

Dementia-Related Serious Games: A Comparative Study

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Abstract: Dementia is a disease that adversely effects the cognitive functioning. Serious games for dementia (SG4D) have manifest the beneficial role in Health domain. Though, the SG4D discipline is yet unexplored and not fully categorized. As dementia is a sensitive issue, we aim to study the current literature including the usage of serious games related to dementia for providing guidelines to the researchers of this field. In this paper, we included articles on dementia related serious games having published, peer-reviewed results and being approved by experimental studies on dementia patients. This comparative study explored the serious games associated to dementia (Big Brain Academy, Complete Brain Workout, Lumosity, MasterQuiz, Wii Fit, Wii Sports, Posit Science, Smart Brain Games, Xavix Hot Plus.), in the context of platform, distribution, input method, targeted health area, targeted audience, health game category. This comparative study shows the positive side of such games in dementia care and motivate to continue development of serious games. If these games really do work in daily life, requires advance scientific research

Keywords: Dementia; serious games; comparative study; gamification; cognitive impairment; mobile game;

I. INTRODUCTION

Aging is a worldwide procedure that wholly creates go through and differs individually. In the ageing, the intellectual ability declines due to which, the capability to use stored and novel information depreciates [1]. One becomes visible to several diseases related with aging and one such disease is Dementia. Dementia is an incurable neurodegenerative disease [2] and it has currently affected estimated 47 million people globally, and this number is expected to rise to over 141.5 million by 2050 [3]. The word dementia is derived from the Latin term “dement-” which means ‘out of one’s mind.’ It indicates the conversion from a well standard of living to having debility in mental capacity severe enough to hinder daily life activities and is distressing for the victims as well as their families. [4] Dementia is identified by the presence of marked deterioration in the various zones of cognitive working, such as memory, visuospatial perception, conception, attention, learning capability, coordination, verbal abilities, reasoning, judgement and executive functions, which are related to social behavior, motivation and psychological symptoms (apathy or agitation) [5].

Dementia occurs as a result of devastation in the association among neurons. Once dementia is developed, it can’t be cure completely. Preventive measures (peculiar fitness routines and health maintenance) are essential in the approach to dementia in daily life.

Intelligence degradation and memory impairment can be averted by physical and intellectual activities. Lack of

activity, or boredom, is a problem reported for people with dementia both living at home and living in care services [6, 7]. Facilitating independent activity that is alluring, can be helpful to rise positive sentiments and lessening dullness [8]. Technology is progressively being used in prevention of dementia. In order to handover assistive technology to dementia people, touch screen is a more adequate format as dementia people are capable of operating them. The foremost concern is to determine the accessible and appropriate activities/apps on these touchscreen devices [9].

Video games are capable of developing new forms of conception and performance. Cognitive control in elderly people can be improved by video game training. Researchers are now exploiting the potential of video games in medical field [10]. Presently, the concept of integrating games with dementia care has given importance to advancement of serious games (SGs) particularly suitable for the evaluation and convalescence of older adults with dementia. Serious games (SG) – digital applications designed for a primary purpose (such as health care, informing, educating, and science) along with entertainment elements of typical games– are effectual means of conveying clear themes. Serious games are now generally known as auspicious non-pharmacological tools that are useful to evaluate patients’ functional deterioration, in addition to help the patients’ rehabilitation, assessment and stimulation [11].

Over the last 5 years, interest in such games has increased remarkably. There is a rapid growth in the world market of Serious games and is estimated to extent \$6,558.64 million in 2021, and expected to show a yearly growth rate of 18.27% from 2016 to 2021 [12]. Serious games for

dementia are divided into three main categories: physical, intellectual and social. There are various mediums (Desktop, mobile devices and gaming consoles) on which dementia games can be accessible [13]. Prefatory evidence have shown the beneficial influence of serious games and such games can efficaciously be utilized to develop the physical and intellectual potential of dementia people [14].

