 1. Cambridge, MA, USA: MIT Press, 1969, p. 123. ISBN: 0262691914. arXiv: 0262191938.

[27] R M Ryan and E L Deci. *Self-Determination Theory: Basic Psychological Needs in Motivation, Development, and Wellness*. The Guilford Press, 2018. ISBN: 9781462538966.

[28] Staffan Björk, Jussi Holopainen, Peter Ljungstrand, and Karl Petter Åkesson. “Designing ubiquitous computing games - A report from a workshop exploring ubiquitous computing entertainment”. In: *Personal and Ubiquitous Computing*. Vol. 6. 5-6. London, UK, UK: Springer-Verlag, Dec. 2002, pp. 443–458.

[29] Lucio Gutierrez, Eleni Stroulia, and Ioanis Nikolaidis. “fAARS: A Platform for Location-Aware Trans-reality Games”. In: *Proceedings of the 11th International Conference on Entertainment Computing*. ICEC’12. Berlin, Heidelberg: Springer-Verlag, 2012, pp. 185–192.

[30] Elizabeth M. Bonsignore, Derek L. Hansen, Zachary O. Toups, Lennart E. Nacke, Anastasia Salter, and Wayne Lutters. “Mixed reality games”. In: *Proceedings of the ACM 2012 conference on Computer Supported Cooperative Work Companion - CSCW ’12*. New York, New York, USA: ACM Press, 2012, p. 7. ISBN: 9781450310512.

[31] K Koskinen and R Suomela. "Rapid prototyping of context-aware games". In: *2nd IET International Conference on Intelligent Environments (IE 06)*. Vol. 2006. IEE, 2006, pp. 1–135. ISBN: 0 86341 663 2.

[32] Jan-Peter Tutzschke and Olaf Zukunft. "FRAP: a framework for pervasive games". In: *Proceedings of the 1st ACM SIGCHI symposium on Engineering interactive computing systems - EICS '09*. New York, New York, USA: ACM Press, 2009, p. 133. ISBN: 9781605586007.

[33] Hong Guo, Hallvard Trætte, Alf Inge Wang, and Meng Zhu. "TeMPS: A Conceptual Framework for Pervasive and Social Games". In: *2010 Third IEEE International Conference on Digital Game and Intelligent Toy Enhanced Learning* (Apr. 2010), pp. 31–37.

[34] Jane Evelyn McGonigal. "This Might Be a Game: Ubiquitous Play and Performance at the Turn of the Twenty-First Century". PhD thesis. Berkeley, CA, USA: University of California, Berkeley, 2006.

[35] Luis Valente, Bruno Feijó, and Julio Cesar Sampaio do Prado Leite. "Features and Checklists to Assist in Pervasive Mobile Game Development". In: *XII Brazilian Symposium on Games and Digital Entertainment*. 2013, pp. 90–99.

[36] Fabricio Nogueira Buzeto, Tiago Barros Pontes e Silva, Carla Denise Castanho, and Ricardo Pezzuol Jacobi. "Reconfigurable Games: Games that Change with the Environment". In: *Brazilian Symposium on Computer Games and Digital Entertainment*. IEEE, Nov. 2014, pp. 61–70. ISBN: 978-1-4799-8065-9.

[37] *Battlefield 4*. EA Games. 2013. URL: https://www.battlefield.com/games/battlefield-4 (visited on 06/2019).

[38] *Forza Horizon*. Xbox Game Studios. 2012. URL: https://forzamotorsport.net/en-us/games/FH/Features (visited on 06/2019).

[39] *Dead Rising 3*. Microsoft Studios and Capcom. 2016. URL: https://web.archive.org/web/20130908232007/http://www.xbox.com/en-US/xbox-one/games/dead-rising-3/ (visited on 06/2019).

[40] Clark C Abt. *Serious games*. University press of America, 1987.

[41] David R Michael and Sandra L Chen. *Serious Games: Games That Educate, Train, and Inform*. Muska & Lipman/Premier-Trade, 2005. ISBN: 1592006221.

