A STUDY IN COGNITIVE TRAINING AND RELAXATION FOR ELDERLY PEOPLE

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Iman Farhanieh

Supervisor: Mikael Johannesson
Examiner: Per Backlund
Abstract

The goal of the project presented in this study is to provide a rehabilitation system which is game based in a home environment for elderly people in order to reduce the cognitive decline and halting the progression of memory deficit problems. Recently it has been discovered that cognitive training can initiate brain flexibility and strengthen the neuromodulatory system which controls learning. At the same time we need to consider that elderly people may become stressed while using any type of technology, let alone a video game. That said, another main goal of the project is to reduce the stress level of the player while interacting with the game. The results showed that the stress reducing features used in this study was mostly effective but one of the main problems was most of the participants not having much experience with using a computer which made them more stressed.

Keywords: Elderly, Cognitive training, relax, memory
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1 Introduction

The goal of this study is to provide a rehabilitation system which is game based in a home environment for elderly people. Such a system could possibly also be advantageous for e.g. people suffering from Alzheimer. Considering that Alzheimer’s diseases mostly starts at an elderly age and most of people at an elderly age experience stress while using modern technology, it is very difficult to train cognitive skills using modern technology while the patients are under stress. However, a study (Joels et al., 2006) shows that in some situations the individual memory and learning abilities can improve while under stress but it should be noted that this particular study was conducted on healthy participants. So it is unclear if people with dementia will learn better under stress.

By reading the text above it can be established that the target group for this study is elderly people. This can be a negative factor for the study because most of the elderly people are not used to interact with video games. Still, it is believed that with the use of the right features and mechanisms in a video game, it can be enjoyable and intractable for any age. Another important thing is that the difficulties and circumstances identified for elderly people is a subset of those for people suffering from Alzheimer. This means that the information regarding weaknesses gathered during the testing is likely to be relevant also for Alzheimer patients.

Having this in mind, not only do we have to design and develop a system that trains the cognitive skills of the individual, the system must also be designed in a way that reduce the stress level of the patients as much as possible using different techniques such as color and music. According to an article written by Ines and Abdelkader (2010), traditional rehabilitation does not give enough motivation for training and usually are tiresome for the patients each time they leave the rehabilitation centers. This is why the rehabilitation system must be based in a home and comfortable environment. This project is considered a serious game being that it uses video game elements and features not only for pure entertainment, but also for other reasons like health care as well.

This study was aimed to estimate if different kinds of specific features in a game will reduce or increase the stress level of the player. For this experiment two different prototypes were developed using the Gamemaker engine. One prototype includes features that should increase the stress level of the player while the second prototype uses features like music in order to reduce the stress level. Each participant was asked to play both prototypes and complete a questionnaire in the end of each test session.
2 Background

2.1 Alzheimer’s disease

According to Aprahamian et al., (2013), Alzheimer’s disease or AD which affects most of the individuals that are demented is the most principal cause of dementia. It has been estimated that near 24 million people across the globe suffers from dementia.

In an article published by the Alzheimer's Association (2012), it is mentioned that in early stages of Alzheimer’s, patients will suffer mild memory loss and at late-stage, the individuals will lose the ability to have normal conversations and respond to their surrounding environment. There is no current cure for Alzheimer’s, but there are some special treatments that can temporarily slow down the dementia symptoms to progress more.

The article also mentions that scientists and researchers believe that Alzheimer's disease causes the brain cells to not function well. They also believe that plaques and tangles which are abnormal structures are most like responsible for damaging the nerve and brain cells and blocking the communication between nerve cells.

According to the National Institute on Aging (2012), while not knowing the exact cause of AD and not having a cure, there are certain lifestyle and health factors related to Alzheimer's disease that can control the progress. Researchers also are trying to determine if things such as brain games, diet and exercise will delay the Alzheimer's disease and cognitive decline. Also they are examining in order to see if specific medical conditions like high blood pressure, diabetes and high cholesterol have any influence on cognitive impairment.

The institute also notes that some animal studies suggest that exercise increases the number of connections between the nerve cells and the number of blood vessels supplying blood to the brain. It has also been discovered that exercise will have a positive effect on nerve growth in the area of the brain which is responsible for memory learning. Exercise can also stimulate the brain to sustain old network connections and create new ones at the same time.

Studies from the National Institute on Aging (2012) have shown that to lower the risk of Alzheimer’s disease each individual should participate in social activities as much as possible. Mentally stimulating challenges and activities such as attending lectures, playing games and reading books will also help keeping the mind sharp and busy.

2.2 Memory

As mentioned before, one of the main goals of this study is improving the memory and lessening the cognitive decline as much as possible. Seeing that memory is part of Cognitive science it is important to understand this specific area even more. According to Hofgren (2009):

“Cognitive science covers the different approaches to the study of intelligent information processing system. Cognitive psychology and cognitive neuropsychology are two branches of cognitive science that focus on the study of the same intelligent system – the human brain.”

(Hofgren, 2009, p.9)
Hofgren (2009) mentions in his article that memory, which is the main focus of Alzheimer’s disease refers to information being stored, encoded and retrieved. Memory is considered to have different forms, processes and neural mechanisms. There are two types of memories, one is short term memory (immediate memory, working memory) which has a limited capacity for storing data and information, usually it ranges from seconds to two minutes and the other is long term memory (permanent storage). The working memory holds information both from long term memory and sensory inputs. It is also described as an attention control system with limited-capacity which manages processes that involves learning, reasoning and comprehending. There are two types of long term memory, one is explicit memory which is related to the conscious and declarative, and the other one is the implicit memory which relates to the unconscious or procedural.