II. PROBLEM STATEMENT

Many serious games are developed that claim to be prevention of dementia related disorder (Dementia, MCI, AD), but most of them don't really address dementia disorder and they are just normal entertainment games. The problem is that gaming field related to dementia is still uncharted. As dementia is a serious and sensitive issue, we need those serious games that are supported by experimental studies. Stakeholders (Doctors, Caretakers and Public) related to dementia disorder are interested to know which game is just 'game for health' and which are dementia fighting tools so that they can play that and suggest them to patients for dementia treatment.

III. RESEARCH QUESTIONS

A. Questions related to Dementia Disorder

- What should be the situations for serious games to be used by dementia patients?
- For what motive was serious games preferred?
- Which types of platforms were used?
- Is there any evidence that dementia patients were capable to play serious games on touchscreen interfaces individually?

IV. METHODOLOGY

An organized comparative study was conducted on the usage of serious games for people living with dementia. We outlined the comparative study of dementia games in two phases:

1) to search the games that are related to category of general health and then find the dementia-related serious games among those games

2) Study these games to find the ones that provide an article which is published and addresses the health issues related to dementia.

A section "dementia games to be deliberated" (Section 4.1) is included, in which we reviewed games with auspicious capability but they are underrated due to deficiency of study on their efficacy for dementia patients.

The subsequent electronic databases were retrieved for the literature search, chosen due to their content being related to the discipline: Library database search, Google Scholar and Web of Knowledge search techniques, browsing over educational records comprising IEEE Xplore, Springer Link, ScienceDirect, and ACM Digital Library.

The following inclusion and exclusion criteria was used for articles: (1) Language: English; (2) Target People: dementia patients, and (3) Games: dementia related serious games.

Google search engine was used to search title of games related to dementia. The search of literature was led from February to April 2019.

V. LITERATURE REVIEW OF SERIOUS GAMES RELATED TO DEMENTIA

In this section, the literature review of serious games associated to dementia is discussed. Serious games that are related with the existing literature review are discussed in the Table 1. First of all, a little introduction of specifically chosen dementia games is presented. After that, the delivery, platforms and input approaches of those games is given in table 1. The column of "health game category" depicts the classification system of McCallum [15], in which he classified the games conferring to their effectiveness on the specific areas of mental health. McCallum in his study [15] classifies the games for health in:

- (1) games for mental health, which aim at the development of intellectual health,
- (2) games for physical health, which support physical strength,
- (3) game for social/emotional health, which embolden the users to interact with other people.

Further columns of table 1 are discussing the targeted health area, the type of study method, the quantity of sample used (N), the participant's health condition and the study period. All these aspects are discussed by means of published study on these games.

VI. DIFFERENT DEMENTIA GAMES

Game 1: Big Brain Academy

Big Brain Academy is a video game with no single game mechanism but the collection of puzzles that comprises of five different categories of quiz: Thinking, Analysis, Computation, Identification, and Memorization. The game has three modes: Practice, Test and versus. The time of each quiz is less than a minute. When you have taken a quiz, you will get the report regarding your brain's weigh, strength and weakness. It's a good game to improve your cognitive functionality [16].

A. *Game 2: Complete Brain Workout*

A collection 46 game brain workout games. It contains 40 mentally stimulating activities and these activities are further divided into five key areas of brain use: language, reasoning, three-dimensional, mathematical, and memory. Every activity is organized from simple to complex. It has six reward games. Games comprise number recall, stepping stones, boxes, linker, path finder, and spider Web [17].

B. *Game 3: Lumosity*

Lumosity is a free brain training platform contains puzzle games that claim to recover memory, attention, flexibility, processing speed, and reasoning. Over 91 million general public are playing lumosity worldwide. Lumosity offers 40 games design of educational games for adults. The games are speedy and simple, but entail huge attention to master [18].

C. *Game 4: MasterQuiz I*

It's a video game that is specially designed for people with mild dementia. This game has the elements of reminiscence therapy. It can be played on tablets. It's a quiz-based game in which an image is shown to the player on the left side of screen and multiple text-based choices on the right side of screen from which the player has to choose related to the image. It helps player in memorizing element of brain [15].

D. *Game 5: Min Wii (MINDs)*

It's an on screen controller game, in which player move on balance board. It includes 41 different tasks and trainings, comprising yoga, strength exercise, calisthenics, and stability games. It contains tasks of every kind for everyone, whether if anyone wants to do yoga or snowboarding. It involves the body movement of player for completing different challenges, so player have to get out of couch and do some action [19].

