

# A Taxonomy of Serious Games for Dementia

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**Abstract.** Serious games for dementia (SG4D) hold their own, unique and significant space within the Games for Health domain. However, the SG4D field still has not been fully mapped out and classified. In this work, we present a generic taxonomy of serious games for dementia, based on the health functions and the health purposes they serve. Firstly, we classify dementia games based on the health function they serve, in: cognitive, physical and social-emotional games. Each of these functions serves a variety of health purposes, leading us to a second, lower level of classification in: preventative, rehabilitative, assessing and educative games. Furthermore, we provide an ex-post evaluation of the proposed taxonomy by exploring whether the existing serious games for dementia can be validly classified, based on the proposed taxonomic characters. To this end, we collect and analyse a set of dementia-related serious games (e.g. WiiSports, Big Brain Academy, Cognifit, MinWii, et al.) by performing a literature review. The results show that the taxonomical system covers a sub-field of “games for health” and indicates areas which are under-explored by current games.

**Keywords:** Alzheimer’s disease; dementia; mild cognitive impairment; serious games; taxonomy;

## 1 Introduction

Video games can be developed for the purpose of changing player’s attitudes and behaviours, being both an expressive and a persuasive medium [13, 15]. With a persuasive strategy in consideration, for purposes other than pure entertainment, the long existing field of “serious games” has found broad application in the video games industry, attempting to educate, train, and inspire the players [28, 32, 36].

One of the key areas of application of serious games is the health domain, targeting changes in health-related behaviours. Games for Health (G4H) provides opportunities for players to improved rehabilitation, disease prevention, assessment, diagnosis and education/training [14, 30].

Within the wider health area, there are areas with particularly strong game development activity. One of these is the issue of dementia. Part of the motivation for research in this area is the current and predicted increases in the cost of dementia, both to the social welfare system, and to the wider fabric of society (Norwegian Ministry of Health and Care Services 2007, McCallum 2012) [26, 22].

However, the serious game for dementia (SG4D) field still has not been fully mapped out and classified. Sawyer and Smith [31] imply the need for top-down

game taxonomical approaches (“You can’t have a serious Serious Games Taxonomy without developing a taxonomy of all games”). The fact that an all-games taxonomy, a serious games taxonomy, and a G4H taxonomy have already been presented [31], opens the way for focusing on more specific parts of the G4H domain. The SG4D field, a part of the G4H domain, contains enough games and research studies and it is mature enough for analysis as a clear and *consistent* taxonomy, which could be further utilised for obtaining *predictive* abilities over the efficacy and efficiency of SG4D.

### 1.1 Contribution & paper organisation

In this paper, we present a new taxonomical scheme for serious games for dementia and we apply it on existing systems for evaluation purposes. The contribution of this work is to:

- present a generic taxonomy of serious games for dementia, based on the health functions and the health purposes they serve.
- present an up-to-date review of dementia-related serious games (i.e. games targeting dementia, Alzheimer’s disease, or Mild Cognitive Impairment), accompanied by their related research studies and classify them according to the proposed taxonomy for evaluating its validity.
- acquire an overview of the SG4D field - based on the proposed taxonomy and the literature review of dementia games - thus identifying the fields problems and potentials.

The rest of the paper is organised as follows. Section 2 examines the related work and Section 3 describes the motivation behind this study. Next, Section 4 describes the proposed taxonomy, Section 5 presents the application of the proposed taxonomy to existing dementia-related game titles and discusses the observations that came out of the application of the taxonomy. The paper concludes in Section 6.

## 2 Related Work

The work of Sawyer and Smith on serious games’ taxonomies [30, 31], under the Serious Games Initiative and Games for Health Project, is of significant value for the scope of this study. Sawyer and Smith in [30, 31] present a games-for-health taxonomy (Fig. 1) based on the type of health uses the games have and the stakeholders they involve. We also extend the work of McCallum [22], categorising the games for health according to the health area that they affect. Finally, our previous work on reviewing the existed dementia-related game titles and the research studies that accompany them [23], provides the basis for the ex-post evaluation of the proposed SG4D taxonomy. In [23], we presented a total of 12 video games targeting dementia-related health problems (dementia, Alzheimer’s disease, and mild cognitive impairment), all of them supported by published, experimental studies.

