Serious games for health

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ABSTRACT

Maintaining and restoring health is a basic aspect of well being. On the other hand, serious games is an emerging technology growing in importance for specialized training, taking advantage of 3D games and game engines in order to improve the realistic experience of users. Thus, according to the advancement of technology and the desire to achieve good health using an interesting and enjoyable way, different serious games for health have been proposed during the last few years. In this paper, we present the core process of serious games and explain their functionalities. Then, we survey more than one hundred serious games for health and propose new classifications in four different aspects. Finally, we use fifteen relevant characteristics to classify all the surveyed games and present them with plenty of graphs and charts with corresponding discussion.

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1. Introduction

Today, the term serious game is becoming increasingly popular. Even though there is currently no single definition of the concept, most researchers and developers agree that serious games are games used for purposes other than mere entertainment. They inherit game play characteristics from entertainment games and have focused on the main objective such as learning or training, with the idea to apply learnt lessons in real-life work environments [67,98,130].

Serious games are present in many areas of knowledge, including military, health, manufacturing, education and medicine. Focusing on the field of health, the use of serious games can provide an additional mean to increase interest in training, education and evaluation of user performance. For instance, serious games can be designed to educate and train health care professionals to avoid medical errors [38,56] or in rehabilitation processes, to reproduce the repetitive tasks that have to be done by the patient [24,91]. The purpose of this paper is to review serious games for health.

Health is one of the main issues that affects people in every stage of life (from infancy to old age). In Maslow's hierarchy of needs [67], see Fig. 1, health is represented in the second lowest level after basic needs required for life are fulfilled. Health is then a very basic need, and maintaining health is a priority. Additionally, the desirable human characteristics located in higher levels of Maslow's pyramid, which are needed for a functioning, peaceful society, are negatively impacted by lack of health.

What kind of games can be considered as games for health? The World Health Organization defined health in its broader sense as a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity [126]. Other definitions simply require being free from illness or injury [121]. If we use the stricter definition, we may only consider games dealing with the different phases of illness development: both doctor training and patient familiarization with his illness. However, the use of the WHO definition allows us to consider a third variety of games which has recently had a big success. These are games dealing with healthy habits such as exercise (including dancing and fitness games). We shall use this broader definition to select the games.

In this paper, which is an extended version of [124], we will survey serious games for health, present new classifications regarding their different aspects and analyze each game based on the functionalities described in the classifications. The paper has been structured as follows. Section 2 presents the main concepts and related work. Section 3 explains the method and scope of the study. Section 4 details the different ways in which serious games for health can be classified. Then, Section 5 presents the characteristics according to different parameters of all surveyed serious games for health that appeared from January 2004 to December 2012. Section 6 presents a summary of their main characteristics, a comparison table, graphs and a discussion of the results. Finally, Section 7 concludes the paper.

2. Concept and related work

In this section we will focus on serious games, describing their main components and also the core processes involved in the

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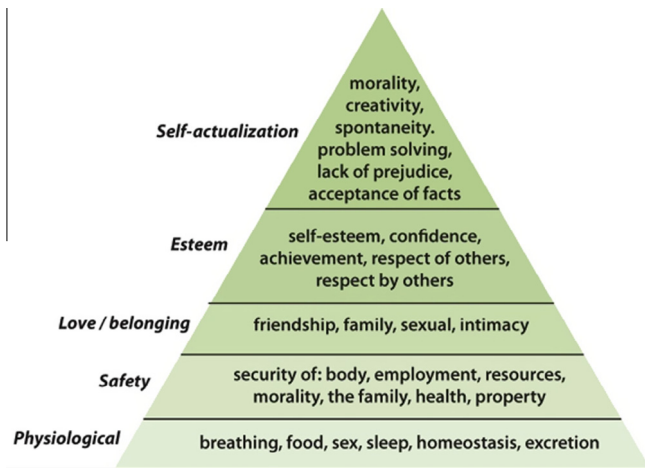
Fig. 1. Maslow's pyramid.

development of a serious game. To end the section, we will review previous surveys about serious games for health.

2.1. Serious games

A game is a physical or mental contest with a goal or objective, played according to a framework, or a set of rules, which determines what a player can and cannot do inside a game world [47]. All games, including computer games, can be specified by means of five different components (see Fig. 2). The first component is the *rule* or *gameplay*, which creates the pattern defined through the game rules that connects the player and the game. The second component is the *challenge*, which determines the bonuses to reward the good actions or the obstruction and barriers that avoid the player reaching the game goal easily. Challenges are used to create the different difficulty levels of the game in order to encourage enjoyment and motivate the player to spend more time with the game. The third component is the *interaction* which represents the way the player communicates with the game. Interaction refers to any action that is done by the player to start some activity. Interaction can be visual, listening, physical (typing, mouse, touchpad, button pressing), dialogue exchange, etc. The different interaction techniques are supported by specific tools, which represent equipment or accessories that are connected to the games to give input information to the system. For example, the player may use a Wii balance board as a tool in an exercise game to improve his or her motor skills after operation. The last
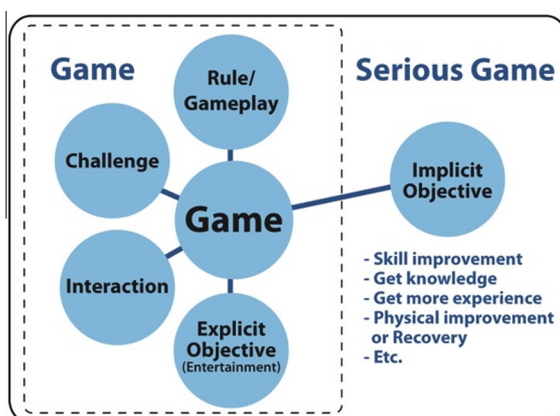
component is the *objective* which is defined as something that one's efforts or actions are intended to attain or accomplish. Two types of objectives can be distinguished: explicit and implicit. While the explicit objective is only entertainment, nature of every game, the implicit objective includes increasing skills and abilities, gaining knowledge or acquiring experience. The type of objectives can differentiate computer games (with only explicit objectives) from serious games (with include both implicit and explicit objectives).

2.2. Serious games core components

The creation of a serious game involves different processes, technologies and specialists. In Fig. 3 we illustrate how they are related. A first component is the developer team which may consist of managers, 2D and 3D graphic designers, programmers, researchers and content providers, amongst others. In a small team one person may be assigned to more than one position; also in medium or big development teams other positions will be added [31] such as game designer, game tester, level designer, animator, software engineer, interface artist or simulation analyst. The number of people in the team depends on the budget, time, and size of the serious game. In the case of serious games, special attention must be paid to the content provider who provides not only the information related to the game but also shares his expertise to define game parameters such as the level of difficulty or the proper rewards and obstructions. Generally, content providers are professionals and experts in a specific application domain. To create the serious game, the developer team has to determine the tools, the technologies and the contents that have to be used in the game. Below we describe these elements.

- *Tools* can be separated into three main groups that work together, the game engine, the database and the design software applications. All of them are working together. First, all art assets in both 2D and 3D formats are created (by various design applications, such as Adobe illustrator, Coral Draw for 2D art assets and Autodesk 3DMax, Maya, Zbrush for 3D assets) and kept in the database. The database maintains all the data and information required by the platform including player information, score, game object, animation, etc. The game engine is one of the most important components and contains the specific code that controls how the system on each game operates. When an application is launched, the game engine dictates what the graphic user interface (GUI) will present to the user. It also defines the set of rules that determines the win conditions, i.e., the necessary steps that a user must take to complete the game. Every input information is gained through GUI; then, feedback action is generated by the game engine which is connected to the database. The engine receives the user inputs, interprets what the user is attempting to do and describes the proper outputs. When the win conditions are satisfied, the proper interface is presented and the game scores are recorded for future reference.
- *Content* can be defined as significant information which will be delivered to the players when the serious game is played. Content is provided by experts and converted to useful information according to the objective of the serious game.
- *Technology* is the branch of knowledge that deals with the creation and the use of technical means and their interrelation with life, society, and the environment; drawing upon such subjects as industrial arts, engineering, applied science, etc. In this context, two outstanding technologies are virtual and augmented reality [62,105]. Virtual reality refers to computer-simulated environments that can simulate physical presence in places located in the real world, as well as in imaginary worlds
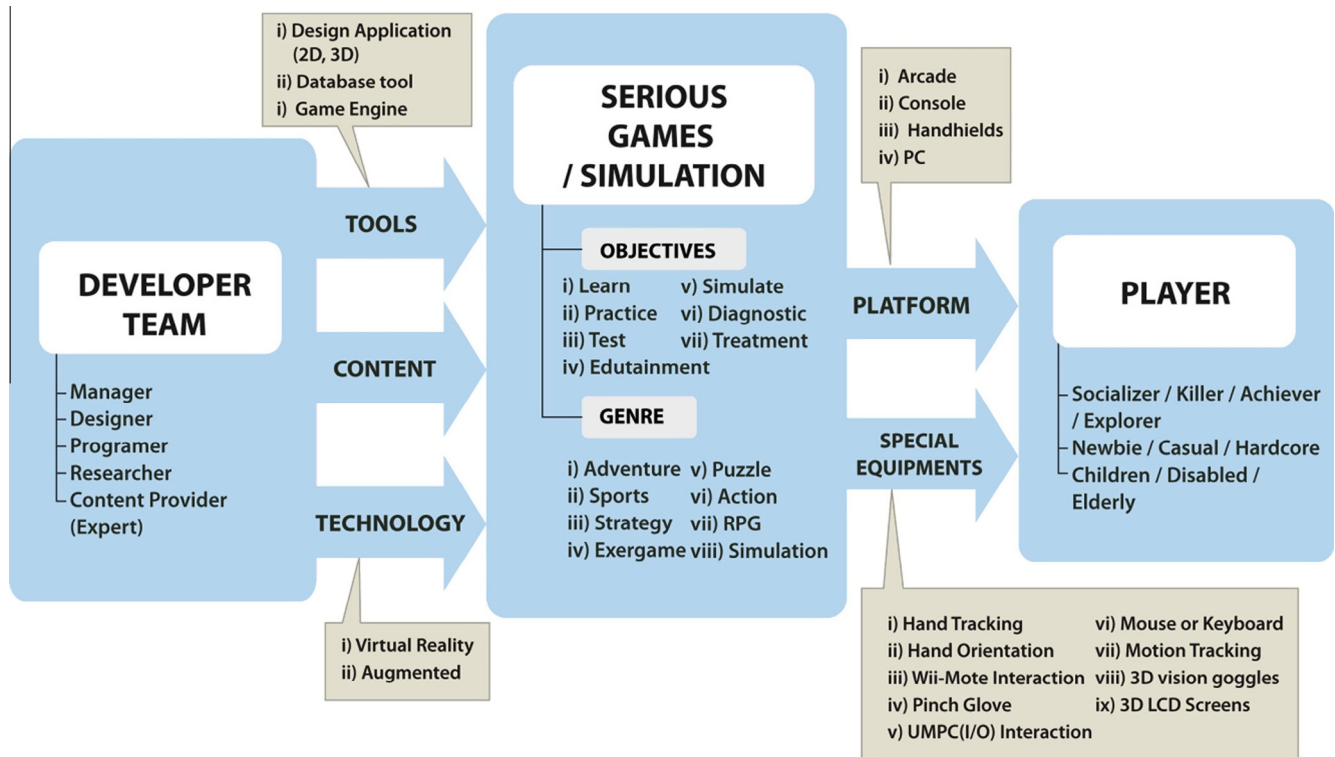

