Abstract – This paper reports our work in designing and developing an android application (“Fight Alzheimer”) to help doctors in diagnosis and treatment of dementia and Alzheimer disease (AD). Historically, doctors examine the progress of their patients through games in a paper format. Although there is a huge number of such games, there isn’t a software application to help doctors in this regard. The application contains different games each of which helps a patient in different section of his mind which tends to be damaged due to the disease. The application can be used to keep the progress of the patient and help therapists to apply these games for his/her treatment.

Keywords— android application, dementia, Alzheimer disease.

I. INTRODUCTION

The term Dementia (originally meaning "madness") comes from the Latin de meaning "without" + mens from the genitive mentis meaning "mind". Dementia relates to the gradually decline of brain functionalities and it is a syndrome with a set of signs and symptoms rather than a single disease. It is incurable, and slowly interferes an unimpaired person's ability to carry out the normal daily tasks of beyond what might be expected from normal ageing.

The brain injury of a person with Dementia may be static or progressive which means that the symptoms will gradually get worse. Although dementia is far more common in the geriatric population, it can occur before the age of 65, in which case it is termed "early onset dementia". The affected areas by dementia can be memory, attention, language and problem solving. Normally, symptoms must be present for at least six months to support a diagnosis.[1] Cognitive dysfunction of shorter duration is called delirium.

Dementia can be classified as either reversible or irreversible, depending upon the aetiology of the disease. Its treatment depends on its cause and tries to treat the symptoms but it has no effect on the underlying pathophysiology. [2] Fewer than 10% of cases of dementia are due to causes that may be reversed with treatment. Until now no medications have been shown to prevent or cure the cases of most progressive dementias, including Alzheimer's disease. There are drugs that may improve the symptoms temporarily but not slow or stop the disease progression. The same medications used to treat Alzheimer's are among the drugs sometimes prescribed to help with symptoms of other types of dementias. Also, Non-drug therapies can also alleviate some symptoms of dementia. [3]

In 2010, was estimated that there are 35.6 million people with dementia worldwide will nearly double every 20 years, to an estimated 65.7 million in 2030,
and 115.4 million in 2050. Until then the 58% of people with dementia live in developing countries but this number will increase by 2050 to 71%. The fastest growth in the elderly population is taking place in China, India, and their south Asian and western Pacific neighbours. Finally, there are 7.7 million new cases of dementia each year, implying that there is a new case of dementia somewhere in the world every four seconds. [4]

Alzheimer’s disease (AD) is the most common non-cure form of dementia. It causes problems with memory, thinking and behaviour. It get worse as it progresses and eventually leads to death. Figure 1 shows the brain sections which are damaged by Alzheimer’s disease.

![Figure 1: Brain sections which are damaged](image)

Alzheimer’s disease is divided into four stages pre-dementia, early or mild, moderate and advanced (or severe)

1. Pre-dementia - At this stage there are the first symptoms which are mistakenly attributed to ageing or stress. These symptoms affect the most complex living activities [5] and the most noticeable is the memory loss as long as the patience has difficulties in remembering recently learned facts and learning new information.

2. Early or Mild –The increasing impairment of learning and memory at this stage helps doctor to diagnose the disease. During this face a small portion of patients have more problems with language, executive functions, perception (agnosia), or execution of movements (apraxia) than memory. Patients here, start to lose words from their vocabulary and have problems with oral and written language but they are capable of communicating basic ideas adequately. In most cases, at this stage people with AD don’t have problem with their mobility and if problems exist they are unnoticed. As the disease progresses, patients continue to perform many tasks independently, but may need assistance or supervision with the most demanding activities [6]

3. Moderate - At this stage the patient eventually being unable to perform most common activities of daily living. He has difficulties in speech as long as he is unable to recall vocabulary and frequently uses incorrect words. Also, reading and writing skills are also progressively lost. During this phase the person faces worsen memory problems. He is unable to recognise close relatives and the long-term memory, which was previously intact, becomes impaired. [6] Also, some behavioural and neuropsychiatric changes become more prevalent. The patients develop wandering, irritability and labile affect which leads to crying, outbursts of unpremeditated aggression, or resistance to caregiving. Approximately 30% of people with AD develop illusionary misidentifications and other delusional symptoms. Also, many of them lose their limitations (anosognosia) develop urinary incontinence and as a result, these symptoms create stress to relatives and caretakers [6]

