

# Increasing Engagement in Elderly People through Tangible and Distributed User Interfaces

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## ABSTRACT

Ageing population will be an increasing challenge. Latent growth curve analyses of accelerating decline in cognitive abilities in late adulthood. The games-based therapy is an alternative that helps them improve and maintain their cognitive abilities. However, playing for a day is not enough, as improvements are achieved with regular playing. Thus, it is necessary to design games that motivate and provide incentives to keep playing. In this paper we describe an application based on tangible and distributed user interfaces, which has been designed according to guidelines that allow users to feel motivated and engaged using the system.

## Categories and Subject Descriptors

H.5.2. Information interfaces and presentation: User Interfaces. – Graphical user interfaces

## General Terms

Design, Human Factors, Experimentation.

## Keywords

Engagement, Tangible Interaction, Distributed User Interfaces, Cognitive abilities, Games, Elderly people

## 1. INTRODUCTION

Due to the increasing life expectancy in the world, the number of elderly people is also augmenting. A 2009 United Nations report states that by 2050 there will be more people over 60 than under 15 years of age in developed countries [22]. As the population ages, the need for effective methods to maintain or even improve older adults' cognitive performance becomes increasingly pressing.

Cognitive processes that decline with age include attention processes, working memory, discourse comprehension, problem solving and reasoning, and memory encoding and retrieval. Moreover, the number of cases of dementia worldwide in 2010 has increased. Rates increase significantly with age, with dementia affecting 5% of the population over 65 and 20–40% of those over 85[2].

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Training programs based on cognitive stimulation are one of the methods to maintain or even improve older adults' cognitive performance.

Technology is a tool to support training programs. Specifically, digital games can have a significant positive impact in the older person's mental and physical health and wellbeing [6].

There are studies that indicate the potential benefits of digital gaming in older age, especially on self-esteem and mental stimulation [4][7][15][16].

Some of the systems developed to support training programs are *serious games*, whose main objective is to simulate real situations, are designed around solving a problem. In addition to being entertaining, their goal is to train and educate the user [11].

There are solutions that make possible to create cognitive activities easily, which make use of devices such as computers and tablets [13].

The smartphone is another means which has been used to improve quality of life; it enables training and learning, with a view to facilitating daily activities [1].

*Kinect* is a line of motion sensing input device. It enables users to control and interact with their console/computer through a natural user interface using gestures, and has been used to improve motor cognition in users [8].

The advantages offered by these systems are numerous. They enhance positive attitudes in users while being appealing and encouraging, as well as providing information quickly. However, the systems present the following disadvantages:

-The user needs a minimum degree of computer literacy. Not everybody can use a computer, and some devices, such as the mouse or the keyboard, are not intuitive for people with cognitive disabilities. They need someone to help them.

-The system requires highly specialized hardware/software, which can be expensive (simulators, virtual reality).

Furthermore, when probed for their motivations to play, gamers show a marked interest in the social component. This study [17] supported by 60% of the gamers prefer to be able to play with friends.

Game usability is a very important topic to study, because it is one factor that makes the game to have an engaging gameplay and the users to feel pleasure in playing it. However, it is not sufficient to satisfy the needs and requirements of the elderly people. In this paper [9] it is stated that usability is essential in games, but "usability in itself is not a sufficient motivation to use software".

The aim of this paper is to study the guidelines for playful and engagement by the user. In order to do so, an application has been developed based on Tangible User Interfaces and Distributed User Interfaces, where such guidelines have been applied.

Tangible User Interfaces (TUI) refers to user interfaces which give physical form to digital information, making the parts directly malleable and perceptible [10]. Tangible User Interfaces are based on smart objects, and provide a natural and easy style of interaction that proves intuitive and motivating for non-experts in technology and people with special needs.

According to Niklas Elmqvist [5], Distributed User Interfaces (DUI) can be defined as a user interface which components can be distributed through one or more dimensions. These dimensions are: input, output, platform space and time.

In this way we get a low-cost game, we took advantage of the familiarity of common objects in the elderly, and allow the user to feel confident and therapy may lead collaboratively with other people.

## 2. GUIDELINES FOR DESIGN GAMES

Some studies [3], [9] emphasize important alternatives that could help to encourage the use of games by the elderly. In their studies, they found out that the lack of confidence in playing can cause them to give up this activity. Thus, the game should provide mechanisms that make older people **feel confident** in their ability to play. Therefore, it is important that games provide encouraging **feedback** showing **levels** of success that the player is reaching.