[42] U Ritterfeld, M Cody, and P Vorderer. *Serious Games: Mechanisms and Effects*. Taylor & Francis, 2009. ISBN: 9781135848910.

[43] Tom Baranowski, Richard Buday, Debbe I. Thompson, and Janice Baranowski. "Playing for real: video games and stories for health-related behavior change." In: *American journal of preventive medicine* 34.1 (Jan. 2008), pp. 74–82. ISSN: 0749-3797.

[44] Paula Rego, PM Moreira, and LP Reis. "Serious games for rehabilitation: A survey and a classification towards a taxonomy". In: *Information Systems and ...* (2010).

[45] Hiroki Kayama, Kazuya Okamoto, Shu Nishiguchi, Minoru Yamada, Tomohiro Kuroda, and Tomoki Aoyama. "Effect of a Kinect-Based Exercise Game on Improving Executive Cognitive Performance in Community-Dwelling Elderly: Case Control Study". In: *Journal of Medical Internet Research* 16.2 (Feb. 2014), e61. ISSN: 14388871.

[46] Jaime A Garcia Marin, Karla Felix Navarro, and Elaine Lawrence. "Serious Games to Improve the Physical Health of the Elderly : A Categorization Scheme". In: *International Conference on Advances in Human-oriented and Personalized Mechanisms, Technologies, and Services*. 4th. IARIA, 2011, pp. 64–71. ISBN: 9781612081670.

[47] Simone Hausknecht, Robyn Schell, Fan Zhang, and David Kaufman. "Building Seniors' Social Connections and Reducing Loneliness Through a Digital Game". In: *Proceedings of the 1st International Conference on Information and Communication Technologies for Ageing Well and e-Health*. SCITEPRESS - Science, 2015, pp. 276–284. ISBN: 978-989-758-102-1.

[48] Shulamith Weisman. "Computer Games for the Frail Elderly". In: *The Gerontologist* 23.4 (Aug. 1983), pp. 361–363. ISSN: 0016-9013.

[49] Wijnand Ijsselsteijn, Henk Herman Nap, Yvonne de Kort, and Karolien Poels. "Digital game design for elderly users". In: *Proceedings of the 2007 conference on Future Play - Future Play '07*. Future Play '07. New York, New York, USA: ACM Press, 2007, p. 17. ISBN: 9781595939432.

[50] Kenta Ogomori, Mitsuo Nagamachi, Keiko Ishihara, Shigekazu Ishihara, and Masahiko Kohchi. "Requirements for a Cognitive Training Game for Elderly or Disabled People". In: *2011 International Conference on Biometrics and Kansei Engineering*. IEEE, Sept. 2011, pp. 150–154. ISBN: 978-1-4577-1356-9.

[51] Yvonne Barnard, Mike D. Bradley, Frances Hodgson, and Ashley D. Lloyd. "Learning to use new technologies by older adults: Perceived difficulties, experimentation behaviour and usability". In: *Computers in Human Behavior* 29.4 (July 2013), pp. 1715–1724. ISSN: 07475632.

[52] Wendy A Rogers and Arthur D Fisk. "Human factors, applied cognition, and aging." In: *The handbook of aging and cognition, 2nd ed.* Mahwah, NJ, US: Lawrence Erlbaum Associates Publishers, 2000, pp. 559–591. ISBN: 0-8058-2966-0 (Hardcover).

[53] Rusel DeMaria and Johnny L Wilson. *High score! : the illustrated history of electronic games*. Vol. 1. McGraw-Hill/Osborne Berkeley, CA, 2002, p. 328. ISBN: 0072224282.

[54] Bob De Schutter and Vero Vanden Abeele. "Towards a Gerontoludic Manifesto". In: *Anthropology & Aging* 36.2 (Nov. 2015), pp. 112–120. ISSN: 2374-2267.

[55] Bob De Schutter and Vero Vanden Abeele. "Designing meaningful play within the psycho-social context of older adults". In: *Proceedings of the 3rd International Conference on Fun and Games - Fun and Games '10*. September. New York, New York, USA: ACM Press, 2010, pp. 84–93. ISBN: 9781605589077.