4 Advanced or Severe – At this stage the patience is completely dependent upon carers as long as he/she is unable to perform even the simplest tasks without assistance. People with Alzheimer at severe stage loose the muscle mass and their mobility and as a result they are bedridden. They don’t feel the need for food or drink and there unable to feed themselves. As regards as the language ability of patient, is reduced to simple phrases or even single words. Gradually this situation drives to complete loss of speech. Nevertheless the patient can often understand and return emotional signals.

AD is a terminal illness with the cause of death typically being an external factor and not the disease itself. Some of these factors are inflection of pressure ulcers or pneumonia [6] Figure 2 shows the difference between a healthy brain and a brain with Alzheimer’s and the brain damage by Alzheimer’s disease during all stages.
II. THE BRAIN TRAINING AND STUDIES FOR THE ROLE OF COMPUTER GAMES

Studies show that exercise and other types of physical activity have many benefits because they help our hearts, waistlines, and ability to carry out everyday activities. Also, epidemiological studies and some intervention studies suggest that physical exercise may also play a role in reducing risk for Alzheimer’s disease and age-related cognitive decline. [7]

Animal studies in older rats and mice show that exercise increases both the number of small blood vessels that supply blood to the brain and the number of connections between nerve cells. Exercise raises the level of a nerve growth factor (a protein key to brain health) in an area of the brain that is important to memory and learning. Also, exercise can stimulate the human brain’s ability to maintain old network connections and make new ones that are vital to healthy cognition [7]

Except from exercise and physical activity it is very important for patients with dementia and more specifically for those with Alzheimer’s disease to stay cognitively active throughout life via social engagement or intellectual stimulation. Several observational studies show that social engagement through work, volunteering, or living with someone and mentally stimulating activities such as reading books and magazines, going to lectures and playing games keep the mind sharp and are associated with a lower risk of Alzheimer’s disease. [7]

Researchers believe that the computer games and programs aimed at increasing person’s mental activity and mental function, can be helpful in addition to the medications which are being used with the disease. It is very difficult for a person with Alzheimer’s disease to concentrate enough to remember for example to turn off the water or when was the last time that he prayed. As the dementia increases it is increasingly difficult for the patient and creates stress to him. So, playing games, causes the brain to have interaction and get excited with the thought of winning. Patients concentrate on games, the stress alleviated and hopefully they feel much better. [8]

People with Alzheimer disease exhibit diminished levels of dopamine, a neurotransmitter. Without dopamine, people aren’t able to learn properly. Disturbances in dopamine levels affect behavior, feelings, appetite, and memory. Current research indicates that altering the levels of dopamine in the body may alleviate some of the mood and emotional imbalances associated with Alzheimer’s. [9] There number of studies which have indicated that game-playing triggers the release of dopamine in the brain. In addition to the benefits of dopamine and game-playing, it has been found that a person who stays intellectually active can reduce the risk of Alzheimer’s by one-third. [9]

Studies have now shown that video games also improve visual skills, attention span and information processing time. One study, by Shawn Green and Daphne Bavelier at the University of Rochester, found that gamers consistently out-performed non-gamers on standard tests that measured these skills. [9] Playing computer games in later life may substantially cut the risk of dementia, according to a new study. Activities which exercise the brain, including reading novels and playing computer games, can have a protective effect on the mind and help prevent memory loss. "This study is exciting because it demonstrates that aging does not need to be a passive process,” said Dr Yonas Geda, a neuropsychiatrist at Mayo Clinic in Rochester, Minnesota. "By simply engaging in cognitive exercise, you can protect against future
memory loss." But she added: "Of course, the challenge with this type of research is that we are relying on past memories of the participants, therefore, we need to confirm these findings with additional research." [10]