E. *Game 6: Posit Science*

Posit science is an online brain training game whose advantages has been approved by more than 100 published research papers in the field of neuroscience and brain health. It has 30 exercises that targets the cognitive functions like retention, responsiveness, intelligence, brain quickness and navigation. Each task of this game take less than five minutes and after each task player get the feedback about the performance compared to previous performance. The specialty of this game is that player can create his/her own task by selecting exercises and trainings according to player peculiar interest, temper and timetable [20].

F. *Game 7: Smart brain Games*

Smartbrain Games is a modern interactive brain training program to keep fit your brain, whichever your age, that helps you to work-out and strengthen all your mental skills in order to prevent their loss and to maintain your independence, autonomy and quality of life for long. Smartbrain Games can be used online, with any PC, tablet or smartphone; or. It can also be play offline by installing it in a computer with the help of a CD-ROM. It contains over 28 puzzle games with over 650 tasks to train attention, reasoning, memory and concentration. All levels are designed to give you more cognitive skills bit by bit. Each completed level gives you point. Each level take around 1 minute of your time so you can easily fit it into your daily routine [21].

G. *Game 8: Wii fit*

This game can be played on Wii game video console which involves the Wii Balance Board. The Wii balance board is outlying podium on which player stands throughout playing the game and this board identify COB (center of balance) and weight of the player. This is an exercise game and consists of more than 50 tasks specifically developed for the physical workout of the player comprising aerobics, yoga postures, balance trainings and strength exercise. The main aim of these tasks is retaining COB and refining pose [22].

H. *Game 9: Wii sports*

This game consists of virtual reality of five sports (comprising golf, baseball, boxing, bowling, and tennis) and can be played with the help of Wii remote which exhibit the motion-sensing competencies and simulator the factual movements executed in sports like swaying the golf stick. The game has basic procedures to be manageable for every first-hand player and also has a capability of fitness approaches that indicates the improvements of player in the sports [23].

I. *Game 10: Xavix Hot Plus*

A fitness-based video game console . The console uses wireless controllers. The controllers are made as the design of sports apparatus such as baseball sticks or tennis bat. The actions of players are shown on the television screen with the help of sensors used in the controller [24].

VI A. More Dementia Games to be Deliberated
Accompanying the literature review of serious games related to dementia, here and now we will enlist those serious games in this part of paper, whose developers have declared the auspicious capability of the games, but those games have not yet assessed by research, to analyze the efficiency of those games on victims of dementia.

By taking the foundation of foregoing outcomes of the research study of Kawashima et al. [25], a brain training

game was developed by Nintendo named as ‘Brain Age’ [26]. In his study [25], he observed the influence of reading audibly and reckoning estimation on aged persons with dementia disease. Kawashima and his group analyzed the intellectual level of aged dementia victims, by and by training of six months, through two generally used assessments for treating dementia: 1. Frontal Assessment Battery (FAB), 2. Mini-Mental State Examination (MMSE). Participants (dementia patients) of this training came out to be further talkative, corresponsive and individualistic by sustaining their MMSE, and upgrading their FAB notch.

KiMentia, proposed in the research paper of Breton et al. [27], is a Kinect-based Windows software which was created for dementia patients for the improvement of their intellectual incentive. The aim of software is on beneficial characteristics of both intellectual and physical incentive by letting the user to accomplish conceptual and physical tasks altogether. Seven professionals (three psychologists and four physiotherapists) participated in the simple individual discussion on the approval of using kiMentia for treating dementia and the outcomes of review article were progressive.

By means of serious games as an exemplar of satisfying method for treating dementia, the scheme of ‘eMotiva’ developed a number of reasoning games for dementia patients, endeavoring to arouse multiple of intellectual developments (memory, perception, logic and reasoning), for retaining the enthusiasm of dementia patients [28,29].

An untitled cooking game suggested by Imbeault and Bouchard et al. [30, 31], is a serious game proposed especially for curing dementia. The model of the game has been created in the study of Imbeault and Bouchard et al. The game is utilizing the benefits of artificial intelligence methods to generate the manageable means for mental exercise and permitting assessment of users’ mental improvement within the game.