2.3 Cognitive science and training

Choi and Twamley (2012), explains that in order to stimulate mental activity, a person should engage in everyday tasks, this is called cognitive stimulation. Some particular cognitive exercises that are included in cognitive stimulation are word games, using money, famous faces and present day information. The main focus of this kind of therapy is the reminder of specific information to the patients using themes such as food and childhood in an effort to create stability between different information.

On the other hand, Choi and Twamley (2012) also mention that cognitive training focuses on patients who have enough cognitive means to use a computer program or a therapist to help them to complete tasks for exercising particular cognitive functions, the reason for this is to support the cognitive skills that are damaged. Neuroplasticity is the main premise of cognitive training, and by using these kinds of training it is possible to improve or maintain the performance in the this kind of domain. There has also been some computer based studies in cognitive training that focus on specific types of cognitive skills such as spatial memory, object discrimination or divided attention.

Choi and Twamley (2012) discuss that in moderate and early Alzheimer’s disease, cognitive enhancements are becoming more available to the elderly to prevent the extreme decline in cognitive performance. Cognitive enhancement and treatment focuses on improving cognitive skills by practicing restorative and compensatory strategies. Beside Alzheimer’s disease, cognitive training also targets people with other cognitive impairments like stroke, head injury and schizophrenia but it is more effective for people with dementia considering their unique circumstances presents unique challenges for making cognitive therapies more efficient.

Choi and Twamley (2012) write in their article that recently it has been discovered that the nervous system in the brain can modify its structural organization depending on the environment. It had the ability to adapt itself to different circumstances. Cognitive training can initiate brain flexibility, training like psychomotor, cognitive and sensory activities. These kinds of training will help reengages and strengthen the neuromodulatory system which controls learning.

2.4 Stress

The Klinic Community Health Centre (2010) explains that every situation is automatically evaluated mentally when something happens to us. At that moment, it is decided if the situation is threatening or not, how the situation should be dealt with and which skills are
more effective in the situation. If in that particular moment we realize that our skills are not enough to handle the situation, we will label the circumstances as "stressful" and react with a "stress response".

Any kind of situation or thoughts that make you frustrated, anxious or angry, can create stress. Of course each person sees situations differently and copes with the situation differently. That is why each person will respond differently in any given situation.

### 2.4.1 Sources of Stress

The Klinic Community Health Centre (2010) gives 4 basic sources that cause stress which are:

**Environment**: The environment can contain extreme burdens for you to adjust. For example weather, crowding, noise, traffic, crime and pollution can cause stress.

**Social**: A person can experience stress from multiple sources in society that we live in, such as being a spouse, being a parent, being an employee and etc. Some examples for social stressors are deadlines, job interviews, disagreements, loss of a loved one, financial problems and divorce.

**Physiological**: The circumstances and situation that are affecting our body can also be a source of stress. For example menopause, aging, illness, lack of exercise, sleep disturbance and poor nutrition causes stress.

**Thoughts**: Like mentioned before, our brain perceives and interprets circumstances as stressful, painful, pleasant or difficult. It should be mentioned that some circumstances in life are stressful, but it is our brain that determine if it is a problem for us.

### 2.5 Learning under stress

In a study written by Joels et al., (2006) they mention how stress affects memory and learning abilities. They suggest that if the events are stressful and more important, that event is better remembered. It should be also noted that a person would rather forget the experience they had but cannot, like post-traumatic stress disorder. Using genetic and pharmacological tools to study animals and humans have shown that stress can be crucial and effective on memory performance and learning. However in some cases, stress has been harmful on the cognitive performance. For example, some people who experience a very stressful situation mostly show undependable memory for details.

### 2.6 Music

Labbe et al., (2007) explains to us that music is one of the important factors in their study, where different types of music were exposed to fifty six participants after participating in a stressful test. It should be mentioned that the study suggests that the type of music plays an important role on the amount of stress one individual has. Studies done by Hebert et al., (2004) show that classical music is more relaxing but on the other hand, rock and techno music have a less relaxing effect (Hebert et al., 2004). In Labbe et al., (2007) study participants that are exposed to self-selected or classical music experience more relaxing feeling. Listing to heavy metal music, produced less feelings of relaxation. Not only did the
participants experience higher level of anxiety while listing to heavy metal music, they were more anxious than when they were stressed.

The image below (Figure 1) provided by Labbe et al., (2007) shows the anxiety scores for the pre music and post music or silence and it is clear that the participants that are exposed to self-selected or classical music experience less anxiety compare to heavy metal music.

![Figure 1](image1.png)

**Figure 1** State anxiety scores form pre music and post music (Based on Figure 1. p. 166 in Labbe et al., 2007)

Figure 2 which is also provided by Labbe et al., (2007), shows the relaxation scores and like the anxiety scores it shows that the participants are more relaxed while listening to self-selected or classical music.