The study comes after John Suchet, the newsreader, told The Daily Telegraph of his devastation since his wife, Bonnie, was diagnosed with Alzheimer’s three years ago and The findings will be presented at the American Academy of Neurology's 61st Annual Meeting in Seattle in April. It looked at the habits of 197 elderly people who suffered from mild cognitive impairment, or diagnosed memory loss, which can be an early warning sign of dementia, and 1,124 people with no memory problems. [10] All volunteers were between 70 and 89 years old. They were asked about their day to day activities within the past year and how mentally active they had been between the ages of 50 to 65. Those who kept mentally active in their middle age, through reading, arts and crafts and other pursuits, were about 40 percent less likely to develop memory loss than those who did not. Those who kept mentally active in later years cut their chance of developing memory loss by between 30 and 50 per cent. [10] On the other hand volunteers who watched television programmes for more than seven hours a day in later years were also 50 per cent more likely to have memory problems than those who spent less than seven hours a day in front of the box. [10]

"While Alzheimer's disease is a progressive degenerative condition, studies have shown that in the early stages, the brain is still able to learn and change. This indicates that increasing brain activity, especially in regards to memory and cognition, may help stave off cognitive loss in people with Alzheimer's," said James T. Becker, Ph.D., professor of psychiatry, neurology and psychology at the University of Pittsburgh, and a co-author on the study.

Dr. John Harrison, a psychologist in the Department of Medicine at Imperial College, London shared his theories on the topic at the Games for Health Europe conference in Amsterdam, according to Wall Street Journal report. [11] He thinks that using video games can be a very effective tool in helping to treat Alzheimer's and believes that games designed specifically for Alzheimer's patients may hold some promise in either treating the disease or slowing it down. Harrison said that these kinds of games could help in treating five different areas of brain function affected by Alzheimer's and they are: [11]

- **executive functioning** (the ability to work out a strategy),
- **working memory** (the ability to use information and skills you have stored),
- **attention and concentration**, **episodic memory** (the ability to recall an event) and **psychomotor skills** (how quickly you can respond to events).

A recent study at East Carolina University's Psychophysiology Lab has identified clear benefits to playing games, after reviewing the cognitive effects of gaming on dozens of people ages 50 and up. Preliminary results of the study show major improvements to mental acuity among the test subjects, who were exposed to 30-minute doses of games like Bejeweled and Peggle, then asked to complete parts A and B of the standardized Trail Making test (a version of which is available in Brain Age). Compared to the researchers' control group, these game-playing subjects exhibited an 87% increase in cognitive response time (the speed at which they complete tasks) as well as a 215% improvement to executive functioning (the frequency of completing those tasks correctly). [12]

"The initial results of the study are very intriguing, in that they suggest that the 'active participation' required while playing a casual video game like Bejeweled provides an opportunity for mental exercise that more passive activities, like watching television, do not," explained the program's director, Dr. Carmen Russoniello. [12]

Games for patients with dementia and Alzheimer’s disease must be simple and uncomplicated with few steps. Patients' cognitive abilities may be childlike but we must not treat them like children. Criteria for choosing brain game for patients with dementia and Alzheimer’s disease are [13]:

- Games must challenge the major cognitive functions language, memory, attention, visual spatial skills, executive function
- Games must offer variety and time constraints. They should challenge the patient to perform at his peak at all times, and they should be designed to emulate cognitive skills used in the real world.
- Games must meet patient’s demographic.
Games should be fun in order to enjoy patients and encourage them to continue practice.

People with any form of dementia including Alzheimer’s may be able to slow the progression of the disease by exercising their brains. According to Andrew Carle, a professor at George Mason University some good games for the brain as he considers are [14]: Crossword Puzzles, Word find games, Scrabble and other word games, Trivia games and other games to stimulate and exercise the brain such as Sudoku, checkers, chess, card games as solitaire, video and computer games.

III. “FIGHT ALZHEIMER” APPLICATION

There are two types of users associated with the application. The first is the doctor who plays the role of the administrator by registering another user (doctor or patient) to the application, managing the profile of his patients and viewing the statistics of patients. The second type of user is an elderly person with or without Alzheimer disease who has the option to view the instructions of each of the developed games, play a game and view his/her statistics.