A learning game by Ijisfontein named as Into Dementia, is the latest progress in the gaming field of dementia. This game utilized the feature of virtual reality in which dementia patients’ world is simulated in the collaborative place and the user is capable of understanding the boundaries and complications in the everyday routine of dementia victims [32]. It has platform of visualization and it happens privately in a custom-made van especially designed for it. The purpose of this game is to arouse compassion for dementia patients and to give information to the normal persons about the complications that these patients have to cope with.

VII. THE SG4D CLASSIFICATION

The classification of dementia-related serious games presented in this paper, is created only on classification types of dementia. The taxonomy of serious games for dementia is founded on different areas and causes of health related to dementia. We also explored the types of dementia games’ users, to whom these games influence, presented in fig.1. , using the circuit diagram method. Dementia games

have the ability to execute more than on health processes and roles concurrently.

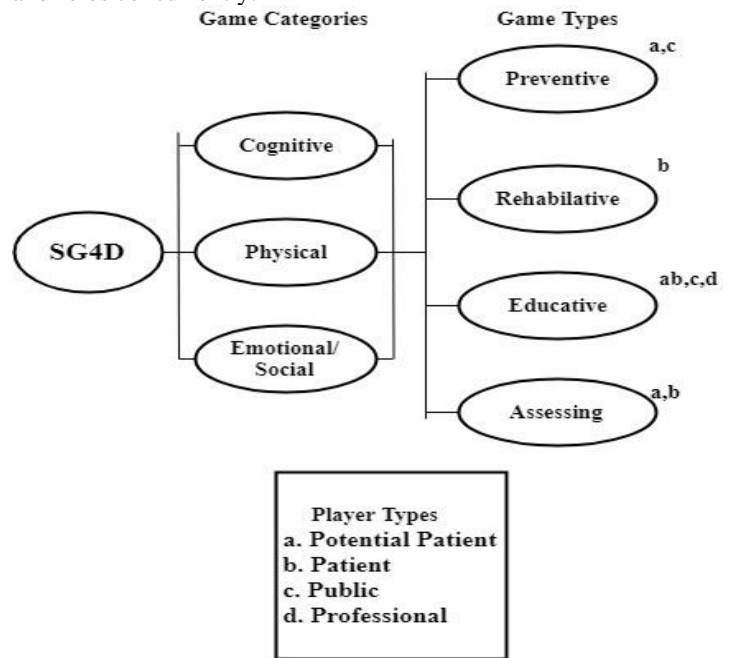


FIGURE 1. THE CLASSIFICATION OF DEMENTIA-RELATED SERIOUS GAMES.

VII A. Towards the SG4D Classification, Classified Groups, Characters and Terminology

With the idea of classification of ‘games for health’ introduced by McCallum[15], the extensive classification kind of the proposed classification is linked with the health processes of dementia on which these serious games influence. Hence, the part of the classification with the greater priority is the “game classification” distributing games into (1) games for mental health, which aim at the development of intellectual health, (2) games for physical health, which support physical strength, (3) game for social/emotional health, which embolden the users to interact with other people.

From the study of Sawyer and Smith [40] and Sawyer [41], the terminology on the classification of ‘games for health’ lead to further classification. Therefore, the four further kinds of serious games can be: (1) preventive, these games used to make the dementia patient energetic and also helps in reducing the indications of dementia; (2) rehabilitative, these games have healing feature and also reinstate the health of users; (3) assessing, these game gives information to the users regarding their health condition; (4) educative, these games deliver information to the users about the condition of dementia patients or problems that the victims have to face in everyday life tasks.

The fundamental of this classification is from two point of views, according to the above-mentioned two essential features associated to games (game kinds and game category). On the other hand, the exploration of players is a valuable demonstration about the relation of people and dementia. Thus, fig.1. comprises the classification of ‘kinds

of players’, as an important facts, which is examined in section 6.2.