[56] Lisbeth H. Larsen, Lone Schou, Henrik Hautop Lund, and Henning Langberg. "The Physical Effect of Exergames in Healthy Elderly—A Systematic Review". In: *Games for Health Journal* 2.4 (Aug. 2013), pp. 205–212. ISSN: 2161-783X.

[57] Bob De Schutter and Steven Malliet. "The older player of digital games: A classification based on perceived need satisfaction". In: *Communications* 39.1 (Jan. 2014), pp. 67–88. ISSN: 1613-4087.

[58] *Brain Age*. Nintendo. 2005. URL: https://brainage.nintendo.com (visited on 06/2019).

[59] Eugène Loos. "Designing meaningful intergenerational digital games". In: *International Conference on Communication, Media, Technology and Design*. Vol. 30. April. 2014, pp. 46–51.

[60] Eng Tat Khoo, Tim Merritt, Adrian Cheok, Mervyn Lian, and Kelvin Yeo. "Age Invaders : User Studies of Intergenerational Computer Entertainment". In: *Entertainment Computing-ICEC 2007* 4740 (2007), pp. 231–242. ISSN: 0302-9743.

[61] Patrick B Mullen. *Listening to old voices: Folklore, life stories, and the elderly*. University of Illinois Press, 1992.

[62] Masato Nakayama, Atsushi Hiyama, Takahiro Miura, Naomi Yatomi, and Michitaka Hirose. "Mosaic-type work support system using touchscreen computers for senior people". In: *Proceedings of the 2013 conference on Computer supported cooperative work companion - CSCW '13*. CSCW '13. New York, New York, USA: ACM Press, 2013, p. 235. ISBN: 9781450313322.

[63] Bob De Schutter. "Never Too Old to Play: The Appeal of Digital Games to an Older Audience". In: *Games and Culture* 6.2 (Mar. 2011), pp. 155–170. ISSN: 1555-4120.

[64] Kathrin Gerling, Bob De Schutter, Julie Brown, and Jason Allaire. "Ageing Playfully: Advancing Research on Games for Older Adults Beyond Accessibility and Health Benefits". In: *Proceedings of the 2015 Annual Symposium on Computer-Human Interaction in Play - CHI PLAY '15*. CHI PLAY '15. New York, New York, USA: ACM Press, 2015, pp. 817–820. ISBN: 9781450334662.

[65] Roberta Nogueira Sales De Carvalho and Lucila Ishitani. "Motivational Factors for Mobile Serious Games for Elderly Users". In: *Brazilian Symposium on Games and Digital Entertainment*. Universidade de Brasília. Brasília, DF, Brazil: SBC, 2012, pp. 19–28.

[66] Túlio Teixeira Cota, Lucila Ishitani, and Niltom Vieira. "Mobile game design for the elderly: A study with focus on the motivation to play". In: *Computers in Human Behavior* 51 (Oct. 2015), pp. 96–105. ISSN: 07475632.

[67] D. Kaufman, L. Sauve, L. Renaud, A. Sixsmith, and B. Mortenson. "Older Adults Digital Gameplay: Patterns, Benefits, and Challenges". In: *Simulation & Gaming* 47.4 (Aug. 2016), pp. 465–489. ISSN: 1046-8781.

[68] Wytske Meekes and Emma Kate Stanmore. "Motivational Determinants of Exergame Participation for Older People in Assisted Living Facilities: Mixed-Methods Study". In: *Journal of Medical Internet Research* 19.7 (July 2017), e238. ISSN: 1438-8871.

[69] Ellen Brox, Stathis Th Konstantinidis, and Gunn Evertsen. "User-Centered Design of Serious Games for Older Adults Following 3 Years of Experience With Exergames for Seniors: A Study Design". In: *JMIR Serious Games* 5.1 (Jan. 2017), e2. ISSN: 2291-9279.