The design is implemented on a mobile device for the reason of portability. As it mentioned, the role of games is very important as they increase person’s mental activity and mental function which can be helpful in addition to the medications which are being used with the disease. For that reason, it is preferable for a patient to play games in mobile devices because he/she can use them anytime and everywhere. In that way he/she has the opportunity to exercise his brain more and daily not only in his doctor’s clinic. The only thing that they have to do is to play without filling stress during the testing process. Considering the physical disability that can result from Alzheimer, it is also apparent that a choice of device that requires minimal effort be made. Touch screen devices have been found useful and easy to use by Alzheimer’s patients in early stage. The use of keyboard and mouse requires a lot of coordination which might be difficult or even impossible for some patients.

User centred design was used for the development of “Fight Alzheimer” application in order to ensure that the user’s needs and requirements are met. It involves an iterative process of going through design, prototyping and evaluation until a satisfactory design has been achieved. One doctor was involved to justify the requirements during the iterations. The final version of prototypes was implemented using Android development environment by using the Java programming language. In “Fight Alzheimer” application four different games were developed. Theirs description is given below.

Game1: Sort them (Figure 3) is a game based on speed and observation. The game consists of 4 modes which player has to play consecutively as different levels.

Figure 3: Sort them game

Its basic rule is simple: touch the numbers/letters in the appropriate order as fast as you can. Game modes: Numbers (The player has to touch the numbers from 1-25 as fast as he can), Letters (The player has to touch the letters from A-Y as fast as can.), Mixed (Firstly the player has to touch the letters (ascending order), secondly the numbers (ascending order) as fast as he can) and Calculator (The player has to calculate...
the number indicated at top right corner (using the numbers and the signs of the board e.g. 20 -- 2x10 or 15+5 etc.) If user doesn’t know what to touch (in any game level), there is an indicator at top of the board (hand) indicating the appropriate letter/number to touch.

**Game2: Word Finder** (Figure 4a), the aim of this game is to find as many hidden words as user can within two minutes! The words that user find must consist of at least 4 letters and certainly contain the central character (in any position). For each word which user finds, gets points depending on the size of the word, and wins an additional 15 seconds. If user finds all the words then go to next “puzzle” automatically getting extra points because he/she found them all, plus additional points depending on the seconds left over. If user gets stuck at some “puzzle” he/she has the opportunity to change it and go to another. He can make it up to 4 times. If user has found a 55% of words in PUZZLE, he can go to the next without any loss.

**Game3: Proverbs** (Figure 4b), game contains four possible answers. The user has to answer as many questions as he can, and collect as many points as he can. For each question he has 15 sec. The quickest rewarded with more points.

The program can be run on android enabled mobile device for the reason of platform independent and portability. It would be overly restrictive if the application can only be run on a single hardware implementation. Motorola, Sony, HTC, Samsung and Toshiba, some of most famous hardware manufacturers are releasing 100’s of android devices into the market due to its open source nature. The Android environment provides the opportunity to develop and test an application design on any android device or emulator without restrictions.

It is preferable for a patient to play games in mobile devices because he/she can use them at their own convenient time and locations. In that way a patient has the opportunity to exercise his brain more and daily instead of only in his doctor’s clinic. Playing at their own convenient time and location can make them without feeling stress during the testing process. Considering the physical disability that can result from Alzheimer, it is also apparent that a choice of device that requires minimal effort be made. Touch screen devices have been found useful and easy to use by Alzheimer’s patients in early stage. The use of keyboard and mouse requires a lot of coordination which might be difficult or even impossible for some patients.

**IV. EVALUATIONS**

Two expert-based evaluation techniques and user evaluation were used to evaluate the usability and usefulness of the application.

- Expert walkthrough is used to identify usability problems before the user evaluation in order to avoid significant bugs. Four HCI colleagues from the Computer Science department at the University of York volunteered to take part in the evaluation. The participants were briefed about the application and they used theirs android tablets to evaluate it. They asked to assess a found problem by giving a grade according to the severity of the problem. Participants were observed as they go about the evaluation. Behaviors and time taken to do some tasks was noted. The participants had a pleasant experience as they enjoyed the games. They found quite easily the navigation into the application and they grasped what was going on within a short period of time. So, they did not require much assistance. At the end of evaluation process each of them made a few observations and they had a discussion about them.
The overall feedback was satisfactory. All problems were fixed and ways to improve the application were identified.