![Figure 2](image2.png)

**Figure 2** State relaxation scores form pre music and post music (Based on Figure 2. p. 166 in Labbe et al., 2007)

### 2.7 Color

The evidence that was provided by the research done by Walters et al.,(1983) suggests that color has an effect on the arousal level for each person. Some colors makes the person feel
more aroused, and some colors makes the person more relaxed. In figure 3 which represents 75 participants, the arousal levels for 7 different colors are shown.

![Mean rank order](image)

**Figure 3** The arousal value for each color (Based on Figure 4. p. 206 in Walters et al., 1983)

They also mention that the level of arousal is related to the wavelength and position of the color. For example, colors like indigo, violet and blue that are short-wavelength colors are considered more relaxing. On the other hand, colors like red, yellow, orange that are long-wavelength colors are more arousing. However the color green is considered to be neutral. In the testing done by Johnson and Toffanin (2012), most of the participants considered the color blue or green to be more relaxing while the remaining participants thought that the colors purple, orange, pink were more calming.

### 2.8 Serious Games

While the term serious games is becoming more and more known every year, there has not been any specific definition for the term and many authors have a definition of their own. However there is one aspect that all of the researchers and authors agree on and that is that the primary goal of serious games is not entertainment. One of these definitions that is mentioned by Zyda (2007; reviewed in Rego, Moreira and Reis, 2010) is:

“A mental contest, played with a computer in accordance with specific rules, which uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives.”(Zyda, 2007, p.26)

As stated by Michael and Chen (2006; reviewed in Rego, Moreira and Reis, 2010) while serious games should be fun, entertaining and enjoyable, it is not the main purpose. Also in the article written by Rego, Moreira and Reis (2010), it is mentioned that serious games can be developed by using many types of technologies and platforms and can be of any genre. They also state that serious games are used to achieve a specific goal like better teaching or improving a specific skill by using engagement and entertainment in order to motivate the players. As mentioned by Michael and Chen (2006; reviewed in Rego, Moreira and Reis, 2010) and also by
Zyda (2007; reviewed in Rego, Moreira and Reis, 2010), serious games can be applied to many types of domains like educational, healthcare, political, military, government, corporate, art and religious games. For example, in the military area one of the well known games was “America’s Army” which was released in 2002 and its main purpose was to interest people in joining the army.

2.8.1 Serious Games in Healthcare
According to Susi, Johannesson & Backlund (2007), serious games are becoming more popular in the Healthcare area nowadays and being implemented in many different ways:

Physical fitness: games like Dance Dance Revolution that make exercise more appealing for players,

Education in self-directed care and health, games that teaches important health habits to children

Distraction therapy: where specific games are used in order to distract patients from uncomfortable situations and treatment like chronically ill children that are in pain.

Rehabilitation and Recovery: games that simulate rehabilitation which also improves motor skills.

Simulation and Training: where games are used to train surgery to doctors and improve their performance

Diagnosis and treatment of mental illness or mental conditions: using these kinds of games can help diagnosing and treating specific disorders like post dramatic stress disorder or deficit hyperactivity disorder.

Cognitive functioning: these games are aimed for training and improving cognitive skills like memory.

Control: games that use biofeedback equipment to measure and understand the player’s vital rates better.

Janarthanan (2012) mentions in his article that in the area of healthcare, rehabilitation can be integrated into games and provide advanced medical services for many patients. A good example that Janarthanan (2012) provides is that the pain felt by wounded soldiers in the army can be reduced with specific gaming strategy. Another example is Combat Medic where the game teaches and tests the players skill how to performing medical tasks in a Middle East battlefield. In the end, Janarthanan (2012) mentions that "serious games" should grow into an organized industry with development studios that uses advance entertainment technologies in order to solve problems in areas like health care, education inter-personal skills and more.
2.9 Related works

2.9.1 Serious Games in Cognitive Training for Alzheimer’s Patients
By using advances in artificial intelligence such as activity recognition, guidance and learning, Imbeault et Al (2011) focused on designing an accessible and affordable tool and serious game for enhancing the Alzheimer patient’s cognitive performance. The game which is in 2D, is a point and click game that focuses on routines actions of everyday life (like having breakfast). For example the player can click on a slice of bread with the cursor in order to grab it. After that the player can click on the toaster in order to put the slice in. Unfortunately no results were available because while writing this article the game was still in development and Imbeault et Al (2011) planned to do an experiment in the future.

2.9.2 Brain training for silver aged gamers
Nacke et Al (2009; reviewed in Imbeault et Al, 2010) were determine to answer this question "Are new ubiquitous technologies and media forms, like digital games on portable consoles, a blessing or a curse for an aging Western civilization?" They performed a research which focuses on providing a positive gameplay experience to the aging population. The research proposes that "players, regardless of age, are more effective and efficient using pen-and-paper than using a Nintendo DS console. However, the game is more fun and induces a heightened sense of flow in digital form for gamers of all ages." (Nacke et Al, 2009)

2.9.3 Interactive computer-training as a therapeutic tool in Alzheimer’s disease
Another experiment conducted by Hofmann et Al (2003; reviewed in Imbeault et Al, 2010) focuses on interactive computer training as a therapeutic tool for Alzheimer’s disease with the use of a shopping route simulation that is close to reality. The interesting thing about the experiment is that while the AD patients could have been frightened during the training, they perceived the experiment quite well. Also the research showed a major improvement in the patients where they did less mistakes. The experiment took place in a 4 week period, after that the patient had 3 weeks without any exercise. Fortunately no difference was detected in week 7 when the patients did the experiment again. This suggests that the Alzheimer's patients were interested in the idea of Interactive computer-training which shows that perhaps interactive media can be used for different kinds of rehabilitation.
3 Problem

Giving the restrictive abilities for elderly people and Alzheimer’s patients, with therapeutic alterations and proper conditions to improve cognitive rehabilitation, elderly people with early stages of dementia can still have the ability to remember and learn useful skills and information in spite of their difficulties. Unfortunately even with improved cognitive rehabilitation there are some deficits that will make the rehabilitation process more complex, one of the most serious deficits being stress.