	Personal	Professional Practice	Research / Academia	Public Health
Preventative	Health Assets: PERMA, Exergaming, Stress, Nutrition	Patient Communication	Data Collection	Public Health Policy & Social Awareness Campaigns
Therapeutic	PT/OT Sensorimotor Rehabilitation Disease Management	Pain Distraction CyberPsychology Disease Management	Virtual Humans	First Responders
Assessment	Self-Ranking	Measurement	Inducement	Interface/Visualization
Education & Training	First Aid, Patient Education Health Literacy	Skills / Training	Recruitment	Management Sims
Informatics	Personal Health Record (PHR)	Electronic Medical Record (EMR)	Visualization	Epidemiology
Production	Personal Data Collection Quantified Self	Biotech Manufacturing & Design	Biotech Manufacturing & Design	Large-scale Data Collection & Monitoring

**Fig. 1.** The Games for Health Taxonomy developed by the Games for Health Project [30].

### 3 The motivation for the SG4D taxonomy

The SG4D is a gaming field of high significance, due to its serious target. The variety of the SG4D game titles and the various health purposes they serve make the need for a classification scheme imperative. The motivation for proposing the SG4D taxonomy is twofold:

- to establish a classification scheme within which the position and, thus properties, of games relative to one another can be understood, and
- to act as a foundation for constructing a SG4D field knowledge base as part of the SG4D design and development process.

More specifically, since SG4D target specific types, stages or symptoms of the dementia disease and they also fulfill various purposes, their classification is of great significance for having a clear understanding of how the games and their properties are related to one another. Furthermore, a clear taxonomy on the field of serious games for dementia will stand as an assistive tool for SG4D developers by enabling them to focus on a specific, distinct research areas and target more accurately the dementia-related purpose that are trying to achieve.

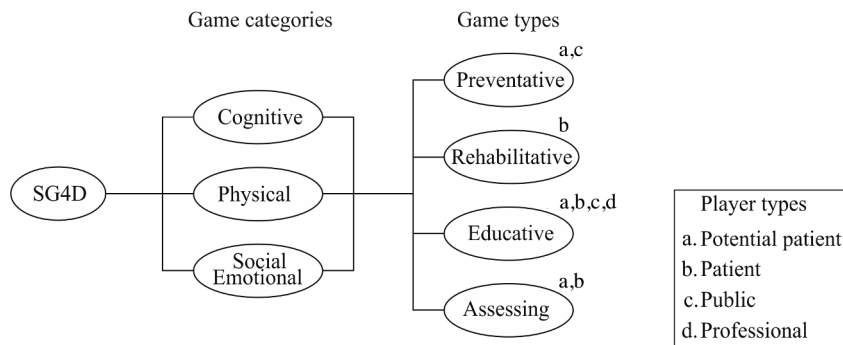
Therefore, the motivation behind developing the current taxonomy further requires that it satisfies three distinct characteristics: *validity*, *consistency* and *predictive power*. The validity element allows the taxonomy to be an acceptable and accredited tool for the researchers and the game developers community. The consistency of the proposed taxonomy will offer high taxonomic resolution and comparability of game datasets [7]. Finally, the predictive power of the taxonomy, given that a game  $A$  belongs to taxon  $x$  in category  $y$ , will allow us to infer that  $A$  has a set of  $X$  properties [9].

The validity and the consistency of the proposed taxonomy will be ensured by providing an ex-post evaluation of the proposed taxonomy based on the existed game titles (in the current study) and by collaborating with expert researchers from the “games for health” field for further evaluation. The predictive power will

be assessed by documenting the correlations between the dementia game traits and their effectiveness' traits, as part of future work which will be based on the current preliminary study. The process will require breaking down each game into its attributes, and extracting the various aspects of the effects on patients. Having created a finer grained matrix of potential relationships, we will be able to examine their relationship, thus creating a potential training set for providing attribute predictions for instances/new SG4D titles that enter the system.