Sweetser and Wyeth [21] have developed a series of criteria for designing engaging computer games on the basis of the flow theory.

Below we have highlighted the following guidelines for further research in the area.

**Challenge:** According to the theory by Malone [14], computer games that provide challenge and rouse the curiosity of the elderly people are intrinsically motivating.

**Control:** Lepper and Malone [12] include control, suggesting that people should have opportunities for making choices about the use, process and interaction with the game. Providing choice within a digital game potentially enhances the player's perception of autonomy, in this way, increasing the user motivation [19].

**Feedback:** It has an impact on a player's experience. It can be visual, auditory and tactile (physical sensation). For games aimed at older people is important to consider the impact of hearing and visual loss. In addition, it can benefit from visual cuing to motivate them.

**Social Interaction:** One of the most important cognitive activities for the elderly is engaging and meaningful conversation and collaboration with more people. In this form, their minds are stimulated and they experience a feeling of self-worth. According to the studied Nielsen [17], elderly people feel more motivated collaborate and play with friends.

## 3. GAMES TO SUPPORT COGNITIVE STIMULATION

The prototype developed is an interactive and collaborative game designed to stimulate cognitive abilities. This has also been used in cognitive stimulation therapy for elderly people or with Alzheimer's disease. It integrates a new way of human-computer interaction. The user can interact with the system through everyday objects such as cards, toys, coins, etc. The object integrates an NFC tag to make it interactive. Users only have to bring the object or tangible interface to the mobile device which includes an NFC reader (see Figure 2, interaction style).

Our main goal has been to design a game that encourages elderly people in order to use it. The digital game has been designed according to the guidelines described in the previous section.

The game interface is executed on a computer and projected onto a wall, what do not require the use of other peripherals like joystick or mouse. This requisite ensures that the game can be set in any environment, provided the existence of the following devices, correctly configured: a projector, the smart objects (tangibles user interfaces) and a mobile device with NFC reader. Smart objects are the main elements to interact with the games.

There is a need to engage and involve the user in the game. To ensure this requisite, the game sends out ludic cues (from PC and mobile device), as invitations to play. These ludic cues correspond to animated images and sounds. Ludic cues include verbal messages to facilitate the use of the game and get the attention, generate enthusiasm, and maintain the concentration of users, who are guided by the game interfaces. With this type of feedback they get the attention of the elderly people.

Another important requirement is avoiding frustration due to failure. Our system shows positive and encouraging messages when the user fails. When the user gives a right answer, the system shows immediate reinforcement based on encouraging messages and points, motivating the progress toward goals and skills development.

Besides, the *Distributed User Interfaces* have been designed taken into account visual impairments. In our system, the game interface is executed on *large-print displays*, *alternative colors* on the screen, and *voice output* to compensate for some reading and attention problems.

*Flexibility of performance* and *continuous gratification* is another requirement included in the system. The game automatically adapts to the skill of the user while in performance. This allows a greater control over the challenge proposed on the different skill levels of the end users.

Collaborative interface offers us *social interaction*. Most opportunities for social interactions among older people occur during the play. This opportunity to play with others is appropriate to develop appropriate social skills. A social interaction game is conducted to allow interaction of a plurality of players.

Smart objects or *Tangible User Interfaces* allow the user to take control of the game. Each player has its own objects to interact with the game. In this way, a *private space* is given to the user, providing confidence when interacting with a shared space as is the screen. Streng [20] emphasizes the importance of a private space in collaborative software to provide confidence.

The interface is the means by which the user interacts with the system, therefore it is very important that they are *easy to understand, simple and intuitive*. The next prototype is implemented in a distributed user interface setting composed of three types of interfaces (See Figure 1):



Figure 1. Therapy session using the proposal game



Figure 2. Style of Interaction. The user brings the digitized object (Tangible User Interface) close to the mobile device (interaction resource) that incorporates the NFC Reader.

-MainUI (Main User Interface). It is the main interface of the system. It graphically displays the information, including animations, texts, sounds and user's score. At all times, it shows the progress and course of the game, the feedback and ludic cues.

-MobileUI (Mobile User Interface). It corresponds to the graphical interface of the mobile device that incorporates the NFC reader. Its function is to recognise the object chosen by the user when they bring it close to the mobile device. It also shows the instructions of the game at the beginning.

-TangibleUI (Tangible User Interfaces). These are common physical objects used as interaction resources to interact with the game. These objects have an NFC tag integrated inside what allows that the system can identify them through the mobile device.