3.1 Aim

As said at the beginning, the main aim of this study is to create a game based rehabilitation system that focuses on cognitive training and reducing stress. One of the main problems is that now days most of the elderly people cannot interact very well with video games because they do not belong to the gaming generation. Another problem is that most of the elderly people experience stress while using any type of modern technology like the washing machine, TV and microwave. Another aspect that is important and might be problematic is the environment in which the rehabilitation is taking place. This aspect applies both for healthy and unhealthy people. So the main question is: can a system be created that trains the cognitive skill and calms an elderly player at the same time?

3.2 Hypothesis

The hypothesis for this study is that the participants would improve their short term memory and feel relaxed at the same time while using a gaming application for memory training if it would include specific features (such as relaxing colors and relaxing music) compared to the one that do not include those specific features.

3.3 Method

3.3.1 Design

The prototypes for this study were developed on the PC platform using the Gamemaker engine which is used for 2D video games. For minimizing the complexity of the game it was decided that the player could only use the mouse to interact within the game.

The first prototype consists of two different shapes (square and circle) with different colors. In the beginning of the game, some specific objects are shown and the player is asked to memorize them. After a few seconds the player is shown the next scene which all of the objects are placed and the player has to select the objects from the previous scene. It should be noted that all the texts in the game that was tested were in Swedish but was translated to English in this article for the reader to better understand the game.
Both prototypes are similar to each other, both have the same gameplay and rules which is selecting the right objects. One of the prototypes includes a timer that if it reaches zero the game will start from the beginning and a counter which counts the amount of mistakes the player makes. The second prototype which is aimed to reduce the stress level of the player used features like music, specific colors and more.

For the first version of the two prototypes which was used in the pilot study, each game consisted of 4 Scenes and only used two types of shapes which were circle and square. At the time, color was not a factor in the research and as a result different types of colors were used not regarding which one will clam the player more. Also, only one genre of music (Jazz) was used in game with relaxing features.

For the second version of the two prototypes, each game had 4 additional Scenes in order to add to the game’s length. Also a new shape (triangle) was added only to the second prototype with relaxing features. Based on Johnson & Toffanin (2012) and Walters et al. (1983) research, it was decided to use the colors blue, green, indigo and violet in the second game in hopes of lowering the arousal level of the participants. Furthermore, a new type of music (Classic) was added to the second game and the players could now choose the music they want to listen to. To see the overall differences between the prototypes, visit table 1.
Figure 7  One of the levels of the second prototype

Table 1  Different features between the two prototypes

<table>
<thead>
<tr>
<th></th>
<th>First Prototype</th>
<th>Second Prototype</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shapes</td>
<td>Circle, Square</td>
<td>Circle, Square, Triangle</td>
</tr>
<tr>
<td>Timer</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Music</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Mistake Counter</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Colors</td>
<td>Random</td>
<td>Specific</td>
</tr>
</tbody>
</table>

3.3.2 Participants

Before the study started, the main plan was to find at least 15 Alzheimer patients. Also the participants need to have specific conditions and criteria which are:

- Age over 60 years
- No terminal disease, no severe hemiparesis
- Independent mobility - with walking devices if needed

At first, two of the elderly homes in Skövde was visited and were asked if some of their Alzheimer patients were wiling to participate in the experiment but unfortunately non of the organizations were able to help, mostly because most of their patients situations were too extreme to participate in the test.

In the end, due to time limitations it was decided to contact an elderly community called SPF Skövde in order to ask them if they want to participate in the experiment which fortunately
they were very interested in. Also the Elderly home were contacted again but this time they were informed that elderly people who do not suffer from dementia could participate in the test. 14 elderly people participated in the test, 8 of them were males and 6 of them females. 10 of the participants lived in an elderly home while the rest were living in their own homes.

3.3.3 Procedure
In each test session, the participants were asked to perform the test in an environment where they felt the most comfortable. Also if possible, the test sessions were done individually. Each test season took about 15 minutes to complete. At the beginning of every test session, some of the participants were asked to play the first game which includes stress increasing features while the others were asked to play the second one at the beginning. While playing the prototype the players actions was observed, for example how many time did the player had to replay the game, how many mistakes they made during each scene, if they did get better at the game after a few playthroughs and etc. The player's actions were also documented during the playthrough. After the test session is complete the participant is asked to complete a questionnaire.

3.3.4 Ethical considerations
For a treatment regarding health care and dementia it is very important to understand the ethical aspects of such treatment if in any case in the future the developed prototype will be used in a bigger scale. One of the definitions stated by Fouka and Mantzorou (2011, p. 3) is that: "Research ethics involve requirements on daily work, the protection of dignity of subjects and the publication of the information in the research."