## 4 The SG4D taxonomy

The proposed taxonomy of SG4D is built on purely dementia-related taxonomic characters. The classification of dementia games is based on the dementia-related health areas they affect and the health purposes they serve. At the end of the proposed taxonomy we identify the user groups affected by the dementia-related games to provide a clearer overview of the health impacts. Schematically, the proposed taxonomy of serious games for dementia is shown in Fig. 2, following a circuit-schematic approach. A serious game for dementia might perform more than one health functions and also serve more than one health purposes simultaneously.



**Fig. 2.** The taxonomy of serious games for dementia.

### 4.1 Towards the SG4D taxonomy, taxonomic categories, characters and nomenclature

Dementia is a disease that affects the cognitive, physical and emotional abilities of the patients. The most common symptom of dementia is impaired memory, however it also results in impairments in thinking, communication, orientation, and coping with everyday tasks. Other symptoms are personality changes, anxiety, depression, suspiciousness, delusions and compulsive behaviours [26].

With this in mind, and based on the categorisation of health games presented by McCallum in [22], the broadest taxonomic category of the proposed taxonomy is associated with the dementia-related health function that the SG4D affect.

Therefore, the upper “layer” of the proposed taxonomy is the “game category” dividing games into *cognitive games*, i.e. games that trigger the cognitive and mental abilities of the player; *physical games*, i.e. games that are developed for physical health, promoting physical activity; and *social-emotional games*, i.e. games that encourage players to link with their friends, providing shared experiences and discussion opportunities which enable the development of a sense of community.

Each of these dementia-related health functions/game categories serves a variety of health purposes. From a gaming point of view, we refer to this taxonomic category as the “game type” based on the nomenclature on the games-for-health taxonomy of Sawyer and Smith [31] and Sawyer [30]. Consequently, the SG4D can be *preventative*, i.e. games that keep the player physically, cognitively and/or emotionally active and slow down dementia’s symptoms; *rehabilitative*, games that have therapeutic functionality and restore player’s/patient’s health; *assessing*, i.e. games that provide direct and accredited health data to the player about his/her health status; and *educative*, i.e. games that educate the player about the dementia disease, raise awareness or train the player to cope with dementia-related situations, thus containing informational and/or training aspects.

The core of the proposed taxonomy is two-dimensional, based on the aforementioned two intrinsic game-related characteristics (game categories and game types), however the identification of the SG4D health user groups/players is a useful representation of how the SG4D are connected with society and the disease itself. Therefore, Fig. 2 includes the “player types” categorisation, as an extra layer of significant dementia-related information, on top of the proposed taxonomical scheme. This categorisation is analysed further in Section 4.2.

## 4.2 Dementia-related health user groups

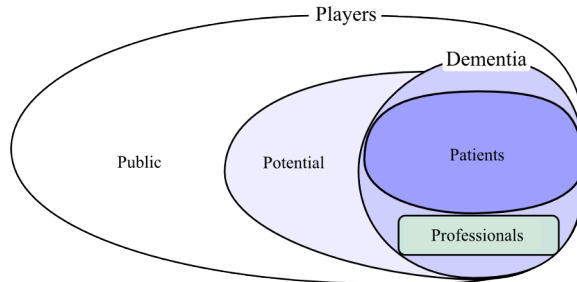
In our attempt to classify the SG4D based on dementia-related criteria, the need of identifying the health user groups that are affected by SG4D has emerged, in order to explore a more user-centric focused approach for the proposed taxonomy. The health user groups are categorised based on their relationship with the dementia disease and they are presented as the “player types” of SG4D.

There are four player types:

- *potential patients*: people who have not had a dementia-related diagnosis but their health status is at a critical point,
- *patients*: people who have been diagnosed with some type of dementia,
- *public*: meaning the part of the population who does not have a first hand relationship with dementia, and
- *professionals*, i.e. people who are not patients themselves but whose lives are directly affected by dementia in a professional way (e.g. academic researchers, professional practitioners, public health workers and caregivers).

The relationship of each player type with the dementia disease is visualised in Fig. 3. This diagram emphasises the distinction between the first hand experiences (patients and professionals) and second hand experiences (general public and potential patients).

The categorisation of the player types derives from the generic categorisation of healthcare stakeholders, presented by Sawyer and Smith in [31] and Sawyer in [30] (Fig. 1), having undergone a number of adjustments to fit the dementia-oriented nature of the study.