The style of interaction of the user with the system simulates the usual style of the user in their environment. Therefore no prior knowledge is necessary, as using the system is easy and intuitive (see Figure 2). The user only has to bring the chosen object closer to the mobile device. The actions that result from this are transparent to the user.

The game interface displayed onto the wall shows the game executed in that moment. Depending on the game, it may show different objects and the user will have to interact with the system by choosing the correct object and bringing it closer to the mobile device. From that moment all processes are run implicitly. The game interface will display the pictures, texts and sounds according to the final result of the user action. In case of failure, the game will keep the game at the same skill level and in case of success, it will move on to the next level of difficulty. The sequence of this gameplay is depicted in Figure 3.

The game presents a word that the user has to memorise. After a few seconds, the word disappears. The goal is that the user remembers the word and looks for the objects related to the missing letters to form the word. Then, the user selects the correct tangible objects corresponding to the missing letters and brings it closer to the mobile device. The result is displayed on the game interface with positive and encouraging messages regardless of the outcome of the game.

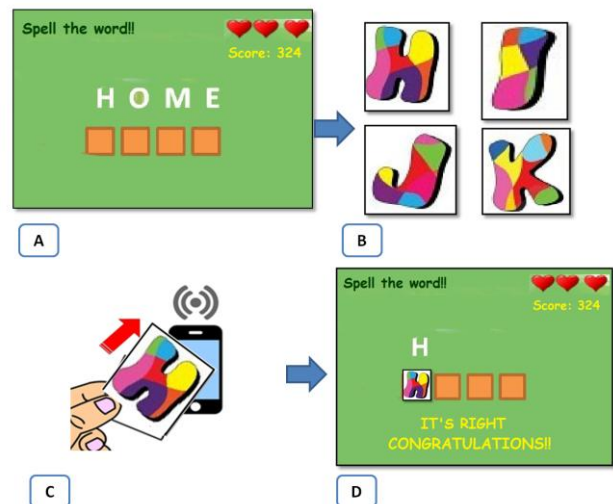


Figure 3. Game Sequence. (a) Main interface of the game.

Firstly, users have to memorize the word (b) The word disappears and the user must seek the letters (tangible objects) (c) Bringing the selected tangible interface close to the mobile device (d) Game results

The system architecture is as follows. The game is a client-server system. The client system runs in the user mobile device. It is connected to the server application through a wireless network and it is communicated with objects via NFC (Near Field Communication) when the user approaches the object to the mobile device. A tag (or more) is integrated inside the object or card depending on the size of the object; each tag describes a unique identifier. When the NFC reader in the mobile device is brought closer to the chosen representative object, the NFC tag inside is recognized by the reader, and then the component controller sends the identifier to the server. The server executes the steps necessary to return the information to the mobile device and the main interface. The games which are running in the PC are shown in the projector.

## 4. CONCLUSIONS

In this paper, we described a digital game to stimulate cognitive abilities in elderly population, based on *Tangible* and *Distributed User Interfaces*. Interaction style is intuitive and simple. The user only has to bring the chosen object (smart object or tangible interface) close to the mobile device to interact. Game interfaces are developed following the specified guidelines, focused on encouraging and enhancing their self-esteem to motivate and engage elderly people. The principles are the following: *Challenge*, the game automatically adapts to the skill of the user while in performance. *Control*, tangible user interfaces allow the user to take control of the game. Each user has its own objects to interact with the game. They feel confident in their ability to play with public and collaborative interface. *Feedback* takes into account visual, auditory and tactile messages, including ludic cues with verbal and positive messages to facilitate the use of the game and get the attention, generate enthusiasm, and maintain the concentration of users. *Social Interaction* through collaboration, which improves social abilities and mood. We have carried out a study to analyze the impact of games based on *Tangible* and *Distributed User Interfaces* in elderly people. Regarding the data obtained from direct observation [18] and comments made by the participants we can highlight the following: (1) If they find it easy to use, they are more motivated and focused on the activities. (2) Direct interaction with the objects provides a better understanding of the task. (3) Tangible interfaces emphasize the connection between body and cognition, facilitating thinking through physical actions. (4) Training helps to stimulate cognitive abilities. (5) The results were positive; users had fun and wanted to play again. As future work, we want to carry out an exhaustive evaluation to obtain more information. The main objective is to check the usability in the system, the improvement of the self-esteem, mood and cognitive abilities in the elderly population.

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