VII B. Category of Health Users Associated to Dementia

We have explored four kinds of people for this classification that have link with dementia games, according to their association with the dementia illness:

- *Professionals*: the kind of people who are not the victims, but due to their professionalism (helpers, expert consultants, educational investigation), they have to deal with dementia,
- *Public*: the people who have no direct association with dementia,
- *Patients*: the kind of people who are the victims of dementia,
- *Potential Patients*: the kind of people who are not yet victims of dementia but their health condition is serious.

VII C. IMPLEMENTING THE PROPOSED CLASSIFICATION

TABLE 1. Implementing classification on elected dementia games

Game Types / Game Categories	Preventative	Rehabilitative	Educative	Assessing
Cognitive	- Brain Age - Big Brain Academy - Lumosity - CogniFit - Smart Brain Games - Posit Science	-Master Quiz -Minwii -eMotiva -Cooking games	-Into D' mentia	N/A
Physical	-WiiFit -Wii Sports	-Minwii -eMotiva	-Into D' mentia	N/A
Social/ Emotional	-WiiFit -Wii Sports -Big Brain academy	-eMotiva	-Into D' mentia	N/A

This table outlines the uses of the fundamental classification (fig. 1) on the games previously mentioned in Table1. The class of 'kinds of players' (fig. 1 and section 6.2) have the ability to be reliably implemented to the game taxonomy in Table 2, based on their kind (for example, the game 'MasterQuiz' because of its rehabilitative nature can only be played by patients).

VIII. CONCLUSION

This study gives an outline of dementia games and the comparative view about the efficiency of these games. The foremost idea of our study is that serious games have an influence on mentally weakened persons. To explore further about the ongoing influence of these games to the everyday tasks of life, is the deal of scientific research. In the period of searching literature for the dementia games, we explored several field of health that involved the several participants associated to domain of dementia games. Due to the consequence of this connections, we have made a classification about dementia games. By the foundation of existing research on aforementioned information, aided us to make a full classification scheme that emphasizes more on the "games for health" field.

This classification is helpful to be assessed be the professional scholars of the specific domain, having aim of making a shared, modernized and authenticated program, generating a collaboration among designers of game and dementia experts. The vital aim is to propose a classification of serious games for dementia with analytical capability, targeted to offer quality analysis for any other game to be developed.

TABLE 2. COMPARISON TABLE OF DEMENTIA RELATED GAMES

Title of Games	Gaming Platform	Distribution	Health Game Category	Input Method	Targeted Health Area	Type of Study	N	Participants' Health Condition	Study Period	References
Big Brain Academy	Nintendo Wii, Nintendo DS	Commercial	Cognitive	Wii mote & Movement(Wii), Controller(DS)	Behavior	controlled Trial	40	AD	10 weeks	[25]
Complete Brain Workout	Computer	Commercial	Cognitive	Type & click	Psychology	N/A	50	MCI	10 weeks	[26]
Lumosity	Computer, Mobile	Commercial	Cognitive	Type & click(Computer), Tap(Mobile)	Psychology	Controlled Trial	60	Dementia	10 weeks	[27]
Master Quiz	Tablet PC	Academic	Cognitive	Tap	Cognition	Usability Study	N/A	MCI	5 weeks	[28]
Min Wii(MINDs)	Computer	Academic	Emotional	Wii mote & Movement	Motor Skills	Pilot Study	10	MCI	8 design cycles	[29]
Posit Science	Computer	Commercial	Cognitive	Type & click	Response	Pilot Study	30	Dementia	6 sessions per week for 8 weeks	[30]
Smart brain Games	Computer	Commercial	Cognitive	Type & click	Cognition	Pilot Study	40	AD	1 session per week for 6 weeks	[31]
Wii fit	Nintendo Wii	Commercial	Physical	Wii mote & Movement	Balance	Pilot Study	20	AD	10 weeks	[32]
Wii sports	Nintendo Wii	Commercial	Physical	Wii mote & Movement	Motor Skills	Pilot Study	15	MCI	200 gaming hours in 12 weeks	[33]
Xavix Hot Plus	XaviXPORT console	Commercial	Physical	Controller & Movement	Cognition	Controlled Trial	5	Dementia	4 sessions per week in 6 weeks	[34]

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