Fig. 2. The functions of serious games.

Fig. 3. Core components of serious games.

[130]. It is commonly associated with immersive technology which provides perceptually-real environments by special equipment such as holography, head-mounted displays (HMDs), haptic tactile equipment, etc. Augmented reality is a technology which allows computer generated virtual imagery to exactly overlay physical objects in real time [129].

These three components (tool, content and technology) are fundamental in the game development process. To select them we need to identify the game objective and the game genre, both described below.

- *Game objective*, in the case of serious games, is mainly focused on education, training and informing in an effective and incisive manner [40,52,94,128]. Other objectives can be practice, testing, simulation, diagnosis and treatment. A serious game can contain more than one objective. For example, serious games for health are not only focused on edutainment but they can focus on diagnostic and treatment as well [7,8,69].
- *Game genre* is used to categorize video games based on their gameplay [22]. Some of the proposed game genres are: *Adventure games* which involve exploration of, and interaction with, the environment as a main facet of gameplay; *Sport games* which emulate traditional physical sports such as basketball, golf football, etc.; *Strategy games* which players require tactics and sagacity to achieve the targets; *Exergame* which combines exercise equipment with video games, to encourage people to exercise by making activity more fun; *Puzzle games* which require the player to solve a puzzle such as a maze, logical problem or positioning different pieces together; *Action games* in which players are required to have good reflexes, hand–eye coordination and quick reaction times in order to overcome challenges such as combats, avoiding traps, jumping, running, completing tasks within a pressing time limit, etc.; *Role Playing Games* in which the player's character has skills and abilities

represented by statistics. The gameplay involves the characters exploring and completing quests that build up their statistics and possessions. The game can be single or multi-player; and finally *Simulation games* that attempt to realistically mimic the conditions of a particular environment or activity.

The target player specification is one of the more important parts of the game development process. The objectives are creating the most satisfactory game for the intended users and also obtaining the most efficient results on implicit objectives, as mentioned in Section 2.1. The player can be designated by various contexts such as playing style (socializer, killer, achiever and explorer), playing skill (newbie, casual and hardcore) and status of player (children, disabled and elderly). Focusing only on the player status will be not enough to encourage repeated use when the target player skills are upgraded. In order to satisfy players of all levels, the challenges need to be carefully considered providing suitable rewards and obstacles. A cross study of various combinations of player types would be interesting for serious games developer teams in order to satisfy all target players.

To provide the serious game to the players, two last components must be considered:

- *Game platform*, also called a video game platform or video game system, refers to the specific combination of electronic or computer hardware which, in conjunction with software, allows a video game to operate. Game Platform can be separated into four types: Arcade (Large devices normally found in commercial game centers); Console (NintendoNES, PlayStation3, Wii, Xbox360, etc.); Handhelds (Game Boy, iPad, iPhone, Nintendo DS, PSP, Mobile, etc.) and Personal Computers (Desktop, Laptop).
- *Special equipment* or interface devices used in virtual environments serve as portals into a virtual world. The data input devices perform special interaction purposes such as gesture recognition or performance capture. For example, hand track-

ing, hand orientation, Wii-mote, pinch glove or motion tracking. On the other hand, the special devices for data output devices such as 3D vision goggles or 3D LCD screens are used for vision based image control on serious games.

As Fig. 3 shows all described processes and elements must be considered together since they are related to each other.

2.3. The use of serious games to promote health

In the last decade, many serious games in the field of e-health have been developed [95]. These deal with a wide variety of aspects such as surgeon training, radiology operation, cardiopulmonary resuscitation (CPR) and patient care. Different surveys on serious games for health have been published. Watters et al. [125] explored the use of games for children with long-term treatment regimes, where motivation for compliance is a key factor in the success of the treatment. Papastergiou [85] reviewed thirty-four articles on the use of computer and video games in health education and physical education and presented a synthesis of the available empirical evidence on the educational effectiveness of them. Kato [54] summarized the scientific literature of commercially available and tailor-made games used for education and training with patients and medical students and doctors; her classification is based on diseases. Rego et al. [92] proposed a classification designed to properly distinguish and compare eight serious games for rehabilitation systems with respect to their fundamental characteristics. They also described a particular serious game for rehabilitation, RehaCom, as a case study. Lopes and Bidarra [66] presented the state of adaptability in general games and simulations focusing on the purposes, targets and methods from both academia and industry. Bartolome et al. [8] presented a systematic review of twenty-one serious games for health and education, described at scientific papers, and projects from the 7th Framework Program.

The main novelties of our survey with respect to reported ones, are the new classifications of serious games focused on health and the number of considered games (one hundred and eight from January 2004 to December 2012).

3. Method and scope of study

In this survey we have considered not only serious games that have been described and evaluated in peer-reviewed publications but also commercial games (consoles and PCs), online games, games on mobile platforms and games running on specialized platforms in clinics, hospitals and patients homes.

To carry out our research, we have considered the following sources: The international online bibliographic databases of Science Direct, Association for Computing Machinery (ACM), Institute of Electrical and Electronics Engineers (IEEE) Computer Society Digital Library (CSDL), Cambridge Journals Online, Oxford University Press (journals), NRC Research Press, The CINAHL database, BioMed Central and Emerald. We have found other references using Google and Google scholar. Our searching key words have been "game", "video games", "play", "serious games", "simulation", "virtual", "reality", "game based learning", "training", "health", "clinical", "treatment", "rehabilitation" and "medicine". Some specific keywords may have been derived from a previous search: such as "Role play game" or "RPG", "exergame" and "edutainment". All the terms have been addressed in conjunction to increase the efficiency of possible outcomes.

If we focus on the number of serious games for health according to the year of publication from January 1989 to December 2012 which we present in Fig. 4, we can see that before 2004 few games

were proposed while from 2004 until now the production increases. Therefore we decided to take into consideration only the serious games for health published from January 2004 to December 2012. To be included in this review, papers must show empirical evidence related to the main objective of this paper (serious games for health and their many aspects).

The result of our search is presented in Section 5 but before, in next section, we present the proposed four new classifications of serious games for health.

4. Classification of surveyed serious games for health

Among the literature reviews, which were studied and presented in Section 2.3, Sawyer and Smith (2008) presented an interesting taxonomy on game for health categorized by a set of users (personal, professional, research/academic and public health) cross related with a set of serious games objectives (preventive, therapeutic, assessment, educational, and informatics) [98]. Compared with their assortment, our survey deals with all their game objectives but for the scope of users, as our study identifies the users as someone who play serious games in order to affect their personal health, we do not mention the research and academia field of study as users in our survey. According to the divergence in scope and objective of our study, in this section we propose new parameters to categorize serious games for health in four different classifications.

As it is illustrated in Fig. 5, our classifications are based on three related subjects: serious game, health and player. Focusing on serious game subjects, we can classify by game purpose and game functionality. For health subject, we can classify by state of disease. Finally, focusing on player subject, two types of players can be considered (player/non-player and professional/non professional), and both are included into the same classification. More details of each classification are given below.