[70] E. Katz, J.G. Blumler, and M. Gurevitch. *The uses of mass communication:Current Perspectives on Gratifications Research*. 1974, pp. 19–32. ISBN: 0803903405.

[71] Stanley Colcombe and Arthur F. Kramer. "Fitness Effects on the Cognitive Function of Older Adults". In: *Psychological Science* 14.2 (Mar. 2003), pp. 125–130. ISSN: 0956-7976.

[72] Gary R. Lee and Masako Ishii-Kuntz. "Social Interaction, Loneliness, and Emotional Well-Being among the Elderly". In: *Research on Aging* 9.4 (Dec. 1987), pp. 459–482. ISSN: 0164-0275.

[73] Luciano Gamberini, Francesco Martino, Bruno Seraglia, Anna Spagnolli, Malena Fabregat, Francisco Ibanez, Mariano Alcaniz, and Javier Montesa Andres. "Eldergames project: An innovative mixed reality table-top solution to preserve cognitive functions in elderly people". In: *Conference on Human System Interactions*. IEEE, May 2009, pp. 164–169. ISBN: 978-1-4244-3959-1.

[74] Ellen Brox, Luis Fernandez-Luque, Gunn Evertsen, and Juan González-Hernández. "Exergames For Elderly: Social exergames to persuade seniors to increase physical activity". In: *Proceedings of the 5th International ICST Conference on Pervasive Computing Technologies for Healthcare*. January. IEEE, 2011, pp. 546–549. ISBN: 978-1-936968-15-2.

[75] Lorna Paul, Stephen Brewster, Sally Wyke, Angus K McFadyen, Naveed Sattar, Jason Mr Gill, Aleksandra Dybus, and Cindy M Gray. "Increasing physical activity in older adults using STARFISH, an interactive smartphone application (app); a pilot study". In: *Journal of Rehabilitation and Assistive Technologies Engineering* 4 (Jan. 2017). ISSN: 2055-6683.

[76] Oriol Marquet, Claudia Alberico, Deepti Adlakha, and J Aaron Hipp. "Examining Motivations to Play Pokémon GO and Their Influence on Perceived Outcomes and Physical Activity". In: *JMIR Serious Games* 5.4 (Oct. 2017), e21. ISSN: 2291-9279.

[77] Tim Althoff, Ryen W White, and Eric Horvitz. "Influence of Pokémon Go on Physical Activity: Study and Implications". In: *Journal of Medical Internet Research* 18.12 (Dec. 2016), e315. ISSN: 1438-8871.

[78] Kimihiro Hino, Yasushi Asami, and Jung Su Lee. "Step Counts of Middle-Aged and Elderly Adults for 10 Months Before and After the Release of Pokémon GO in Yokohama, Japan". In: *Journal of Medical Internet Research* 21.2 (Feb. 2019), e10724. ISSN: 1438-8871.

[79] Richard Buchanan. "Wicked Problems Thinking in Design". In: *Design Issues* 8.2 (1992), pp. 5–21.

[80] David H Jonassen. "Instructional Design as Design Problem Solving: An Iterative Process". In: *Educational Technology* 48.3 (2008), pp. 21–26. ISSN: 00131962.

[81] *Moves App*. ProtoGeo. 2012. URL: https://web.archive.org/web/20180702135646/http://moves-app.com/ (visited on 06/2019).

[82] K. Poels, Y. A. W. de Kort, and W. A. Ijsselsteijn. *D3.3 : Game Experience Questionnaire*. Tech. rep. Eindhoven: Technische Universiteit Eindhoven, 2007.

[83] John Brooke. "SUS - A quick and dirty usability scale". In: *Usability Evaluation in Industry*. Vol. 189. 194. 1996, pp. 4–7.

[84] S Quiller. *Color Choices: Making Color Sense Out of Color Theory*. Watson-Guptill, 2002. ISBN: 9780823006977.

[85] Meredith A. Case, Holland A. Burwick, Kevin G. Volpp, and Mitesh S. Patel. "Accuracy of Smartphone Applications and Wearable Devices for Tracking Physical Activity Data". In: *JAMA* 313.6 (Feb. 2015), p. 625. ISSN: 0098-7484.