Fouka and Mantzorou (2011) also mention that one of the major issues in ethics is informed consent which is the protection of the autonomy for the patient. Informed consent is also used to prevent any attacks on the patient's integrity and personal liberty. Another major issue is invasion of privacy which Treece and Treece (1982; reviewed in Fouka and Mantzorou, 2011) believes it occurs when a patient's personal information like sex, age, amount of income and other details is not kept confidential or when researchers do a study on a specific group without their knowledge or consent.

As regards to the test session, the participants were only informed about the gameplay and purpose since participants with dementia were excluded. Also the confidentiality of any personal data was guaranteed to the participant.

3.3.5 Limitations
The original plan was to work alongside a company called Holosphere Innovation AB on a similar project that included dementia patients. Holosphere Innovation AB would also provide different kinds of recourses like participants for testing, information about dementia or other medical related information. Unfortunately due to certain circumstances, the collaboration was discarded.

Also it was planed at first that the Unity3d game engine was going to be used for the project which would allowed more advanced and polished gameplay but due to lack of time it was later decided to use the Gamemaker game engine which as suggested before it is mostly for 2D game development. Another reason for this change is considering that most of elderly people (especially with dementia) are not very familiar with modern technology like computing, it was realized that it would be better for the participants if the game was as simple as possible.
As mentioned in section 3.1.2, the main focus group for the project was elderly people with dementia. But unfortunately due to the difficulty of gaining access to this particular group, it was decided to change the focus group to healthy elderly people.
4 Tests and Analysis

4.1 Pilot Test

For this research, two pilot tests were conducted. One for the first versions of the prototype and one for the second version. The first pilot test featured 10 healthy participants which were students from the university. Each participant tested the game individually and each test season took around 10 minutes to complete. At the beginning of the test some of the participants were asked to play the first prototype which includes stress increasing features and for some vice versa. While playing the prototype the player's actions were observed, for example how many times did the player have to replay the game, how many mistakes they made during each scene, if they did get better at the game after a few playthroughs etc. The player's actions were also documented during the playthrough.

After the test the participants were asked specific questions which were:

- From 1 to 5, how much stress did you feel while playing each prototype?
- Did the music affect your stress level?
- Did the timer affect your stress level?
- Did you feel that you got better at the playing after the first time?

After the questions the participants were asked if they had any additional comments about the games.

After the second version of the two prototypes was developed a second pilot test was conducted which it was mostly similar to the first pilot test. The changes that were made for the second version consisted of allowing the player to choose the genre of music they want to listen to, one additional shape, specific relaxing colors for the second prototype and a better interface.

4.2 Main Test

Each participant was asked to test the game separately and the test should take more or less around 10 minutes to complete. At the beginning of the test, 9 of the participants were asked to play the first prototype which included stress increasing features and 5 of the participants were asked to play the second prototype at first which included stress reducing features. While playing the prototype, specific actions from the player were observed which were:

- How many times did the player had to replay the game
- How many mistakes they made during each scene
- If they did get better at the game after a few playthroughs
- If they were immersed in the game

The players' actions were also documented during the playthrough. After the test the participants were asked to complete the questionnaire which were in Swedish (visit Appendix A).

After completing the questionnaire, the participants were asked if they had any additional comments about the games.
Table 2 shows the age of the participants, where they conducted the test and if they had any experience with a PC.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Age</th>
<th>Computer experience</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
<td>P2</td>
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<td>P5</td>
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</tr>
<tr>
<td>P8</td>
<td>68</td>
<td>Yes</td>
<td>Own Home</td>
</tr>
</tbody>
</table>

**SPF Skövde**

The first organization that was visited was SPF Skövde which mostly consisted of retired elderly people. Due to the busy schedule, only one participant was able to test the game. Considering this was the first time testing the game on an elderly person it was expected that the test session would last around ten minutes similar to the pilot test that was mostly conducted on young students. However, it was soon realized that more time was need for the elderly in order to complete the game. This was mostly due to the fact that the participant was not very familiar to these kinds of test sessions or video games in general. The participant was able to complete the test around 15 minutes and it seemed that the participant's memory slightly improved at the end of the test but also seemed stressed in the end, mostly because the organization had a meeting right after that.

**Tomtegården Elderly Home**

In the second test, five of the residence in the elderly home participated in the test. At first, the game was explained to each participant and they were asked to play the first prototype and later the second. It should be noted that because of some physical disabilities which mostly consisted of vision and hearing disabilities, the aid of the participants accompanied them in order to help if they were stuck in the game in any way.

The first participant suffered from some sight and hearing disabilities and was not very experienced in using a laptop so after a few minutes instead of using the mouse, the participant was asked to use their finger to point at the correct figure and their aid would
click on it. For the first prototype the participant was not aware of the timer and replayed the level again and again after the timer ran out. The participant's playing skill's only slightly improved after playing each level a couple of times. For the second prototype the participant did not seem to be aware of the music that was playing in the background and choose the specific type of music randomly. In the beginning of each level which consisted of more than two figure to select, the participant was able to find one or to object and more in some cases, but in the end started to choose figures randomly hoping to be the correct one.