**Fig. 3.** The proposed player types and their relationship with the dementia disease.

## 5 Applying the proposed taxonomy

To assess the practical value and validity of the proposed taxonomy, we turn our attention to its application to existing systems. In essence, we are interested in exploring whether the existing serious games for dementia can be validly classified, based on the proposed taxonomic characters. To this end, firstly, we collected and analysed a set of dementia-related serious games by performing a literature review [23]. The methodology for developing the dementia games literature review can be summarised in two stages:

1. Scan the games which have been associated with general health and filter those to extract the dementia-related game titles.
2. Narrow these games down to the ones that present a documented, peer-reviewed, and published effect on dementia-related health issues.

The motivation for the second stage is that we are dealing with a sensitive and serious health issue and the reviewed game titles have to be accompanied by credibility and validity. For a publication to pass stage 2, it has to be peer-reviewed, published and to examine the efficacy of a video game on dementia, MCI or Alzheimer’s disease patients. We include a “games to be considered” section (Section 5.1), which includes games with promising potential but that lack studies supporting their effectiveness on players [23].

The reviewed publications were collected during November and December 2012 via a library database search, Google Scholar and Web of Knowledge search tools, scanning through academic databases including IEEE Xplore, ACM Digital Library, ScienceDirect, and Springer Link. The keywords used were [“dementia” or “mild cognitive impairment” or “Alzheimer”] and [“serious games” or “video

games”]. Furthermore, the Google search engine was used to find commercially available cognitive training game titles.

Table 1 presents the games that are associated with the dementia games literature review. It contains a short description of each game, general information, as well as the supported gaming platforms and input methods. The final column presents all the related research studies [23].

### 5.1 Dementia-related games to be considered

Supplementarily to the literature review, we covered those dementia-related games, which present promising potential, however they have not been evaluated by studies, testing their effectiveness on dementia-related patients [23].

The brain training game *Brain Age* by Nintendo was developed based on the previous findings of the study of Kawashima et al. [18], which examined the effect of reading aloud and arithmetic calculation on elderly people diagnosed with dementia.

*KiMentia* is a Kinect-based Windows application, developed to help cognitive stimulation for individuals with dementia and presented in the study of Breton et al. [5]. The tool focuses on therapeutic aspects of both cognitive and physical stimulation by allowing the player to perform mental activities and physical exercise at the same time.

Using the paradigm of a serious game as a therapeutic tool for dementia, the *eMotiva project* introduces a collection of cognitive games for dementia, attempting to stimulate different cognitive processes such as memory or attention, trying to keep the patient motivated at all times [2, 6].

Another serious game, specifically designed for treating dementia/Alzheimer patients is an *untitled cooking game*, proposed by Imbeault and Bouchard et al. [3, 17] where a prototype has been developed, taking advantage of artificial intelligence techniques to create an accessible tool for cognitive training and allowing in-game estimation of the patient’s cognitive performance.

A recent development in the dementia gaming area is the educational game *Into D’mentia* by Ijsfontein. The game consists of a physical, interactive space where the world of a person with dementia is visualized using Virtual Reality and players are able to experience the limitations and obstacles that a dementia patient faces on his/her daily life [16]. The game uses a simulation platform and it takes place inside a specifically customised truck. The goal of the game is to stimulate empathy for people with dementia and to raise awareness for the difficulties faced by these people.

Table 1. The games of the dementia games' review.

Game Title	Game description	Platform	Distribution	Input method	Dementia-related studies
Big Brain Academy	A puzzle video game by Nintendo, testing the player's mental acuity in a five-category quiz: thinking, memorization, computation, analysis, and identification.	Nintendo Wii, Nintendo DS	Commercial	Wiimote & movement (Wii), Controller (DS)	[11]
Complete Brain Workout	A collection of brain training games by Oak Systems, with 40 activities to stimulate and exercise the brain in an entertaining way.	Computer	Commercial	Type & click	[33]
Lumosity	An online brain training platform using personalized training to harness brain's neuroplasticity.	Computer, Mobile	Commercial	Type & click (Computer), Tap (Mobile)	[12, 8]
MasterQuiz	A tablet-based reminiscence game for mild dementia patients. The core of the game is a quiz with an image displayed on the left and text-based answers on the right.	Tablet PC	Academic	Tap	[22]
MinWii (MINDs)	A serious video game targeting Alzheimer and demented patients, working as a simple music therapy tool, which allows the player to improvise or play predefined songs on a virtual keyboard.	Computer	Academic	Wiimote & movement	[4]
Posit Science	Cognitive training gaming software that effectively address cognitive issues related to healthy aging as well as a broad range of other conditions.	Computer	Commercial	Type & click	[1, 29]
SmartBrain Games	A collection of brain training games by Educamigos, for youngsters, adults or seniors, to exercise the intellectual skills and to prevent their loss in a practical and entertaining manner.	Computer	Commercial	Type & click	[34]
Wii Sports	A sports game by Nintendo, which is actually a collection of five sports simulations: tennis, baseball, bowling, golf, and boxing.	Nintendo Wii	Commercial	Wiimote & movement	[19, 10, 37, 35]
WiiFit	An exercise game for the Wii console, with more than 40 activities and exercises, including strength training, aerobics, yoga and balance games.	Nintendo Wii	Commercial	Wiimote & movement	[27]
Xavix Hot Plus	A collection of twenty-four physical/sport games, offering rehabilitation support to the elderly.	XaviXPORT console	Commercial	Controller & movement	[38]



## 5.2 Categorising the selected games

Table 2 presents the application of the core proposed taxonomy (Fig. 2) on the games described in Table 1. The player types categorisation (Fig. 2 and Section 4.2) can be consistently applied to the classified games of Table 2, according to their types (e.g. the game Brain Age, being of preventative nature, can be played by potential patients and the public).

**Table 2.** Applying the proposed taxonomy.

Game Categories \ Game Types	Preventative	Rehabilitative	Educative	Assessing
<b>Cognitive</b>	- Brain Age - Big Brain Academy - Lumosity - Posit Science - CogniFit - Complete Brain Workout - SmartBrain Games	- MasterQuiz - MinWii - Cooking game - eMotiva	- Into D'mentia	N/A
<b>Physical</b>	- WiiFit - Wii Sports	- MinWii - eMotiva	- Into D'mentia	N/A
<b>Social/ Emotional</b>	- WiiFit - Wii Sports - Big Brain Academy	- eMotiva	- Into D'mentia	N/A

## 5.3 Observations made from applying the proposed taxonomy

After applying the proposed taxonomical system on the existing research-supported dementia game titles, we can reach some interesting conclusions about the form of the SG4D field, as well as about the performance of the proposed taxonomy. At first glance, it is obvious that the majority of the existed dementia-related game titles are focusing on the cognitive and physical categories, serving preventative and rehabilitative purposes. The social-emotional function of the SG4D is mostly operating as a secondary element, coming from the multiplayer function of the games.

The educative type of games presents a small number of titles, presumably because of the difficulty to clearly define and cover the varied nature of the dementia disease within an educational game. However, there are informational and

training programs and games that are currently being developed, and this space will hopefully fill out over time [20].

The most important observation is the complete lack of assessment games. The fact that there are no games in this category could mean that it is unnecessary and out of the scope of the proposed taxonomy. However, this type of game is being developed and there are already several dementia-related screening tools, like the Mini Mental State Examination [21], Montreal Cognitive Assessment [24], Neurotrack [25] et al., that could be gamified in order to keep track of the player's cognitive status and keep him/her motivated. Consequently, we consider this game type to emerge in the near future and we consider its inclusion to the proposed taxonomical system necessary for the system to be complete and up-to-date.

## 6 Conclusion & future work

The proposed taxonomy is able to give us an overview of the current SG4D field, classifying the dementia-related game titles according to dementia-related criteria. Having based the current study on previous knowledge, helped us to create a complete taxonomical system that focuses further inside the “games for health” field.

As future work, the proposed taxonomy will be evaluated by expert researchers of the field, with the goal of creating a collaborative, updated and validated tool, creating a synergy between game developers and dementia professionals. The ultimate goal - as described in Section 3 - is to develop a SG4D taxonomy with predictive power, aiming to provide attribute predictions for each new game title that is introduced.

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