[86] Yukitoshi Aoyagi and Roy J. Shephard. "Habitual physical activity and health in the elderly: The Nakanojo Study". In: *Geriatrics & Gerontology International* 10.SUPPL. 1 (June 2010), S236–S243. ISSN: 14441586.

[87] Dartagnan P Guedes, Angélica C Hatmann, Fábio Antônio N. Martini, Marcelo B Borges, and Rinaldo Bernardelli. "Quality of Life and Physical Activity in a Sample of Brazilian Older Adults". In: *Journal of Aging and Health* 24.2 (Mar. 2012), pp. 212–226. ISSN: 0898-2643.

List of Publications

As a result of the investigations procured during this research, many academic publications were produced. The most relevant of them are listed as follows.

Journals

1. **Luciano Henrique de Oliveira Santos**, Kazuya Okamoto, Shusuke Hiragi, Goshiro Yamamoto, Osamu Sugiyama, Tomoki Aoyama, and Tomohiro Kuroda. "Pervasive game design to evaluate social interaction effects on levels of physical activity among older adults". In: *Journal of Rehabilitation and Assistive Technologies Engineering* 6 (Jan. 2019), p. 2055668319844444. ISSN: 2055-6683.
2. **Luciano Henrique de Oliveira Santos**, Kazuya Okamoto, Silvana Schwerz Funghetto, Adriana Schüler Cavalli, Shusuke Hiragi, Goshiro Yamamoto, Osamu Sugiyama, Carla Denise Castanho, Tomoki Aoyama, and Tomohiro Kuroda. "Effects of Social Interaction Mechanics in Pervasive Games on the Physical Activity Levels of Older Adults: Quasi-Experimental Study". In: *JMIR Serious Games* 7.3 (July 2019), e13962. ISSN: 2291-9279.

International Conferences

1. **Luciano Henrique de Oliveira Santos**, Kazuya Okamoto, Shusuke Hiragi, Goshiro Yamamoto, Osamu Sugiyama, Tomoki Aoyama, and Tomohiro Kuroda. "Pervasive Game Design to Evaluate Social Interaction Effects on Levels of Physical Activity among Older Adults". In: *International Conference on Disability, Virtual Reality and Associated Technologies*. 12th. 2018, pp. 157–164. ISBN: 9780704915480.

2. **Luciano Henrique de Oliveira Santos**, Kazuya Okamoto, Adriana S Cavalli, Shusuke Hiragi, Goshiro Yamamoto, Osamu Sugiyama, Carla D Castanho, Tomoki Aoyama, and Tomohiro Kuroda. "Designing Pervasive Social Interaction Mechanics for Elderly Players: A Multicultural Study Case". In: *Innovation in Medicine and Healthcare Systems, and Multimedia*. Ed. by Yen-Wei Chen, Alfred Zimmermann, Robert J Howlett, and Lakhmi C Jain. Singapore: Springer Singapore, 2019, pp. 293–303. ISBN: 978-981-13-8566-7.

3. **Luciano Henrique de Oliveira Santos**, Kazuya Okamoto, Shusuke Hiragi, Goshiro Yamamoto, Osamu Sugiyama, Tomoki Aoyama, and Tomohiro Kuroda. "Design Elements of Pervasive Games for Elderly Players: A Social Interaction Study Case". In: *Human Aspects of IT for the Aged Population. Applications in Health, Assistance, and Entertainment*. 2019, pp. 204–215.

Domestic Conferences

1. **Luciano Henrique de Oliveira Santos**, Kazuya Okamoto, Goshiro Yamamoto, Osamu Sugiyama, Tomoki Aoyama, and Tomohiro Kuroda. "A Pervasive Game to Evaluate the Effectiveness of Social Interaction to Increase Daily Activity of Older Adults". In: *Entertainment Computing Symposium 2017*. Vol. 2017. Information Processing Society of Japan, 2017, pp. 232–236.