The second participant did not have any severe disabilities however, the participant did not have any experience with a mouse or keyboard. So like the first participant, the second participant was asked to use their finger to point at the correct figure. The playthrough was mostly the same as the playthrough for the first player. The player's skill increased slightly after playing each level a few time and after 10 minutes stopped playing due to mental exhaustion.

Like the first two participants, the third participant did not have any experience in using a laptop. Unlike the first two participants, this participant showed very little interest in the game and did not finish the levels. After a few moments it was realized the participant was not putting much effort in finishing the game so it was decided to stop the experiment and test the game on the fourth and last participant.

The fourth and last participant was similar to the first two participants. Although one major problem was that the participant did not understand the instructions and thought that the game asked the player to remember actual figures from the real world.

It should be noted that in end the end of the experiment, none of the participants was willing to answer the questionnaire, mostly due to mental exhaustion.

**Billingen Elderly Home**

Fortunately for this test session, most of the participants were quite experienced in using a normal pc and knew how most of the basic functions work. Unfortunately, there were no extra available room so that each participant could test the game individually so the player had to play the game in the presence of the other players. At first the participants were asked to let the player finish the game by them self.

The first participant showed good progress during the session but became nervous and unfocused each time the timer ran out. After a while, the other participants decided to join in and test the game together. It was decided to let the players work together to see how much it will affect their progress in the game and interestingly, their cognitive abilities improved quite significantly!

During the session, the participants help and cheered each other but in the end the participant mostly finished the game by them self. Almost all of the participants choose not to have any music in the game, when asked why, they said that it will distract them rather than calming them. Only one participant chose to play the game without any help and was able to finish the game but with some difficulties. Overall, the gaming session went well with only one of the major complaints from the participants was that pointer was too small for the participants to detect.
Bagaren Servicehouse in Skövde

For this test session three elderly people participated in the test. It should be noted that for the first time, the game was played on a television screen which made it easier for the participants to observe the objects in the game. The testing process was more or less the same as the previous test sessions where the goal of the game and the actual gameplay was explained to the participant and each of them tested the game for at least 6 minutes.

It was clear that the first participant was not very experienced with a laptop which seemed to make them very stressful knowing that they are not doing something correctly. The first game seemed quite hard for the player, seeing that after almost 4 minutes the player decided not to play anymore. The second prototype with stress relieving features appeared easier for the participant but again, decided to quit after a few minutes.

The second participant was very similar to the first. The level of experience with a laptop was low and the level of stress rose each time a mistake was made. It should be noted that every one of the participants experienced some kind of physical disability (mostly hearing).

The third and final participant was the only one that was experienced with a laptop and seemed interested in the game. Throughout the game the participant's skill appeared to slightly improve but did not finish any one of the games. At the end only one of the participants agreed to answer the questionnaire while the other two were too exhausted to continue the test session.

4.2.1 Observation

By performing the test it was discovered that participants older than 75 years old were not very immersed in the game and did not have much experience with a computer and had to be constantly reminded about the goal of the game. While each test session were done individually, for some test sessions the participant's aid had to be present in order to guide them through the game.

Another main discovery was that most of the participants that were mostly over 70 years old became mentally exhausted after almost 5 minutes of playing and were not immersed after that. The level of exhaustion for some of the participants was so high that they were not able to complete the questionnaire.

One of the major complaints were that some of the colors in the first game were too similar. Another complaint was that both of the games became too difficult in the end. Some of the participants mentioned that it would be better if the second game had a back button in order to see the objects in the game again if necessary. More interesting was that the many of the participant felt that music was too loud and was not in the background of the game which made the player lose focus.

4.2.2 Questionnaire Results

From the 14 participant that conducted the test, only 8 agreed to answer the questionnaire. The graphs below show the results of the questionnaire that the 8 participants from the test sessions answered.

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1 By observing the body language and listening to the comments from some of the participants, the conclusion was made that they were mentally exhausted.
Figure 8 displays the results of the responses regarding "The environment where I was playing the game made me feel comfortable" for both games. The chart shows which level of relaxation was mostly chosen by the participants and as seen in the chart, four of the participants were at level 3 at the relaxation level and felt almost comfortable while playing the game. This maybe because some of the participants had to play the game in a crowded environment while some participants played in better environments like in the comfort of their home.

![Chart showing relaxation levels for environment comfort](chart.png)

**Figure 8**  
Result for: "The environment where I was playing the game made me feel comfortable"

It should be noted that in figure 8, 13 and 15 the horizontal axes L# each represents a specific level. For example in figure 8, L1 means that the relaxation level for the participant is 1 which is low.

Figure 9 shows the results of the responses regarding “I enjoyed the game without feeling bored or anxious”. It can be seen that there is not much difference between the two prototypes mostly because both of the prototypes requires the player's full attention and engagement. Some felt more anxious while playing the first prototype. This is due to them being aware of the timer in the game.

![Chart showing enjoyment levels](chart2.png)

**Figure 9**  
Results for "I enjoyed the game without feeling bored or anxious"
Figure 10 shows the results of the responses regarding "The colors in the game made me less stressful" for both games. As can be seen there is a notable difference between the first and second prototype which suggests that the participants were more comfortable with the colors in the second prototype which used stress relieving colors. This may be in line with Walters et al.,(1983) hypothesis that some specific colors are more relaxing than others. Unfortunately this may not be 100% accurate due to not knowing if the results are statistically significant.