- For the cognitive walkthrough evaluation three participants were carefully chosen and invited to perform it. All participants were Greek neurologists doctors specialized to Alzheimer disease with many years’ experience. Doctors performed the cognitive walkthrough evaluation at different times individually at their own clinics in Greece using theirs Android tablet. Before evaluation started, participants were reminded that the “Fight Alzheimer” application is intended for elderly people without diagnosed Alzheimer’s disease and patients at the first stage (Early or Mild) of the disease. The doctors were asked to sign an Informed Consent Agreement. A description of the application was given to evaluators along with some pre-designed tasks. All doctors reach the following remarks.

“Fight Alzheimer” application is a quite good transformation of paper based games to computer games. Undoubtedly it could be able to contribute to diagnosis of Alzheimer disease and replace the paper based format as it fulfills the brain criteria of good games but it needs time to be achieved. The reason for this is that elderly people, mainly in Greece where the evaluation was done, are not so familiar with this type of technology. So, it would be preferable if paper based tests and “Fight Alzheimer” application coexist for a few years. Also, doctors believe that playing games, causes the brain to be interacted and excited with the thought of winning. Patients concentrate on games, and therefore the stress is alleviated and they are expected to feel much better. Finally doctors highlighted that it is very difficult to conclude if “Fight Alzheimer” application could help in treatment of Alzheimer. That needs much more than 6 months in order to be tested with both diagnosed and not diagnosed with Alzheimer’s disease groups of people.

A user-based evaluation was also carried out in order to assess the usefulness of the application. Although the doctors who took part in cognitive walkthrough evaluation have patients with Alzheimer disease, only three were in the early or mild stage and they didn’t accept to take part in user evaluation. For this reason the “Fight Alzheimer” application was evaluated by 15 other elderly people (67-77 years olds) who are not diagnosed Alzheimer disease but with other brain problems. All of these people according to neurologists, are in Pre-dementia stage. All participants played the four games of the application. After the evaluation process they were asked to give their comments (describing what they are trying to do, why, what they believe is happening) about the application and answer to a 17-item questionnaire to measure the overall satisfaction.

The results are summarized as follows:

- The interface of application is easy and pleasant to use
- They can find theirs statistics easily
- They enjoyed playing each of the games and they would like to play again.
- The most difficult game for them was the Word Finder game.
- During the game they did not feel anxious or being tested.
- They prefer playing digital games rather than filling the paper based tests.

V. CONCLUSIONS

Alzheimer’s is the most common form of dementia and one of the most disabling afflictions among older people. Although Alzheimer’s is detected more often among senior citizens, individuals as young as 50 may show signs of Alzheimer’s. It holds no boundaries, it is located cross culturally and it is found in both sexes in equal proportions.

This project aims to create an android application with games for both doctors and patients. Its aim was to help in diagnosing and treatment of dementia and more specifically Alzheimer disease keeping the patient enthusiastic without the filling of being tested. The idea of “Fight Alzheimer” application was based on two things. The first was that in medical sector this type of application would be helpful. That’s because historically, doctors examine the progress of their patients through games in a paper format and there is no android application to help them in diagnosis and treatment of dementia and Alzheimer disease. So, this type of application will help them in this regard. The second was to prevent people with dementia and Alzheimer to develop depressive symptoms when realising that they are losing their minds gradually.

In general, the idea of transforming the paper-based tests for diagnosis and treatment of Alzheimer’s disease to an android application with games has been
realized and evaluated. The application could be used to improve the self-esteem, confidence and social interaction of patients. The demand of the type of applications remains great in order to make other types of disabled individuals benefit from it. We must not forget that Alzheimer and all diseases have no boundaries. All of us are possible patients in the future and all of them were like us someday!

VI. REFERENCES