4.1. Classification by game purpose

There are three main categories of serious games for health according to their main purpose. We can consider games:

- *Focused on entertainment (FE)*, in this case, in addition to entertainment there is a need to move some parts of the body so the wellness is obtained as a bonus. As an example we can consider Dance Dance Revolution (DDR) [127] which is the pioneering series of the rhythm and dance genre in video games. The commercial exercise games became famous with the Wii [51]
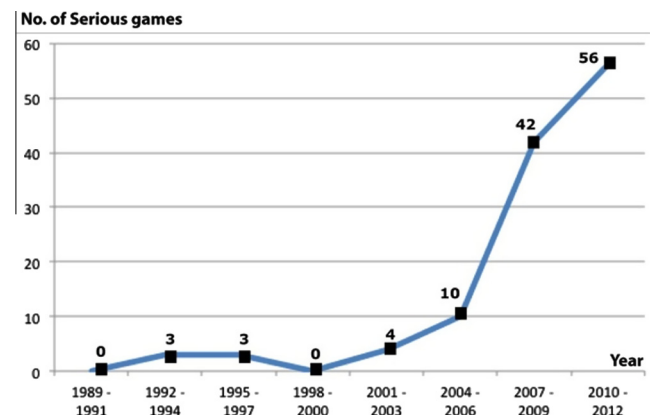
Fig. 4. Number of surveyed serious games for health according to the year of publication.
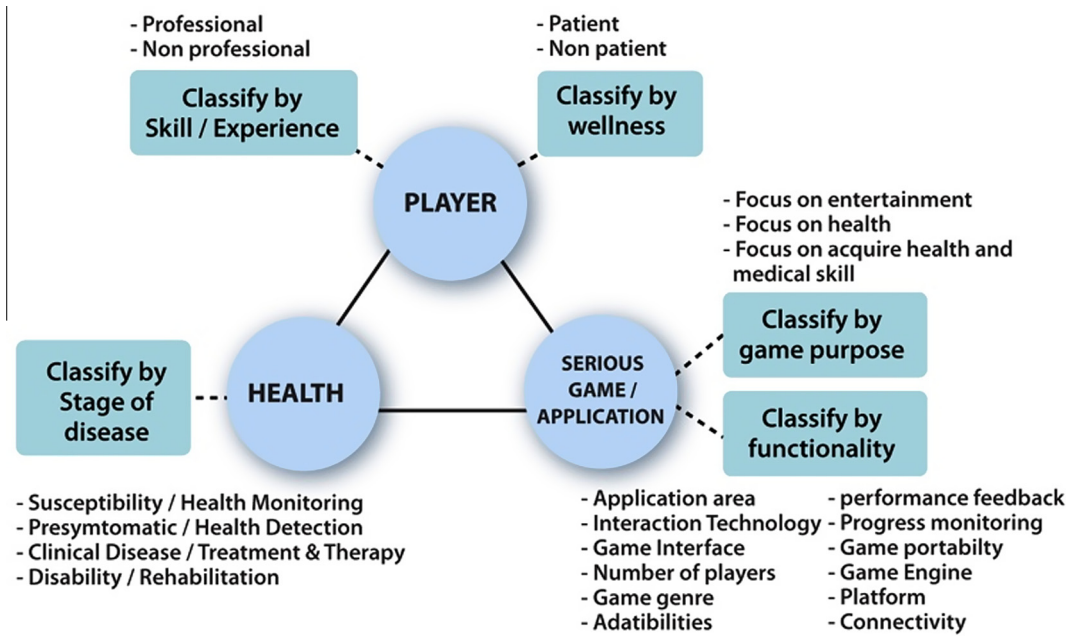
Fig. 5. Classifications of serious games for health.

released by Nintendo on 2006. The motion control over the avatar by various accessories inspired people to exercise with the video games.

- *Focused on health (FH)*, in this case, the main goal is health but the game is used as a tool to pass on knowledge or skills. To use the capabilities of the game engine, various serious health contents are conveyed to players. For example, Fatworld [33], Re-Mission [107], Air medic sky1 [112] and many other games described in Section 4.
- *Focused on health acquisition and medical skills (FA)*; in this case, the game has serious use for health purposes regarding a need of a virtual viewpoint or simulation to avoid or alleviate the risk, safety, budget, etc. Most of the games in this category are simulation games with virtual reality or augmented reality technology such as the Virtual dental implant training simulation program [70], Emergency medical services for the disabled virtual environment (EMSAVE) [44], Olive: 3D hospital training [97], etc.

4.2. Classification by functionality

Rego et al. [92] identified some criteria for the classification of serious games for health. We build upon their criteria (application area, interaction technology, game interface, number of players, game genre, adaptability, progress monitoring, performance feedback and game portability) and add some more characteristics (game engine, platform and connectivity) which have been consistently reported or published in descriptions of the games we surveyed (some of them have already been defined in Section 2.2). The descriptions of our classification system are based on:

- *Application area* or domain, which describes the part of the real world being modeled by the software. In serious games for health, we will distinguish two main aspects: cognitive skills (Cog) such as memory, attention span, concentration and reasoning, and motor skills (Mot) such as general coordination or re-learning to walk after injuries.
- *Interaction technology* has the different paradigms for establishing communication between humans and computers. Both hardware and software interfaces are included. Traditionally,

mouse and keyboard have been used; newer means of interaction include virtual reality (using head-mounted displays), computer monitors, haptic or pseudo-haptic devices such as gloves or pens, or tracking devices. Webcams and web applications are also common. Patients can affect virtual objects in real-time using a variety of senses (vision, hearing and touching).

- *Game interface* is related to the virtual world inside the game which can simulate the real world in three-dimensions (3D) or provide a top-down scrolling and side scrolling for the perspective of a simpler world in two-dimensions (2D). Some techniques can be applied such as simulating the appearance of being 3D in isometric view with 2D objects which is called 2.5D or pseudo-3D. In some games a combination of hybrid 2D/3D are employed.
- *Number of players* concurrently using the world of the game. In general, we distinguish single player games (for one person) and multiplayer games (for two or more people).
- *Game genre* is a categorization according to gameplay; we can distinguish adventure, strategy, simulation, sports and puzzles, among others. In games for health, the games which evaluate coordination and movement are common in rehabilitation; other genres are also used for different tasks.
- *Adaptability* (Yes/No) represents the adaptability of the difficulty according to the skill of the player, in order to increase playability and enjoyment. Traditional games used to have a fixed difficulty level, which could either be programmed or chosen before the game started. In health, adaptability is an excellent trait because it allows the patient to test and overcome his limits in a controlled manner.
- *Progress monitoring* (Yes/No) is an advantage function for patient evaluation; having logs of the patient actions inside the game can be an invaluable asset. We call this feature progress monitoring, since it allows the doctors to monitor the progress of the patients as a function of time.
- *Performance feedback* (Yes/No) are the indications of the game which deal with showing the users their status and abilities. They allow patients to feel confident with their progress and to detect and fix their failures. The feedback can be audio, visual or haptic.

- *Game hardware portability* (Yes/No) refers to being able to physically move the game hardware. In particular, we distinguish between games located at a hospital or clinic from the ones that can be portable or used at home.
- *Game engine* is a platform which provides commonly used game functionalities and tools that allow the developers to create, edit design and functionalities themselves. The engine provides an API to access lower level functionalities and a set of predefined models, materials and scenes [19].
- *Platform* means the hardware the game runs on. This may include personal computers (PCs), commercial game consoles (Nintendo Wii, Microsoft Xbox), portable consoles or custom hardware.
- *Connectivity* is the ability to link to and communicate with other computer systems, electronic devices, software, or the Internet. Games might require an internet or network connection (online) or they may be played in standalone computers (offline).

4.3. Classification by stage of disease

This classification is based on the stage of the disease the game is focused on. Following the classification proposed by [71], we can consider the four different categories, represented in Fig. 6, together with the purpose of the game, as described below.

- *Susceptibility Stage*: This is the first stage, in which the person is still healthy. A serious game in this stage helps the user to familiarize with monitoring procedures, and with illnesses that he or she could develop later in life.
- *Pre-symptomatic Stage*: In this stage, people still feel healthy although the illness is already present. For example, the number of virus particles may still be too small to produce a response in the body, or a failing organ may still be able to cope with the added pressure of the illness with no external indications. The beginning of this stage may be discovered by the periodic checkups mentioned above. In this stage, the specific illness is now known, and the chances of developing it are very high, so more focused serious games can be used to show the patient the relevant aspects of his illness and his treatment. EEG-based serious games [122] and PlayWithEyes [23] are examples.
- *Clinical Disease Stage*: In this third stage, the symptoms of the illness are already manifesting in the patient either as acute conditions or as the beginning of a chronic illness. During this phase, recognizable diseases manifest and diagnosis of the specific disease can be made. If the illness was not detected in the previous stages, serious games can be used to familiarize the patients with the expected progression of their illness, and

the treatment procedures. Alternative treatments can also be shown using games. Games intended to be played by doctors or other medical staff usually focuses on this stage as well. Some examples are Social skills [8], *speech* disorder children therapy [16] and *improve* bimanual coordination in children with spastic cerebral palsy [65].
- *Recovery, Disability Stage*: In this last stage of the illness, two different outcomes are possible: the illness may be cured, returning the patient to health or to another stage of susceptibility, or it may have serious effects on the patient's health, making them unable to function at previous levels, that is, the illness may become chronic. In serious cases, a state of disability may occur. Serious games in this stage normally deal with the rehabilitation procedure, or helping the patient cope with their disabilities such as Neuropsychological rehabilitation [78], Chronic pain rehabilitation [100], Upper limb rehabilitation following stroke [15] or After Parkinson's disease [91].

4.4. Classification by player's wellness (patient/non-patient)

Regarding the definition of health, referred in Section 1, which covered both patients and non-patients, we classified serious games according to these two target player groups (see Fig. 7) and described as follows.

4.4.1. Serious games for patients
Serious games for patients can be classified according to their use into five different categories which are:

- *Health Monitoring* aims to keep an eye on patient health by monitoring the bio-signals, such as Heart failure tele-management system [35], Healthcare monitoring [34] and the U-health monitoring system [61].
- *Detection* focuses on analysis or tracing of irregular symptoms of the patient. For example Unobtrusive health [69], EEG-based serious games [122] and PlayWithEyes [23].
- *Treatment* or therapy is used to remedy a health problem. The examples are Match-3 [99], Diagnosis and management of Parkinson [7], Social skills [8] and Speech disorder children therapy [16].
- *Rehabilitation* is a restoration of health and life skills after illness such as Neuropsychological rehabilitation [42], Chronic pain rehabilitation [100] and Upper limb rehabilitation following stroke [15].
- *Education* for self/directed care increases understanding about the disease or health problems and learning how to get and stay healthier with them. Some examples are Re-Mission [107], Serious game for diabetes [79], First aid education for autism spectrum disorder [113] and Cognitive training for Alzheimer [48].

4.4.2. Serious games for non-patient
Serious games for non-patients can be classified according to their use into three different categories which are:

- *Health and wellness* games focus on lifestyle issues and their relationships with functional health. We have surveyed the serious games regarding to the Alameda county study [46] which suggested that people can improve their health via (1) exercise, (2) enough sleep, (3) maintaining a healthy body weight, (4) limiting alcohol use, and (5) avoiding smoking. Some examples are Sensory gate-ball game [55], Dancing in the streets (DITS) [19], Fitness adventure [58], Virku [120] and Mo-Fun circus [84].
- *Training and Simulation games for professional* are serious games used as learning and practicing tools for health professionals. Some examples are HumanSim (Preview) [4], Virtual dental
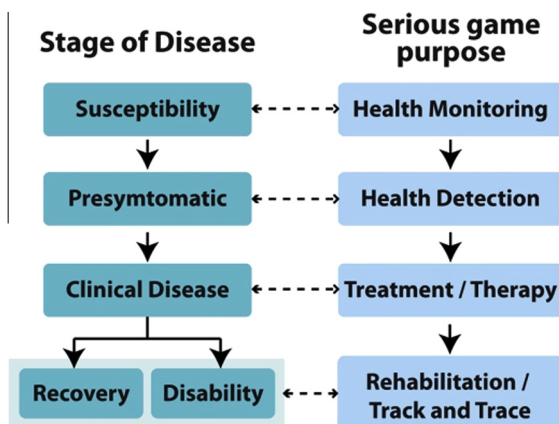
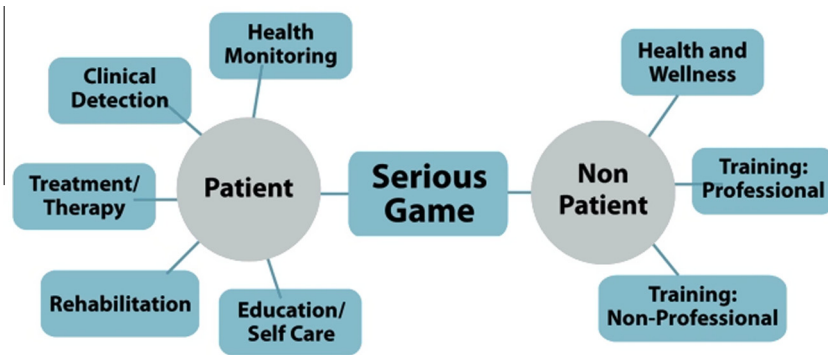**Fig. 6.** Serious games purpose related to stage of disease.

Fig. 7. Classification of serious games for health by player.

implant training simulation program [14] [70], Nursing and midwifery [103], Pulse: the virtual clinical learning lab [1] and Emergency medical services for the disabled (EMSAVE) [44] [117].

• *Training and Simulation games for non-professional* are games used by laypersons to learn to improve their healthcare. In this group there are games such as Fatworld [33], the food detectives fight BAC! game [109], Hand hygiene training [114] and Nutri-trainer [38].

5. Results

In this section, we present the surveyed games with respect to the proposed classifications. To better present the results, we create Table 1 that collects the information of games designed for patients and non-patients. From left to right, column (1) contains the name or the author of the game together with the publication year and column (2), presents the disease related to the game (or general health if no specific disease is mentioned). Column (3) presents purpose, following the classification of Section 5.1, where FE represents focused on entertainment, FH focused on health and FA focused on health acquisition and medical skills. From columns (4) to (15), we present the information according to the classification by functionality (see Section 5.2). Column (4) is the application area which can be motor (Mot) or cognitive (Cot). Column (5) shows the tool that players use to connect to the game. Column (6) is game interface that can be 2D or 3D. Column (7) presents the number of players: single or multi player. Column (8) is the game genre that can be action, puzzle, simulation, etc. From columns (9) to (12), we present adaptability, progress monitoring, feedback and portability, respectively. These columns are filled with three symbols (Y, N and –), where Y and N represent yes and no, and (–) represents that this feature is not mentioned in the game description. Columns (13) and (14) present the engine/ tool and the platform, respectively. Finally, column (15) shows connectivity that can be online (On) or offline (Off). In Table 1, rows have been grouped according to the classification by player's wellness for patients (see Section 5.4.1), from top to bottom, health monitoring, detection, treatment, rehabilitation, and education for self/directed care (self-education). We continue with the classification by player's wellness for non-patients (see Section 5.4.2). In this case, we consider three different categories, from top to bottom, health and wellness, training and simulation for professional and finally, training and simulation for non-professional.

6. Discussion

The information collected from Table 1 has been used to compare the characteristics of the surveyed serious games with respect to different parameters. Below, from Figs. 8–24, we present the obtained results by a graphical summary together with a brief description.

Fig. 8 shows the production of games according to the player (patient and non-patient). In Fig. 8a we illustrate the number of games for patients with respect to games for non patients. We observe that serious games for non patients are about twenty seven percent more common than serious games for patients. In Fig. 8b, we present the evolution of game production, according to the year of publication, distinguishing between games for patients and non patients. We see that the maximum of the production is reached in 2010. Then in 2011, the interest on serious games for patients increases. The intersection point in 2010–2011 indicates that the interest in serious games for patient may be higher than that of serious games for non patient in the future.

Focusing on the objectives of the developed serious games (Fig. 9), we can see that their objectives are quite varied, but an emphasis can be seen on professional training and health & wellness (almost a quarter) followed by serious games for non professional training, rehabilitation, treatment, education and detection respectively.

We classified serious games for learning purposes (professional training, non professional training and self education) from medical care as illustrated in Fig. 10. We see that number of serious games for learning in our survey is almost half of them, see Fig. 10a. The trend of serious games focused on learning objective is moving up even though the graph shows the fluctuation of the number of serious games published per year until now, see Fig. 10b.

Fig. 11 presents the distribution of serious games according to the disease for which they have been designed. The chart shows the wide variety of the use of serious games in many different diseases. About forty percent of the serious games are designed for general health. Within specific diseases, stroke together with diabetes and brain health are the most common, followed by autism and neuro health. We notice that most of serious games for health and wellness and training for nonprofessional are made for general health purposes. On the other hand, there are no serious games for general health presented in patient detection and treatment purposes.

Fig. 12 presents the production of the serious games focusing on the diseases related to the brain which amount to a quarter of all games, see Fig. 12a. We observe that the interest in brain related diseases became higher during the year 2009 and the number of games published fluctuates every year.

Focusing on the game purpose by the classification in Section 5.1, Fig. 13 presents the distribution of serious games according to its purpose. In the top chart, Fig. 13a we can see that three quarter of serious games focused on health while a quarter focused

Table 1
Classification and Comparison of Health Games form our survey.

Author	Disease	Purpose	Application area	Interactive tool	Interface	Players	Genre	Adaptability	Progress monitoring	Feedback	Portability	Engine/tool	Platform	Connectivity
Detection (Patient)														
Mckanna et al. [69]	Alzheimer	FH	Cog	Mouse	2D	Single	Puzzle	Y	Y	N	Y	–	PC	Off
Wang et al. [122],Brain Chi	Neurofeedback	FH	Cog	EEG	2D	Single	Action	–	–	–	N	–	PC	Off
Wang et al. [122],Dancing Robot	Neurofeedback	FH	Cog	EEG	3D	Single	Action	–	–	–	N	–	PC	Off
De Bortoli and Gaggi [23]	Eye Test	FH	Mot	Touch	2D	Single	Puzzle	Y	Y	Y	Y	SDK	iPad	Off
Treatment (Patient)														
Johnston and Duskin [30]	Cancer	FA	Cog	Mouse	3D	Multi	Adventure	Y	–	Y	Y	–	PC	Off
Believe in Tomorrow [11]	Chronic paining	FH	Cog	VR Headset	3D	Single	Action	–	–	Y	Y	Tailor-Made	PC	Off
Hatfield [43]	Quit Smoking	FH	Cog	Mix	2D	Single	Action	Y	Y	–	Y	–	Mix	On
Vermont Department of Health [116]	Quit Smoking	FH	Cog	Mouse	3D	Single	Action	Y	Y	–	Y	Unity3D	PC	On
Atkinson and Narasimhan [7]	Parkinson	FH	Cog	Novint	2D	Single	Action	Y	–	–	Y	SDK	PC	Off
Bartolome et al. [9]	Neuro-disability	FH	Cog	Wiimote	3D	Single	RPG	Y	Y	Y	Y	Director	PC	Off
Finkelstein et al. [35]	Autism	FH		VR	3D	Single	Exergame	Y	Y	Y	Y	Tailor-Made	PC	Off
Botella et al. [13]	Cockroach phobia	FA	Cog	Camera	3D	Single	Puzzle	Y	Y	Y	Y	J2ME	Mobile	Off
Lakeside Center for Autism [59]	Autism	FA	M+C	Kinect	3D	Single	Simulation	Y	Y	Y	Y	–	Xbox360	Off
Scarle et al. [99]	Obesity	FH	Mot	WiiFit	3D	Single	Adventure	Y	–	Y	Y	–	Wii	Off
Van Loon et al. [65]	Cerebral palsy	FH	Mot	External	–	Single	Action	Y	Y	Y	Y	D-Flow	PC	Off
Cagatay et al. [16]	Speech disorder	FH	Cog	Mouse	3D	Single	RPG	Y	Y	Y	Y	Unity3D	PC	Off
e-Learning Studios [26]	Autism	FH	Cog	Mouse	3D	Single	RPG	Y	Y	Y	Y	Unity3D	PC	Off
Rehabilitation (Patient)														
Edheads [27]	Knee Surgery	FH	Cog	Mouse	2D	Single	Action	N	Y	N	Y	Flash	PC	On
Burke et al. [15], Arrow attack	Stroke	FH	Mot	Webcam	2D	Single	Action	Y	Y	Y	Y	XNA	PC	Off
Burke et al. [15], Catch task	Stroke	FH	Mot	VR	3D	Single	Action	Y	Y	Y	Y	ORGE	PC	Off
Burke et al. [15], Rabbit chase	Stroke	FH	Mot	Webcam	2D	Single	Action	Y	Y	Y	Y	XNA	PC	Off
Burke et al. [15], Virtual vibraphone	Stroke	FH	Mot	Wiimote	2D	Multi	Action	Y	Y	Y	Y	–	PC	Off
Burke et al. [15], Whack a mouse	Stroke	FH	Mot	HMDs	3D	Single	Action	Y	Y	Y	Y	–	PC	Off
Deponti et al. [24]	Wrist injury	FH	Mot	Mobile	2D	Single	Exergame	Y	Y	Y	Y	–	Android	Off
Fishing Cactus [36]	Organizational Problem	FH	Cog	Kinect	3D	Single	Puzzle	Y	Y	Y	Y	–	Xbox360	Off
Grau et al. [42]	Nero illness	FH	Cog	Mouse	3D	Single	RPG	Y	–	Y	Y	–	PC	Off
Lin [64]	General Health	FH	Mot	Webcam	3D	Single	Puzzle	Y	Y	Y	Y	ARToolkit	PC	On
Moya et al. [78]	Upper limb injury	FH	Mot	Sensor	3D	Single	Action	Y	Y	Y	Y	–	PC	Off
Red Hill Studios [91]	Parkinson	FH	Mot	Sensor	2/3D	Single	Mix	Y	Y	–	Y	Tailor-Made	PC	–
Schnauer et al. [100]	Chronic pain	FH	Mot	Kinect	3D	Single	Adventure	Y	Y	Y	N	Unity3D	PC	Off
GENIOUS Interactive [40]	Upper limb rehabilitation	FH	Mot	Kinect	3D	Multi	Adventure	Y	Y	Y	Y	–	Multi	On
Milo Foundation [74]	Language Disabilities	FH	Cog	Touch	3D	Single	Adventure	Y	Y	Y	Y	Unity3D	iPad	Off
Education (Patient)														
Hopelab (2009)	Cancer	FH	Cog	Mouse	3D	Single	Adventure	Y	Y	Y	Y	–	PC	Off
CCCP [17]	General Health	FH	Cog	Mouse	2D	Single	Simulation	Y	Y	Y	Y	Flash	PC	On

Study	Topic	Type	Cog/Mot	Input	Dim	Player	Genre	C1	C2	C3	C4	Engine	Platform	On/Off
Fuchslocher et al. [37]	Diabetes	FH	Cog	Mouse	2D	Single	Adventure	Y	Y	Y	Y	–	PC	–
Imbeault et al. [48]	Alzheimer	FH	Cog	Mouse	3D	Single	Action	Y	Y	Y	Y	Torque	PC	Off
Nauta and Spil [79]	Diabetes	FH	Cog	Mouse	3D	Single	Adventure	N	Y	N	Y	Flash	PC	On
The Diablotines [108]	Diabetes	FH	Cog	Mouse	2D	Single	Adventure	Y	Y	Y	Y	–	PC	Off
de Urturi [113]	Autism	FH	Cog	Mobile	2D	Single	Quiz	Y	Y	Y	Y	–	Mobile	On
IKARE [49]	Cystic Fibrosis	FH	Mot	Mouse	3D	Single	Puzzle	Y	Y	Y	Y	–	PC	On
Verduin et al. [115]	AUDs	FH	Cog	Mouse	2D	Single	Puzzle	Y	Y	Y	Y	–	PC	–

Health and Wellness (Non-Patient)

Study	Topic	Type	Cog/Mot	Input	Dim	Player	Genre	C1	C2	C3	C4	Engine	Platform	On/Off
Montreal Science Centre [77]	General Health	FH	Cog	Mouse	2D	Single	Puzzle	N	N	Y	Y	Flash	PC	On
Respondesign [93]	General Health	FH	Mot	Kinect	3D	Single	Exergame	Y	Y	Y	Y	Unity3D	PC	Off
Nintendo [81]	Brain Health	FH	Cog	Button	2D	Single	Puzzle	Y	–	Y	Y	–	DS	Off
Gameloft [39]	Brain Health	FH	Cog	Mix	2D	Single	Puzzle	Y	–	Y	Y	–	Mix	Off
McGIll University [68]	Chi	FH	Cog	Mouse	2D	Single	Puzzle	Y	–	Y	Y	Flash	PC	On
Intelligent System [51]	Face Exercise	FH	Mot	Camera	2D	Single	Action	–	Y	–	Y	–	DS	Off
Nintendo EAD [82]	General Health	FH	Mot	Wii Balance Board	3D	Multi	Exergame	Y	Y	Y	Y	–	Wii	On
Nordic Innovation Centre [83]	General Health	FH	Mot	Camera	2D	Multi	Action	–	Y	–	N	–	PC	Off
SEGA [102]	Brain Health	FH	Cog	Button	2D	Single	Mix	Y	–	Y	Y	–	DS	Off
BBG Entertainment GmbH [10]	Brain Health	FH	Cog	Mouse	2D	Single	Puzzle	Y	Y	–	Y	–	PC	Off
Blitz Games Studios [12]	General Health	FH	Mot	Wii Balance Board	3D	Single	Exergame	Y	Y	–	Y	–	Wii	Off
Collision Studios [21]	General Health	FH	Mot	Wii Balance Board	3D	Single	Exergame	Y	Y	–	Y	–	Wii	Off
Kim et al. [55]	General Health	FH	Mot	Sensor	3D	Single	Sport	Y	Y	Y	N	–	PC	Off
Laikari [58]	General Health	FH	Mot	RFID	2D	Single	Exergame	Y	Y	Y	Y	SMAC	Mobile	On
Lightning Fish Games [63]	General Health	FH	Mot	Wii Balance Board	3D	Single	Exergame	Y	Y	Y	Y	–	Wii	On
Raylight [90]	Eyes and Ears Health	FH	Mot	Mouse	2D	Single	Puzzle	Y	Y	Y	–	–	DS	Off
Succubus Interactive [106]	Over Alcohol	FH	Cog	Mouse	2D	Single	Adventure	Y	Y	N	Y	Flash	PC	On
Vtnen and Leikas [120]	General Health	FH	Mot	Cycle	3D	Single	Exergame	Y	Y	–	N	–	PC	Off
Anchor Bay Entertainment [2]	General Health	FH	Mot	Wii Balance Board	3D	Single	Exergame	Y	Y	Y	Y	–	Wii	Off
Clawson et al. [20]	General Health	FH	Mot	Sensor	2D	Single	Exergame	N	Y	N	Y	–	Mobile	Off
Electronic Arts [28]	General Health	FH	Mot	Mix	3D	Multi	Exergame	Y	Y	Y	Y	–	Mix	Off
HopeLab [45]	Obesity	FH	Mot	Accelerometer	2D	Single	Exergame	N	Y	N	Y	–	Multi	Off
Ubisoft Divertissements [111]	General Health	FH	Mot	Kinect	3D	Multi	Exergame	Y	Y	Y	Y	–	Xbox360	Off
Zumba Fitness (2010)	General Health	FH	Mot	Kinect	3D	Multi	Action	Y	–	Y	Y	–	Mix	On
Nike + Kinect Training [80]	General Health	FH	Mot	Kinect	3D	Single	Exergame	Y	Y	Y	Y	–	Xbox360	On

Training for Professional (Non-Patient)

Study	Topic	Type	Cog/Mot	Input	Dim	Player	Genre	C1	C2	C3	C4	Engine	Platform	On/Off
BreakAway (2007)	Injuries	FA	Cog	Mouse	3D	Single	Simulation	Y	Y	Y	Y	Tailor-Made	PC	Off
Anderson [3]	Maternal Child Health	FH	Cog	Mouse	–	Single	RPG	Y	Y	Y	Y	–	PC	Off
Glasgow Caledonian University [41]	General Health	FA	Cog	Mouse	3D	Single	Simulation	–	–	–	Y	Second Life	PC	On
Imperial College [32]	Respiratory illness	FA	Cog	Mouse	3D	Single	Simulation	Y	Y	Y	Y	Second Life	PC	On
Mili et al. [72]	General Health	FA	Cog	Mouse	3D	Single	Simulation	Y	Y	Y	Y	–	PC	On
Sliney and Murphy [104]	General Health	FA	Cog	Mouse	3D	Single	Simulation	Y	Y	Y	Y	Torque	PC	On
TruSim [110], Triage Trainer	Triage	FA	Cog	Mouse	3D	Single	Simulation	–	Y	Y	–	TruSim	PC	Off
Keele University (2009)	General Health	FA	Cog	Voice Record	3D	Single	Simulation	Y	Y	Y	Y	–	PC	On
Virtual Heroes [118]	General Health	FH	Cog	Mouse	3D	Single	Simulation	Y	Y	Y	Y	Unreal	PC	–
BreakAway [14]	Dental	FA	Cog	Mouse	3D	Single	Simulation	Y	Y	Y	Y	Tailor-Made	PC	Off
Innovation in Learning [50]	General Health	FA	Cog	Mouse	3D	Multi	Simulation	–	Y	Y	Y	–	PC	Off
KTM Advance [57]	General Health	FA	Cog	Mouse	3D	Single	Simulation	–	Y	–	Y	Flash	PC	On

Table 1 (*continued*)

| Author	Disease	Purpose	Application area	Interactive tool	Interface	Players	Genre	Adaptability	Progress monitoring	Feedback	Portability	Engine/ tool	Platform	Connectivity
Miller [73]	General Health	FA	Cog	Mouse	3D	Single	Simulation	Y	Y	Y	Y	–	PC	On
Sabri et al. [96]	Knee Replacement	FA	Cog	Mouse	3D	Multi	Simulation	Y	Y	Y	Y	Tailor-Made	PC	On
Skills2Learn [103]	Pregnancy	FA	Cog	Mouse	3D	Single	Simulation	Y	Y	Y	Y	–	PC	Off
TruSim (2010), Patient Rescue	General Health	FA	Cog	Mouse	3D	Single	Simulation	–	Y	Y	–	TruSim	PC	Off
Vidani et al. [117]	General Health	FA	Cog	Mouse	3D	Single	Simulation	Y	Y	Y	Y	NeoAxis	PC	Off
Visual Imagination Software [119]	General Health	FA	Cog	Mouse	3D	Single	Adventure	Y	Y	–	Y	Star Force 3D	PC	Off
Diehl et al. [25]	Diabetes	FH	Cog	Mouse	3D	Single	Simulation	Y	Y	Y	Y	Flash	PC	Off
Queiros et al. [88]	General Health	FA	Cog	Laparoscopic	3D	Single	Simulation	Y	Y	Y	Y	XNA	PC	Off
Applied Research Associates [4]	General Health	FA	Cog	Touch	3D	Single	Simulation	Y	Y	Y	Y	Unreal	iPad	Off
Chan et al. [18]	General Health	FA	Cog	Mouse	3D	Single	Simulation	Y	Y	Y	Y	Tailor-Made	PC	Off
EMCO3 [29]	General Health	FA	Cog	Mouse	3D	Single	Simulation	Y	Y	Y	Y	–	Multi	Off
MIRROR project [75]	General Health	FA	Cog	Mouse	3D	Single	Simulation	Y	Y	Y	Y	Unity3D	PC	Off
SAIC [97]	General Health	FA	Cog	Mouse	3D	Multi	Simulation	Y	Y	Y	Y	–	PC	On
University Medical Center Utrecht [112]	General Health	FA	Cog	Bio-Feedback	3D	Multi	Simulation	Y	Y	Y	Y	–	PC	On
Training for Non-Professional (Non-Patient)														
MIT Teacher Education Program [76]	Avian influenza	FH	Cog	Button	2D	Single	Action	–	–	Y	Y	–	Pocket PC	On
Archimage [5]	Diabetes	FH	Cog	Mouse	3D	Single	Adventure	Y	–	Y	Y	–	PC	Off
Janomedia [53]	Nutrition	FH	Cog	Mouse	2D	Single	Action	Y	–	Y	Y	Flash	PC	On
Nordic Innovation Centre [83], MC Urho	General Health	FH	Cog	Mouse	2D	Single	Puzzle	Y	N	–	Y	Flash	PC	On
Nordic Innovation Centre [83], Valion Energiasummaaja	General Health	FH	Cog	Mouse	2D	Single	Quiz	Y	Y	–	Y	Flash	PC	On
Fatworld.org [33]	Obesity	FH	Cog	Mouse	2D	Single	RPG	Y	Y	Y	Y	Flash	PC	Off
Food Safety Education [109]	General Health	FH	Cog	Mouse	2D	Single	Puzzle	Y	Y	N	Y	Flash	PC	On
Warner Bros. [123]	AIDS	FH	Cog	Mouse	3D	Single	Adventure	–	Y	–	Y	–	PC	Off
Learning Games Lab [60]	General Health	FH	Cog	Mouse	2D	Single	Adventure	Y	Y	N	Y	Flash	PC	On
Persuasive Games [86]	Flu	FH	Cog	Mouse	2D	Single	Action	–	N	N	Y	Flash	PC	On
QOVEO [87]	H1N1	FH	Cog	Mouse	2D	Single	Action	N	Y	N	Y	Flash	PC	On
RANJ Serious Games [89]	Flu	FH	Cog	Mouse	2D	Single	Strategy	N	Y	N	Y	Flash	PC	On
Gago et al. [38]	General Health	FH	Cog	Touch	2/3D	Single	Puzzle	Y	Y	Y	Y	WPF	Mobile	On
Association RMC/BFM [6]	Cardiac arrest	FH	Cog	Touch	3D	Single	Simulation	Y	Y	Y	Y	–	Multi	On
Public Health Agency of Canada (2010)	Epidemics	FH	Cog	Mouse	2D	Single	Adventure	N	N	N	Y	Flash	PC	On
Vazquez [114]	General Health	FH	Cog	Mouse	2D/3D	Single	Action	Y	Y	Y	Y	Flash	PC	On
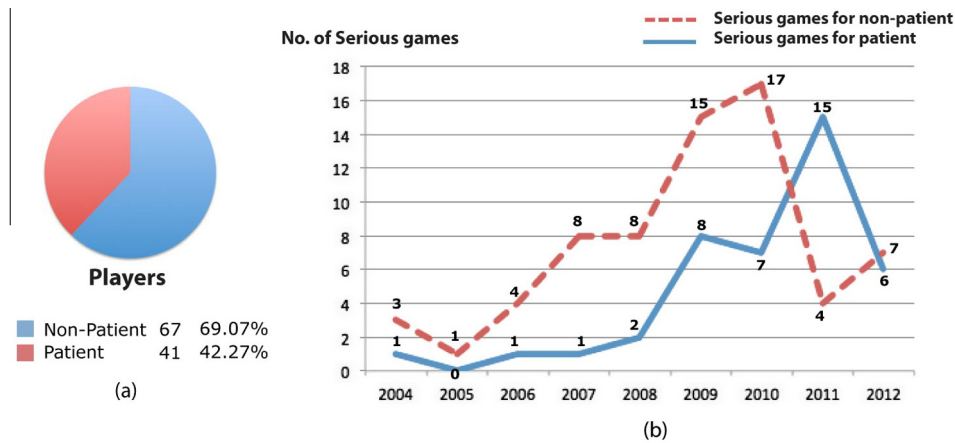
Fig. 8. Breakdown of the "Players" values present in our survey (a) and number of serious games designed for patients and non patients according to the year of publication (b).

Fig. 9. Breakdown of the "Game Objective" values present in our survey.

on health acquisition and medical skills; 88 percentage (23 out of 26) of serious games for professional training are in this group. Furthermore, we classified game purpose according to the player (patient and non-patient) as shown in Fig. 13b and c; we can see that almost all serious games for patient are focused on health. On the other hand, serious games for non patients focused on health are approximately thirty percent more than the ones focused on health.

Focusing on application area, Fig. 14 shows that both motor and cognitive abilities are well represented in our survey. An amount of two thirds of serious games are for cognitive improvement while

one third serious games are for motor improvement and only one of the one hundred and eight games surveyed has been designed to improve both cognitive and motor skills. Almost all (50 out of 51) of the serious games for education purposes (self education, training for both professional and non-professional) are focused on cognitive skills. On the other hand two thirds (18 out of 25) of the serious games for health and wellness purposes are designed for motor skills. From Fig. 14b and c which present the number of application areas for patients and non patients, we can see that the number of motor improvement games for patients (16) and non-patients (17) is similar.

Fig. 15 presents the distribution of surveyed serious games according to interaction tools. The results are quite varied, however the standard mouse interface is used in about half of the games, followed by Wii peripheral, Kinect, camera and touch screen, respectively.

Additionally, if we focus on Fig. 16 where we show the distribution of games according to the top four interaction tools and the year of publication we will see that mouse is in the leader position except in the year 2011 which was led by other tools.

Focusing on the graphic user interface, Fig. 17a shows that 2D and 3D interfaces are both well represented in the surveyed games. However, the number of 3D games is twenty five percentage higher than 2D games. We also observe that almost all (24 out of 26) of
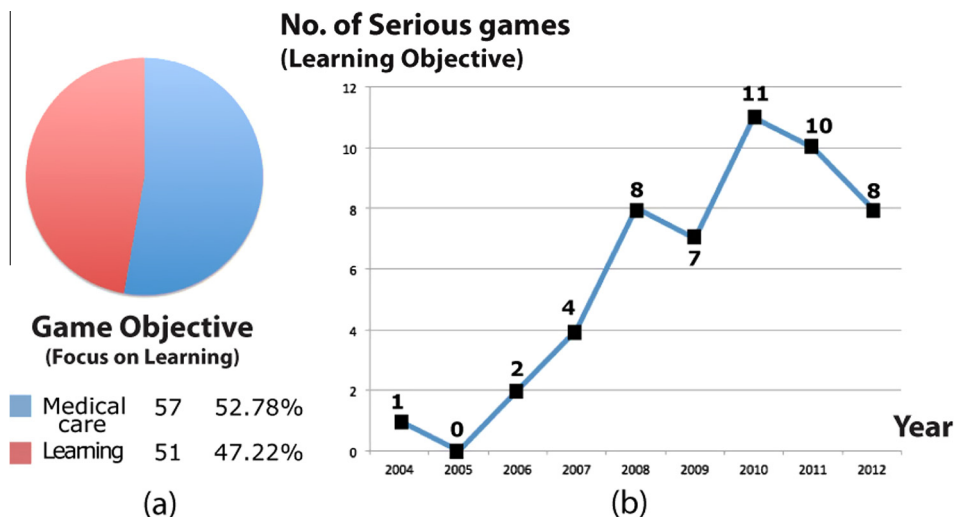
Fig. 10. Breakdown of the "Serious Games Objective" values focus on "learning" (a) and number of serious games objective focus on learning according to the year of publication (b).
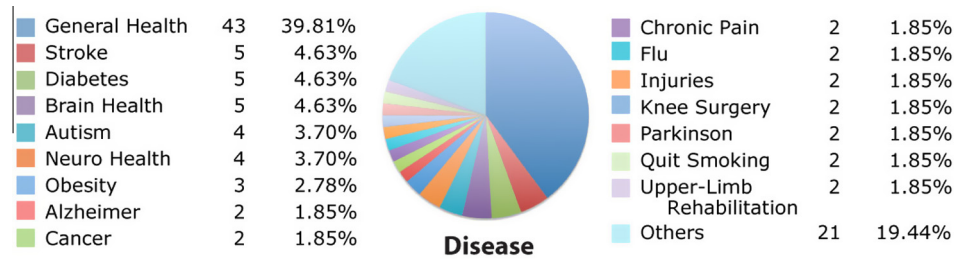
General Health	43	39.81%
Stroke	5	4.63%
Diabetes	5	4.63%
Brain Health	5	4.63%
Autism	4	3.70%
Neuro Health	4	3.70%
Obesity	3	2.78%
Alzheimer	2	1.85%
Cancer	2	1.85%
Chronic Pain	2	1.85%
Flu	2	1.85%
Injuries	2	1.85%
Knee Surgery	2	1.85%
Parkinson	2	1.85%
Quit Smoking	2	1.85%
Upper-Limb Rehabilitation	2	1.85%
Others	21	19.44%

Fig. 11. Breakdown of the "Disease" values present in our survey.
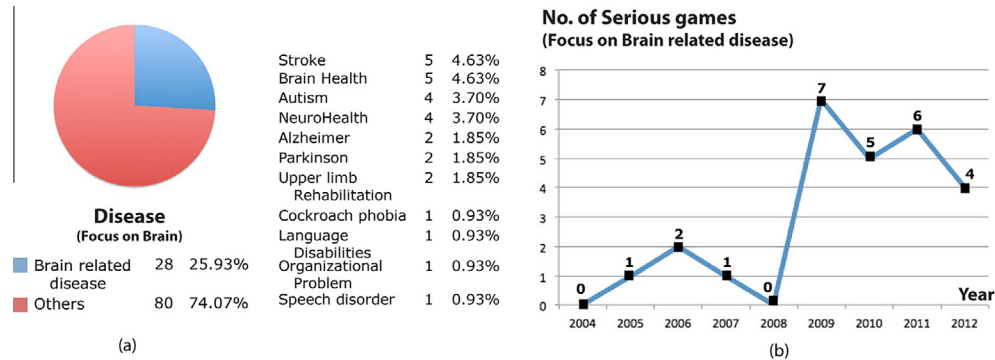
Fig. 12. Breakdown of the "Brain Disease" values present in our survey (a) and numbers of surveyed serious games for health which focus on brain disease according to the year of publication (b).
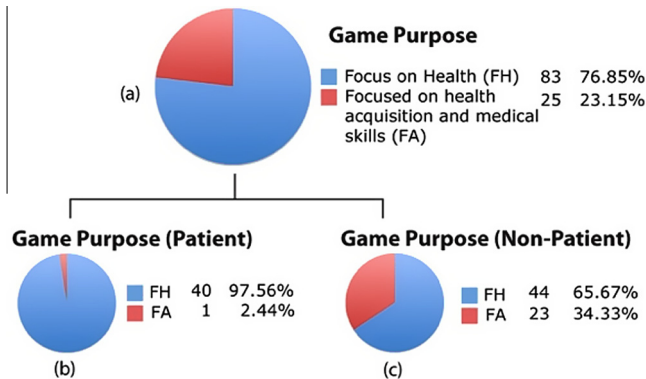
Fig. 13. Breakdown of the "Game Purpose (a)", "Game Purpose for patient (b)" and "Game Purpose for non-patient (c)" values present in our survey.

the interface for professional training are 3D. The 3D interface also shows a major presence in both serious games for patients and non patients which can be seen in Fig. 17b and c.

Fig. 18 presents the evolution of both 2D and 3D interface in our surveyed serious games according to the year of publication. We see that the trend of 3D interfaces is growing up in average since 2007, with the maximum value on year 2010. At the same time, the 2D interface graph fluctuated from 2007 to 2009 then decreased since year 2009. We can say that the interest in 3D interfaces overcame 2D interfaces since 2010.

Fig. 19 reports the distribution of our surveyed serious games according to the number of players. We can see from Fig. 19a that most of the games (9 out of 10) are currently single player. Multi player is presented mostly in the health and wellness games, followed by serious games for professional training. Fig. 19b and c show that multi player games are represented in serious games for non patients rather than in serious games for patients.

Fig. 20 illustrates the distribution of the surveyed serious games according to game genre. Fig. 20a shows that the Simulation and Action genres dominate, followed by puzzle, exergame and Adventure respectively, although there is a large variety of other genres. Almost all of serious games for professional training are 3D
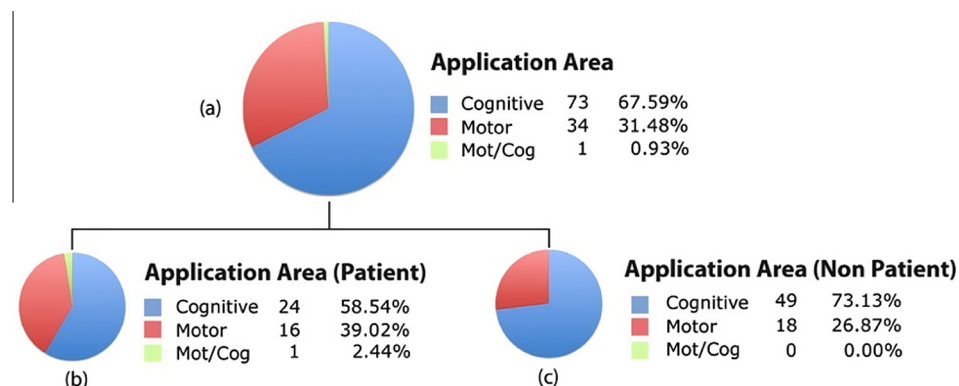
Fig. 14. Breakdown of the "Application Area (a)", "Application Area for patient (b)" and "Application Area for non-patient (c)" values present in our survey.
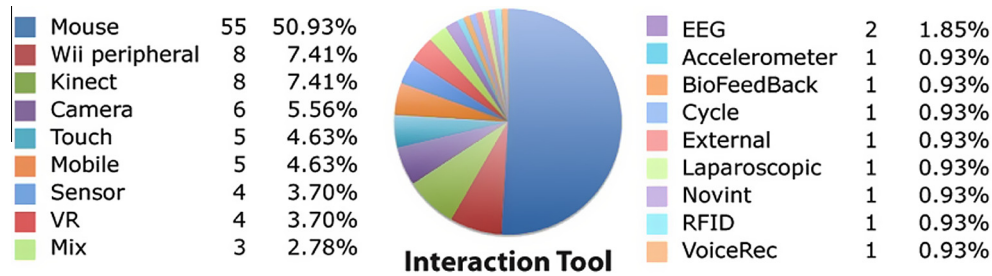
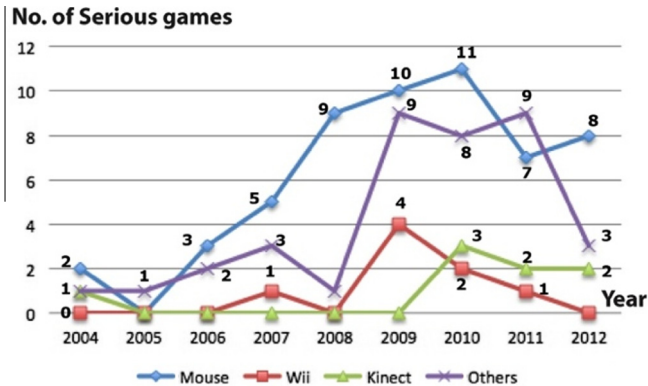**Fig. 15.** Breakdown of the "Interaction Tool" values present in our survey.

Fig. 16. Numbers of surveyed serious games for health according to "Top four Interaction Tools" and the year of publication.
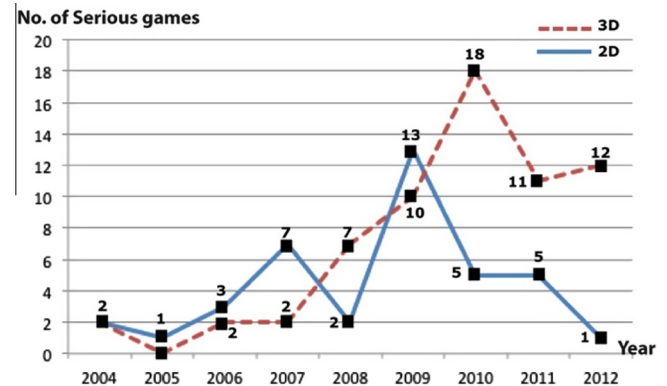

Fig. 18. Number of "2D and 3D Interface" in our survey according to the year of publication.

simulation genre (24 out of 26). Although action games are used for many objectives (treatment, health and wellness, etc.) the most important one is rehabilitation, as well as exergame which is the prominent genre on serious games for health and wellness. From Fig. 20b, the top three game genres for patient are action, adventure and puzzle. From Fig. 20c we can see that the top three game genres for non patients are simulation, exergame and puzzle.

Fig. 21 presents the statistics on our survey (from left to right) in adaptability, progress monitoring, performance feedback and hardware portability respectively. All are important features, with useful characteristics, and are included in the majority of the serious games as mentioned in Section 5.2. These charts show that each of these functionalities is considered as major (more than three quarters of the surveyed serious games implement them).

About the production tools, Fig. 22 shows a wide variety of engines used in surveyed serious games, although this is not an often reported characteristic. For the reported ones, Flash is the most often used engine, followed by tailor made engines and Unity3D.

Fig. 23 presents the distribution of our surveyed serious games according to game platform. From Fig. 23a we will see that there are few used platforms, most of the games (two thirds) have been designed to run on personal computers followed by console and handheld platforms. There are some serious games which were developed for use in multiple platforms, which appear in games for non patients rather than in games for patients. From Fig. 23b and c, personal computers are the most often used platform in both serious games for patients and non patients. The console and multiple platform are more common in serious games for non patients
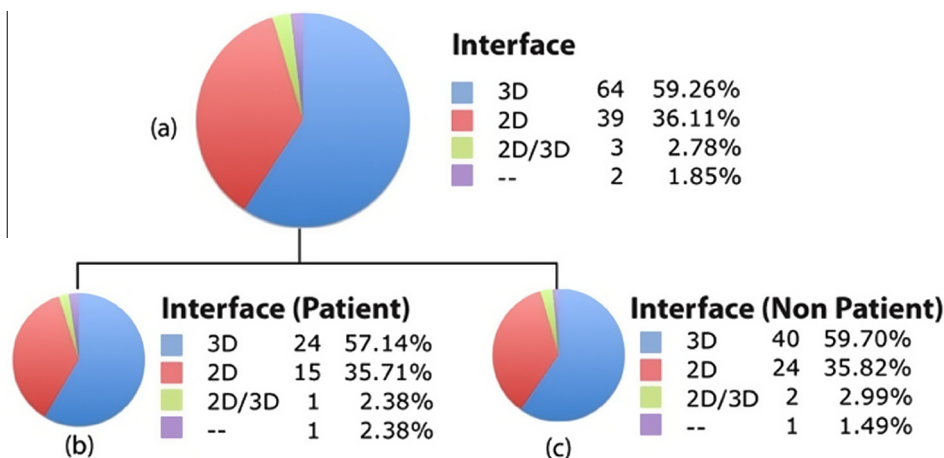

Fig. 17. Breakdown of the "Interface (a)", "Interface for patient (b)" and "Interface for non patient (c)" values present in our survey.
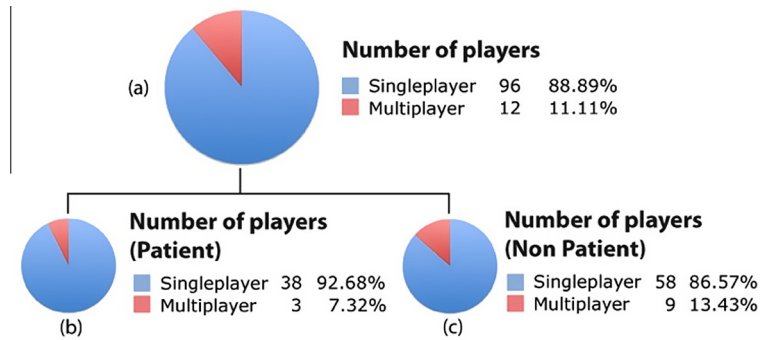
Fig. 19. Breakdown of the "Number of players (a)", "Number of players for patient (b)" and "Number of players for non patient (c)" values present in our survey.
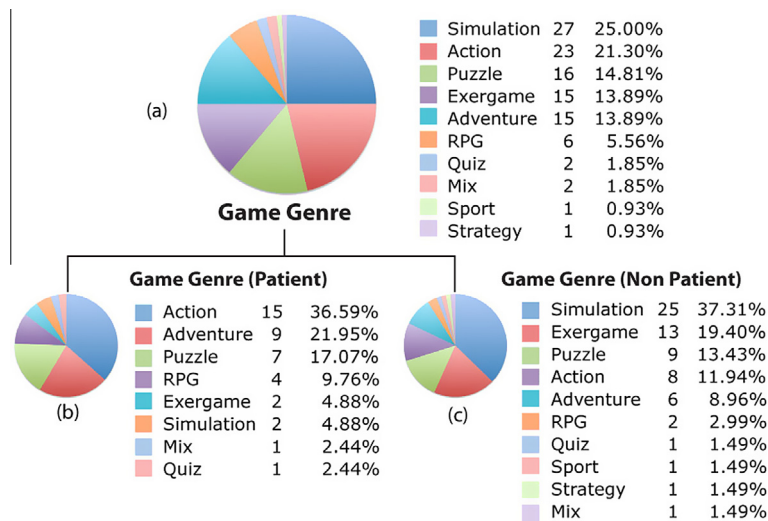

Fig. 20. Breakdown of the "Game Genre (a)", "Game Genre for patient (b)" and "Game Genre for non patient (c)" values present in our survey.
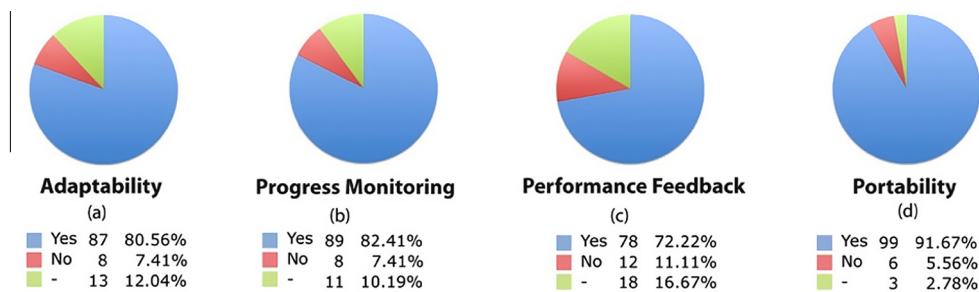

Fig. 21. Breakdown of the "Adaptability (a), Progress Monitoring (b), Performance Feedback (c) and hardware Portability (d)" values present in our survey.

while handheld platform is present more in serious games for patients.

Finally, Fig. 24 illustrates the distribution of our surveyed serious games according to internet connection. From Fig. 24a we will see that the internet connection is used in one third of the games surveyed. Fig. 24b and c show that most of the internet connectivity present in serious games for non patients (32 out of 41). Most of serious games for non-professionals (13 out of 16) are online games which aim to be seen by laypersons. On the other hand, most (11 out of 13) of serious games for treatment are offline. Most of serious games for rehabilitation, patient self education and health and wellness purposes are also offline due to the size of the game which might be huge and difficult to play smoothly in
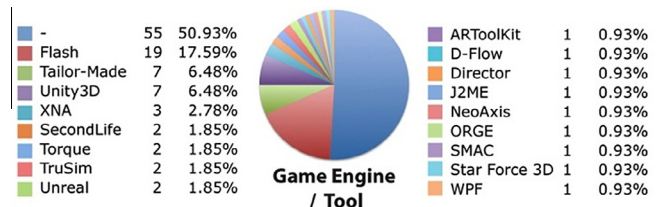

Fig. 22. Breakdown of the "Game Engine" values present in our survey.

an online environments or because the games may need some special external tools to perform the tasks given.
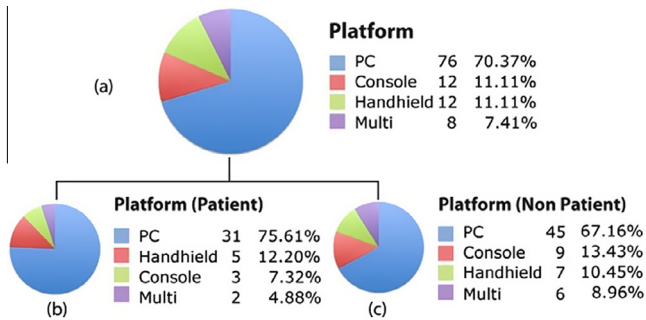
Fig. 23. Breakdown of the "Game Platform (a)", "Game Platform for patient (b)" and "Game Platform for non patient (c)" values present in our survey.
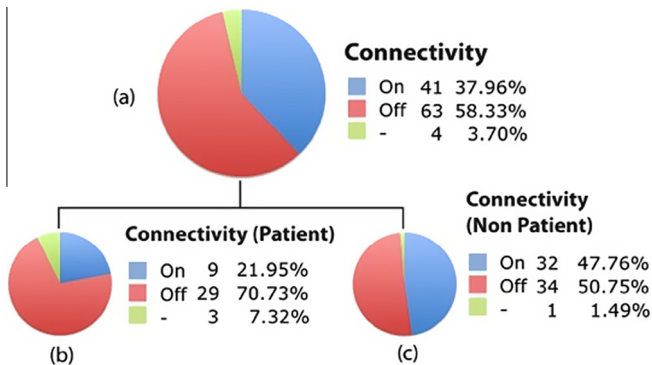

Fig. 24. Breakdown of the "Connectivity (a)", "Connectivity for patient (b)" and "Connectivity for non patient (c)" values present in our survey.

We did a statistical analysis of the different variables to see if certain characteristics correlated with certain game requirements. In particular, we considered that the type of user (patient/non-patient), stage of disease, disease, purpose, application area, adaptability, progress monitoring and feedback were chosen a-priori by medical staff, while the interactive tool, the interface, connectivity, players, genre, portability, engine and platform were chosen by the game designers. However, we could not find statistically significant correlations between different variables. Therefore, we consider that in principle, games of different characteristics are uncorrelated to the different requirements.

7. Conclusion

We have studied one hundred-and-eight serious games from academic and commercial environments (including a variety of online games) dealing with health in a broad sense, including medicine, nursing, health care and physical exercise. The games have been classified according to their main purpose (entertainment and teaching or health), stages of the disease being treated (health monitoring, detection, treatment, rehabilitation and education) and the type of users of the system (general population, patients and health professionals). Additionally, fifteen criteria dealing with the game technology have been selected for a fine-grain classification: application area, interaction technology, platform, game engine, interface, portability, connectivity, adaptability and genre, number of players, performance feedback, progress monitoring and health objective.

Although for most of these criteria there were a wide range of possibilities, which have been explored by at least one game, our results indicate that one of the possibilities in each category has been predominantly chosen by game designers. The average game can therefore be summarized as a portable PC game, using mouse interaction and including progress monitoring, performance feedback and adaptability. The most common genres were simulation and action (which account for half of the games). However, we found little correlation among the characteristics. As an example, only seven of the one hundred-and-eight games reviewed have all the characteristics of the average game described. The variability of games is quite large in many aspects.

The detailed description and classification of all the previous successful games presented here can be useful for researchers developing new games by raising the awareness of the different possibilities. While we cannot make hard predictions on the future of serious games for health, we expect two different directions: new, innovative games exploring the rest of the parameter space of our classification, and more classic games concentrating on the most commonly used features.

As a future trend, we expect that the 3D interface in both PC and handheld platform with online connectivity will dominate the serious games for health market, given the increasing capability of handheld devices with PC-like functionality. We also expect the real-time interaction between therapist and player will lead to a powerful tool for patient recovery and treatment.

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