![The Colors in the Game Made Me Less Stressful](image)

**Figure 10**  Results for: "The colors in the game made me less stressful"

Here, figure 11 displays the results of the responses regarding "I felt that it was easier to remember the objects in the end of the game than when I started the game" for both games. The difference in this section (although not significant) is may be due to the timer from the first prototype. This can mean that the timer from the first game takes a lot of concentration from the player.

![I Felt That It Was Easier to Remember the Objects in the End of the Game Than When I Started the Game](image)

**Figure 11**  Results for "I felt that it was easier to remember the objects in the end of the game than when I started the game"
Figure 12 shows the results of the responses regarding "The interface made me feel comfortable". The chart shows that the participant felt more comfortable with the interface for the second game. This may be due to the use of a more calming background color, clearer shapes, more relaxing colors and better positioning of the shapes.

![The interface made me feel comfortable chart](chart12.png)

Figure 12  Results for: "The interface made me feel comfortable"

Figure 13 displays the results of the responses regarding "The timer made me feel more stressful". As seen in figure 13, more than half of the participants felt a degree of stress because of the timer. The rest of the participants did not feel the same level of stress, mostly because some of the participants had a very hard time concentrating and did not notice the timer at all. It should be pointed out that the participants that did not notice the timer had some kind of physical disability like hearing or vision disability.

![The timer made me feel more stressful chart](chart13.png)

Figure 13  Results for: " The timer made me feel more stressful"
Figure 14 displays the results of the responses regarding "I felt calm while I was playing the game" for both test games. Interestingly, Most of the participant felt that the second prototype was more calming and relaxing. This shows that many factors in the second prototype like the absence of a timer or more relaxing colors can have a direct effect the stress and anxiety level of the player. But unfortunately due to the low amount of participants, the results may not be accurate.

![I felt calm while I was playing the game](image)

Figure 14  Results for: I felt calm while I was playing the game

Figure 15 displays the results of the responses regarding "The music in the game made me less stressful" for both test games. It should be noted that three of the participant chose not to listen to music during the test, thinking the music made them lose their concentrate and become more stressful. Also for some participants, listing to music during the test made it more stressful, stating that it made them lose focus while playing the game. But overall, most of the participants that listened to music during the test session felt less stressful.

![The music in the game made me less stressful](image)

Figure 15  Result for: "The music in the game made me less stressful"
Figure 16 displays which type of music was mostly used by the participants. The chart shows that most of the participants chose not to have any music while playing the game and for those who chose to have music in the game prefer listing to jazz or classical music. These results are similar to Labbe et al., (2007) and Hebert et al., (2004) studies that suggest rock music that was played for the participants has less relaxing effect compared to classical music that was played for them. This means most of the participants felt that jazz and classical music were more relaxing than rock music.

It should be noted that after seeing the participants that were experienced with a computer did much better than those who were not experienced, the data was too important to go unnoticed. Most of the experienced participants felt more clam and that their memory skills slightly improved after doing the test by observing the amount of mistakes they made which was less than the mistakes they did in the beginning of the test, also in the questionnaire they stated that they felt it was easier to remember the objects in the end of the game than when they started the game. However their stress level was low while playing the second prototype considering that because the participants were more experienced, they also noticed the timer in the first prototype which made them more stressful. Figure 17 shows the summary of results for the questionnaire.
5 Conclusions

The purpose of this thesis was to explore the different aspects and factors for creating a suitable rehabilitation system for mainly elderly people using multimedia tools like video games which also at the same time reduce stress. However, in a longer perspective, such a system may also be relevant also for Alzheimer related difficulties. Two different game prototypes were developed for this project using the Gamemaker game engine. Both games shared the same rules and gameplay but with different features (visit table 1), both games were simple memory games in order to test and improve the player's cognitive skill. The differences between the two prototypes were that the goal of the first one was to increase the stress level of the player while the second prototype reduces the stress level, for more information about each prototype visit table 1.

The test was conducted on 13 participants but unfortunately due to restrictions, healthy elderly participants were used in the test. In the beginning of the test each participant was asked to play the first game (sometimes the second) and later was asked to play the second game. Each test took about 15 minutes to complete, during the playthrough the players actions and reactions was monitored. At the end of the test the players were asked to complete a questionnaire regarding the game.

5.1 Summary of results

As mentioned in the beginning of the article, the main question was if it was possible to create a home based rehabilitation system using video games to improve specific cognitive skills such as memory and reducing the stress level of elderly people as the same time? The results showed that the features used in the prototypes that increase and decrease the stress level were effective for example, the participant that noticed the timer was more stressful than the others and the music in the second prototype made the participants calmer. One of the main issues that prevented the players to feel relaxed was not being very experienced with a personal computer which suggest that older and less modern instruments and technology that are more common to elderly people should be used or modern technology should be used for future generations that have more experience with these kind of technology.

As mentioned earlier, finding participants for this study proved to be quite difficult and not all of the participants agreed to complete the questionnaire considering become tired and frustrated in a short amount of time. However the overall results indicate that the aspects and features used in the games have a direct effect of the stress and cognitive level for the player. Comparing with the pilot test which was a test on a younger group, the test session took much longer to complete and most of the participants were not even able to finish the game due to being tired during the test session. However in the end of each session, the participant's memory improved slightly. This may show that if one spends more time playing these kinds of games their cognitive skill would improve.

Almost all of the participants thought that the colors used in the second prototype were more calming. Also, those that decided to listing to music during the test felt less stress while the other participants decided not to have music in the game, stating that the music would make them more stressful. One of the interesting things is that while playing the first prototype, some of the participants did not notice the time thus did not felt more stress comparing to
the participants that noticed the timer. Although having more participants and more time for testing would generate better results and would make proving the hypothesis easier, overall the results shows interesting data can be used in similar and future works.

5.2 Discussion

For this study, some of the main plans had to be changed after considering some of the circumstances. For example, finding actual Alzheimer patient for testing proved to be very difficult considering the extreme situation they were in which meant that they would not be very responsive during the test sessions. Later it was decided to test the game on healthy elderly people. However this also proved to be a problem considering most of them were older than 75 years old had no experience with a computer which made the participants more stressful due to the lack of knowledge of modern technology and being worried that they would damage it in some way made them more stressful. On the other hand some of the participants were quite experienced with a computer and according to the results; they were the ones who did well on the test. Here we get to one of the important conclusions which is that most of the elderly people nowadays do not use any modern technology which will decrease the efficiency of rehabilitation systems similar to this study. However this does not mean that researchers should not conduct studies in this kind of area considering this generation that are quite skilled in using modern technology will perhaps need these kind of rehabilitation. Until then, we can to our best in improving the rehabilitation for future generations.

As mentioned in the result section, most of the participant preferred not to have any music in the game, when asked they said that it made them lose focus. It became obvious that the music was not adjusted in way that would be in the background, meaning that the music were too loud in volume which made them distracted.

While observing the test sessions it was clear that the resolution for the game was too small and the participant spent most of their energy trying to read the instructions and find the mouse arrow. This is important considering some of the participants had visual disabilities which made it difficult for them to play the game.

It should be noted that while talking to the participants and explaining the goal of the test most of them seemed very interested and more importantly, most of them have not ever heard of such types of game and rehabilitation techniques. For example one of the participants that lived in an elderly home, after finding out about that there were video games that could improve the cognitive skills, the participant wondered why the elderly home did not have these kind of games and wanted to know where someone can find and play them. This is very important because this kind of curiosity would suggest that if most of the elderly people were informed about these types of rehabilitation techniques, the demand for these kinds of system would likely grow and more time and recourses would be spent on improving them.

One contribution that this study might give to serious games and future studies is that if researchers plan to develop a similar rehabilitation system, they can have a better understanding of what kind steps they should take and what kind of features they should use in order to make the system more efficient. One of the most important steps to make an efficient system similar to this study is to keep the interaction with modern technology at a
minimum, especially if the rehabilitation system is targeted for Alzheimer's patients which are unfamiliar with modern technology.

5.3 Future work

It would definitely be interesting to continue this study and improve different aspects of the study. One of them is finding more people to participate in the test, after conducting the tests it was realized that in order to get better results it is vital that each of the participants have some experience with modern technology like a computer and should be very comfortable interacting with it. This means that not only more people should participate in the test, they also should be comfortable around modern technology. Also more time and test session are needed for each participant in order to observe the progress they have during the study.

Another aspect that should be improved is the amount of technology and devices that the participant should interact with. By observing the test sessions it was clear that most of the participant spent a high amount of energy in learning how the devices work and how to interact with them for example, using the mouse and trying to find the mouse arrow. A good way to achieve this is using a tablet instead of a computer which only requires the use of the player's finger.

Other features that can be improved in future works include bigger and better resolution, a better tutorial, more positive and negative feedback and including more music types.
References


Chen, S., Michael, D., 2006. Serious Games: Games that Educate, Train and Inform. Boston: Thomson Course Technology PTR.


## Appendix A - Questionnaire

Age:  
Sex: Male  Female

<table>
<thead>
<tr>
<th>Environment</th>
<th>Not at all</th>
<th>Below average</th>
<th>Average</th>
<th>Above average</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The environment where I was playing the game made me feel comfortable</td>
<td></td>
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<tr>
<td>First Prototype (Without music)</td>
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<tr>
<td>2. The colors in the game made me less stressful</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. I felt that it was easier to remember the objects in the end of the game</td>
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<tr>
<td>4. The interface made me feel comfortable</td>
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<tr>
<td>5. The timer made me feel more stressful</td>
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<tr>
<td>6. I felt calm while I was playing the game</td>
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</tbody>
</table>
Second Prototype (With music)

1. I enjoyed the game without feeling bored or anxious

Not at all  □  Below average  □  Average  □  Above average  □  Always  □

2. The colors in the game made me less stressful

Not at all  □  Below average  □  Average  □  Above average  □  Always  □

3. I felt that it was easier to remember the objects in the end of the game than when I started the game

Not at all  □  Below average  □  Average  □  Above average  □  Always  □

4. The interface made me feel comfortable

Not at all  □  Below average  □  Average  □  Above average  □  Always  □

5. The music in the game made me less stressful

Not at all  □  Below average  □  Average  □  Above average  □  Always  □

6. I felt calm while I was playing the game

Not at all  □  Below average  □  Average  □  Above average  □  Always  □

7. I chose this type of music

Jazz  □  Classic  □  Rock  □  No music  □

Because:

Additional Comments: