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STUDY AND DEVELOPMENT OF CUSTOM "SERIOUS GAMES" FOR PATIENTS AND USERS

Dissertation submitted to the Catholic University of Portugal
in partial fulfilment of the requirements for the Master's Degree in Management for the Creative Industries

Catarina Matos Vieira

Porto, July 2020

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Supervised by

Professor Dr. André Perrotta

And co-supervised by

Professor João Novais

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Abstract

Video games are part of our culture and permeate several segments of society, from casual entertainment to serious purposes. This research work focuses on the latter, more specifically on the use of Serious Games in the healthcare context.

In this sense, Serious Games have been researched through clinical studies, implemented to improve several conditions and have already proved to be efficient and valid, especially due to their ability to captivate and motivate the patient. With this in mind, this research explored the use of Serious Games for physical rehabilitation of stroke impaired patients and how this approach could be implemented in the Portuguese healthcare system.

The research started with a thorough literature review of the validity and effectiveness of the use of Serious Games for this type of patients. Then, through surveys and interviews with healthcare professionals and game developers, the main barriers to the implementation and development of Serious Games for physical rehabilitation were accessed. Posteriorly, the feasibility of implementing a business model for this specific niche (in Portugal) was evaluated through a market analysis, abridging social, economic, political and technological aspects that culminated in the design of several hypothetical scenarios that envisioned the possibility of making this approach work.

This research allowed to achieve an understanding of what needs to be overcome in order for this technique to be successful: Serious Games are still widely unknown among healthcare professionals and there is an underlying stigma against video games that clouds the possible benefits of using Serious Games. Moreover, the social context of future users will also determine their acceptance and compliance. Nevertheless, the research has evidenced that the implementation of this paradigm is economically viable as it would indirectly allow the monetization of rehabilitation therapies by making them available to a larger slice of the disabled population, which is of utmost importance, mainly during the times we currently live in.

Keywords: serious games, healthcare, physical rehabilitation, stroke rehabilitation

Resumo

Os videojogos fazem parte da nossa cultura e permeiam vários segmentos da sociedade, desde entretenimento casual até propósitos mais sérios. Este trabalho de investigação concentra-se na segunda opção – mais especificamente, no uso de *Serious Games* no contexto da saúde.

Neste sentido, os *Serious Games* têm sido investigados através de estudos clínicos, implementados para melhorar diversas condições e patologias e já provaram ser eficientes e válidos, principalmente graças à sua capacidade de motivar e cativar o paciente. Tendo isto em conta, esta investigação explorou o uso dos *Serious Games* para reabilitação física de pacientes pós-AVC e de que forma é que esta abordagem poderia ser implementada no Serviço Nacional de Saúde.

A investigação começou com uma revisão bibliográfica completa da validade e eficácia do uso de *Serious Games* para este tipo de pacientes. De seguida, através de questionários e entrevistas a profissionais de saúde e desenvolvedores de videojogos, as principais barreiras para implementação e desenvolvimento de *Serious Games* para reabilitação física foram levantadas. Posteriormente, a viabilidade de executar um *business plan* para esse nicho específico (em Portugal) foi avaliada através de uma análise de mercado, abrangendo aspetos sociais, económicos, políticos e tecnológicos, que culminou no desenho de vários cenários hipotéticos que previam a possibilidade de fazer com que este paradigma se tornasse possível e funcional.

Este trabalho de investigação permitiu atingir uma compreensão daquilo que necessita de ser ultrapassado para que esta abordagem tenha sucesso: os *Serious Games* ainda são amplamente desconhecidos entre os profissionais de saúde e existe um estigma subjacente aos videojogos que obscurece os possíveis benefícios do seu uso. Para além disso, o contexto social dos futuros utilizadores também irá determinar a sua aceitação e adesão. No entanto, esta investigação evidenciou que a implementação deste modelo é economicamente viável, pois iria permitir, de uma forma indireta, a rentabilização de terapias de reabilitação ao fazer com que estas fossem acessíveis a uma fatia mais larga da população debilitada, o que é de extrema importância, principalmente nos dias de hoje.

Palavras-chave: jogos sérios, saúde, reabilitação física, reabilitação pós-AVC

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List of Acronyms

2D: two-dimensional

3D: three-dimensional

AR: augmented reality

CNCV: Clínica Neurológica da Coluna Vertebral

CNF: Clínica de Neurologia e Fisiatria

COTS: commercial off-the-shelf

DDA: dynamic difficulty adaptation strategy

EMG: electromyographic controlled

IDA: incremental difficulty adaptation strategy

MMO: massively multiplayer online

MR: mixed reality

PC: personal computer

PRehab: platform games for rehabilitation

PvE: player versus environment

PvP: player versus player

RGS: rehabilitation gaming system

RPG: role-playing game

SG: Serious Games

T-TOAT: Technology-supported task-oriented arm-hand training

VR: virtual reality

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1. Introduction

1.1. Motivation and Context

Have you ever walked through a video game map and felt like you were actually there, and that you belonged there? Wandering through the virtual forests and cities of a video game can be a very freeing and captivating experience. It allows the player to feel as if they are actually inside a different parallel world without having to leave the comfort of, for example, their homes. The possibility to travel through the world of a video game using a persona that represents the self can closely resemble real life to the point where the maps of the video game are nearly perceived by the user as real places. Everyone who has played video games has probably experienced this feeling at least once. People say that "home is where the heart is" and the immersion provoked by a video game (responsible for capturing the user's full attention), if the player is emotionally invested, can make its virtual realm feel like home.

The same way cinema and television played a big role in our parents' youth, video games heavily shaped the childhood and teenage days of younger generations. Having grown up to explore the wonders of video games and the internet, experiencing a sense of belonging while playing a video game is not an uncommon feeling found and felt among teenagers and young adults. Nowadays, the use of video games is common practice among younger generations, who spend hours on end on their consoles or computers, seeking excitement or even escapism through the virtual universes offered by them. The characteristics that make video games appealing and immersive are the ones responsible for allowing the player to experience feelings of "wanting to play more". Obviously, this can lead to addiction if it takes unhealthy proportions, but a video game's inherently motivating nature might come in handy when there is a shift in the game's objective – what if we stop using games solely for mere entertainment, but use the characteristics that make games fun, engaging, entertaining and motivating to potentiate the development of certain capabilities?

With this in mind, the idea of using a video game as a physical rehabilitation tool started to feel very appealing and relevant, considering the growing number of people experiencing strokes every year (Piassaroli, Almeida, Luvizotto, & Suzan, 2012). In cases like that, the patients are often left with pariahs that will place a toll on the way they live and approach day-to-day activities. These patients with reduced mobility will need and benefit from physiotherapy sessions in order to try and regain some of their original capacities. Wouldn't using a video game as a therapy tool automatically make the approach to therapy more appealing, enthusing patients and, therefore, raising the compliance, acceptance and participation in these sessions?

What if it was possible to allow patients to temporarily experience a reality that aesthetically appealed to them through the use of a video game, while undergoing rehabilitation training?

Moreover, the human species is naturally drawn to stories and narratives. Stories are as old as human civilization and have been passed on from generation to generation. Narratives can, and often are, included in games, in order to give a sense of mission to the player, to accomplish a goal that has a context and a meaning that the user can connect to. In this sense, they add to the immersive qualities that are already intrinsic to video games.

So, what if we could explore all those properties and make games something that answered an objective that went beyond the mere prospect of "fun" or "entertainment"? So called "Serious Games" answer this exact premise.

1.2. Research Questions and Objectives

With the imminent possibility of using video games for the greater good by exploring their immersive and captivating properties, we have identified a lack of academic research concerning the relation between game design and its effectiveness when used for physical rehabilitation purposes. A design of a game can go from a simple Point & Click approach to a complex open world[1] online universe. Depending on the design, a game can tackle different objectives, but also be perceived as more (or less) motivating. As motivation is an important factor when adherence and compliance to physical rehabilitation therapy is the topic, it is also important to discover if there is any link between the design, aesthetics and gameplay[2] adopted and the feelings of interest (or disinterest) experienced by the players and how these affect the outcomes. The starting point was the broad concept of Serious Game, vastly explored by Michael and Chen in their book *Serious games: Games that educate, train, and inform* (2005). The authors explained the emergence of the concept and analysed it from a commercial point of view, but also tackled the broad range of application possibilities and opportunities for Serious Games. From there, the research focused on its desired application for Serious Games: healthcare and, more specifically, physical rehabilitation, where video games would assume the role of clinical enhancers.

Despite the increasing interest in video games, observed over the last decades, as well as market growth (Dörner, Göbel, Effelsberg, & Wiemeyer, 2016; Laamarti, Eid, & El Saddik, 2014), it is still possible to find a cloud of stigma surrounding this millennial multimedia tool. Video games are occasionally perceived as something negative and the endless possibilities of

[1] Virtual game world that allows the player not to be subjected to a structured pre-planned gameplay. The exploration of the game's universe is done freely, this is, in a non-structured way.

[2] Gameplay refers to *"the pattern defined through the game rules which connects the player and the game"* (Wattanasoontorn *et al.*, 2014).

use are generally overlooked. There are countless studies (Griffiths, Kuss, & King, 2012; Van Rooij, Schoenmakers, Vermulst, Van Den Eijnden, & Van De Mheen, 2011) on video game addiction and how bad it can be for the health of, for example, teenagers. But, as video games can lead to prejudicial outcomes, there are also several studies on the use of video games for serious purposes, be it healthcare (see Chapter 3.1), education or training (Kato, 2010; Rosenheck, Clarke-Midura, Gordon-Messer, & Klopfer, 2017). This stigma around video games automatically leads to one of the largest barriers that needs to be overcome in order for Serious Games to prosper as an innovative tool – lack of knowledge. As the research progressed, it became clear that Serious Games were a concept that was widely unknown among the health sector professionals in Portugal. If people are not interested in video games and disregard them as a "waste of time", they will not be interested in knowing more about their uses and how they can actually be beneficial for our lives. Thus, it is of utmost importance to fight this lack of knowledge. Such can be achieved by exploring what has already been done and by pinpointing other barriers found among professionals to the use and implementation of Serious Games in their day-to-day procedures.

Considering all of this, the broad main goal and research question for this dissertation is understanding how video games can be used for healthcare purposes and what kind of game design is adopted for each case. Moreover, knowing that alone is not enough to understand the context of Serious Games in Portugal and, for that, it is also crucial to understand which barriers are encountered to the use of Serious Games for healthcare, and which are the possible ways to overcome them in order to be able to implement a tool that might come out as beneficial, both clinically and economically. Barriers can refer to the evident lack of knowledge of what Serious Games are, but also to other things, from monetary to issues with the law (both encountered during the process of research) to even a persistent preference towards the use of traditional methods that can, eventually, be an indirect result of the fear of change often experienced by humans of all age groups. In this sense, another question that needed to be answered was whether or not it was possible to develop a business plan to be used upon the implementation of Serious Games in healthcare. This required a previous analysis of the market, of the target audience (doctors and health professionals, from the point of view of the mediator, as well as the patients, who would assume the role of the active users of the video games). Is it possible to implement Serious Games in the healthcare sector, while remaining beneficial and efficient in terms of clinical results, but also economically affordable and eventually, even profitable?

1.3. Methodology

The methodology implemented for the development of this investigation dissertation begins with a bibliographic revision of relevant authors, starting by a brief contextualization of video games as a form of entertainment, their emergence and their historical evolution, followed by a shift in focus to the Serious Game sub-genre and its healthcare applications. This phase had the objective of understanding the state-of-the-art of Serious Games, in order to grasp the contexts (not only healthcare related) where these kinds of video games can be successfully implemented. After exploring the vast range of applications, the focus tightened once again to analyse the way Serious Games could be used in healthcare contexts – from rehabilitation aiding tools to awareness raising ones. This allowed us to explore the evolution of Serious Games and what kind of work has been done in the area, by understanding which kinds of medical applications are possible for this video game subgenre. During this bibliographic review, the Visual Novel video game subgenre was also explored from both historical and aesthetic approaches, in order to understand the relevance of narrative in video games and how games that are technically simple (*i.e.* mostly text based) can still be fun and immersive experiences for the player.

In a second moment, various case studies where different kinds of games were used to improve the health of physically disabled or impaired people were analysed, in order to understand the link between game design and aesthetic, therapeutic efficacy and patient motivation. The evaluation of the efficacy of these cases was qualitative and took into account parameters such as the patients' conditions (pre- and post- intervention), the context, the setting where the intervention took place and the kind of game that was used. The kinds of video games used, when offered enough insight by the authors behind the analysed cases, was also reviewed and interpreted, in order to better understand which designs were used and how efficient they were claimed to be and thus, what needs to be improved.

The following step and the third moment of this investigation consisted of fieldwork, resorting to interviews and questionnaires, in order to better understand the relevance, pertinence, openness, availability and receptivity to the use of video games as something more than a mere form of entertainment. With this in mind, two questionnaires were developed by us, directed at two different audiences:

a) healthcare professionals (i.e. medical doctors, physiotherapists, nurses, …);
b) game developers.

The questionnaire targeting people from the medical field allowed a better understanding on how the concept of "Serious Game" was perceived across the sector. It also aimed to offer

insight on the opinions on video games shared among people working in this field and how those will be reflected on the main barriers to the implementation and use of Serious Games.

On the other hand, the questionnaire targeting developers aimed to understand the workflow of designing and developing a game for serious purposes. Aspects such as the size of the working teams, the duration of each project, the programming language and/or game engine used, or the budget were some of the topics abridged by this questionnaire.

The interviews shared the same goals as the questionnaires but opted for a face-to-face one-on-one approach, in order to delve in deeper than the questionnaires. The interviews had the objective of taking a closer look on how things actually happen in the real world, allowing some distance from academic research based on reading, in order to better understand the context where we live in and its specific needs.

The last step of this dissertation consisted of evaluating the video game industry and the Serious Games market, in order to better understand the possibility of implementing a feasible business plan for deploying Serious Games for healthcare purposes in the Portuguese reality. For this, it was imperative understanding who we – Portugal – are, from social, technological, political and economic perspectives, so that it would help us envision the future and where we are headed. Additionally, it would access specific needs in terms of physical rehabilitation, allowing an understanding of how these can work in favour of overcoming the barriers encountered upon the implementation of a stable and abridging Serious Game-based policy as a physical rehabilitation strategy. The strengths, opportunities, weaknesses and threats to this plan were laid out and examined. Once this pre-analysis was concluded, the goal was to design hypothetical scenarios that would either promote or demote the implementation of Serious Games as something beneficial from both clinical and economic perspectives. For these, it was necessary to carry out a data survey in order to collect:

- The estimated salary of physical therapists;
- The estimated salary of professionals (programmers, designers, artists) who could join the development team of a Serious Game;
- The number of cases per year of the pathologies under study (focusing on strokes);
- Specifications of a physiotherapy session (duration, how many professionals monitor the patient, weekly frequency, cost per session).

Most of this data had previously been collected in the previous phases of this dissertation, such as during questionnaires and interviews. With these, we were able to elaborate scenarios where the financial viability of the application of Serious Games as a routine physical rehabilitation procedure was gauged and evaluated.

1.4. Road Map

This research is divided in 3 distinct and abridging steps and, therefore, it has been organized in 3 master chapters, that are consequently divided into subchapters.

Chapter 2 contextualizes video games as a broad multimedia tool, going from a brief analysis of their emergence and evolution, touching the entertainment sector of nowadays' video games' industry, before delving in deeper the subgenre of Serious Games. Once the topic of Serious Games is tackled, an analysis of its historical context is done, followed by a broad contextualization of the fields that can resort to video games for serious purposes. As the main theme of this thesis has to do with Serious Games for healthcare, we inspected the possible applications of Serious Games in a closer manner, exploring not only the possibility of using Serious Games as rehabilitation tools, but also, for example, as anxiety controllers, as distraction factors during complicated or painful medical procedures or even as awareness raising tools. In this chapter, the Visual Novel video game subgenre is also explored, in order to better understand how narratives can play a big role in video game and, even if a game is designed to be mostly text based, it can still be perceived as immersive.

Chapter 3 describes the study cases survey that was done in order to understand how Serious Games are being used for physical rehabilitation across the globe (analysing their design and their effectiveness) and focuses on all the field work that was undertaken to answer the questions behind this dissertation. This second half of the chapter is divided in two subchapters – the first one investigates the prospect of Serious Games' use for medical healthcare in Portugal, through both a questionnaire and interviews. The second does the same, but from a design and development point of view. It also resorted to a questionnaire and an interview.

Chapter 4 is divided in two subchapters: the first describes the Portuguese context from social, technological, economic and political points of view and how it moulds and adapts to a possible integration of Serious Games as a rehabilitation policy. During this first subchapter, the strengths, opportunities, weaknesses and threats to this approach are also explored. The second subchapter focuses on designing hypothetical scenarios, proposing a financial framework and a budget range that can give an overview of what to expect if this policy was to be implemented in the National Healthcare System.

The conclusion of the dissertation presents topics that still need to be further researched in order to mitigate the issues and barriers found throughout the development of this investigation.

2. Video Games: From Fun to Serious

2.1. The Era of Video Games.

The concept of "game" is as old as human civilization (Lopes *et al*., 2018). It is hard to define the idea of a "game" – some defend that a game directly implies the existence of guiding rules that one must follow, while others state that a game ought to be a fun and pleasant experience that involves any form of competition (Michael & Chen, 2005).

The fact that adults and children have been engaging in games ever since before written history began implies that the act of playing a game satisfies the self's psychological needs, mostly because games allow their players to experience both autonomy and competence which, consequently, makes them motivating because of the need humans have for feeling like they are in charge of themselves (Ryan, Rigby, & Przybylski, 2006). In this sense, a game can be described as a voluntary activity, that takes place in a different spectrum from real life, that fully absorbs the player's attention. Games are played in a specific time and place; they follow a set of established rules and they stimulate the formation of social groups among their players. It is important to mention that the concept of "fun" is not an ingredient necessary to create a game, but it is an outcome – something that the players get out of the act of playing said game (Michael & Chen, 2005).

Video games often engage the player by capturing their full attention. This phenomenon is called *immersion* and it triggers a feeling of presence (in this case, in the virtual universes of video games, by making the player feel part of the whole that is the video game). This happens because of the players motivation[3], more specifically, intrinsic motivation, which can be defined as what drives people to act freely, conferring a sense of individuality. Intrinsic motivation englobes the aspects of "fun" and "mastery" and, in this sense, predicts the continuation of the behaviour that has been established. On the other hand, extrinsic motivation calls to factors that are external to the self to engaging in a specific activity, being related to the response when confronted with things like rewards or threats (Baranowski, Buday, Thompson, & Baranowski, 2008; Denis & Jouvelot, 2005). Ryan *et al*. (2006) adds that intrinsic motivation is closely associated with presence, this is, the sense that the player is actually part of the game world. Consequently, this feeling of presence is closely related to the need of satisfaction that can be fulfilled thanks to the perception of autonomy granted by in-game environments, by pursuing goals or completing quests. Lohse, Shirzad, Verster, Hodges, & Van Der Loos (2013) add that motivation can be achieved through two different factors - personally motivating

[3] Lohse *et al.* (2013) defines motivation as a "*psychological property that encourages a person's action towards a goal by eliciting and/or sustaining goal-directed behavior*".

factors (such as perceived control, curiosity, exploration and imagination) and socially motivating factors (cooperation, competition and recognition).

The evolution of technology and the emergence of computers and, later on, the internet, allowed games to expand their barriers, as they had the chance to become digital. The first commercial video games emerged in the 1970s, with a promise of entertainment to their players. In 1972, Allan Alcorn (an engineer who worked for Atari[4]) created Pong, one of the first ever video games, a game that is still well-known and appreciated up to this day. At first, games were only available in arcades but, later on, they were transferred to the homes of the players (Horne-Moyer, Moyer, Messer, & Messer, 2014; Kent, 2010). According to James D. Ivory, "*the video games of today represent a convergence of substantially different trajectories of technological developments providing discrepant forms of entertainment to audiences with different needs"* (Ivory, 2015, p. 1). This implies that video games are not restricted to a single gender, age range or social class – games can be adapted to respond to the audience's needs. The dawn of the video game era, that dates to the beginning of the 21st century, is outlined by the crescent belief that video games actively promote some transversal skills, such as attention, memory, and overall performance in executive functions (Lopes *et al*., 2018).

Over the years, games started being designed for different platforms: computers, consoles (such as the PlayStation), handheld-consoles (for example, the Gameboy and, more recently, the Nintendo Switch) and, more recently, even mobile phones and tablets (Machado, Moraes, & Nunes, 2009). A game can be classified according to the platform it is played on, the style of play (multiplayer, online, etc.), the point of view of the player (first person, third person) or the characteristics or underlying objectives of the game (Arsenault, 2009). This allowed games to expand its possible genres, and nowadays we are offered a vast panoply of possible themes, gameplays and different levels of immersion. Some of the most common genres are action/adventure (*King's Quest, The Legend of Zelda*), educational games (considered edutainment, for example *Big Brain Academy*), racing/driving games (*Super Mario Kart, Forza*), *RPG* (role-playing games, such as *Final Fantasy* or *Kingdom Hearts*), simulation (*The Sims, Animal Crossing*), sports (*Pro Evolution Soccer*), strategy (*The Lord of the Rings: The Battle for Middle-Earth, Fire Emblem*), among others. These can be divided in subgenres or categories, for example [*Action > Shooter > First Person*] or [*Sports > Traditional > Ice Hockey*].

The decade of the nineties heavily changed the PC paradigm: they became multimedia, allowing them to perform a larger range of activities and tasks. The first computer-based games and software aiming to teach instead of just entertaining emerged (*Math Blaster, Reader*

[4] A company founded in 1972 in the USA, pioneer in arcade games, home video game consoles and home computers.

Rabbit). Additionally, PCs became economically accessible, allowing them to move into people's homes and schools. As families invested in these computers, parents sought to justify the money they spent on it by purchasing anything that was labelled "educational" for their children. These games fell under a new category, named *"Edutainment"*, that abridged math games, reading games, typing games and so on. Even large game companies that are still riding on the forefront of the video game industry these days joined the bandwagon — Nintendo, for example, used their famous character *Mario*[5] as the protagonist of a typing game, called "*Mario Teaches Typing*" (1992). Edutainment was widely popular in the 2000s, offering plenty of different games and software with a broad range of objectives and goals. This new market seemed appetizing enough for a large number of companies, which led to a boom in the production and release of this kind of games, which ended up "killing" the credibility of edutainment due to the large number of poorly conceived and designed games under this genre (Michael & Chen, 2005).

According to Stokes (2005), educators largely agree that edutainment did not successfully reach its purposes because it mostly focused on short-term achievements. Stokes also claims that game developers attribute the failure of edutainment because the games overlooked the importance of "fun" and "pleasure" underlying a game. Zyda (2005) declares that edutainment has failed its purpose and classifies it as "*an awkward combination of educational software lightly sprinkled with game-like interfaces and cute dialog*", stating that it does not fulfil its role because the importance of the story is taken too lightly. Therefore, the author suggests that, when talking about Serious Games, the plot or the story of the game must come first and foremost, as participants must find it immersive and entertaining, so they learn something through collateral learning. In this sense, the author states that it is imperative to combine instruction (more broadly said, the underlying game's objectives) with story creation and the process of developing the game.

2.1.1. The Visual Novel as a video game genre

Stories are undeniably linked to human culture from the very beginnings of civilization – they are something so inherent to the self, that it is plausible to say that they are something humans *need*. So, what if the player of a video game had a chance to partake in a story instead of being a simple bystander or a total outsider? The possibility of direct interaction with the story is linked to a video game type called a "Visual Novel".

[5] The mascot of a series of platform games created and developed by Nintendo.

A Visual Novel can be described as a video game genre that mainly focuses on its narrative. This concept was born in Japan, as a part of the universe of *anime*[6] and *manga*[7] and therefore, it is heavily linked to the Japanese culture and aesthetic. A Visual Novel can be defined as a game that merges literature with game elements, such as interactivity, participation and role-playing. Its narrative is branched and, therefore, the plot of the game depends on the choices the player makes during the play through. A Visual Novel is a video game doted of a participatory nature that consistently uses the player's productivity and input to design its own narrative, which inherently allows to overgrow restrictions found by games whose narratives are linear and solely designed by the author of the game's plot. The Visual Novel consists in a group of alternating narrative arcs that intersect each other, which makes it possible for game endings to vary in function of the choices and the paths picked by the user in certain key points of the game (Cavallaro, 2009).

A Visual Novel presents long textual passages, that consist of either conversations between characters (usually the protagonist and a game character) or interior monologues. These are complemented by frames that feature a visually attractive background (that means to represent the location where the scene takes place) together with sprites[8] of the characters (embodying the intention to represent whoever the main protagonist is talking to). Therefore, Visual Novels thrive to make a difference through their, more often than not, psychologically complex plots, their character design and their vibrant, colourful and detailed backgrounds (*ibidem*). The character sprites often match the text that is being shown at the time by displaying facial expressions that bring the dialogue to life. In recent times, it is common to have fully voiced Visual Novels, together with sprites that are animated (using, for example, the Live2D[9] technique), in order to enhance the feeling of belonging and immersion created by the story.

The first Visual Novel to be commercialized was "*The Portopia Serial Murder Case*" (Chunsoft, 1983, Japan) and it was heavily inspired in titles such as "*King's Quest*" (Sierra Entertainment, 1980), and "*Mystery House*" (On-line Systems, 1980). This marks the first attempt to introduce the Japanese people to a new kind of game – one that heavily relied on its ability to tell a story. Before the consoles took over the Japanese market and the videogame industry by storm, the personal computer was a powerful gaming platform and, due to its characteristics, the Visual Novel quickly became one of the dominating genres of video games in the country. Since Visual Novel are mostly visually static, and due to the limitations and the

[6] Japanese animation.

[7] Japanese comics.

[8] Computer-graphics term referring to two-dimensional bitmap integrated into a larger scene that often tends to be a 2D video game.

[9] https://www.live2d.com/

characteristics of the hardware available in the eighties, they were a desirable video game genre for developers (Lada, 2015).

In 1994, Konami published a Visual Novel (the first of the subgenre *dating sim*) named *Tokimeki Memorial*, that revolutionized the aesthetic paradigm of this video game genre. This game followed a visual layout that received the name of theatrical storytelling, having shaped the aesthetic described above, that nowadays visually describes the genre (Crimmins, 2016).

2.2. More than Entertainment

Games were, even before they became digital, a source of fun, entertainment, and engaging experiences. A simple *Musical Chairs* game can be an exciting activity that is thoroughly enjoyed by people of all ages. When games became digital, they had the chance to allow the players to be immersed in the game's universe, as they combined three elements that were essential to achieve this objective: story, art and software (Zyda, 2005). Therefore, it is safe to say that video games are the result of the combination of several elements that aim to entertain people. But what if these very features and elements were used with a purpose other than mere entertainment? What if it was possible to create an engaging and motivating "video game-like" experience whose primary goal was not only satisfying the players need for "fun"?

The concept of Serious Games answers this exact proposition: using games in order to achieve a goal other than pleasure, happiness or satisfaction (although, it is implied that the player still experiences these positive emotions, despite the fact that it is not the main objective of the game). Video games are very attractive when it comes to the option of being applied to fields other than mere entertainment, because they can offer extended playtime, if they are perceived as captivating enough by their players, there is a high probability of being replayed and it is expected that the users' participation and usage of the game comes off as voluntary (Lohse *et al*., 2013). In this sense, several fields, such as healthcare, education, military, business, etc., decided to adopt the paradigm offered by Serious Games and use elements of video games for their own personal needs (Trigo Algar, 2014). Serious Games are known to promote something that is called *collateral learning*, which means that the act of learning achieved through some method other than formal learning. Serious Games aim to apply entertainment elements, such as creativity and technology, to accomplish their goals and meet their ends (Zyda, 2005).

Before we go any further, it is fundamental to understand this seemingly broad concept of "Serious Game". Is it safe to define a game of this sort merely as a digital application whose primary goal is not pure entertainment? Michael and Chen claim, in their book *Serious Games: Games that Educate, Train and Inform*, that Serious Games are "[...] *games that do not have*

entertainment, enjoyment or fun as their primary purpose. That isn't to say that games under the Serious Games umbrella aren't entertaining, enjoyable or fun. It's just that there is another purpose, an ulterior motive, in a very real sense" (Michael & Chen, 2005, p. 21). The authors also note that what can be seen as a Serious Game for a specific group of people, can be a mere source of entertainment if applied to a different context. For example, games designed for the military to train soldiers for war/emergency situations can be serious when in this specific context but, if that same game was applied to a different circumstance, it could perhaps be seen solely as a "fun shooting game". Serious Games can also be defined as "*a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy and strategic communication objectives*" (Zyda, 2005). These kinds of games thrive to apply ideals belonging to the video game industry to a new environment with the goal of making learning or training an enjoyable activity that is both visually stimulating and mentally engaging.

As mentioned previously, edutainment has largely failed. Serious Games aim to embrace the same goals of edutainment – go beyond mere entertainment – but they are broader and not only restricted to the idea of teaching something to their players (Michael & Chen, 2005).

Some authors also come forward with a new plausible way of defining the pertinence of Serious Games, according to their purpose of use instead of their nature, this is, all games can be "serious" (even those designed with the objective to be exclusively a source of entertainment) if they are used for serious purposes. This concept aims to overcome the limitations of the ongoing distinction between entertainment games and Serious Games, allowing all games to be serious if used for that objective. If the ends are met, it does not really matter if a game is solely designed for that purpose or not (Lopes *et al*., 2018).

Therefore, it is essential to address the fact that a Serious Game does not necessarily call for "serious" content: it can be totally unrelated to the reason of use/application of the game if 1) it successfully tackles the topic that is supposed to be addressed and 2) it gets positive results and feedback. For example, if the goal of the game is teaching math or science to children/ teens, the content of the game does not need to be an interactive textbook or a simulation of a classroom – perhaps addressing the objective through a fictional world, with otherworldly beings as characters, might be more successful and stimulating than forcing children to sit through a simulation of school (Michael & Chen, 2005). Rosenheck, Clarke-Midura, Gordon-Messer and Klopfer, in "*Tipping the Scales: Classroom Feasibility of the Radix Endeavor Game*", chapter 10 of the book *Serious Games and Edutainment Applications — Volume* II (2017), discuss the use of *Radix Endeavor*[10], a massively multiplayer online game (MMO) with

[10] https://www.radixendeavor.org

the underlying objective of teaching both math and science, striving to make teaching and learning a meaningful and customizable experience. This game is set in a virtual world, which allows players to participate in missions that enhance learning of math and biology concepts while exploring the game's universe. According to the authors, it *"builds a conceptual understanding, leaving students open to make connections between experiences in the game and experiences in their classroom and even their lives outside of school"* (p. 231). The teachers that used this game and considered its employment successful claim that *Radix Endeavor* is a pedagogically fit tool that aligns to the students' curriculum as well as content learned, allows students to practice and develop soft skills[11] while being engaged in a motivating experience filled with unique qualities.

Some people may argue that this focus on the "serious" side of things may strip the game of its artistic qualities, but games are undeniably a form of artistic expression and for that reason, even if it is not the main objective of the game, it is there nevertheless (Michael & Chen, 2005).

Laamarti, Eid, & El Saddik (2014) claim that the academia and the industry share different views on the topic of Serious Games. While the video game industry believes that Serious Games must combine a strong entertainment dimension while carrying a practical serious objective underneath, the academy chooses to defend that every single game ever made, in a way, always carries a purpose that can be considered serious (*e.g.*: gambling, fortune telling or politics). This brings about a new problematic - is the concept of Serious Games nothing more than a mere marketing strategy? The authors suggest that the answer to this problem lies within the design goals of the video game. The issue here is that there is no possible way to tell what most game designers are thinking when they design a game. Nevertheless, both the academy and the industry agree on the fact that Serious Games require an entertainment dimension, that can be achieved through multimodal interaction[12], thus enhancing and improving the user experience. Therefore, as was already mentioned and addressed previously by other authors, most definitions for Serious Games agree that this particular kind of video game embodies and assembles a diverse group of media types, including text, graphics, animation, audio, haptics, among others. The authors also state that "*the 'serious' term in Serious Games comes from their role of conveying some message or input, be it knowledge, skill or in general some content to the player*", which makes Serious Games stand on three pillars: multimedia, experience and entertainment (Figure 1).

[11] Soft kills refer to non-technical skills that are related to how a person works. They abridge, for example, interpersonal, communication, time management and empathy skills, among others (Doyle, 2020).

[12] The user is allowed multiple and different forms of interaction with a system.

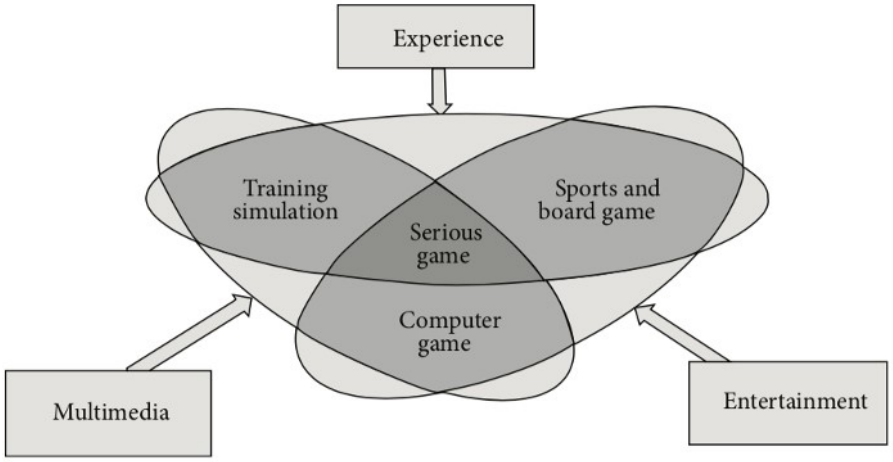

Figure 1 – The three dimensions that make a Serious Game (in Laamarti et al., 2014)

Historically contextualizing Serious Games, they emerged in the United States in the 1980s for the military (Machado *et al*., 2009) but, the concept did not grow to be well know till 2002, when America's Army (a first-person shooter video game published by the military itself, that was distributed online, free of charge) was designed as a mechanism to inform, educate, and recruit prospective soldiers as well as a training tool for their actual recruits — it was being used for a purpose other than pure entertainment. America's Army was then recognized as the first successful Serious Game, achieving the aim of capturing people's attention (Zyda, 2005). This rooted the concept of "Serious Game" and, in the same year that this game was released, the Serious Games Initiative was founded by Ben Sawyer. This association supported the pro-Serious Game movement and advocated the interest of using these games for educational, medical, military, governmental and business purposes. In this sense, this movement then rooted the concept proposed for Serious Games (Susi, Johannesson, & Backlund, 2007).

The first Serious Game, as mentioned before, was developed for the military and its intention was to be a flight simulator that resorted to the use of Virtual Reality (VR) in order to recreate the experience of flying an aircraft. This was developed so that it would be possible to train pilots without any aircrafts having to leave the runway. In fact, the first attempt of using a simulator dates back to World War II. Soon after, these types of simulations found new markets and fields, adopting new paradigms and aesthetics. Currently, Serious Games are undeniably linked to the use of both Virtual Reality and Augmented Reality (AR) (Machado *et al*., 2009). It is safe to say that, according to this train of thought, Serious Games aim to allow their players to learn and experience particular situations within a controlled environment, where there is no risk for the player or any third party because, all in all, it is nothing but a simulation. The situations and elements that make the simulation can be both managed and controlled to respond to the player's needs and, moreover, these simulations allow the emulation of situations that may be both difficult and expensive to perform in real life. This can be useful in situations such

as training of medical personnel, for example, teaching young surgeons how to perform certain interventions without the risk of killing the patient with a single mistake. In this specific case, these simulations allow doctors to prepare for delicate procedures without risking the lives of other people. This is not only applied to the healthcare field, but there are other situations where these simulations allow the players to experience dire situations in a risk-free environment: driving simulators and war simulators present themselves as relevant examples (Trigo Algar, 2014).

This creates a new problem: are all 3D simulations apt to be considered Serious Games or, even, games? Despite the fact that the value of a simulation that can replace something from the real world can be immediate, not all simulations using 3D can be classified as games, as they do not present certain characteristics that define what a "game" is. They might use the same technology when being brought to life, but it is not safe to call them games if they do not embody any component of game design. Consequently, some 3D applications are not games, while others can be classified as such and, as expected, not all games are 3D applications (Susi *et al*., 2007).

2.2.1. Serious Games in healthcare

Serious Games emerged to be a resource proven to be useful in a vast ensemble of distinct fields. The first reports of Serious Games being used in the medical field date back to 1983 (Kato, 2010).

According to Wattanasoontorn, Hernández, & Sbert (2014), Serious Games used in healthcare contexts can be classified according to four different taxonomies: main purpose, player type, stage of disease and functionality.

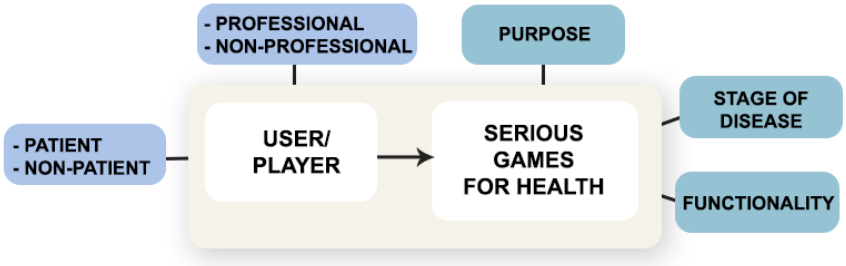

Figure 2 – Classification taxonomies (Wattanasoontorn et al., 2014)

The main purpose refers to the objective behind the use of the game. In this sense, it can be to provide entertainment to the player, experiencing health benefits from the act of playing the game as a side effect (*e.g.*: *Dance Dance Revolution*). Another possibility is when the game is used with the purpose of enhancing the player's health by transmitting skills or knowledge through the gameplay. The last possibility is that of the game being a simulation that is used in

order to avoid taking risks, in case the tasks depicted in the simulation gameplay were performed in a real environment (Wattanasoontorn, Sbert, & Girona, 2014).

The player type is quite self-explanatory and refers to whether the player is a patient or a non-patient. If the player is a patient, the game can be subcategorized as tackling one of the following objectives: health monitoring, detection, treatment, rehabilitation and education for self/directed self-care. If the player is a non-patient, the game can be targeted at both health professionals and healthy people. When it is aimed to health professionals, training and simulation are the most common ways of categorizing the game. If not, the game can probably be considered to be addressing issues such as health and wellness (Wattanasoontorn *et al*., 2014).

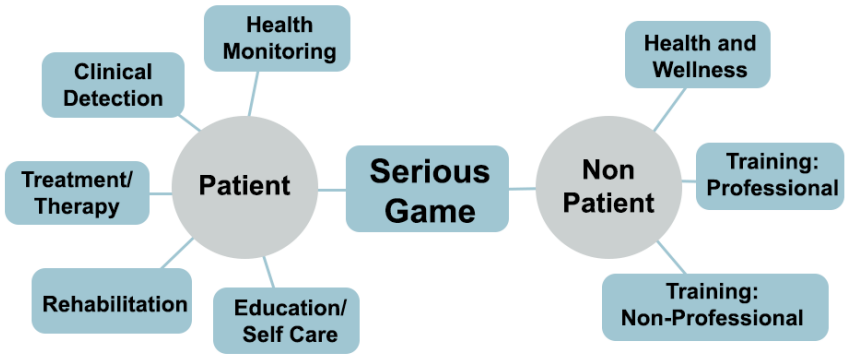

Figure 3 – Classification of Serious Games according to player type (Wattanasoontorn et al., 2014)

The classification by stage of disease is split in four phases: stage of susceptibility, presymptomatic stage, stage of clinical disease and stage of disability. The stage of susceptibility refers to when an individual is not ill/is healthy, but has, for example, a genetic predisposition to contract a specific illness. Games that are developed with the aim of being implemented during this stage have the goal of monitoring the healthy user. The presymptomatic stage happens when the patient is already ill but shows no symptoms. Games developed for this stage are generally targeted towards detecting the illness. During the stage of clinical disease, the user is ill, and the game has the objective of enhancing the treatment or therapy that the patient must undergo in order to become improve his/her health. The stage of disability is the last stage and is related to the disabilities, handicaps and pariahs experienced by the patient in the post-treatment phase. In this case, the main objective of using a Serious Game is to track and trace of the patient's rehabilitation (Wattanasoontorn *et al*., 2014).

The last suggested way of classifying Serious Games is linked to their functionality and this classification was originally presented by Rego, Moreira, & Reis (2010). This classifies the games according to features they may or may not possess, as well as the way the gaming aspect is approached, both technologically and in terms of interaction. A Serious Game for healthcare can, therefore, be classified according to its application area. In this sense, there are two major

areas that need to be highlighted: cognitive and motor. A Serious Games can also be classified according to the interaction technology it uses. It is important to mention that interaction technology and hardware are two distinct things and that this aspect has to do with which hardware devices are used to interact with the game (*e.g.*: Kinect, Head-mounted display, …). A game can also be classified according to its platform and, in this case, we refer to the kind of hardware used to play the game (*e.g.*: PC, Nintendo Wii, PlayStation, Smartphone, …). The game interface - if the game features a 2D or 3D environment - can also be used as a way to classify and characterize a Serious Game, as well as the number of players that can play the game simultaneously (sharing a game instance, server or location: if a game is single-player or multiplayer). Following this train of thought, connectivity is also one of the characteristics that can tell two games apart. Some video games might require internet connection to work, and therefore requiring that the player partakes in the game while being online, whilst other games might not need any kind of connectivity, working integrally as offline standalones. A Serious Game can also be classified according to its genre, and this is defined by the kind of gameplay that the game has to offer. Another way to approach this kind of game taxonomy is the game portability: can you take the game anywhere or do you need to be in a specific location to be able to play it? Adaptability (if the game's difficulty level is adaptable to the player's needs), performance feedback (if the video game offers the players feedback on their performance as the game advances; feedback can be auditory, visual or haptic) and progress monitoring (if the game records and monitors the player's performance throughout the game) are also ways of classifying a Serious Game for healthcare. Sometimes, whether the game was developed resorting to a game engine can also be a distinguishing factor among games, as well as its health objective, that is closely linked to the player type or stage of disease taxonomies (Rego *et al*., 2010; Wattanasoontorn *et al*., 2014).

Video games have been known to be the cause of lesions common among "hard-core" gamers, such as tendinitis, and they are usually a reason for discussion when it comes to their relation to both mental health of players and aggressive behaviour. Although the association of video games to negative outcomes is not uncommon, the medical field started looking at video games under a different light – what if these games could actually be useful tools to help enhance and improve the healthcare system? Michael and Chen claim that "*new studies have shown that videogames can assist patients as they recover, help doctors as they prepare for delicate surgery, promote general wellness, help patients with mental problems, and more*" (Michael & Chen, 2005, p. 179).

In this sense, several possible applications for video games in healthcare have been studied and discussed over the years, and some of the most common ones include improving cognitive

abilities of the elderly, as well as improving neuropsychological abilities of alcoholic patients, supporting physical rehabilitation of disabled patients (through simulations and/or VR environments), promote healthy behaviour and consciousness in children, educate patients, enhance treatment adherence (mostly among young children and adolescents), training medical personnel (Graafland *et al*., 2014), using video games to distract patients during painful medical procedures, enhancing physical fitness and improving mental health (Michael & Chen, 2005). These fields can also be grouped in four larger groups, namely health monitoring, detection and treatment, therapeutic education and prevention and rehabilitation (Laamarti *et al*., 2014). It is also suggested that, although Serious Games have proven themselves to be precious tools in the medical field, it is not advisable to use them as the main course or the core of a therapy, but as a complement to more traditional ways of proceeding with the treatment. They should not be seen as substitute, but as a tool to overcome the lack of motivation to adhere to treatments often displayed by patients (Lopes *et al*., 2018).

Games are known to stimulate the brain as they require attention. According to Kueider, Parisi, Gross and Rebok, in their systematic review "*Computerized Cognitive Training with Older Adults",* it is concluded that video games are an effective tool when it comes to enhancing cognitive abilities of elderly, such as their reaction time, processing speed, executive function and their global cognition. According to the authors, it is beneficial to turn to computer-based cognitive training since it can offer a larger possibility of individualizing the experience, in order to match the elder's needs more accurately and, therefore, achieve better results. Besides, the authors believe that these computer-based training programs can be more easily disseminated, reaching population groups that, otherwise, would not have access to these initiatives (Kueider, Parisi, Gross, & Rebok, 2012).

As mentioned above, one of the many uses of Serious Games in healthcare has to do with improving neuropsychological abilities of alcoholic patients. Alcohol dependence can culminate in some severe consequences that go beyond the physical realm to affect the brain itself, damaging several cognitive domains. This leads to brain dysfunction of the prefrontal cortex. It has been tested and concluded that the use of mobile Serious Games for neuropsychological stimulation attained positive results in overcoming executive dysfunction observed in alcohol dependent patients (Gamito *et al.*, 2014).

Another use that is attributed to Serious Games in healthcare consists in using these games in the form of simulations or VR environments as a therapy tool to stimulate physical movement and, therefore, rehabilitation of physically impaired or disabled patients. Video games are beneficial for both cognitive and motor skill learning, which makes them a powerful tool for mental and physical rehabilitation. More often than not, lack of motivation to adhere to

rehabilitation therapies is observed within patients and video games can help overcome those issues (Lohse *et al*., 2013). According to Ma and Bechkoum (2008), in their paper "*Serious Games for Movement Therapy after Stroke*", the use of VR environments can be highly beneficial to help patients left with impairment sequels in the follow-up of a stroke. They describe the use of Serious Games with the objective of encouraging stroke patients to practice physical exercises and engage in therapy through games. This study concluded that "*computer-based motor therapy using both functional training and Serious Games was more effective than using functional training solely, in terms of improving motor functions shortly after completion of the intervention and it may bring long term benefits as well*". The authors of this paper also state that the integration of simulation through VR is very relevant, as it adds richness and depth to the game, stimulating the patient's engagement and motivation, which will increase the potential for a better outcome in the treatment.

According to Michael and Chen (2005), self-management is an important issue and key element in the treatment and awareness when it comes to chronic diseases, because it can prevent serious consequences, such as further health complications or even death. The authors then discuss the relevance of using Serious Games for promoting children's self-management in two chronic diseases: diabetes and asthma. The use of Serious Games here aims to educate the patients on their health issues, in order to better control the progression of said diseases by reshaping lifestyle. Kato (2010) mentions that the use of games to educate and raise awareness among diabetic children can be beneficial: the game *Packy and Marlon*[13], originally made for Super Nintendo, obtained positive results as the patients learnt how to better deal with their illness and how to adapt their lifestyle in function of their needs, which consequently led to better communication and less visits to the emergency room. The author also mentions the use of video games to help children deal with asthma by learning how to properly breathe. It can be difficult to get children to comply to treatments that involve their cooperation in order to obtain results - doctors tend to find it complicated to get children to inhale and exhale as asked. In this sense, *SpiroGame*[14] was developed and it aimed to teach children how to breathe by using biofeedback[15] to control the movements of a caterpillar or bee through inhalations and exhalations. Kato concludes that interactive technology is a good way to motivate and shape behaviours, but also a way to enhance children's adherence and compliance to treatments. The

[13] This game depicts two elephants who are taking part in a diabetes summer camp. The game aims to teach the children how to manage their food intake and diet, consequently managing their insulin levels. The objective of the game is raising awareness among young patients by enhancing self-efficacy for diabetes self-management.

[14] SpiroGame is a game that was developed to use together with a device that can read the breathing activity to be used for spirometry (a measure of lung function used to monitor patients with poor lung activity, such as asthma patients).

[15] A biofeedback game uses the physiological responses of the player in order to affect gameplay, this is, bodily functions are electronically monitored in order to be used as input to the game (for example, using breathing as a way to control the flow of the game) (Michael & Chen, 2005)

author also states that video games can be useful for situations such as bladder and bowel dysfunction and paediatric cancer.

When one talks about using games in order to train professionals of the medical field, the first thing that, more often than not, comes to mind is using video games in the form of simulations to prepare young surgeons for surgical interventions or just to improve their skills. Kato (2010) addresses the pertinence of using games to enhance medical related skills. But the author not only talks about specific games that aim to simulate real life situations but also that playing video games in general might be beneficial for surgeons, as it increases their ability to perform tasks faster, better and it also confers them shorter reaction times. The author then mentions the use of tailor-made games for the sake of learning and bettering skills. Kato proposes the use of games for the following situations: cancer care, breast health and the teaching of clinical skins via simulations. Michael and Chen (2005) claim that resorting to simulations and games to train professionals has several advantages over more traditional ways, namely: being a cost-effective platform for training and skill development, the wide availability and portability of video games, being a captivating way to recruit new doctors and physicians and lowering the number of implications of training and practicing, for example, on real patients, as well as prevention and reduction of errors.

Michael and Chen (2005) also note that games can be used in the form of distraction therapy. The perception of pain is directly linked to the amount of conscious attention a person gives to the stimuli the body is getting. This said, immersive situations can help shift the patient's attention to something else other than the pain signals. Simulations and video games resorting to VR can be very effective as they heavily rely on the player's immersion. Pain tolerance will be enhanced since the person will be distracted absorbing the virtual world of the game, so they will involuntarily lose part of the pain signals that their body is receiving, since both their conscious attention and awareness are somewhere else. Besides being a solid theory for validating the use of games in situations where patients have to undergo painful and abrasive medical procedures (for instance, treating burns), video games can also be used as way to lower the levels of anxiety (called anticipatory anxiety) felt before said procedures. This tends to affect children even more than adults, so using games to make children feel calmer and at ease might be highly beneficial for them. On this topic, Kato (2010) claims that using immersive games to reduce anticipatory anxiety is proved to be as effective as a pharmacological intervention. Moreover, in comparison to the use of a television or a book, video games (from VR to handheld consoles) revealed higher levels of engagement, which add to the fact that they are an easy-to-implement and portable method.

While video games are often associated with sedentary and non-healthy behaviours, some games require the players to move in order to actually play the game. When we are talking about Serious Games applied to education, it is common to refer to them as "*Edutainment*". When it comes to games to enhance and promote physical fitness, a new term was created — "*Exergaming*" or "*Exertainment*". These products therefore attempt to transform physical activity into something appealing through the application of mentally engaging elements usually attributed to the characteristics of video games. Technological evolution allowed the development of games that forced the players to get up from their chairs or couches and actually move and exercise. The emergence of dance mats or of the EyeToy (released by Sony for the Playstation 2 in 2003) in the nineties and the first decade of 2000 allowed video games to approach the realm of physical activity (Michael & Chen, 2005). Later on, the idea of games that make you move got the chance to be solidified thanks to platforms such as Nintendo Wii and Xbox (through the Kinect sensor). The dawn of the VR games is also enhancing the use of movement as the source of input and output of the game. Haptic feedback is also changing how video games are perceived by making them feel closer to reality. This has allowed new fields to be explored, new hypothesis to be studied and new paths to be conquered. Nevertheless, VR is still experiencing some downsides that need to be worked on, for example, motion sickness (Sherman & Craig, 2018). Kato (2010) mentions the use of *COTS* (Commercial Off the Shelf games, this is, games that were not designed with the purpose of being serious or tackling serious issues) was successful because it sparked feelings of engagement and motivation among players upon the act of participating in the game. As was mentioned before, games that aim to encourage physical movement are, not only good for healthy and physically capable people, but they are a precious and underexplored tool to help those medical patients with physical impairments. The author also points out that, despite the fact that "hard-core" gaming is usually linked with lesions (such as tendinitis), the use of video games to help those with physical impairments exercise or recover their motor abilities will rarely ignite the appearance of lesions of that kind, because games ought to be prescribed and monitored by a professional of the area (physician or physiotherapist, for example), therefore they will never reach the risky level of addiction that is usually linked to the lifestyle of "hard-core" gamers. Besides favouring physical activity, Michael and Chen (2005) also mention that there are games designed to tackle topics such as nutrition and sexually transmitted diseases — in short, there are plenty of games to ensure that those are healthy stay healthy by promoting general wellness.

Serious Games can also be used to improve, not only physical health and wellness, but also mental health. Some of their applications include fighting/coming to terms with phobias, learning how to deal with social anxiety or promoting interpersonal interactions to people

suffering from mental impairments, promoting self-discovery (by making the player face situations that can be morally ambiguous, for example) and as a tool to fight feelings of loneliness or even depression. Trigo Algar (2014) discusses the use of Serious Games for fighting fears and treating phobias as they permit taking part in simulations that consist of exposure to the feared situation in a controlled environment. This allows patients not to exert themselves but also feel a sense of security because they know they can quit the simulation whenever their levels of anxiety start getting uncomfortable or unbearable. Bowman (2018) addresses the use of video games of the Visual Novel genre in order to help cancer patients feel less lonely. The game consists of a virtual support group whose story and interactions unfold in real time to allow the patient to experience a sense of reality and belonging.

3. Understanding the relevance, development, design and application of Serious Games for physical rehabilitation

3.1. Case Studies

Physical rehabilitation of impaired or disabled people is one of the fields of research among the ones that are abridged by the broad scope when talking about rehabilitation processes. Jonsdottir, Bertoni, Lawo, Montesano, Bowman and Gabrielli (2018) propose two different ways of approaching the use of video games for physical rehabilitation: gaming through games that were conceived, designed and developed solely with the purpose of achieving that end (custom-made Serious Games), or gaming through *COTS* (Commercial Off The Shelf games), which consists of using games aimed at the entertainment market but inside the context of the desired goal and end. (Jonsdottir *et al*., 2018). This allows all kinds of games to be seen as "serious" as long as they serve a serious purpose, which can be completely unrelated to the reason why the game was designed and developed in the first place (Lopes *et al*., 2018).

When talking about using Serious Games for physical rehabilitation, a quick online search can lead to the following conclusion: most of the results that are presented describe the use of this kind of games for stroke rehabilitation, since stroke is one of the main causes of adult non-congenital physical disability worldwide (Ferro, n.d.; Johnson, Onuma, Owolabi, & Sachdev, 2016). This literature review started by searching keywords related to the field of study, namely "Serious Games + healthcare + physical rehabilitation" in the Google Scholar and Cochrane databases. The results obtained were filtered by title, and then by abstract according to their relevance to the problematic proposed by this paper. The selected papers were read, and a recursive analysis of the references presented in the primary articles was done. This totalled 26 papers discussing relevant issues (including other survey papers), but only 12 described results of specific games applied to physical rehabilitation. These 12 articles were then analysed from a therapeutic point of view and from a game development and design point of view (see Appendix A).

Figure 4 – Article selection process for systematic literature review

The games selected focused on the rehabilitation of physical impairments resulting from conditions such as stroke follow-up (Broeren *et al*., 2008; Cameirão, Bermúdez, Duarte Oller, & Verschure, 2009; Jack *et al*., 2001; Ma & Bechkoum, 2008; Saposnik *et al*., 2010), multiple

sclerosis (Jonsdottir *et al*., 2018; Thomas *et al*., 2017) or cerebral palsy (Lopes *et al*., 2018), although some of the studies focused on the perception of the games among healthy players (Abdelkader & Hocine, 2011; Ghassemi *et al*., 2019) in order to refine the games or evaluate the pertinence of their application in therapy with actual patients. Some studies also conducted multiple tests in order to reach plausible and viable conclusions on the topic at hand (Abdelkader & Hocine, 2011; Bower *et al*., 2015; Delbressine *et al*., 2012; Hocine *et al.*, 2015). Some of the selected cases also resorted different kinds of games to healthcare, from custom-made Serious Games designed specifically for rehabilitation purposes to Commercial Off the Shelf Games (*COTS*), eventually even establishing a comparison of the efficacy observed between the two (Jonsdottir *et al*., 2018; Saposnik *et al*., 2010; Thomas *et al*., 2017).

3.1.1. COTS (Commercial Off-the-Shelf Games)

COTS, or commercial off-the-shelf games, as explained in the previous chapter, are games that were developed with the entertainment market in mind but are considered adaptable and relevant for serious purposes – physical rehabilitation, in this specific case. In this sense, two articles described the use of COTS as a therapy tool.

Saposnik *et al*. (Saposnik *et al*., 2010) described a pilot randomized, single-blinded clinical trial (that took place in a clinical setting – Toronto Rehabilitation Institute) with two parallel groups that had the objective of comparing the feasibility, safety and efficacy of using virtual reality as stroke rehabilitation therapy method by determining whether Nintendo Wii (VRWii) enhances post-stroke motor function recovery. The sample counted with 22 randomized patients within two months after stroke (subacute period). The mean age of the patients was 61.3 years (with ages ranging from 41 to 83 years old). The selected patients were then randomly allocated in a 1:1 ratio to one of two groups: a group that used the VRWii gaming system (Nintendo Wii) and a group that participated in recreational therapy (used as control group). Incidentally, the patients that were assigned to the Wii group were younger, had more severe strokes and had a lower arm function at baseline. The patients that participated in the study took part in 8 intensive interventional sessions (Wii or Recreational Therapy). Each session lasted for 60 minutes and they were scheduled in a flexible manner over a 14-day period, being separated between them by at least 5 or more hours. As to be expected, the Wii group played COTS (namely Tennis, Bowling and *Cooking Mama*) and aimed to train shoulder movements (rotation, flexion and extension), elbow movements (extension and flexion) and wrist movements (supination, pronation, flexion and extension). Thumb flexion was also involved in all activities. The patients were asked to play the games while in a sitting position and to use their more affected arm or hand (despite the fact that Wii is adaptable to answer to

patients' needs). The Wii sessions' total time was 364 minutes. The participants in the recreational therapy group played cards, bingo or "Jenga". The recreational therapy sessions totalled a time of 388 minutes. The outcomes (safety, feasibility and efficacy of the proposed method) were then measured and evaluated 4 weeks after intervention.

This study concluded that using games and, in this case, VRWii was a viable alternative to more conventional therapy methods for stroke patients. No adverse events were noted throughout the duration of the intervention. The participants in the Wii group showed significant improvements in motor arm function in comparison to baseline, but the authors state that the differences between the individuals of the two groups (mentioned above) can make it hard to pinpoint the exact reason for the positive outcomes obtained in this study. Nevertheless, the authors pointed out that Wii is both accessible and fairly inexpensive, which can make this method appealing and easy to implement.

Thomas *et al.* (Thomas *et al*., 2017) presented a pilot randomized controlled trial that aimed to access the acceptability and suitability of a Nintendo Wii-based intervention named *Mii-vitaliSe* as a method for encouraging multiple sclerosis patients to increase their physical activity levels while in their own homes. In this sense, the study took place in the homes of the selected participants (one of the selecting criteria was whether they owned a suitable television at home) but, beforehand, the patients participated in two orientation sessions in the hospital. 30 randomized multiple sclerosis patients (ambulatory and relatively inactive) participated in this trial and they were divided in two groups: group that received the intervention either immediately (for 12 months) and a group that started after a 6-month wait (for 6 months). This design allowed to evaluate long-term follow-up (in the immediate group only). The intervention consisted of, as explained by the authors, "*two supervised Nintendo Wii familiarization sessions in the hospital followed by home use (Wii Sports, Sports Resort and Fit Plus software) with physiotherapist support and personalized resources".* During the initial 6 months of the intervention, both groups had a mean usage time of 27 min/day, twice a week and the cost to deliver this intervention to a single patient was of £684 (~799€) per person. The measured outcomes were self-reported physical activity levels, quality of life, mood, self-efficacy, fatigue, assessments of balance, gait, mobility and hand dexterity. They were measured at baseline, 6 and 12 months. Interviews and a questionnaire were also conducted, and adherence was measured based on a daily play log.

The use of Wii was frequent (around 2 times per week) and approached aerobic activity guideline levels, which led to the fact that the *Mii-vitaliSe* intervention was well received by both patients and the physiotherapists delivering the intervention. No serious adverse events were reported throughout the duration of the intervention, but it is necessary, feasible and

warranted to conduct a future trial. The authors also concluded that the use of Wii allows the patients to participate in physical activities at home, as it is a "*relatively inexpensive, convenient, immersive and fun way to exercise*". However, the patients showed reluctance and difficulty travelling to the hospital to participate in the first orientation sessions, so it is important to find a new way to deliver these beginner sessions.

COTS proved to be an efficient and economical way of using games for physical rehabilitation purposes, enhancing the patients' motivation to participate in therapy.

3.1.2. Custom-Made Serious Games: "Point & Click" and "Drag & Drop"

Point & Click and Drag & Drop seem to be popular among the games that are designed and developed for serious purposes. Point & Click games are those centering around the action of moving the cursor to a specific point in the game and then clicking or pressing a button to trigger an action. Drag & Drop games are identical, but the player is expected to simulate the act of grabbing a virtual object (through the cursor, for example) and then dragging it across the screen to a specific location to trigger an action or outcome. 5 cases where games embodying these features were developed with rehabilitation purposes in mind were identified and analysed.

Broeren *et al*. (Broeren *et al*., 2008) described three different studies (that took place in the department of rehabilitation medicine at Sahlgrenska University Hospital, in Göteborg, Sweden) with a control group of healthy individuals. For the stroke patient group, this experiment selected 29 individuals (aged 44-85). The intervention resorted to the use of a VR activity station and the patients were invited to reach into a virtual space and to interact with 3D objects through a stylus (haptic device) positioned in the line of sight. The patients had to reach for virtual targets using the stylus they were holding in real life. The targets appeared at random locations on the screen, one after the other, and disappeared when the user pointed the stylus at them. The participants showed a favourable response to the use of VR.

This study also concluded that this kind of treatment is promising when it comes to stroke rehabilitation, as it offers a vast plethora of possibilities of applicability. As for quantitative results, this study compared average velocity of the movement and the time spent executing the required motion pre- and post- interventions, and all the patients had better values after participating in the study.

Bower *et al*. (Bower *et al*., 2015) stated that, as COTS have limitations when it comes to their use for rehabilitation purpose, custom made Serious Games might be the way to go. In this sense, a study divided in 2 phases was conducted. Its objective was to "*investigate the feasibility of using a suite of motion-controlled games in individuals with stroke undergoing*

rehabilitation". Phase 1 consisted in an initial feasibility testing while phase 2 was a pilot randomized controlled trial. Both phases were held in a single rehabilitation facility in Melbourne, Australia. For phase 1, 40 individuals (mean age 63 years) who were stroke patients and were able to sit unsupported were recruited. They showed no cognitive deficits nor visual problems. Patients were randomly assigned to trial one of the four available games during a single session, under the supervision of a physiotherapist. Participants were expected to complete all 10 levels of the game they were playing, first in sitting, then standing as able, preferably taking approximately 1 minute to complete each level. These games were developed purposefully for this study. The motion tracking was achieved through the use of a depth-sensing camera named PrimeSense. The participants could play the game either sitting or standing. Three games – Ball Maze, Fridge Frenzy and Tentacle Dash – required torso movement (motion of the shoulders and hips was tracked) and one game – Bubble Fish – was controlled by upper limb movement (motion of the wrist joint relative to the shoulder was tracked). Ball Maze (figure 5 – A) was a game that used leaning movements of the torso in order to tilt a maze board to allow a ball to be guided through it. The objective of this game was to manoeuvre the ball into the hole. Fridge Frenzy (figure 5 – B) depicted a track inside a fridge and the player's objective was to guide the ball through the track thanks to lateral flexion movements of the torso that resulted in side-to-side movement of the ball. The player must hit milk cartons as they show up along the track. Tentacle Dash (figure 5 – C) was a game that had the players performing movements such as leaning or side-stepping (torso movement in relation to the initial midline position) in order to make the ball move forward while avoiding hitting the tentacles. The goal was to travel as far as possible in the shortest amount of time. Bubble Fish (figure 5 – D) was a game that resorted to arm movement to shoot bubbles in different directions, aiming to hit the fish (that moved in from both the left and right sides of the screen, as well as at different depths). All the games were adaptable to users in order to match their levels of balance, motor control and possible perceptual problems commonly found in stroke patients. For phase 2, 16 participants (mean age 61 years) from phase 1 were recruited and then were randomly assigned to the intervention group or to the control group. Eligibility criteria were identical to that of phase 1. The participants in the intervention group took part in eight 40-minute sessions over the course of 4 weeks (in addition to their standard inpatient or outpatient therapy) and used all 4 available games. During the first two sessions, they were obliged to use all four available games. In the last six sessions, the participants could choose which games they wished to play. Meanwhile, participants in the control group were receiving standard care only. Phase 1 measured the feasibility of the intervention resorting to factors such

as recruitment and willingness to participate, adherence, acceptability and safety. Phase 2 accessed feasibility and took into account functional outcomes as well.

This study concluded that, in terms of enjoyment, the participants claimed that they felt the games were a fun and fresh way to participate in therapy, finding the sessions enjoyable and helpful. During phase 2, the intervention group improved significantly in several of the measured outcomes (unlike the control group), which proved that using games might be a good way to motivate patients to do better in therapy and, therefore, achieve better results and motor function improvements.

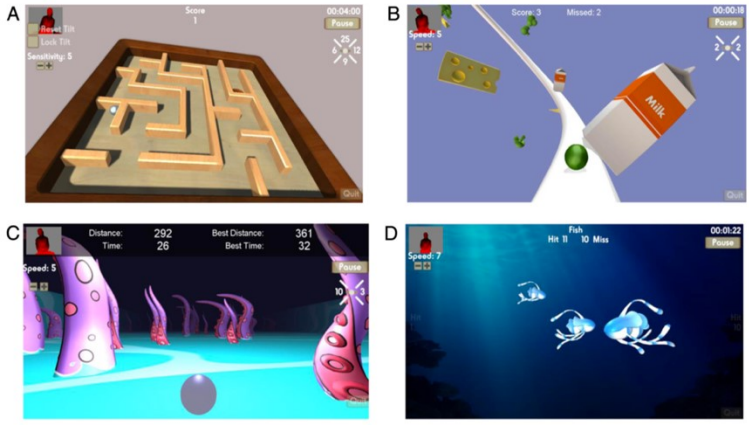

Figure 5 – Ball Maze game (A), Fridge Frenzy (B), Tentacle Dash (C) and Bubble Fish (D) (in Bower et al., 2015)

Ma and Bechkoum (Ma & Bechkoum, 2008) presented a pilot study (already mentioned in Chapter 2.2.1), that took place at the University of Ulster (United Kingdom), once again intending to prove the efficacy of using games to rehabilitate patients who were recovering from stroke by encouraging the practice of physical exercises through the use of games designed for that purpose. The sample consisted of 8 post-stroke patients (mean time since stroke until beginning of the intervention: 10.7 months) suffering from upper limb motor disorders (aged 56.4±4.3). The patients participated in around 15 sessions each, where they were invited to play a game named *Whack-a-Mouse*. This game resorted to VR, and simulated a table where mice appeared at random locations, stood there for a couple of seconds, before disappearing and reappearing in a different random location. The player interacted with the game by managing a virtual hammer and the proposed task was to hit the mice while they were still visible. The game featured three difficulty levels: Beginner, Intermediate and Expert (in this level, besides mice, dogs also appeared at random locations at the same time as the mice and the player should prove to be able to distinguish the two animals by hitting the correct one with their virtual hammer). This game had the main goal of improving patients' movement accuracy and speed, while encouraging upper limb gross movement. Besides the physical rehabilitation aspect of the game, it also tackled cognitive aspects by promoting visual discrimination and selective attention. *Whack-a-Mouse* is also described by the authors as

immersive (thanks to the qualities inherent to VR technologies) and highly adaptable, which made it responsive to particular patient needs, by monitoring the player's progress and tracking play sessions data.

The patients who participated in this study claimed that they have enjoyed using the game and showed improvement both in the in-game performance and in the real world. This study also indicated that using games was more efficient therapy-wise than resorting to traditional methods such as functional training. It is hinted that adopting this sort of therapy might also bring long term benefits. The authors stated that "*the integration of VR simulation with Serious Games adds richness to the virtual environment which has the potential for improving patient outcome*". Besides, this study concluded that Serious Games can invite the patients to participate in motivational tasks with the rehabilitation goal in mind.

Figure 6 – Whack-a-Mouse game (in Ma and Bechkoum, 2008)

Hocine *et al*. (Hocine *et al*., 2015) presented a study divided in three distinct test phases, based on a participatory design that involved physicians, therapists and stroke patients. All the phases took place at the Lapeyronie Hospital of Montpellier and Grau de Roi Hospital of Nimes (both in France). The study resorted to PRehab (Platform Games for Rehabilitation), which can be played on a graphics tablet (in this case, the study used an Intuos A3) and had the main therapeutic goal of increasing both the range of motion and the training volume of an average rehabilitation session. The first phase consisted of a playtest with healthy players and medical experts and had the objective of identifying game bugs as well as determining whether the gameplay was perceived as fun or not; the second phase was a usability test that was conducted in hopes of evaluating the adequacy of the graphic user interface for stroke patients by having a single patient play the game for thirty minutes, based on the proposed Difficulty Adaptation Technique[16], while being observed by five therapists; and the last phase, that was conducted over a 2-week period, in which each patient took part in three 20-minute rehabilitation sessions, followed a repeated-measure single-blinded design and could be described as an experiment to

[16] Refers to the way the game's difficulty is presented to the patient.

assess patient performance. Concerning the aesthetic and gameplay, the games designed for PRehab looked very much like Nintendo's *Super Mario Bros*. games and invited the users to reach for virtual targets within the game. Three games were tested (Turtle game, Rabbit game and Cat game – figure 7 left, middle and right, respectively), and each game offered a different difficulty strategy in order to determine which would be the best way to assess physical therapy. Moreover, the gameplay was identical in each difficulty version, but the graphics (namely characters, images, backgrounds, animations) were different in order to grant the player a sense of novelty. The three difficulty strategies were: Dynamic Difficulty Adaptation Strategy[17] (DDA, applied to the Turtle game), Incremental Difficulty Adaptation Strategy[18] (IDA, used in the Rabbit game) and Random[19] (the cat game used no actual difficulty strategy). The third test had the patients play all game version and experience each difficulty strategy that had been selected at random. The participants of the first test suggested adding more feedback moments to the game in order to boost patients' motivation. After the suggestion was taken into consideration and adapted to the PRehab games, the patient who participated in the second test claimed to be immersed in the game and perceived the difficulty level to be just right for him. When the game was tested with a larger group of patients, all of them affirmed having been engaged and immersed in the game and mentioned they experienced feelings of wanting to play more. This study also concluded that all the patients preferred DDA as it was the most adaptative difficulty strategy.

Figure 7 – PRehab games, namely cat game (desert), turtle game (sea) and rabbit game (forest). Their visuals are identical to those of the Super Mario Bros. games (in Hocine et al., 2015)

Ghassemi *et al*. (Ghassemi *et al*., 2019) conducted a pilot study that had the objective of assessing the performance of an EMG-controlled[20] Serious Game for rehabilitation. This study

[17] DDA relies on the player's abilities, adapting the presented game tasks in order to maximize their efforts without exceeding their abilities. This aims to control the patient's effort, in order to improve training outcomes by preventing fatigue (Hocine *et al*., 2015).

[18] IDA consists in gradually increasing the difficulty of the tasks that are presented to the patient over the course of the game, starting with the easiest task, to the most difficult. This strategy does not adapt to the patients' needs, therefore all patients are presented with the same the increase of task difficulty (Hocine *et al*., 2015).

[19] Random implies the use of no difficulty adaptation. This provides the players with targets in different locations of the workspace, without following a specific logic, as the positions are randomly generated and do not take the patient performance into account, nor the difficulty of the task performed previously (Hocine *et al*., 2015).

[20] EMG-controlled stands for electromyographic controlled and it is a type of biofeedback.

analysed the performance of 20 neurologically intact individuals (adults, 7 women, 13 men, ages ranging from 21-40 years), having them randomly assigned to one of two groups: unilateral group (training with their non-dominant hand) or bilateral group (training with both hands). The game was played through electromyographic control and the user manipulated his/her EMG patterns in order to move the cursor around the tiles of the game - the hand movement controlled the cursor on the screen. The intervention lasted for 3 sessions and each session had 3 phases: calibration, test, and training. This phase lasted for around 30 to 45 minutes and by the end of this phase, another test was conducted. Both groups performed the tests only using their non-dominant hand. Five Serious Games were developed and were played during the training phase: Target (figure 8 – A), Picture Reveal (figure 8 – B), Targeted Picture Reveal (figure 8 – C), Maze (figure 8 – D) and Coin Collector (figure 8 – E). In the Target exercise, the patient had to provide an appropriate EMG pattern in order to move the cursor to a specified tile. In the Picture exercise, like the previous exercise, the user also is invited to move the cursor to different tiles and, as the authors describe, "*once the cursor meets the stationary criteria, the tile disappears to reveal part of a picture beneath*", which implies that the user is free to choose which tile he/she unveils next. Targeted Picture Reveal was the same as the Picture exercise, but the order to reveal the tiles was chosen at random by the computer and the player had tofollow the established order. In the Maze exercise, the player must solve the maze, and, for that, the EMG patterns controlled the cursor and allowed the user to navigate through the maze. The Coin Collector is reminiscent of the arcade classic *Space Invaders* and the user was invited to collect coins that appear on the screen by moving the cursor (that takes the shape of a spaceship) without hitting any moving asteroids. The authors stated that all game's interface can be described as intuitive.

The success of the study was determined after analysing three parameters: time of completion, EMG patterns employed and cursor kinematics. The study concluded that all individuals showed improvement in using their non-dominating hand, retaining said improvement from a session to the next. The authors suggested that this situation could be the result of better control of existing activation patterns over time. The time to complete the test phase also decreased over the sessions, which can be an indicator of the study's success. Although, it was not possible to gauge the effectiveness of this method with actual stroke patients, since the sample used consisted of neurologically intact subjects.

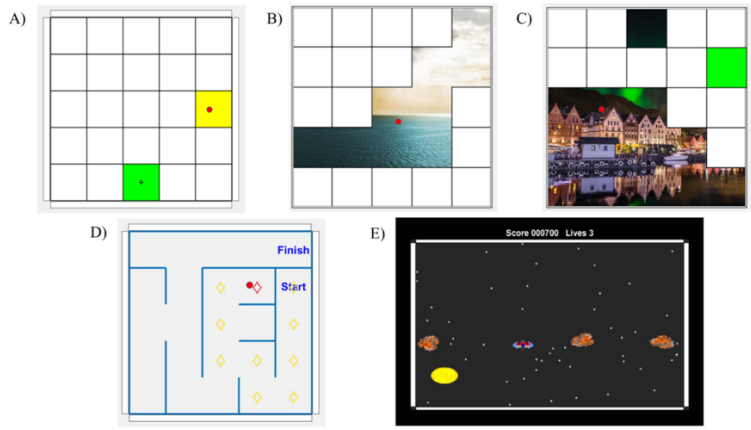

Figure 8 – Serious Games developed to be played using EMG patterns. Game A corresponds to the Target Exercise, game B to the Picture Reveal, game C to the Targeted Picture Reveal, game D to the Maze exercise and game E to the Coin Collector. (in Ghassemi et al., 2019)

Besides the five papers mentioned above, Rodrigues (Rodrigues, 2018) presented a doctoral thesis in which the development, design and implementation of a custom-made Serious Game for physical rehabilitation was the goal. The game was tested in a clinical setting (Centro de Fisioterapia da Santa Casa da Misericórdia de Arouca, Portugal) and counted with the collaboration of patients and health professionals (non-probabilistic convenience sampling). The sample of the patients of this study featured a total of 11 patients, with ages ranging from teens (under 18) to the elderly (65+). The patients suffered from various conditions: 6 were stroke patients, 3 suffered from Strumphell-Lorrain disease, 1 had previously suffered from meningitis and another suffered from spastic dysplegia (due to being born premature). The intervention lasted for 10 weeks and each patient played the game twice a week (in physiotherapy sessions), each session lasting around 30 minutes. The total number of sessions per patient varied from 12 to 15 sessions. The game developed was *Physioland*, which can be described as a 3D medieval-themed physical rehabilitation-oriented game that resorted to Kinect to detect patient motion. This video game was a reboot of a previous game called *PhysioVinci*, therefore some of the code of this game was reutilized to develop *Physioland*. The game featured two gaming modes – normal and free – and, while the normal mode required the patient to be linked to a rehabilitation centre and be monitored by a health professional, the free mode allowed the user to play when they were not registered in the database or when there was no Internet connection. The game's level corresponded to a specific physiotherapy exercise and each level depicted a different situation/simple narrative (*e.g.*: protagonist in town, watching sunset, boat, fishing). The objective of the player was catching coins to help the protagonist's family. The protagonists representation and point of view also varied from level to level, in order to better match the required exercise, and it can be either mirrored, 1st person or the player can see the protagonist from the back. As for difficulty levels, the game was adaptable and could be configured to go from "Easy" to "Very Hard". This game also accepted an error margin

in terms of limb position according to the protagonist's limb coordinates, in order to lower the number of times that the patients needed to be corrected, leaving that to situations when the player's posture or movement was really far from the desired one. This was implemented in order to keep the patients from feeling frustrated or demotivated.

This study concluded that it is important that the game is adaptable to the patients' needs. It must also be easy to understand and to play/use. In some cases, success in the game's implementation was only achieved because it was possible to make the game's difficulty match the needs of the patient. The authors stated that, although the emotional status of the patients influenced their performance, none of the participants showed signs of behaviours classified as negative whilst playing *Physioland*. The elderly sector of the patient sample was the group that showed the most interest and actively tried to follow the established rules of the game. Once again, the game is said to be a great complement to traditional rehabilitation practices and procedures.

3.1.3. Custom-Made Serious Games: Rehabilitation Assisted through Virtual Reality

Michael A. Gigante, in the book "Virtual Reality Systems", defines Virtual Reality (VR) as "the illusion of participation in a synthetic environment than external observation of such an environment. It relies on three-dimensional, stereoscopic, head-tracked displays, hand/body tracking, and binaural sound. VR is an immersive, multisensory experience." (Gigante, 1993, p. 3). Virtual Reality can be perceived as a simulated environment (often three-dimensional) that seems real, and that allows the player to experience a new interaction context, in real-time, through specific equipment, such as a helmet or haptic[21] gloves. VR also embodies three essential concepts that are complementary to each other: Interaction, Immersion and Imagination (Gupta & Hassanien, 2020). VR is widely used as a way to approach rehabilitation assisted through virtual methods, such as games. 2 articles where virtual reality was used as a training assistant for the patients who were undergoing rehabilitation were found and analysed. The emergence of Virtual Reality also helped settle rehabilitation through contact with virtual environments a valid paradigm.

Cameirão *et al*. (Cameirão *et al*., 2009) presented a randomized longitudinal study with controls with the goal of analysing the relevance of using Virtual Reality (VR) as a physical rehabilitation tool in impaired patients who are recovering from stroke. The study took place in a clinical setting (Hospital de L'Esperança, in Barcelona, Spain) and the sample consisted of 17 patients, within 3 weeks post first-time stroke. The patients that took part in this intervention

[21] A haptic interface can be described as a "*device that allows a user to interact with a computer by receiving tactile and force feedback*". (Orozco, Silva, El Saddik, & Petriu, 2012)

showed severe to mild deficit of the paretic upper extremity but bore no aphasia or other cognitive deficits. The patients were divided in three groups: a group of seven patients that used the proposed rehabilitation system (Rehabilitation Gaming System – RGS[22]) and two control groups (A, composed by 4 patients and B, 3 patients). The rehabilitation game used in this study (RGS) is described as an innovative VR tool for motor deficits of the upper extremities' rehabilitation (following brain lesion caused by stroke). The system offered a specific deficit-oriented game, moulded to match the patient's needs by combining movement execution with the mirroring (first-person perspective) of the action by virtual limbs. In this case, it featured three training tasks of graded complexity and could be described as a "*virtual reality-based system that is targeted for the induction and enhancement of functional recovery after lesions to the nervous system using non-invasive multi-modal stimulation*". The rehabilitation therapy sessions had the duration of 20 minutes and happened three times per week, over the course of 12 weeks, with a 12-week follow-up.

This study suggested the possibility of transferring the results achieved through game-based rehabilitation systems (such as RGS) to measurable improvements in the real world.

Jack *et al*. (Jack *et al*., 2001) conducted, in the USA, pilot clinical trials in order to assess the use of VR environments as rehabilitation technique. The sample of this study featured 3 chronic stroke patients, aged between 50-83, that had experienced stroke 3 to 6 years prior to the time when the intervention took place, and that had not engaged in any sort of therapy in the previous two years. The selected protocol was used daily, for 2 weeks and each session consisted of 4 blocks of 10 trials each (multiple sessions were run each day, for five days, followed by the weekend break, where no sessions happened, only to be resumed the following week for another 4 days). Each block aimed to improve parameters such as range, speed, fractionation or strength movement. The patients engaged in VR sessions around 1-1.5 hours per day and the remaining time was spent participating in traditional therapy procedures. This protocol can be described as a PC-based rehabilitation workstation, running both VR simulation exercises and a database. The patients positively evaluated the intervention both subjectively and objectively, having presented improvements in most of the hand movement parameters.

Virtual Reality is a powerful tool that can elevate physical rehabilitation to a new level by allowing the patient to experience a virtual universe that aims to make therapy more motivating and engaging. Although VR offers these possibilities, further studies need to be conducted, analysing the influence the virtual world design has on the clinical results.

[22] http://www.aal-europe.eu/projects/rgs/

3.1.4. Custom-Made Serious Games: Virtual x Real Approach

Two cases used an approach where real objects were paired with a virtual universe. Delbressine *et al*. (Delbressine *et al*., 2012) conducted a user test in a clinical setting and it could be described as the first iteration of Playful Rehabilitation System, namely the user test of the first prototype. For this, 7 sub-acute and 3 chronic stroke patients were selected. The intervention resorted to the T-TOAT (Technology-supported Task-oriented Arm-hand Training), since this method had been verified as effective in previous clinical trials and aimed to improve the state-of-the-art of the proposed paradigm by providing changes that would enhance the challenge, fun, performance feedback and exercise variability offered by the T-TOAT. Before starting the experiment, the authors conducted an interview with 12 chronic stroke patients and a therapist, in order to identify the design challenged to be tackled. The interview resulted in the acknowledgement that it was important to support task-oriented training for arm-hand rehabilitation while avoiding compensatory movements with shoulder and torso. Another challenge that arose after the interview was the necessity to ensure that engagement and motivation were achieved through the use of an interactive game. The feedback obtained through the interview culminated in the design of a tabletop game where physical objects had to be manipulated (for example, there was a task-oriented game that uses an actual fork and knife on a pressure sensitive touchscreen device. The game then offered graphical vibrotactile feedback regarding the patient's posture through a motion sensing jacket, and it directly influenced the gameplay while aiming to control possible compensation movements).

This study resulted in the conclusion that the use of a video game might be a possible variation to regular physical therapies. The game was also efficient in terms of time spent participating in therapy-related activities. The patients perceived the game as a credible and fun training approach but, in this specific study, pointed out the lack of the possibility to adapt the game's difficulty level to their particular needs. This study also suggested the importance of audio and spoken feedback in addition to graphic and vibrotactile feedback.

Abdelkader and Hocine (Abdelkader & Hocine, 2011) described two tests/experiments: the first one tested the use of Mixed Reality[23] (MR) with professionals in the area of stroke rehabilitation and had the primary goal of assessing the perceived utility, usability and likeability of the mixed reality system through affective evaluation, while the second experiment was a pilot study with healthy players, and aimed to compare the difficulty proposed by the used algorithm to the real difficulty perceived by the player. The first experiment had 17

[23] Mixed reality aims to merge real life with virtual worlds, by creating a new paradigm that allows real-time interaction between physical objects and digital objects (Abdelkader & Hocine, 2011).

participants, all members of the medical staff of the rehabilitation department of a French hospital[24] (with an average of 17 years of experience in the field), the second experiment followed an independent-measures design with two independent groups formed by a total of 8 healthy players: group 1 (composed by 4 people, 3 men and 1 woman) and group 2 (composed by 4 people, 1 man and 3 women). The first experiment consisted of several 10-minute sessions that aimed to test the Mixed Reality game (developed solely for therapy purposes) using a computer, a mouse and a Wiimote. It is important to mention that the game played in MR was identical, design wise, to the one played on the computer and thus, aimed to prove the relation between hardware and efficacy. The gameplay of the MR game depicted a maize plantation being attacked by crows and the objective of the game was to chase away the intruders while training free movements. The second experience aimed to compare the difficulty level perceived to that assumed by the algorithm, by simulating difficulty conditions that are similar to those experienced by patients while partaking in their rehabilitation programs. In this sense, group 1 used a strategy of difficulty adjustment that would increase the difficulty level if the player succeeds in the previous one, while group 2 used the difficulty adjustment strategy proposed by the authors.

The first experiment indicated that using Mixed Reality is an effective tool when it comes to usability, ease of use and simplicity (scoring the highest score in these aspects according to the evaluation criteria used). However, in terms of perceived fun, the Wii was preferred. This could validate the possibility of using both systems as complimentary forms of therapy. MR was also considered intuitive in terms of human-computer interaction, making it valuable among inexperienced users. The second experiment of this study indicated that motivation and frustration experienced while playing games are of dynamic and temporal nature and, therefore, they can influence perceived difficulty.

The mixture of real physical objects with a virtual universe can be very interesting because it allows the patients to keep a tactile and visual sense of reality while being immersed in a parallel world. This also allows for a broad range of game designs and permits a large versatility in terms of clinical objectives.

3.1.5. Comparison between Custom-Made Serious Games versus COTS

Two of the articles found for this review featured, in a way or another, a comparison between the efficacy of custom-made Serious Games and COTS.

Jonsdottir *et al*. (Jonsdottir *et al*., 2018) presented a pilot single-blind randomized (2:1) study, controlled in clinical trial. This intervention took place in a rehabilitation centre

[24] 3 occupational therapists, 9 physiotherapists, 3 students in physiotherapy and 2 general doctors.

(Foundation Don Gnocchi Onlus, Milan, Italy) and had 16 multiple sclerosis (cognitively capable and able to follow instructions) patients selected (with a mean age of 56.8), who suffered from upper extremity motor deficits, but were able to flex their shoulder and elbow at least 45 degrees. The participants were then divided in two different groups: 10 patients used the Serious Game Platform – *Rehab@Home*[25] – while the remaining 6 patients were part of the control group and used the commercial Nintendo Wii Console™ and were invited to play COTS that were selected in function of their motion requirements such as holding or gripping the controller and pressing the main buttons of the object. This division had the objective of comparing the efficacy and pertinence of use between the two types of games by accessing, as explained by the authors: "*the feasibility of using the final therapeutic gaming system (Rehab@Home) to augment upper extremity neurorehabilitation services and to provide preliminary evidence of clinical efficacy of the gaming approach in increasing arm performance and health related quality of life*" of people with multiple sclerosis. The intervention lasted for 4 weeks and a total of twelve 40-minute sessions (4-5 sessions per week). Rehab@Home offered six arm rehabilitation games (for example, putting cans away in a cupboard or avoiding being stung by bees) that could have their difficulty levels adjusted to match the patient's need. Besides, because they required the player to perform a large variety of hand/arm movements by demanding the player to grab or grasp various virtual objects in a virtual space, the game was expected to improve patients' movement coordination, reaction speed and timing, hand-eye coordination and spatial awareness.

The group who used Rehab@Home showed clinically significant improvements in arm function, while the Wii group did not seem to particularly improve in any of the tests used to evaluate the parameters. Despite this fact, only the Wii group perceived themselves as having improved their health, which leads to the following conclusion: Serious Games are proved to be effective, but they need to be more engaging and motivating design wise.

Lopes *et al*. (Lopes *et al*., 2018) presented a systematic review on cases where Serious Games were used in order to rehabilitate patients suffering from cerebral palsy that, besides comparing the effectiveness of playing games as part of physical rehabilitation at home versus clinical setting, also offered some insight in the comparison between COTS and custom-made Serious Games. This paper reviewed 16 cases (featuring a total of 203 participants suffering from the condition mentioned above). The authors sought to understand the difference between

[25] Rehab@Home is a Serious Games system that aims to enhance and promote upper arm rehabilitation of people suffering from neurological disorders. This product uses Kinect and focuses on training fine and gross arm and shoulder movements through the interaction with a virtual environment. The game is also adaptable through calibration to match the participant's ability. The system also allowed the patient to play the games either standing up or sitting, depending on each person's individual balance ability (http://www.rehability.me/#athome, retrieved October 17th, 2019).

intervention settings (home setting *vs.* clinical setting). Most of the selected cases dealt with children or teenagers, but 3 of them were conducted with adult participants. The home setting cases (7 out of 16) aimed to "*evaluate the efficacy of autonomously playing a game, or a set of games, at home*" and showed mixed results in terms of improvements of the trained skills. Nonetheless, the familiar setting allowed participants to keep focused for longer periods of time and to foment and deepen family bonds. Most of the cases in this intervention setting resorted to COTS, which lead to the conclusion that it is important to offer the patients a large variety of games/things to do within the game in order to keep long-term interest. Another way suggested by the authors to fight this problem was keeping therapy interventions short but intensive. On the other hand, the clinical setting experiments (9 cases) had the objective of evaluating "*the efficacy of playing a game, or a set of games, in a clinical setting, usually under the supervision of a therapist*". Unlike the home setting cases, the ones that took place in a clinical setting showed positive results and measurable improvements in the skills abridged by the intervention. This analysis mentioned that patients usually preferred to participate in multiplayer versions of the games, but therapists suggest the use of single player versions instead, in order to achieve better practical results, although sacrificing some of the motivation levels achieved through group participation. Both studies concluded that "*game-based training should be regarded as a complement of traditional rehabilitation sessions, particularly with the possibility of including competitive and collaborative play*".

Although COTS can be beneficial by enhancing the patients' motivation, the studies explored above prove that there is still a lot to be done in order for commercial titles to answer what is considered clinically desirable.

3.1.6. Clinical Analysis and Results

The efficacy of the use of video games was measured differently from case to case. Some of them used questionnaires in order to access a qualitative evaluation of the affective dimension experienced by the player upon the contact with the game world, while others opted for quantitative results in terms of movement improvement. Some of the tests used for this were Functional Independence Measure (Bower *et al*., 2015; Cameirão *et al*., 2009) Box and Block Test (Jonsdottir *et al*., 2018; Saposnik *et al*., 2010), Fugel-Meyer Assessment test (Cameirão *et al*., 2009; Jack *et al*., 2001), ANOVA (Ghassemi *et al*., 2019; Hocine *et al*., 2015) or the Motricity Index (Cameirão *et al*., 2009; Ma & Bechkoum, 2008) (see Appendix A).

All studies showed positive results in terms of therapy efficiency and claimed that the patients that tested the games found them motivating. Cameirão *et al*. (Cameirão *et al*., 2009) mentioned that the in-game achievements would turn to measurable improvements in the real

world. Ma and Bechkoum (Ma & Bechkoum, 2008) pointed out the motivating nature of games and how the relation between the improvements in terms of game performance would match real world improvements. This study also showed that games proved to be more efficient than traditional therapy methods. Jack *et al*. (Jack *et al*., 2001) claimed that the use of video games resulted in hand movement improvements. Broeren *et al*. (Broeren *et al*., 2008) got positive results in improving movement range and speed through the use of VR-based games. Jonsdottir *et al*. (Jonsdottir *et al*., 2018) pointed out that games specifically designed for therapy interventions were effective, but they needed to embody the motivating and fun characteristics of COTS (for example, Wii games). Hocine *et al*. (Hocine *et al*., 2015) mentioned the importance of giving patients feedback during rehabilitation gaming sessions in order to achieve better results and proved that having difficulty levels responsive to patients' needs was crucial for success. Delbressine *et al*. (Delbressine *et al*., 2012) showed that thanks to video games effectiveness in rehabilitation therapies, they can be used as a variation to regular traditional therapy methods. Once again, this study also mentioned the need of adapting difficulty levels to match the patients' physical conditions. Abdelkader and Hocine (Abdelkader & Hocine, 2011) showed that Mixed Reality was an interesting approach to video game-based therapy and pointed out that it would be beneficial to mix video games with traditional therapy sessions. Lopes *et al.* (Lopes *et al*., 2018), in their systematic review of Serious Games applied to cerebral palsy rehabilitation, concluded that it is important to offer the patients a large variety of games or things to do in game in order to keep their motivation levels high throughout the duration of the therapy. Besides, the authors stated that games should not be used as a first-line therapy procedure but as a complement to traditional rehabilitation sessions. Rodrigues (Rodrigues, 2018) stated that the game used for the intervention matched the patients' needs and that was one of the key factors to obtain successful and positive results. The author also stated the necessity to focus on what's important in the game and remove all things that can be taken as distractions. Saposnik *et al*. (Saposnik *et al*., 2010) accessed the feasibility of using Wii games for stroke rehabilitation, which proved to be successful, fairly inexpensive and a better alternative to recreational therapy. In this sense, Thomas *et al.* (Thomas *et al*., 2017) also presented a rehabilitation intervention based on the use of Nintendo Wii, but for multiple sclerosis patients. The intervention was successful but this study pointed out that it might be necessary to think of ways to allow rehabilitation sessions to be performed in the home of the patients in their totality, since traveling to a specific site might be complicated for these patients due to their lack of autonomy and the fact that they tire easily. Ghassemi *et al*. (Ghassemi *et al*., 2019) concluded that using EMG for rehabilitation might be a new way to perform rehabilitation but this method needs further testing, since the study was based on healthy

subjects. Bower *et al.* (Bower *et al.*, 2015) concluded (like other studies mentioned above) that using games for rehabilitation was a great way to motivate and interest patients to participate more actively in therapy, besides being effective as rehabilitation method.

In this sense, it is plausible to conclude that video games are effective as physical rehabilitation tools in order to treat impairments of disabilities resulting from diverse pathologies.

3.1.7. Serious Game Development: Analysis

From a game development and design point of view, the studies analysed in this paper prove that there is a need to make Serious Games more "fun", as Jonsdottir *et al*. (Jonsdottir *et al*., 2018) pointed out that patients perceived more improvements when playing Wii games (COTS) than when playing a game specifically designed for therapy.

In this sense, there is a lack of information when it comes to the actual development or design of a video game for medical rehabilitation purposes from an artistic or conceptual point of view, as most of the studies found focus on the clinical aspect of using games for therapy, they tend to overlook the creative and artistic side of games of such nature. This is something that needs to be further explored and researched, as it has been pointed out that there is a need to implement characteristics of commercial games to those specifically designed for the health sector, thus enhancing the potential to be creative and imaginative in Serious Games for healthcare.

Some of the games used in the cases previously mentioned seem to be inspired by classic arcade games, following their gameplay, aesthetic and dynamic. *The Whack-a-Mouse* game described by Ma and Bechkoum (Ma & Bechkoum, 2008) readapted a former well known arcade game to a rehabilitation game that has the same purposes, but works through VR. The same happened in one of the games presented by Ghassemi *et al.* (Ghassemi *et al.*, 2019), since one of the games presented in this study highly resembles (theme, gameplay and visual wise) the classic arcade game *Space Invaders*.

In other situations, the games resemble adaptations of classic video game titles. Hocine et *al.* (Hocine *et al*., 2015) resorted to this method and the game used (PRehab) is based off the *Super Mario Bros.* games, both visual and structure wise. *Mario* games have a main goal and, to achieve said goal, the player must complete several stages while achieving objective stage goals that will lead up to the final main goal. In a rehabilitation context, the authors explained that the game itself will define the goal that the patients must reach by the end of the rehabilitation program, and therefore, each game act or level will correspond to a 20-minute training session. Each level will have achievable and objective goals, in order to keep the patient motivated, without experiencing feelings of frustration. However, it is important to point out

that while *Mario* games feature a large number of levels/stages and worlds, all featuring identical gameplay (but, as the players advance in the game, they experience increasing difficulty) but different graphics (strategy employed by PRehab), the game used in this case only had three different games, which made the game's scale much inferior to that of *Mario*'s. But this does not seem to be a problem, since rehabilitation programs only last for a predetermined number of weeks and sessions and, as long as the game is able to retain patients' interest throughout the duration of the treatment, it is possible to conclude that the game was successful while not being perceived as boring.

When studies resort to COTS, they generally opted for *Wii* games that require the player to move around and, therefore, execute the needed motions for rehabilitation. Although this seems like a great way to avoid the production costs of customized Serious Games, these did not prove to be as effective as the games purposefully developed to be used in therapy, although they were perceived by the patients as "fun" and "engaging", bringing to light a need to make Serious Games embody these traits, perhaps by paying more attention to the visuals or the ambience created by the virtual world (Jonsdottir *et al.*, 2018). In this sense, Laamarti *et al.* (Laamarti *et al.*, 2014) pointed some of the disadvantages of using Wii games for rehabilitation: as the tracking of the movements solely relies on the joystick, it makes it possible to cheat, that is, the player can just sit on the sofa and, as long as the correct movements are detected based on the motion executed by the joystick, the game will perceive the achieving of its objectives as successful, although medical efficacy may suffer due to incorrect postures or movements driving from this possibility to cheat. The authors then proposed a way to avoid this situation: using intelligent interfaces in order to enhance the sense of realism, which will avoid the situation mentioned above. Bower *et al.* (Bower *et al*., 2015) mentioned that using COTS (Wii games or Xbox Kinect games) for rehabilitation can be very limiting and therefore suggests the use of Serious Games designed specifically for rehabilitation purposes. Hocine *et al.* (Hocine *et al*., 2015) mentioned the importance of graphics in games: the authors stated that, for therapy to be effective, it is important to keep patients' motivation levels and one of the ways of doing that is presenting new game content in the form of new visuals. This allows for the gameplay to remain the same and, therefore, keeps the patients repeating the necessary motions for therapy, while providing a sense of newness through graphics. Changing the game's scenery can, according to the authors, be effective because it makes the players feel like they are playing a new game, while the gameplay remains the same, only the graphics change.

Point and Click games (Broeren *et al*., 2008), games to guide a cursor or a ball through a specific track of path (Bower *et al*., 2015; Ghassemi *et al.*, 2019) or games that invite the patients to grab and manipulate virtual objects (Hocine *et al.*, 2015; Jonsdottir *et al.*, 2018) also

seemed to be popular. These usually featured simple designs and objectives (which can answer the rehabilitation needs and requirements) and revolved around the virtual playout of quotidian situations or tasks. Most of the games described above do not seem to involve anything that can equal the quests found in popular commercial video games. Mixed Reality can be a way to "spice things up", as described by Abdelkader and Hocine (Abdelkader & Hocine, 2011), whose game features the simple task of chasing away crows that are attacking a maize plantation, by presenting a new form of interaction that allows real objects to be used in order to manipulate a virtual world. Delbressine *et al.* (Delbressine *et al.*, 2012) also used a game that combines physical objects with a virtual universe.

3.1.8. Wrapping up

After analysing the selected cases, one can conclude that the most relevant aspect of the application of video games to therapy is their ability to both motivate and captivate the patients' attention, which intrinsically leads to better adherence and compliance to therapy sessions. Video games proved to be useful for multiple health issues (from stroke to multiple sclerosis) by enhancing and promoting patients' motivation, which acts as a facilitator to obtain better post-therapy results. However, it was often mentioned in the outcomes of the analysed studies that some of the Serious Games that had been purposefully designed for therapy did not fully embody the characteristics that make people perceive a video game as a "fun" experience. Patients find COTS more engaging and motivating, however, the outcomes show that COTS do not deliver the same results in terms of therapy efficiency. This leads to the conclusion that it might be beneficial as well as imperative to merge both aspects in a single game: design a Serious Game that fully embodies the characteristics that make COTS be seen as "fun" and "exciting", by focusing more on the aesthetic, gameplay and design aspects and not only the way the game will serve its serious purpose.

Several authors also concluded that Serious Games might be a great addition to regular therapy but should not be used solely as the main therapy course of action. This said, all the cases analysed prove that the use of Serious Games as rehabilitation tools is relevant and should be further investigated and implemented.

From a game development and design point of view, the authors stated that it is crucial that the games used in therapy are understood as fun and motivating experience, in order to keep therapy adherence levels high. The authors concluded that it is important to pay attention to the game's graphics and that a large variety of game universes within a single game can grant the players a sense of newness that will make up for the game play, if it remains the same. Although the number of published sources on what makes Serious Games appealing (from a development

point of view) is scarce, those two aspects were pointed out in the papers that were included in this survey, therefore making them relevant and worth of taking into account. In this sense, it is important to analyse several games used in rehabilitation therapies in order to understand what patients prefer, from the point of view of game enjoyment, but without discarding medical results and improvements.

3.2. Understanding the needs, availability and openness of the users

The concept of "Serious Game" is around twenty years old, but video games have been used for serious purposes since the eighties (Zyda, 2005). Despite this, although Serious Games are vastly studied in academic and research settings, not only from healthcare and rehabilitation perspectives, but also as educational and training tools, they are not frequently used in the contexts they were designed and developed for. As we explored in the previous section, Serious Games can be a powerful tool in motivating patients and enhancing their cooperation when it comes to adherence to physical rehabilitation linked to conditions such as stroke, cerebral palsy and multiple sclerosis, amongst others.

In order to better understand the context of Serious Games in the actual field, a series of interviews and questionnaires targeted at healthcare professionals was conducted.

3.2.1. Questionnaires

Questionnaires are an easy, quick and inexpensive way to get in touch with the desired audiences without requiring a face-to-face conversation or presential participation. This helps gathering a larger sample and, therefore, get a larger scope and better insight on the subject at hand. In this sense, with the objective of analysing the point of view, knowledge, openness and availability of healthcare professionals as well as their thoughts on the adaptability, suitability, relevance and efficacy of Serious Games for healthcare, focusing on physical rehabilitation purposes, a questionnaire targeting healthcare professionals (preferably medical doctors, specializing in physical rehabilitation medicine, neurology or physiatry and physiotherapists) was designed by the author (the full questionnaire can be found in Appendix B).

Before being sent out, the questionnaires were submitted to a group of 5 external subjects, who evaluated the adequacy of the proposed questionnaire by giving their opinion on what needed to be made clearer or what should be changed in order to make the questionnaires more accessible and effective. After the changes were made, the questionnaires were sent out. The approach was made by email, text messages and word of mouth.

The questionnaire embodied a total of 24 questions, including multiple choice questions,

short answer questions, long answer questions and questions using the Likert Scale[26]. These questions focused on characterizing the sample (by asking their age group, area of expertise, years of experience and what kind of entity they work for), on understanding their thoughts on video games as a whole and then their thoughts on Serious Games as a subgenre of video games. This second section focused on understanding the main barriers found to the use of Serious Games as well as compiling a group of situations where these games were, in fact, used for healthcare purposes, from both a results and game design point of view. The questions were subjected to a logic system, where participants that had never used Serious Games previously/had not heard of the concept prior to the questionnaire automatically skipped the questions related to the analysis of the use of games in medical contexts (see Appendix C for full questionnaire results).

In this sense, 59 subjects participated in the investigation process by taking the questionnaire. The participant's anonymity and confidentiality were safeguarded (no nominal identification of the participant). Confidentiality and exclusive use of the data collected for this study were guaranteed, under conditions of anonymity (no registration of identification data). The collected data was kept for the duration of the research and will be deleted after its completion.

The sample was highly diverse in terms of the participants' age. Despite the variety, the majority of the participants were mostly between 35 and 44 years old and between 55 and 65 years old. Most of them claimed to have over 20 years of experience in the field and their specialization areas were also very heterogeneous. Around 41% of the sample works for public entities and around 95% exercise their job in Portugal.

In order to better understand the general perception of the participants concerning video games (not necessarily from the serious spectrum), they were asked to rate 7 statements according to their agreement or disagreement of their content (resorting to a Likert Scale).

Generalizing, it was mostly agreed that video games are both a contemporary form of entertainment as well as a good multimedia tool. Despite this fact, nearly half of the participants do not consider video games to be a form of art.

While the majority of the participants agree that video games can be interesting for adults, nearly half of the sample does not find video games to be useful or takes a neutral position towards this statement. 23 out of 59 participants find them to be a waste of time or have no opinion on the topic, and 36 out of 59 do not enjoy them or are neutral towards the enjoyment of playing a video game.

[26] Five (or seven) point scale used to allow the individual to express how much they agree or disagree with a particular statement (McLeod, 2008).

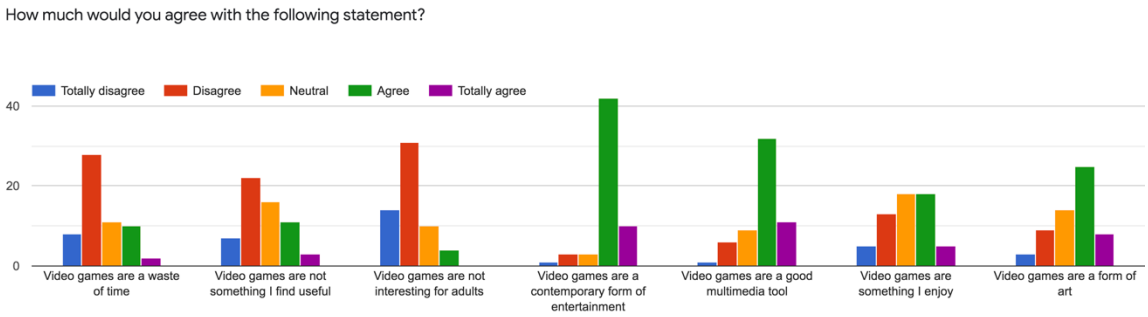

Figure 9 – Opinion on video games of the questionnaire participants.

A deeper analysis taking age groups and their opinion on video games allowed us to conclude that prejudice against video games is mostly found in those belonging to an older generation (8 participants of the 55 - 65 age group gave negative responses to the statements referring to their view on the utility and usefulness of videogames) or to the 35 – 44 age group (6 participants view video games in a negative light). A possible justification for the lack of acceptance coming from an older generation can possibly be attributed to the fact that, unlike younger generations, these individuals did not grow up surrounded by technology and video games.

The 55-65 generation is also the one that seems to disregard video games as a possible form of art, followed by the 35 – 44 generation. Surprisingly, there is a gap between the generations and the participants that are part of the 45 – 54 generation seem to see video games in a positive light and as a form of art.

This allows to conclude that despite the prevalence of the 55 – 65 generation as the one who seems to be the least interested in video games and available to see them as something other than entertainment, the stigma crosses all generations of health professionals and it is still present in the world we live in.

This questionnaire allowed to gauge the unfamiliarity surrounding the concept of "Serious Game", as out of 59 participants, only 16 were aware of what these games were and the principles and ideals they embodied. Out of these 16 participants, only 5 have had a chance to actually use them in practice.

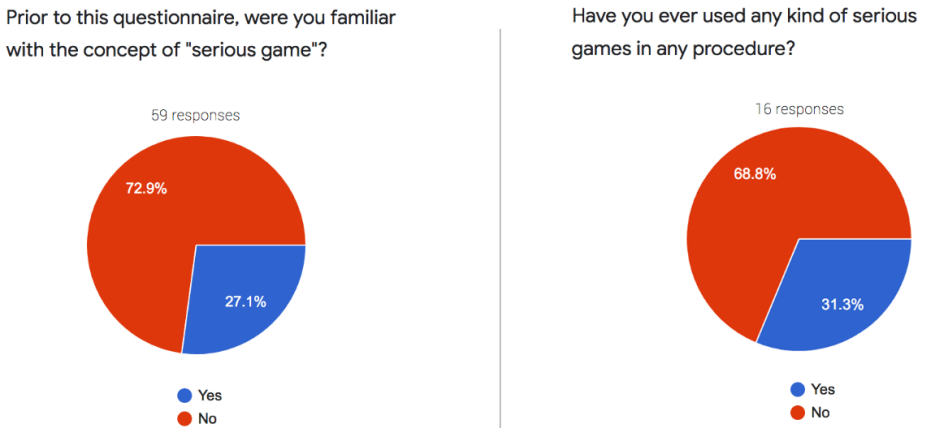

Figure 10 – Familiarity and use of Serious Games among questionnaire participants.

Despite the small number of participants who could actually answer the questions targeted towards their experience using Serious Games, the reason why they were used was unanimous: rehabilitation (be it physical or psychological). As such, the games were used for 1) physical recovery of breast cancer patients, 2) neurology and psychiatry; 3) rehabilitation of neurological lesions; 4) rehabilitation of children suffering from cerebral palsy and 5) research in the field. Two cases resorted to custom-made Serious Games, one used COTS and two opted for both approaches (SG and COTS). Regardless, the developers of the used game are not generally known. In terms of which device was used to play the game, 3 out of the 5 described cases using Wii as their main device. The interventions were mostly held in a clinical setting or inserted in the context of research.

When asked about the relation between physical rehabilitation therapy and the patient, 3 out of 5 cases claim they spend between 0 and 2 hours per week with each patient. Nevertheless, these individuals undertake physiotherapy sessions up to 15 hours per week.

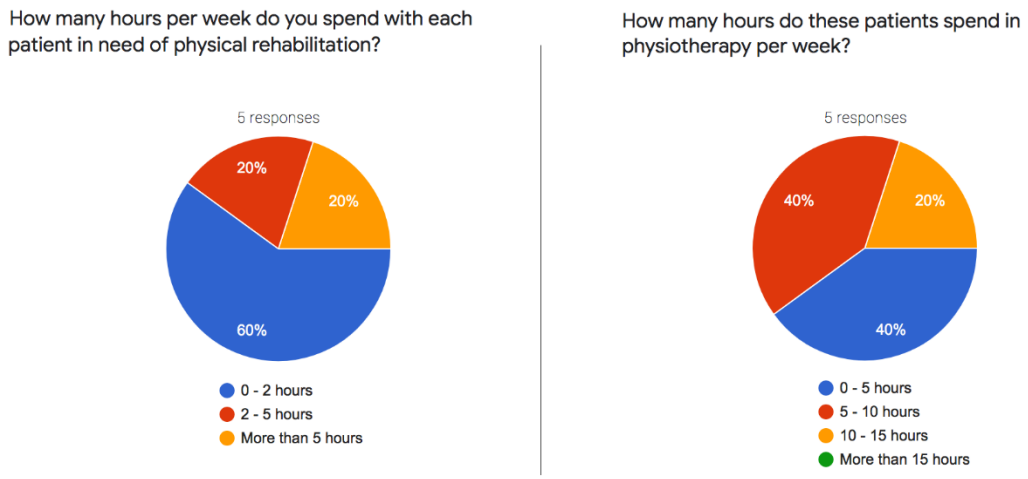

Figure 11 – Hours spent in physical rehabilitation.

Concerning the adequacy of using Serious Games for physical rehabilitation, these 3 out of the total of 5 participants believe that 0 to 5 hours of weekly use of Serious Games might be beneficial. The other two cases claim that these games can be used for even longer periods of time, up to 15 weekly hours. In this sense, 3 out of 5 participants believe that the replacement (traditional therapy -> physiotherapy through the use of Serious Games) percentage should be no higher than 40%, assuming that the patients participate in five 1-hour physiotherapy sessions per week. This means, a maximum of 2 hours of conventional therapy could be replaced by this new approach. Moreover, it is important to point out that Serious Games are advantageous in the sense of how many hours of physiotherapy you can do per week, or even day: there is no limit other than the patients' physiologic limitations (such as tiredness).

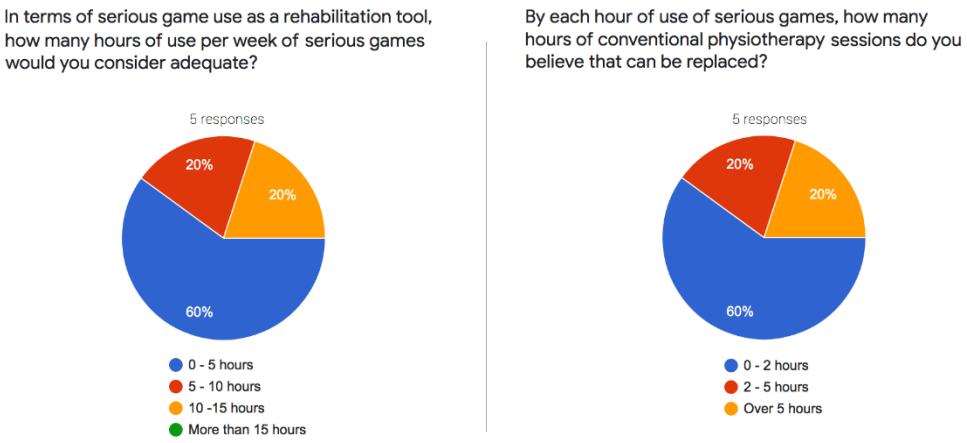

Figure 12 – Physiotherapy and replacement percentages.

After the analysis of the small number of cases that were brought forward for this thesis, it is compulsory trying to understand why these games are not more widely known or used. Some of the main reasons identified (by the participants of this questionnaire) as the main causes were (ordered by number of votes):

1) Lack of knowledge about this kind of video game/of this approach (mentioned by 26 out of 59 participants);
2) Lack of appropriate video games to use for therapeutic purposes (mentioned by 23 out of 59 participants);
3) No access to the games/technology purposes (mentioned by 23 out of 59 participants);
4) Too expensive (mentioned by 20 out of 59 participants);
5) Preference towards traditional methods (mentioned by 12 out of 59 participants);
6) Not applicable in their area of expertise (mentioned by 9 out of 59 participants);
7) Issues related to the law (unspecified, mentioned by 2 out of 59 participants).

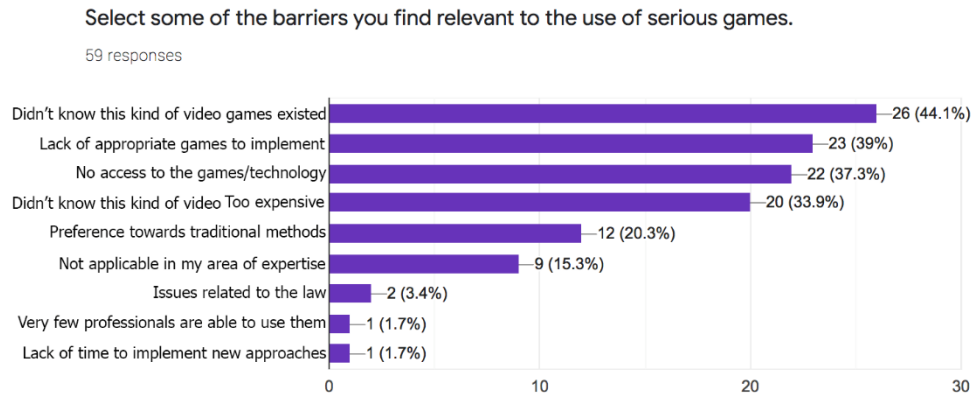

Figure 13 – Main barriers to the use of Serious Games.

Despite all the barriers that were brought to light by the participants, they showed interest in trying this new approach: 57 out of 59 participants said they were willing to implement Serious Games in their medical procedures if they were given a chance to do it.

Concerning the question asking about the participants opinion on the benefits of the use of

Serious Games, 34 out of 59 participants claimed they thought them to be beneficial. The main reason for a non-clear answer was attributed to the participants' lack of knowledge of the topic at hand (which is concordant with the results of one of the first questions – whether or not they were familiarized with the concept of "Serious Games" prior to their participation in the questionnaire). Those who claimed they believed in the benefit of Serious Games pointed out the main gains are the imminent ability of these games to motivate the patients and distract them from pain and the enhancement of treatment/therapy. They also seem to expect this kind of approach to be more successful among younger generations (children, teenagers).

In this sense, some of the features that were considered to be important in a Serious Game were accessibility, ease of use (it must be easy to understand and intuitive), act as a capacity potentiator and not as a substitute and it should embody the characteristics that allow video games to be perceived as something "fun" (present a narrative, having clear specific goals, interaction with the game and with other users). But, considering the context of application, there are features that must be avoided, namely violent content and the risk of the players experiencing addiction to the game.

3.2.2. Interviews

To further grasp the research explored above, as well as the results of the questionnaires and in order to get an in-depth look at the health sector and their needs, 3 interviews were conducted. The interviews took place between the 26th of February 2020 and the 5th of March 2020 and involved professionals in the area from the district of Porto, Portugal and the district of Braga, Portugal. Some of the discussed topics involved understanding the perception of video games in general among health professionals and gauging the knowledge about the existence and use of Serious Games in this specific context. Possible game designs and approaches were also discussed, as well as how physical rehabilitation sessions work, from their duration, costs, type of activities and targeted patients.

The first interview took place on the 26th of February 2020, with the participation of José António Moreira[27,28], a neurosurgeon with over 30 years of experience in the field and the clinical director of CNCV[29] in Braga, Portugal. The first discussed topic was the neurosurgeon's general opinion on video games, which he stated that he found them good in the sense that they enhanced an individual's reflexes and attention. One of the negative characteristics of video games pointed out by the interviewee was the risk of them becoming too addictive, but he quickly added that it could turn out to be a positive outcome if the game had the objective of

[27] See Appendix D for signed informed consent document.

[28] See Appendix E for the full interview transcription (Portuguese).

[29] Clínica Neurológica e da Coluna Vertebral (http://cncv.com.pt.)

motivating the player to spend more time on it, which is one of the desired outcomes of the use of games for therapy. After concluding that the prospect of using video games to enhance the motivation and participation in physical therapy, Doctor José António Moreira then explained that, in his area of work, there were two types of patients who needed physical rehabilitation training sessions – the neurological patients (such as those who suffer from neurodegenerative conditions or are, for example, post-stroke patients) and the musculoskeletal or neuromuscular patients. The interviewee believed that Serious Games might be beneficial for both types of patients, but in different ways. Nevertheless, he pointed out that neurological patients might be more suitable to engage and participate in rehabilitation aided by Serious Games, in order to mitigate their pariahs. In this sense, Doctor José António Moreira suggested that games focusing on diction, precision and attention might be ideal. According to him, the games should be simple but efficient, responding to the clinical objectives they were developed for. For the neuromuscular or musculoskeletal patients, he believed that using video games might be an interesting approach among paraparetic patients (*e.g.*: post-spinal cord traumatism). The interviewee also believed that the physical games available for Nintendo Wii are not ideal, which supports the research presented above, that Serious Games developed specifically for physical rehabilitation are bound to achieve better clinical results than COTS. Nevertheless, it was suggested that custom made games that were based off popular and well-known commercial titles could work well with the patients by establishing a sense of familiarity. The objective of using games in therapy has to be offering the patient a positive reinforcement.

During the interview, the duration, cost and type of physiotherapy sessions were also discussed. It is advisable that patients in need of physical rehabilitation participate in rehabilitation sessions for periods between 20 and 60 days, each session lasting around 20 to 30 minutes. In Doctor José António Moreira's opinion, some of the traditional sessions could be replaced by sessions resorting to the use of specifically designed and developed video games. He also added that patients from the neurological spectrum could participate in therapy for longer than 30 minutes per day. That does not mean longer sessions but having more sessions in a single day. Despite this fact, using video games could eventually be considered beneficial, if the cost of having access to such games was not so high. The interviewee believed that physiotherapy sessions are offered for way too cheap, considering the agreements with the Portuguese National Health Service.

On the 4th of March 2020, another interview was conducted, this time in CNF[30,31], in Póvoa de Varzim, Portugal. During this interview, four different professionals participated in the

[30] Clínica de Neurologia e Fisiatria da Póvoa de Varzim (http://cnf.pt)

[31] See Appendix F for the full interview transcription (Portuguese).

discussion and gave their opinion on the topics at hand, namely the relevance of using Serious Games for physical rehabilitation and in which cases these games should (or should not) be implemented. The first part of the interview focused on a discussion with Mrs. Paula Costa[32], the head of the clinic about the costs of the physiotherapy sessions offered by the clinic, as well as the duration of each session and their workflow. Each physiotherapy session lasted between 45 minutes to 1 hour and, with the support of the Portuguese Health Service, the patient paid 104€ to the clinic for a pack including 20 sessions with a therapist and two consultations with a specialist doctor. According to these numbers, the head of the clinic said that rehabilitation sessions were poorly paid, being undercharged. This arose another question: video games could contribute for the monetization of each therapist, by allowing them to ideally supervise more than one patient at a time (session price is the same for all types of patients – those who barely need any supervision and more serious cases pay the same fee). Speaking of costs, the director believed them to be very costly, so a guarantee of use is virtually mandatory and that does not change the fact that re-earning the spent money is a complicated and slow process.

The second, third and fourth parts of the interview counted with other health professionals working in the clinic. Rui Coelho[33], one of the physiotherapists working at the clinic pointed out a large barrier he found upon trying to implement new technologies in medical processes. He affirmed that social classes played a big role in the suitability and aptness of the patients to undertake rehabilitation sessions focusing on the use of video games. Traditional rehabilitation methods are too familiar to older populations with less means, who expect the therapist to touch them – if there is no touch, massage or guided movement, this fraction of the population believes that there is no achieved benefit. Therefore, using Serious Games as a line of therapy would make the members of this social class feel cheated. Moreover, the physiotherapist believed that video games should never replace traditional rehabilitation sessions but be used as a complement. The social class barrier in this case solely concerns the using population as the healthcare professionals (the interviewees from this clinic) showed interest in the possibility of implementing new and motivating technologies. In this regard, it allowed them to recognize how effective and beneficial these technologies could be for user patients. The physiotherapist also raised the possibility of Serious Games being a better tool for younger populations who are used to the digital world. Consequently, a screening, as well as a pre-selection of the patients who are considered apt to use video games for therapy (in terms of their acceptance, compliance and benefit) is crucial. CNF has a Nintendo Wii installed and ready to be used and, in

[32] See Appendix G for signed informed consent document.
[33] See Appendix H for signed informed consent document.

conversation with Filipe Mendes[34], another physiotherapist and employee, it was possible to understand that this selection was also important to ensure that the patient is able to retain their motivation levels, without experiencing feelings of frustration induced by the game's difficulty level or the task's complexity. Filipe Mendes said that the patients who have been using the Wii over the years gave positive feedback to the type of intervention, as they found it motivating. The therapist said he had no opinion on the interference of a game's visuals or sound in the outcomes, but he believed that a narrative could enhance the game's capabilities. Nintendo Wii is already a fairly good tool for rehabilitation, but the interviewee stated that games designed and developed with a particular objective and end in sight could be even better, achieving better results in terms of physical improvement. He suggested that games recreating motions we use every day, such as brushing our teeth or combing our hair, could be beneficial.

On a different light, CNF's occupational therapist frequently uses an iPad with children in need of therapy (resorting to puzzle or shape sorting games). But, once again, not all patients are apt to use technology. For example, using the iPad for therapy among children with autism is advised against, because the iPad is too strong of a stimulus. The monetization aspect behind the use of video games is also crucial, as well as the time needed to implement these technologies with the patients. For it to be possible, according to the interviewees, there would need to be some changes in the workflow of entities external to the clinic, such as those who are in charge of patients' transportation to and from the clinic.

This interview led to the following conclusions: social class, as well as age groups, are some of the main barriers to the use of Serious Games as rehabilitation tools and it influences the ability of comprehension, understanding and perception of an individual. The cost of implementation is also seen as a barrier, because in the short term, it is not considered profitable. In addition to it all, there is a generalized resistance to change felt among patients that is a relevant common denominator to most social classes and age groups. In Portugal, physiotherapy is heavily based on the touching factor and that differentiates it from the way physiotherapy is practiced in other countries. This is considered a positive aspect of the way Portuguese therapists engage with patients so, and according to the physiotherapist Rui Coelho, going against that by adding games to the therapy repertoire might face some resistance from patients and healthcare professionals.

Another interview with Professor Nuno Sousa[35] was held on the 5th of March 2020[36]. The interviewee is a doctor and a medicine Professor at Minho's University Medical School with

[34] See Appendix I for signed informed consent document.
[35] See Appendix J for signed informed consent document.
[36] See Appendix K for the full interview transcription (Portuguese).

over 30 years of experience, working for both public and private entities. Besides his clinical and pedagogical activity, he also works as a researcher in the field of neurosciences. Professor Nuno Sousa believed that video games, in general, are just as any other human product: they can be extraordinarily beneficial if intelligently used but, if used for perverse purposes, they can be highly nefarious. The academic showed to be familiarized with the concept of Serious Games, having used them in the past for therapeutic intervention as a cognitive enhancement tool (targeting patients suffering from cognitive deficits, preferably light to mild). The objectives behind the use of the games were helping the mitigation of the patient's handicap. Simple games were preferred because, according to the interviewee, using simpler low-complexity games allows a better control of the variables (when analysing the results from an investigation point of view). The game tasks are presented to the user in an incremental difficulty mode and they aim to grant the patient benefits in terms of cognitive and emotional control (*e.g.*: control of the electric activity of the brain). Professor Nuno Sousa said that the devices used to implement Serious Games in cognitive impairment therapy depend on the situation and context and that there are no restrictions when it comes to devices used. Although the Professor believed that a custom-made game, tailored for a specific patient and a particular and unique conditions would be the utmost ideal, he claimed that it is said in the field that Nintendo Wii already answers some of the needs when it comes to games for physical rehabilitation. In this sense, he also believed that the design of the games specifically developed for medical causes falls short when compared to commercial titles. Economically speaking, a broadband video game, that could be adapted and used for several different pathologies and conditions would be the best choice, although a patient-specific game would be the ultimate goal. To conclude this section, Professor Nuno Sousa suggested that it would be important to find the ideal commitment – not too costly but still adaptable and clinically efficient. Some of the barriers to the use of Serious Games as a medical tool that were pointed out and discussed during the interview are the development time of custom made games, as well as the human and economic effort needed to develop the game (from a game development point of view) and the stigma against videogames that is still prevalent among nowadays' society (as it was already observed through the questionnaire results). Professor Nuno Sousa also suggested that the fact that the elderly are not so used nor comfortable with digital devices, it might make it harder to implement such methods among that fraction of society. In this sense, and corroborating some of the main ideas from the interviews held in CNF, the benefit experienced between two individuals virtually in the same physical and cognitive condition will depend on many external factors that will influence the outcomes, namely motivation, comprehension, attention and tiredness. Moreover, even the same patient can experience rehabilitation through a video game

differently because their mood and disposition (that will affect the factors mentioned above) is different and variable every living moment.

The interview also aimed to discuss some gameplay variations and assets in order to understand what the Professor found the most useful and beneficial. The interviewee, after being asked about the importance of narrative in games and, more specifically, in games used for serious purposes, claimed that it would always help motivating and thrilling the patient, although some conditions would benefit more from a narrative than others. Another subject that was talked about during the interview was Professor Nuno Sousa's opinion on using multiplayer games instead of single player. As multiplayer games are seen as interesting from both cognitive (in various dimensions) and social points of view, the interviewee claimed they could be a good tool. Nevertheless, he added that instances where players are expected to compete against each other (PvP[37]) would not be entirely desirable. Cooperation between players was very much preferred, therefore opting for games where the players had to work in teams and coordinate their actions to attain a specific goal (for example, PvE[38]).

These interviews allowed us to better grasp the context of rehabilitation therapy and customization needs in Portugal, by bringing to light relevant barriers that need to be crossed, as well as goals for the future of rehabilitation aided through Serious Games. One of the mentioned aspects that is considered the most relevant is the role social class plays in the acceptance and openness to the use of Serious Games, as brought to light during the interview at CNF. Prior to these interviews, it had never been considered as a possible barrier. It was expected to be accepted widely as something new and beneficial. But considering that the understanding of this premise may vary with the social class and context of each patient is a relevant aspect that cannot be neglected. Even if, in comparison to traditional methods, the use of a Serious Game is considered beneficial by enhancing the patient's motivation, this may never even happen if the patient previously displays reluctance in using/playing an adequate video game, by feeling neglected or discarded by the professional in charge. This will not lead to the desired feeling of motivation and, therefore, it will not enhance compliance and participation in the rehabilitation sessions. This idea is also corroborated by Professor Nuno Sousa, who stated that patient reaction to the video game might vary, depending on aspects such as motivation, comprehension, attention and tiredness.

Costs of development and acquisition are also one of the concerns shared by all the interviewed professionals. For the implementation of Serious Games for therapy, it is critical to take into account the monetization aspects behind it. In regard of the positive qualities of the

[37] Player versus Player
[38] Player versus Environment

use of Serious Games, all interviews led to the same conclusion (that also matches the findings from the study cases): Serious Games are bound to make rehabilitation therapy more motivating and fun for the patients. If the game is made specifically for rehabilitation purposes, even better. The utmost goal would be having a game tailored for the unique needs of each patient. It is also possible to conclude that all interviewees agree that adding a narrative to a game might enhance its capability of motivating a patient and help creating feelings of "wanting to play more". In terms of clinical adequacy, Serious Games for rehabilitation are considered (among the interviewed healthcare professionals) suited to both neurological patients and musculoskeletal or neuromuscular patients.

3.2.3. Final considerations

The analysis of the common points mentioned during the interviews and by the participants of the questionnaire allows us to draw some conclusions. As it was already pointed out previously, health professionals perceive Serious Games as a complement to traditional therapy instead of a full substitute. The interaction between the patient and the therapist is still considered of utmost importance among both health professionals and patients. This was mentioned by some of the participants of the questionnaire, as well as during the interviews at CNCV and at CNF. The possibility of a partial substitution is not impossible nor seen as negative.

Although, for such a paradigm to be successfully achieved, there are other factors that cannot be discarded and that will influence the users' acceptance of this technologically innovative approach: social status (mentioned by CNF), the lack of comfort with the digital felt among older generations, and how one's mood and disposition will affect their achieved gain from using Serious Games as a therapy tool (brought to light by Professor Nuno Sousa and CNF). These match the suggestion given by the participants of the questionnaire: that these games would probably work better with younger generations that already grew up with technology as part of their everyday life (children, teenagers and young adults). There is also some underlying stigma against the use of video games (as people tend to generalize them, discarding their differences in targeted objectives and audience), proved by the answers collected in the questionnaire, that needs to be overcome in order for the implementation of this technological approach to be successful.

Nevertheless, these games are generally understood as something potentially positive and beneficial to the patients, such as those suffering from neurological pathologies, as they stimulate things like attention and reflexes. The adaptability of the game to the needs of the patient is seen as crucial, a theme that was explored in both the questionnaire and during the

interview with Professor Nuno Sousa. The possibility of interaction between players during the game is also seen in a positive light, since it is considered to enhance users' motivation to play more and play better.

Financially speaking, the implementation of Serious Games is perceived as a large investment for private clinics or hospitals to undertake on their own.

3.3. Understanding the workflow of the developers

Serious Games, in order to be used as a finished product (be it for healthcare, education or other areas), need to be planned, designed and developed. As it happens with any other software, they have particularities that makes their development unique and challenging. In order to better understand the trials of developing a video game for serious purposes (targeting healthcare as the main objective of the Serious Game), we opted to follow the same methodology used with the health sector – an approach resorting to a questionnaire and interviews.

3.3.1. Questionnaires

Following the same methodology used with the questionnaires targeted at healthcare professionals, another one was developed in order to get to know the workflow of game developers, mainly those working in the Serious Games area. Likewise, before being sent out, the questionnaires were submitted to a group of 5 external subjects, who evaluated the adequacy of the proposed questionnaire by giving their opinion on what needed to be made clearer or what should be changed in order to make the questionnaires more accessible and effective. After the changes were made, the questionnaires were stent out. The approach was made by email, text messages and word of mouth (the full questionnaire can be found in Appendix L).

Once again, the anonymity and confidentiality of the participants of the questionnaire for developers were safeguarded (no nominal identification of the participant). Confidentiality and exclusive use of the data collected for this study were guaranteed, under conditions of anonymity (no registration of identification data). The collected data was kept for the duration of the research, being deleted after it has been concluded.

This second questionnaire featured 18 questions, including multiple choice questions, short answer questions, long answer questions and questions using the Likert Scale. This time, the questions were directed towards the process of developing a game. The questionnaire opened with questions that had the objective of characterizing the sample (by asking their age group, job, years of experience and what kind of entity they work for). After that, there was a pre-selection process, where the participants had to answer whether or not they had been involved

in the making of a video game for serious purposes. If they answered “Yes”, they were asked whether the project they participated in was related to healthcare. After that, once participants had been filtered, the questions revolved around aspects relevant to development, such as game engines, programming language used, the size of the working team and functions of each member, the budget and the timeframe for the development. This questionnaire also aimed to gauge the creative and technological challenges that the participants faced during their experience in the field, as well as client engagement during the design and development process (see Appendix M for full questionnaire results).

In this sense, 19 subjects participated in the investigation process by taking the questionnaire. The participants’ ages were predominantly between 45 and 54 years old (8 participants). Despite the broad range of areas of expertise inside the field of game developing, 8 out of the 19 participants classified themselves as programmers. As for the years of experience, most of the sample (7 participants) claimed to have between 10 and 20 years of experience. 14 participants worked in Portugal or for Portuguese companies, while 3 of the participants worked either in the United Kingdom or for British companies. Two participants worked in Brazil.

The questionnaire brought to light that despite the fact that all participants work in game development, about half of them (9 participants) have never worked for a game that can be considered serious and, from those who have, not all of them worked for the medical field (5 have worked for the medical field while 5 have not).

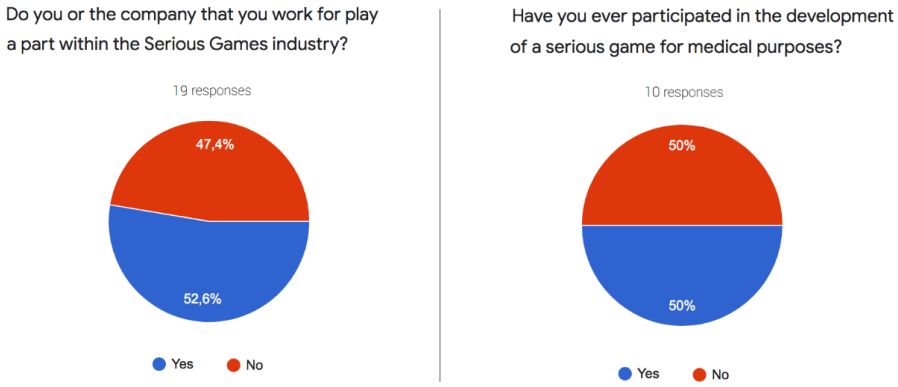

Figure 14 – Presence of Serious Games in game development.

Among the 5 projects that were developed with healthcare in sight, their purposes varied, but 4 out of 5 games tackled issues concerning physical and/or cognitive rehabilitation. Three of these were targeted towards post-stroke rehabilitation.

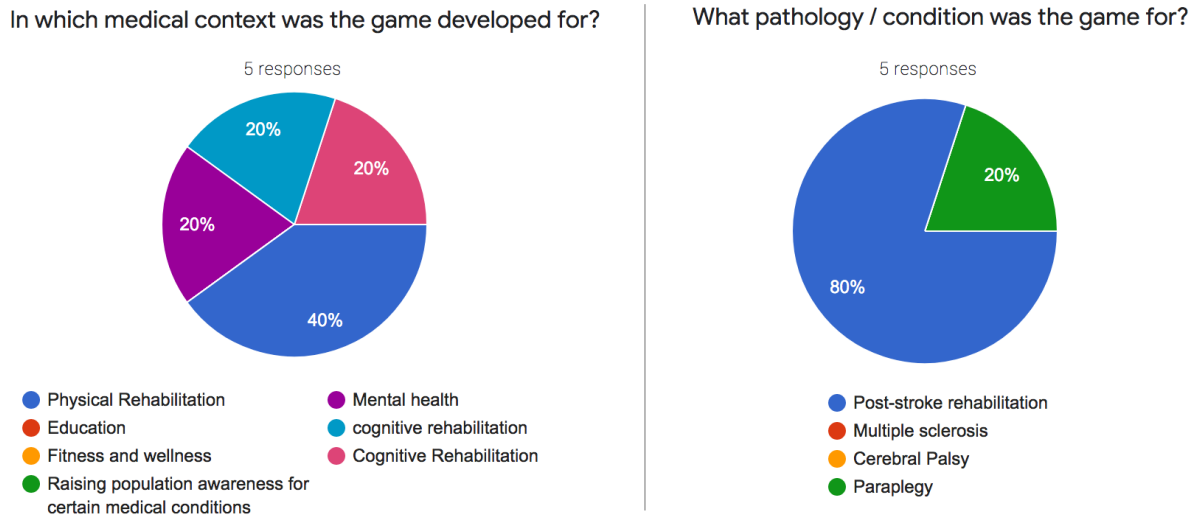

Figure 15 – Pathology and goals tackled by Serious Games.

Concerning the actual development of the game, the questionnaire brought to light the relevance of the use of Unity 3D as the game engine behind the development of the Serious Games designed and developed by the participants of the questionnaire, therefore making C# the preferred/most used programming language. The most common time range for the development was between 1 and 3 years, the budgets were generally under 10,000€ and the development teams were no bigger than 5 people. Most of the developed games were designed to be used on Windows (and, therefore, on a personal computer – no distinction between desktop or laptop).

As it would happen with the development of any other video game, there are both creative and technological challenges that must be overcome in order to reach the end product. Adapting the aspects that make video games creatively alluring to medical protocol requirements is often seen as a creative challenge because, as it implies, a video game, to be accepted in the field, needs to be medically correct in its way of tackling its objective. In this sense, the content development is seen as a challenge. Another challenge that was mentioned (not only from the creative spectrum, but also from a technological point of view) was the necessity to design a game that could be accessible online (while being multiplayer, allowing both competitive – PvP - and collaborative – PvE – environments) in order to keep the patients and users from having to travel in order to have access to therapy. According to the participant who mentioned this necessity, this is bound to increase the patients' motivation, urging their adherence to therapy.

Technologically speaking, the main challenges concern the tracking of the patient's body motions and how to adapt these to the user's limitations and difficulties. Another concern is finding the best way to provide feedback to the player.

The only issue with the market that was pointed out by the participants of this questionnaire was its low maturity. According to the questionnaire, the clients' engagement during the

development process was generally good but, in some cases, it could be better, which would, eventually, lead to a final product that was more satisfying for the client and more medically efficient for the patient.

3.3.2. Interviews

In order to better understand the workflow and to explore the topic in a closer manner, an interview, taking place on the 28th of February 2020 was conducted and involved professional in the area from the district of Porto, Portugal. Some of the topics that were addressed during the interview were the creative and technological challenges experienced during the process of developing a Serious Game, as well as design, gameplay and game mechanics considerations. The market and the barriers that one needs to overcome to be able to enter it and strive were also discussed and analysed.

In this sense, on the 28th of February 2020, an interview with Professor Carlos Vaz de Carvalho[39,40], who is the vice-director of the GILT[41] Research Group (Games Interaction and Learning Technologies), that is part of ISEP[42] (where he also teaches a subject related to Serious Games) took place. The interviewee has been working with Serious Games (from development and investigation points of view) for over fifteen years. Besides his pedagogical component, he is also the director of a company called Virtual Campus, whose main activity is developing educative software, therefore focusing on the possibility of adapting technology to education in new and innovative ways. Over the years, the Professor has worked on multiple projects and he stated the need of deeply understanding the target audience before undertaking any project and starting any kind of development: it is of utmost importance getting to know the audience, what they are comfortable with, what they are looking for in the software and, concerning their many characteristics (age, social context, job…), what is the best kind of video game for them and what is the best way to adapt it to their needs and goals. The interviewee pointed this aspect as the largest creative challenge encountered during the development and design processes.

In terms of actual development, Unity 3D is the main tool for development, being the game engine of choice. In this sense, as Unity 3D works with the programming language C#, that is, consequently, the language used for the coding and development of most Serious Games. After being asked about budgets, the professor said that they could vary and would depend on the project, ranging from 50.000€ to 500.000€, which is quite a large difference. He, then, explained that the project that had a 500.000€ budget did not use that amount solely for the

[39] See Appendix N for signed informed consent.
[40] See Appendix O for the full interview transcription (Portuguese).
[41] http://gilt.isep.ipp.pt
[42] Instituto Superior de Engenharia do Porto

development of the product, but that was the total cost of the project (where the game was included) as a whole. Moreover, the budgets, according to the Professor, are one of the main limitations when it comes to the design of the games. The interviewee believed that it is better to have good game mechanics over good design, although it would be ideal to have both, but the budget not always allows that to happen, so it is important to find the ideal balance between the two. If the design is completely neglected, we fall into another extreme – the final product stops being something that can be considered a videogame to be solely identified as a software used for serious purposes (for example, educational software). From a technological point of view, the largest challenge, according to the Professor, is identifying the best platforms to distribute the videogame.

When asked about his opinion on multiplayer video games, Professor Carlos Vaz de Carvalho stated that he found them very interesting because of the phenomenon they inherently trigger – competitivity. This can be very motivating and very useful, although not applicable to all Serious Games areas due to other factors, usually external to the development of the game. The interviewee believe that Serious Games are stimulating and convenient to develop competences and abilities, while not being so practical as a tool used for transmitting knowledge.

The interviewee was also asked about his opinion on using commercial titles (such as those produced for Nintendo Wii), and he said that if it was possible, given the context and circumstances of a specific situation, to reuse commercial titles for serious ends, it would be a waste not to do it, considering they were good enough for the pretended goal. As for the barriers, he explained that the stigma around videogames is one of the largest obstacles for Serious Games to prosper, because those who have the means to access and buy this technology still show signs of being weary about the benefits and efficacy of the use of video games.

3.3.3. Final considerations

Intersecting the results obtained in the questionnaire with the information collected in the interview, it is possible to conclude that the biggest challenge is adapting the game to the needs of patients (target audience) while following the medical protocols for the treatment and/or rehabilitation of the condition in cause (the problem that the Serious Game seeks to solve).

Crossing both sources, it is also plausible to conclude that Unity 3D is the main game engine and resource used to develop these Serious Games, making C# the most common programming language among this type of video games.

Moreover, besides these technical and creative conclusions, it was also noted that budgets are generally small (more commonly up to 10,000€), which will eventually lead to some loss

in quality (conceptual, visual, artistic) of the final Serious Game products.

4. Serious Games: just a dream or financially viable?

4.1. Serious games and the market: who we are and where we are headed

In the previous chapters, the concept of "Serious Game" was vastly explored: from its origins, definition and coverage to actual cases where these games were used with patients, it was possible to understand where we stand concerning this innovation and which paths are left to take and explore.

Besides aiming to obliterate the lack of knowledge surrounding Serious Games amongst the target audience, the market possibilities for the implementation of this setup are still greatly underexplored.

Due to the COVID-19 outbreak, another point of interest surged: up until now, only conventional physiotherapy was considered but what if all presential sessions were suspended, as it happened during the pandemic that took the world by storm in early 2020. APFISIO[43], the Portuguese association of Physiotherapists, advised the suspension of all physiotherapy units[44] during the Emergency State lived in Portugal between the 18th of March 2020 and the 2nd of May 2020. In this sense, and in order to understand what could be done in order to overcome the restrictions imposed by the lockdown, an interview held via phone took place on the 24th of April 2020. The target was a physiotherapy clinic that focused on offering therapy sessions at the patients' homes. This interview allowed a brief understanding of the way this institution worked and how they were getting through lockdown while still assisting the patients who sought their services.

The sessions offered by this clinic last between 45 and 60 minutes and are accompanied by one health professional, selected accordingly to the patient's condition and specific needs. Under normal circumstances, the sessions would take place in the home of the patient and a single session would cost 38€. During COVID-19, the clinic resorted to videoconference tools as their chosen method and the price per session was lower: 30€ per session.

The fact that, during a situation like the one caused by COVID-19, presential physiotherapy sessions had to be suspended, opens a whole new universe to the emergence and perceived importance of innovations such as Serious Games for physical rehabilitation. Up until now, they were seen as a mere complement, but during a situation where the patients had to undergo physiotherapy without leaving their houses due to the confinement, a Serious Games presented itself as an interesting and effective solution that could be highly beneficial and easy to use.

Broadly speaking, the way the world portrays itself is actually very inviting to new

[43] Associação Portuguesa de Fisioterapeutas

[44] http://www.apfisio.pt/posicao-da-associacao-portuguesa-de-fisioterapeutas-sobre-a-covid-19-provocada-pela-infecao-por-coronavirus-sars-cov-2/ (retrieved April 3rd, 2020).

approaches such as the one offered by Serious Games. From a social spectrum, we can conclude the following:

1) The Portuguese population is an aged one and its aging index has increased over the course of the last few years, with no improvement in sight. In 2006, for each 100 young people, we could find approximately 112 elders in Portugal. In 2017, this number grew to approximately 154 (PORDATA, 2018a). If the scenario and the trend we are experiencing today remains unchanged (in terms of mortality and birth rates), in 2060, INE projects Portugal to have 370 elderly people for every 100 young people (Instituto Nacional de Estatística [INE], 2017). A projection for 2030 by the Francisco Manuel dos Santos Foundation claims that for every 100 people of working age, there will be 41 elderly, while in 2010, there were only 29 (Mendes & Rosa, 2012);
2) In the face of an aging population, rehabilitation becomes essential. Medical and scientific advances will allow an increased longevity, which will consequently entail problems related to old age, such as a higher probability of disabilities and functional limitations. As health conditions related to advanced age become more frequent, physical rehabilitation assumes a crucial role in healthcare (Sampaio *et al*., 2017).

From a social point of view alone, it is already possible to understand the relevance of physical rehabilitation in the upcoming years. Politically speaking, the need for physical rehabilitation has already been acknowledged by the Portuguese government and the main issues found in the rehabilitation sector of the National Healthcare System are already being addressed, namely (Administração Central do Sistema de Saúde, 2018):

1) Lack of equity in access to rehabilitation;
2) Need of promoting the articulation of models that are currently offered in the sector under study;
3) Lack of material and human resources to offer a complete response to citizens.

Accordingly, the implementation of Serious Games would ideally solve all these issues by boosting the physical rehabilitation sector.

Moving on to the economic spectrum, a 2014 study brought to light the fact that the Serious Game market presented a growth rate of nearly 100% per year (Laamarti *et al.*, 2014). They are also seen as convenient in the medical field since they allow to compensate the amount of money that is not possible to spend with long and slow therapies: they indirectly allow the monetization of these therapies by potentially making them available to a larger part of the disabled population who is in need of physiotherapy for the rest of their lives (Lohse *et al.*, 2013).

Serious Games present themselves as a polyvalent tool, so there are organizations that show interest in financing the design and development of these games, but the budget made available by these companies is generally considerably lower than the amounts invested by the producers of video games targeted to general audiences and commercial purposes. Nevertheless, it is important to mention that Serious Games exhibit vertical market segment transversality (Michael & Chen, 2005).

An exponential interest and growth in the area of Serious Games for healthcare has been detected, which has consequently led to an increase in the number of funding opportunities (Kato, 2013). There has been an increase from financial investors in investing to support the development of Extended Reality (abridging VR, AR and MR) based applications in sectors such as gaming, e-commerce, healthcare and wellbeing, education and social media. In this sense, Serious Games for physical rehabilitation fit two of these fields: gaming and healthcare (Alhadeff, 2007; AngelList, n.d.).

Finally, technologically speaking, the video game retail industry (be it the Serious Game or the COTS industry) is driven by its inherent technology. Coincidentally, Serious Games can be taken as a way of monetizing the technology used in commercial games (Michael & Chen, 2005). Moreover, the technological advances we experience and see on the news every day will allow new paradigms of physical rehabilitation, including those resorting to digital tools, such as Serious Games.

As the digital world grows and quickly transforms into something that one cannot escape from, and as social networks play a bigger role in our everyday life, there is a need to offer new and digital answers to issues that were previously dealt with through analogic or traditional methods. There is an everlasting presence of the digital in our lives, as well as a constant desire to experience feelings of novelty. We are constantly in touch with a large number of sensory stimuli. This will make our attention more disperse and that will affect our ability to retain information. These stimuli come from all kinds of things, like ad panels, television, radio, … and even video games. Thus, Serious Games present themselves as yet another way to embody and help boost therapy process by catching the user's attention through the use of digital tools in procedures that were previously solely physical and nondigital (Cameirão *et al.*, 2009; Houston, Bee, & Rimm, 2013).

Even though Serious Games are expected to get a high return on investment, there are issues that need to be considered beforehand, namely the lack of awareness of the existence about this game genre, the fact that game design is still underexplored in the context of rehabilitation and thus, the fact that there is still a long road to conquer concerning academic research on the matter (Lohse *et al.*, 2013).

One of the major threats to the Serious Game approach is that these games are not often available to the regular consumer: you cannot just go to your local video game store and buy a Serious Game for physical rehabilitation and neither can you download them from online shops (through Steam[45] or the Nintendo eShop, or any other identical service). Yes, there are sports games, such as those for the Nintendo Wii, that will partially do the job. But as it was explored in the previous chapters, although the player might perceive physical condition improvement while experiencing feelings of "fun", the actual clinical improvements are not as great as those obtained through custom-made games.

Thus, it is imperative to fight this lack of knowledge surrounding Serious Games and to find a model that will circumvent the unavailability of a "direct-to-consumer" approach.

4.2. How can Serious Games be implemented in the Portuguese National Healthcare System?

Considering the current and future situation of Portugal, Serious Games for healthcare come across as something very appealing. But is their implementation really viable?

In this sense, there was an attempt to come up with several scenarios that could mirror reality behind the possible future implementation of Serious Games in the national (Portuguese) healthcare system as a rehabilitation tool, in order to gauge the financial capability of this innovation.

This step began by collecting data that would highly influence the proposed scenarios. It was decided that it would be better to work with a single pathology instead of trying to tackle multiple ones. The condition chosen was stroke and the Serious Game would be used as a post-stroke rehabilitation tool. This decision had multiple reasons behind it, namely the numbers, the type and nature of sequels the patients experience and the amount of research featuring positive results that has been conducted previously (already analysed in Chapter 3.1 and in the questionnaire targeted at the healthcare sector).

Just in Portugal alone, each year, there are around 25,000 new registered stroke cases (Ferro, n.d.), while other disabling pathologies such as cerebral palsy, only registered around 1,000 cases in 10 years (Virella *et al.*, 2018). Out of these 25,000 stroke cases, around 40% of the patients (~10,000) will suffer from sequels that will affect their independence and their ability to perform (some) regular day-to-day tasks. These patients will most likely depend on physiotherapy for life. As the aging index of the Portuguese population steadily aggravates over the years, the same happens with stroke incidence rate. With an older population and a larger

[45] https://steamcommunity.com

lifespan, stroke is bound to happen even more often. Moreover, the incidence of stroke doubles with every decade of life from the age of 55, with hemiparesis being a major deficit resulting from the condition. 60% of the individuals who experience stroke will have some sort motor dysfunction as a resulting sequel. Despite physiotherapy, the disability/dysfunction is bound to become a "permanent" deficit after one year. (Piassaroli, Almeida, Luvizotto, & Suzan, 2012).

Concerning the importance of physical rehabilitation during the post-stroke phase, it is known that the first three months after stroke occurs are the most important. Stimulating the patient's neuroplasticity will potentiate the recovery of motor functions that have been lost and this can be achieved through physiotherapy (Cameirão *et al.*, 2009; Piassaroli *et al.*, 2012; Rodrigues, 2018).

In this chapter, we will attempt to estimate the cost to develop a Serious Game for physical rehabilitation and, for that, we are going to make several assumptions regarding the factors that define a physiotherapy session (therapist working hours, average salary, number of professionals per session, session duration), the development of a game (team size, average salary per team member, the cost of the device used to run the game, how many weekly work hours would each team member work and initial costs).

Regarding physiotherapy sessions, we are going to assume that therapists work 35 weekly hours and each salary is composed by 4 work weeks. According to PORDATA (2018b), the average salary for workers of the Human Health and Social Support sector is of approximately 892€. As it was understood through the various interviews that were described and explored in chapter 3.2.2, physiotherapy sessions generally last up to 1 hour. These sessions are accompanied by one healthcare professional.

In this sense, the average cost per hour can be calculated through this formula:

$$\text{Average cost per hour} = \frac{\text{Estimated monthly salary}}{\text{Number of weekly hours of work of the physiotherapist} \times \text{weeks per month}}$$

Before moving forward, it is important to think about replacement/substitution percentage. As mentioned before, the replacement percentage tells us the number of traditional physiotherapy sessions that would be replaced by sessions where treatment went underway through the use of a Serious Game. Ideally, and according to the information collected during the questionnaire, interviews and case studies, this percentage should be lower than 50%, as a Serious Game should be perceived as a complement of traditional rehabilitation therapy and not a full-on substitute.

Following this train of thought, the annual cost for 10,000 stroke patients in need of rehabilitation can be calculated by multiplying the number of patients by the average cost per

session, by the number of professionals working per session, by the duration of each session, by the number of sessions per week, by the number of weeks that composes the treatment duration and by the replacement percentage. This long multiplication will give us the annual cost of this kind of approach, which will let us know how much we would be able to save by implementing this approach.

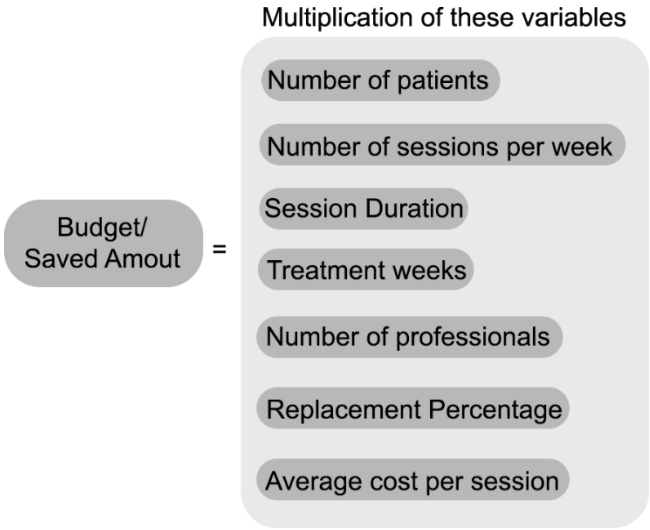

Figure 16 – How to calculate the budget/saved amount

Considering that the software used would last for a certain number of years before being considered outdated, we can calculate the budget we would have available for the development of a Serious Game if we multiply the annual cost/saved amount by the expected life of the software.

Now that we have an estimated budget, it is imperative to understand if, from a development point of view, it would be enough. For this, we need to consider some more data:

- The size of the development team;
- The salary of each member of the development team;
- The cost of the device that would be used to run the game;
- How many weekly hours each member of the development team would work;
- Initial costs (*e.g.*: for licensing, registrations, …)

In order to monetize the devices and to save money for the actual development of the software, another assumption was taken into account: it was assumed that patients would only participate in physiotherapy through this model during the first 3 months after stroke. So, it would be possible to reutilize the devices by splitting the patients in lots assuming that these events (strokes) happen constantly throughout the year (no seasonality).

The formula used for the lots was the following:

$$\text{Lots} = \frac{52 \times \text{life of the software (in years)}}{12 \text{ weeks}}$$

We can know how many users would be needing a device at the same time if we divide the total number of patients (by multiplying the number of yearly patients in need of therapy by the software lifespan) by the lots.

The average cost per hour for the development team can be calculated the same way as physiotherapist hourly cost was calculated, but this time, salary is the one stipulated for each member of the development team. Now, all that is left is calculating how many hours of work we could pay to each member of the team with the budget that we have. Such can be calculated according to this:

$$\text{Hours} = \frac{\text{Budget - initial costs - cost of the device} \times \text{no. of simultaneous patients}}{\text{Number of workers (development team)} \times \text{avg. cost per hour (development team)}}$$

Then, the average time of development of Serious Games must be compared with the number of hours it is possible to buy with this budget and we will know if this approach is financially viable or not.

Following this model, a few hypothetical scenario cases were designed, considering different replacement percentages, salaries, team sizes and software lifespans. The assumptions used tried to be cautious in each step, in order to prevent us from underestimating the cost of development.

Case 1		**Software**	
Condition	Stroke	Software life span	3
No. of new cases per year	25 000,00	Budget	1 632 857
% that becomes disabled	40%		
No. of patients who become disabled	10 000,00	Initial costs (e.g.:licensing, registrations, ...)	50 000,00
Estimated treatment period (weeks)	12	Unit price of the device (hardware)	300,00
Treatment sessions / week	5	Number of concurrent users	2 308
Session duration (hours)	1	Total number of weeks	156
Replacement percentage (traditional -> SG)	20%	Lots of device usage	13
No. of professionals / session	1	Team size	3
Estimated salary	635	No. of work hours / worker	18 998
Weekly hours	35	Average cost per hour	15,625
Weeks per salary	4	Estimated Salary	2500
Average cost per hour	4,54	Weekly hours	40
		Weeks per salary	4
Budget/Saved Amount	544 286		
		Number of weeks (total)	475
		No. of weeks / worker	158
		Years	3,04
		Months	37

Table 1 – First hypothetical scenario: base case.

The first scenario was a base case. It considered the Portuguese minimum wage of 635€ (PORDATA, 2020) for physiotherapists, 5 rehabilitation sessions per week and a replacement percentage of 20% (out of those 5 sessions, one would use Serious Games instead of a traditional human-human interaction approach). According to these criteria, the average cost per hour would be of 4.54€ and the estimated budget/saved amount of 544,286 €. Considering

a 3-year lifespan for the Serious Game, the budget would be approximately 1.6 million €. Assuming that the development team was composed by 3 members (2 programmers and 1 designer, for example), and each one of them earned a salary of 2,500€ per month, it would be possible to have this team work on the game for around 3 years, which is within the usual time range for the development of a game (1 – 3 years), according to the information collected through the questionnaire and interview targeted at developers. Nevertheless, this scenario has faults that make it not entirely in tune with reality: possibly the replacement rate could be higher (considering it would still be under 50%), physiotherapists generally earn more than the minimum wage, and the salary of each development team member was considerably high when inserted in the Portuguese framework, since the average wage for people working in the computing and the game design field is generally right under 2,000€ (Teamlyzer, 2020).

With this in mind, a second scenario was contemplated:

Case 2		**Software**	
Condition	Stroke	Software life span	3
No. of new cases per year	25 000,00	Budget	4 587 429
% that becomes disabled	40%		
No. of patients who become disabled	10 000,00	Initial costs (e.g.:licensing, registrations, ...)	50 000,00
Estimated treatment period (weeks)	12	Unit price of the device (hardware)	300,00
Treatment sessions / week	5	Number of concurrent users	2 308
Session duration (hours)	1	Total number of weeks	156
Replacement percentage (traditional -> SG)	40%	Lots of device usage	13
No. of professionals / session	1	Team size	3
Estimated salary	892	No. of work hours / worker	82 029
Weekly hours	35	Average cost per hour	15,625
Weeks per salary	4	Estimated Salary	2500
Average cost per hour	6,37	Weekly hours	40
		Weeks per salary	4
Budget/Saved Amount	1 529 143		
		Number of weeks (total)	2051
		No. of weeks / worker	684
		Years	13,15
		Months	158

Table 2 – Second hypothetical scenario.

This second case already considered the tabulated value for the wages of health workers of approximately 892€ (PORDATA, 2018b) and considered a replacement percentage of 40% instead of just 20%: this would mean that 2 out of 5 weekly sessions would consist in the use of a specific rehabilitation-oriented Serious Game. This automatically makes the budget skyrocket and, considering the exact same development team and the same wages from case 1, allows to "buy" nearly 13 years of work: up to 3 years could be spent developing the actual software and the rest of the time could be spent updating and improving the Serious Game.

The team salary is still considerably high in the Portuguese context and considering that the team was relatively small (only 3 members), a new case that had a larger team with a slightly lower salary in mind was envisioned.

Case 3		**Software**	
Condition	Stroke	Software life span	3
No. of new cases per year	25 000,00	Budget	4 587 429
% that becomes disabled	40%		
No. of patients who become disabled	10 000,00	Initial costs (e.g.:licensing, registrations, ...)	50 000,00
Estimated treatment period (weeks)	12	Unit price of the device (hardware)	300,00
Treatment sessions / week	5	Number of concurrent users	2 308
Session duration (hours)	1	Total number of weeks	156
Replacement percentage (traditional -> SG)	40%	Lots of device usage	13
No. of professionals / session	1	Team size	8
Estimated salary	892	No. of work hours / worker	38 451
Weekly hours	35	Average cost per hour	12,5
Weeks per salary	4	Estimated Salary	2000
Average cost per hour	6,37	Weekly hours	40
		Weeks per salary	4
Budget/Saved Amount	1 529 143		
		Number of weeks (total)	961
		No. of weeks / worker	120
		Years	2,31
		Months	28

Table 3 – Third hypothetical scenario (featuring a bigger team and a lower salary).

This case explored an 8-person team and considered a salary slightly lower: 2,000€ instead of 2,500€. Nevertheless, it is still considerably high in the Portuguese context. However, with this larger team, it would only be possible to afford 28 months of work, which automatically implied no leftover extra time for improvements or software updates.

Still considering this 3rd case, if the software's lifespan grows longer, from 3 to 5 years, the change would not be too significant: the total number of months of work the investment allowed to "purchase" would be 32 instead of 28.

After analysing several scenarios, it is reasonable to state that Serious Games for physical rehabilitation, besides answering the actual and future context that Portugal is and will experience, are financially sound in the long run from the perspective of a National Government as a sponsor. But a question remained: how could we make this a reality? Subsequently, a different point of view was adopted: instead of considering the healthcare implementation factor (taking into account the number of yearly patients in need of consistent and effective rehabilitation) through replacement of some traditional rehabilitation sessions a new approach considering only the development of the game was studied. This scenario aimed to gauge the budget needed to develop a Serious Game (finished product) to present to the National Healthcare Service within two years (24 months). The following aspects were considered:

- Team size;
- Duration of the project;
- Salary of each team member;
- Weekly work hours;
- Initial costs;
- Price of a single device (since this approach is not taking into account the post-development mass exploration).

Thus, considering these features, 7 scenarios were designed, all of them considering variations in team size, salaries and even an extension from 24 months (2 years) to 36 months (3 years). The formula used to calculate the budget was the following:

Base budget = duration × salary of each member × team size + price of a single device + initial costs

The table below shows the numbers concerning the various possible scenarios:

	MAIN SCENARIO	SCENARIO 1	SCENARIO 2	SCENARIO 3
Team size	8	4	8	6
Project duration (months)	24	24	24	24
Team member salary	2000	2000	2500	2500
Weekly hours/worker	40	40	40	40
Price of a single (1) device	300	300	300	300
Initial costs	50000	50000	50000	50000
Budget	434300	242300	530300	410300

	SCENARIO 4	SCENARIO 5	SCENARIO 6
Team size	6	8	6
Project duration (months)	24	36	36
Team member salary	2000	2000	2000
Weekly hours/worker	40	40	40
Price of a single (1) device	300	300	300
Initial costs	50000	50000	50000
Budget	338300	626300	482300

Table 4 – Serious Game development scenarios

These cases prove that it is technically and financially possible to develop a game within 24 months (2 years) with a budget no lower than 242,300€, but also no higher than 530,000€. Ideally, a budget between 400,000€ and 500,000€ would allow a team composed by 8 members, earning salaries between 2,000€ and 2,500€, to develop a software that could posteriorly be implemented in the National Healthcare Service. If we consider the extra year (extending the development duration to 36 months), the estimated budget would increase up to an average of nearly 630,000€.

Relating this plan to the hypothetical scenarios considered previously, we can estimate how much time it would take for the investment to be fully repaid: we need to take the replacement percentage into account to gauge the amount that it would be possible to save by having Serious Games replace traditional physiotherapy sessions. For this, we will consider a replacement percentage of 20% (the lowest one, if the patient is engaging in physiotherapy 5 times per week), and considering the assumptions concerning the physiotherapy session specifics (number of stroke patients in need of rehabilitation per year, number of sessions per week, session duration, number of professionals per session, salary of the physiotherapists, weekly working hours and weeks per salary) made for the first hypothetical scenario (Table 1), we can assume that, in 1 year, the budget would be of 544,286€, this is, the amount we would save by

having Serious Games replace 20% of the traditional post-stroke physiotherapy sessions. Considering that the ideal budget for a team of 8 people to develop a Serious Game for physical rehabilitation of stroke impaired patients within 2 years would be between 400,000€ and 500,000€, we can assume that this plan would allow a return of investment within approximately 11 months.

If we want to go even further and consider the distribution of the devices needed to play the Serious Game, we can consider the division in lots explored above (taking into account the 3-year lifespan of the Serious Game). In this sense, we would need 692,400€ to cover the costs of the devices (assuming the stroke cases happen in an evenly spread manner through the year). This will add to our budget of a maximum of 500,000€, totaling 1,192,400€. Considering that, in the first year of the use of this software, we would save 544,286€, we would need a maximum of 2 years and 3 months to have the investment repaid in full.

This plan would allow citizens to have equal access to carefully curated rehabilitation sessions, which is something of utmost importance, considering the ongoing aging population trend. However, this plan does not take into account the jobs that would be needed in the development team and *when* they would be needed, since there are specific jobs that are indispensable, but they are not continuously needed during the full development duration. In this sense, and concerning the team member's salaries, the maximum budget needed could be even lower than the value proposed above, if the team deployment and a fixed chronogram were taken into account. The scenarios aimed to explore the various possibilities surrounding team size and salary variables, in order to design a hypothetical scenario and a financial framework that would fit this specific situation.

Possibly, in terms of game to develop, perhaps a Serious Game Visual Novel would be a great choice, if we take both "immersiveness" and production costs into account. As it was explored in Chapter 2.1.1, Visual Novels are mostly text-based, acquiring their immersive properties through the weaving of their narratives, which makes them simpler and less costly in terms of production when compared to other genres. Considering that it is believed that the narrative plays a key role in motivating and retaining the player's interest, a Serious Game Visual Novel can be something to delve into. The genre is already being explored for serious purposes, such as a tool to fight the loneliness experienced by cancer patients (Bowman, 2018). A future possibility might consist of taking the genre and shifting its focus to physical rehabilitation.

5. Conclusion

5.1. General overview

Video games play a large role in the 21st century. They are a great entertainment source, a way to stay connected with other people when everything else fails and a strong form of escapism. But they are also way more than that. Not all games need to be designed "merely for fun" and making them a way to tackle serious, tedious or not so pleasant issues or situations, like physical rehabilitation therapy, is just one of the ways that allow video games to outshine all other forms of media or art thanks to a specific property that distinguishes them from everything else: their interactivity and, consequently, their ability to immerse the player in a virtual world.

Video games have been evolving for several decades. We are always seeking ways to make them more fun, more fulfilling and closer to an alternate reality we wish we could temporarily escape to. In fact, this feeling is often perceived and experienced by gamers: they feel like they belong in the game, although the game's universes are nothing more than virtual maps. Serious Games, as a video game genre, are also endowed with these intrinsic qualities. Not in the "looking for an escape" sense of the word, but Serious Games are used in areas such as the military, medical education, and even treatment of conditions like certain phobias, since they allow the player to be virtually present in a certain place or circumstance while in a controlled and safe environment (Trigo Algar, 2014; Wattanasoontorn *et al.*, 2014).

As physical rehabilitation is often repetitive and monotonous, health professionals could always use a little help to get patients to actively engage more with their therapy routines.

The cases where Serious Games have been used for physical rehabilitation all showed positive results, from a clinical sense, but also brought to light a perceived mental wellness and an increase in motivation among the participating patients. Serious Games proved to be useful in multiple pathologies. Most cases registered an increase in motivation and, therefore, better therapy adherence and better post-therapy results (the capabilities acquired by the player during the gaming experience would be reflected as real physical improvements). So far, everything makes Serious Games sound like the absolute best approach to physical rehabilitation: they allow the patient to have fun while doing something that is tedious or uninteresting (in a controlled environment) while temporarily escaping reality by being transported to the parallel universe of the Serious Game. It sounds like the perfect combination. But why is this not being implemented more often if it is indeed so good? Why is it not being implemented in Portugal?

With the objective of understanding what was lacking, and which part of the process was failing, these barriers were explored through questionnaires and interviews. It figures that the

main issue is not related to the clinical and therapeutic efficacy of this approach, but it is mostly related to a broad lack of knowledge about this video game subgenre among the population who are part of the healthcare sector (out of 59 healthcare professionals, only 16 knew what a Serious Game was prior to their participation in the questionnaire targeted at the Portuguese health sector workers). If they do not know that it is possible to address and engage in physical rehabilitation through a video game, how will they opt to use something that they do not even know about?

Moreover, stigma against video games is still prevalent among older generations, as well as some resistance towards the digital. These are major barriers, but they are short term barriers. The world calls for constant technological evolution. Nowadays, the elderly cannot go without technology and COVID-19 just accentuated that. People who were not used to resort to digital tools in their daily lives and activities were forced to get out of their comfort zone, adapt and change. Humans have always displayed resistance towards change, but when the world makes you get up and face that challenge in order to overcome the fear of novelty, there is not much you can do but adapt. In this sense, from the growing aging index to the challenges the world has faced, the world is now more open and available to digital approaches than it was in the beginning of 2020.

The further we move into the future the more indispensable physical rehabilitation will become. As the incidence of stroke increases with age, it is imperative to give equal access to quality treatment to all those in need. As the development of digital applications that fit in the gaming and healthcare categories is being financially supported, and considering that producing Serious Games can be a way to reutilize and monetize technology that was developed for commercial titles, it is possible to conclude that the Portuguese context of now (2020) and of the future supports these new approaches due to the way that demography is expected to evolve and due to the kind of issues the government is wanting to resolve. Besides this, Serious Games also take the role as a tool that will, in the long run, allow physical rehabilitation to reach more people with a lower cost: an adaptable game would be able to suit several patients, from all kinds of backgrounds, suffering from one specific pathology.

This investigation allowed to design and bring forward a prospect of the budget needed to implement Serious Games as a physical rehabilitation policy in the Portuguese healthcare system by designing cautious hypothetical scenarios and financially marking the costs necessary to eventually put this plan into action. Thus, it is possible for an 8-person team (each member earning between 2,000€ and 2,500€) to design and develop a game for physical rehabilitation within 24 months with a budget no higher than 530,000€. Considering this scenario and taking into account the physiotherapy session specifics, we would be able to have

the investment repaid in full within a maximum 2 years and 3 months. Therefore, it is possible to conclude that Serious Games as a physical rehabilitation tool are worth investing in.

Although healthcare professionals have voiced their concerns, arguing that Serious Games for healthcare cannot be taken as a full substitute to more traditional approaches, they fully support the idea of using them as a complement or a backup plan. During the investigation, it was observed that, although patients seem to find COTS more fun and believe they are getting better therapeutic results from them, custom made Serious Games are still more effective. In this sense, it might be important to take a closer look at what makes COTS appealing as video games and apply some of these characteristics (*e.g.*: present a narrative, have the player overcome specific goals or featuring interaction with other players) to the design of Serious Games developed solely for healthcare purposes. If they are perceived as less fun or less motivating than COTS, we can conclude that the design of these games is partially failing, by not fully exploring the characteristics that make video games so appealing to players. The ultimate goal will be designing a Serious Games for physical rehabilitation that is "fun" and "exciting" as video games should be, while not discarding or overlooking the clinical aspect: it is of utmost importance to always bear in mind the context and the purpose the Serious Game will serve. To achieve this, it is important to focus more on the aesthetic, gameplay and design aspects of the game, instead of discarding them as "less important" than the purpose of the video game. It is necessary to find a balance point - the best of both worlds – by creating a virtual universe that the patient wants to be a part of, while being clinically beneficial and efficient. As there is not a lot of research done concerning the link between game design and clinical efficacy, we can only speculate: multiplayer games seem to be a good way to make games more motivating by stimulating teamwork and player interaction. The presence of a narrative that the player has to follow also seems to be seen as something that can capture the user's attention. Perhaps, a Visual Novel, adapted to the specific physical condition of the patient, would be a good way to deal with this premise, since it merges narrative, gameplay and parallel universes. One aspect is clear enough: it is important to pay attention to the game's visual aspect and its graphics: even if the gameplay remains the same throughout the various stages of the game, if the graphics change, they will allow the player to feel a sense of newness, just from the visual experience alone. As it is commonly said, "we eat with our eyes", and this also happens with video games. If a game's graphics are captivating to the eye, we will want to play it and to further explore the virtual universe the game has to offer.

This research led to multiple questions that sought to be answered during the investigation process. In this sense, two main limitations were encountered during the development of this dissertation. There is an evident lack of research done concerning the link between game design

and clinical efficacy that makes the conclusions related to this specific topic be little more than speculation. Moreover, the outbreak of COVID-19, besides enhancing the potential behind this approach, also hindered the interviews process due to both lockdown and the fact that healthcare professionals were tending to more urgent matters. So far, we have mostly spoken about the future and how time will weave a way to overcome barriers. But what about the "right now"? This research brought to light that one of the main issues and barriers that are encountered nowadays (other than the lack of knowledge about this kind of approach) is heavily settled on how social status affects the way a patient perceives the treatment that he/she is offered: while wealthier individuals might prefer approaches that are based on the use of the latest technological advance, people from poorer backgrounds or from older generations (those that did not grow up interacting with digital devices) still favour more traditional methods: if the sessions do not involve any sort of human contact between the patient and the therapist, these patients will feel discarded and neglected.

Besides, if we are speaking about custom made Serious Games, they are not something that a clinic, hospital or even a professional from the healthcare field can just buy from their local video game store. Even if the sector shows interest towards this kind of approach, if they have no access to the games or the needed technology, they will not implement it. Nevertheless, an alternative that answers the premise is resorting to the use of COTS: studies show that it is not as therapeutically effective (Jonsdottir *et al.*, 2018), but it is motivating enough to keep the patients engaged and cheap enough to implement in private clinics.

In theory, custom made Serious Games are the ideal approach of Serious Games for physical rehabilitation, but there are still issues that are yet to be understood and need to be further investigated, in order to elevate this premise from a daydream to reality.

5.2. Future paths for research

The research behind this dissertation has not exhausted all the issues that surround the implementation of Serious Games for healthcare and its direct and indirect implications. There are still lots of paths to pave. It is important to delve deeper into the relation between game design, therapeutic efficacy, immersion, player enjoyment and motivation, as it holds the key for the success of this approach. Although Serious Games for healthcare have proved to be financially viable, the design aspects of how gameplay, aesthetic, graphics, narrative and world building influence clinic efficacy is still underexplored and asks for further research. In this sense, it is important to look at all the games used for physical rehabilitation from a design point of view and find common links between clinical success, game design and patient preference. It is not enough to figure out what would work best just from an anatomical and clinical

perspective. The patients' preferences are just as important, because they will play a key role in engaging and motivating the patient, which has been proved to lead to better results while promoting positive feelings. This will allow a deeper understanding of the design implications behind clinical success.

On the other hand, stigma against video games can be fought through more research in this area, in order to justify the need, viability and importance of this type of approach for physical rehabilitation.

It is also important to keep a close eye on the variations of the aspects that surround the contexts that dictate and influence the feasibility of applying this policy. Time is not static and what may be a tendency in the present, may be completely reverted in the future. In this sense, what is true right now, might not be, 10 or 20 years into the future.

The financial viability was evaluated in the light of the issues concerning rehabilitation medicine that the government is seeking to tackle, forasmuch as who we are right now and where we are headed in the future. If the aging trend we are experiencing right now does not change, we are bound to be a country of elderly in a couple of years. Elderly means more incapacities and disabilities, and these will require broader access to rehabilitation facilities and procedures. But what if the trend is reverted? What if something no one is expecting happens and everything changes? Nothing is unchangeable. COVID-19 might be nearing the end of its worst peaks, but we never know what we will face in the future. In the light of a situation such as the one experienced during the pandemic, if Serious Games had already been implemented, it would have been possible to reduce the number of citizens affected by fear of attending hospitals or clinics, or even because "non-essential" physical therapy sessions were suspended (in person). Moreover, this approach would allow physiotherapists to spend more time on patients who truly need human-human procedures. This would ideally allow more equality in terms of access to healthcare and rehabilitation medicine and more personalized approaches that would fit the patients' specific needs.

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Appendix A

Big category of the serious games applied to these studies: Rehabilitation[1]

Reference	**Design**	**Sample**	**Intervention Setting**	**Intervention: Nature of game, frequency, type and duration**	**Measures**	**Outcomes**
Cameirão, Bermúdez, Duarte Oller, & Verschure, (2009) - Spain	Randomized longitudinal study with controls.	— 17 patients within 3 weeks post stroke (first time stroke); — Severe to mild deficit of the paretic upper extremity; — No aphasia or other cognitive deficits.	Clinical Setting (Hospital de L'Esperança, Barcelona, Spain).	— RGS (Rehabilitation Gaming System): "*virtual reality-based system that is targeted for the induction and enhancement of functional recovery after lesions to the nervous system using non-invasive multi-modal stimulation";* — 20 min sessions, 3 times a week, for 12 weeks (with a 12 week follow up); — The game featured 3 training tasks of graded complexity.	3 groups: RGS group and 2 control groups (A and B). Quantitative and qualitative evaluation of the results according to: — Motor FIM (Functional Independence Measure); — Barthel Index; — Motricity Index; — Fugel-Meyer Assessment Test; — CAHAI (Chedoke Arm and Hand Activity Inventory); The game aims to evaluate the speed of movements as well as the reaching distance; The evaluation takes place in weeks 5, 12 and 24 (post-follow up).	— *"The study suggests that the improvements measured within the RGS virtual tasks will translate to measurable improvements in the real world";* — *"Grounded on neuroscientific theory about the mechanisms of recovery, activation of the motor system and cortical plasticity".*
Ma & Bechkoum (2008) – UK	Pilot study.	— 8 post-stroke patients who suffer from upper limb motor disorders (ages = 56.4±4.3); — Mean time since stroke until beginning of the	University of Ulster (Clinical setting / Investigation Center).	— This study resorted to a custom-made serious game called *Whack-a-Mouse*, that resembled an arcade classic; —15-17 sessions.	2 groups: — Motricity Index; — ARAT (Action Research Arm Test); The evaluation takes place before the intervention, right after the intervention and 6 weeks after training.	— The patients reported that they enjoyed the game.

		intervention: 10.7 months.				
Jack et al. (2001) – USA	Pilot Study (pilot clinical trials).	— 3 chronic stroke patients (ages 50-83); — Stroke had occurred between 3 and 6 years prior to the study and the patients hadn't participated in therapy in the previous two years.	Clinical Setting.	— The protocol was used daily, for 2 weeks; — 4 blocks (*"an individual block concentrated on exercising one of the aforementioned parameters of range, speed, fractionation, or strength of movement")* of 10 trials each; — Time spent on VR exercises per patient per day: 1 - 1.5hrs (although the full sessions lasted around 5 hours; the remaining time was spent engaging in traditional therapy procedures); — PC-based rehabilitation workstation (running VR simulation exercises and a database).	The subjects were tested clinically (pre and post training): — Jebsen test of hand function; — Hand portion of the Fugel-Meyer assessment of sensorimotor recovery after stroke; — Subjective affective evaluation of this kind of rehabilitation obtained through questionnaires.	— "*Each patient showed improvement on most of the hand parameters over the course of the training*" (objective measurements); — *"Subjective evaluation by the patients was also positive".*
Broeren et al. (2008) – Sweden	3 different studies with a control group of healthy individuals.	— 29 stroke subjects (aged 44-85).	Clinical setting (Department of Rehabilitation Medicine at Sahlgrenska University Hospital + "Home" setting (Stroke Forum, Göteborg, Sweden).	— Resorted to the use of a VR activity station; — The patients' aim is to reach into a virtual space and to interact with 3D objects through a handheld stylus (haptic device) positioned in the line of sight; — *"The subjects had to move the haptic stylus to different targets in the*	— Evaluation based on the monitoring of the time and distance to complete the whole exercise; — Average velocity was measured and calculated; — HPR (hand-path ratio: the quotient between actual hand trajectory and the straight-line distance between two targets);	— Favorable response to the use of VR; — The experience suggests that this kind of treatment is promising when it comes to stroke rehabilitation, by offering diverse possibilities of applicability;

				virtual world. [These] targets appeared one after the other on the screen and disappeared when pointed at".		— *"A comparison between pre/post testing suggests that all patients had a higher median in average velocity (m/s) and a decrease in median for the time (s) and HPR parameters as compared with baseline".*
Jonsdottir et al. (2018) – Italy	Pilot single-blind randomized (2:1) controlled in clinical trial.	— 16 patients suffering from multiple sclerosis (mean age = 56.8); • Suffering from upper extremity motor deficits but were able to flex shoulder and elbow at least 45 degrees; • Able to comprehend and follow directions.	Rehabilitation center setting (Foundation Don Gnocchi Onlus, Milan); — The training was done in the clinic by physical therapists trained in using virtual reality.	— Main objective of this study "*was to access the feasibility of using (...) Rehab@Home to augment upper extremity neurorehabilitation services and to provide preliminary evidence of clinical efficacy of the gaming approach";* — 10 participants used Rehab@Home[2] – experimental group; — 6 participants used the commercial Nintendo Wii Console™ – control group – the games selected required holding or gripping the controller and pressing the main buttons); — 4 weeks – 40min per session; 12 sessions (4-5 sessions per week);	— Feasibility and user experience measures were collected; — Primary outcomes: • 9 Hole Peg Test (9HPT); • Box and Block Test (BBT); — Secondary outcomes: • EQ-5D visual analogue scale (EQ-VAS); • SF-12; — Nonparametric analysis (used to verify changes from pre to post rehabilitation + treatment effect): • Mann-Whitney U test.	— "*Serious games were perceived positively in terms of user experience and motivation*"; —The serious games group showed clinically significant improvements in arm function; — The Wii group showed no significant improvements on any of the tests; — Despite this fact, only the Wii group perceived themselves as having improved their health.
Hocine et al. (2015) – France	*"several tests (...) based on a participatory design*	First test – 8 healthy participants were selected (game	Hospital setting (Lapeyronie Hospital of	— PRehab (Platform games for Rehabilitation): can be played on a graphics tablet	— The patient who participated in the second test was asked to fill a	Results of the first test: — The healthy participants suggested

	process that involves physicians, therapists and stroke patients"; Test phases: 1) Playtest with healthy players and medical experts; 2) Usability test to evaluate the adequacy of the graphic user interface for stroke patients; 3) Experiment to access patient performance - repeated-measure, single-blinded design.	developers and stroke rehabilitation experts); Second test – usability test conducted with a 76-year-old stroke patient with an impaired left arm. Third test – 7 post-stroke patients[3] aged 38 to 73 years old were selected and asked to play the game using their impaired arm.	Montpellier and Grau de Roi Hospital of Nimes – France).	and the gameplay/visual of the game is identical to that of a Super Mario game; — The first test had the objective of identifying the game's bugs and determine whether the gameplay was fun or not; — The second test had a single patient play the game for 30 minutes, while being observed by 5 therapists; — The third test was conducted over a 2-week period and each patient took part in 3 rehabilitation sessions, that lasted 20 minutes each.	questionnaire[4] at the end of the session; — Patients in the third test were interviewed and, by the end of each session, the participants were asked to rate their experience using a 5-item visual scale; The evaluation also focused on measuring: — The number of tasks completed in each game by the patient; — ANOVA test.	adding more feedback moments to the game in order to boost patients' motivation; Results of the second test: — The patient enjoyed the game and was immersed; Results of the third test: — The patients were immersed in the game and found it motivating and engaging enough to experience feelings of wanting to play more.
Delbressine et al. (2012) – The Netherlands	User test.	First Iteration of Playful Rehabilitation System – User Test of First Prototype: • Seven (7) sub-acute and three (3) chronic stroke patients.	Clinical setting (in the Netherlands).	Training method: — T-TOAT (Technology-supported Task-oriented Arm-hand Training).	First Iteration of Playful Rehabilitation System: The evaluation of the results was based on: — An interview (both preceding and following the exposure to the game), aiming to quantify the motivation felt by the patients while in contact with the game; — Intrinsic Motivation Inventory (IMI); — Credibility / Expectancy Questionnaire.	First Iteration of Playful Rehabilitation System: The participants claimed that the game was relatable and something to be used as a possible variation to regular therapy; They also stated that they were willing to spend more time playing the game than they normally would want to spend in therapy; Although a credible and fun training

						approach, there is a lack of the possibility to adapt the difficulty level of the game to patients' specific needs.
Abdelkader, Hocine, & others (2011) – France	2 Tests/experiments were conducted: • User test with professionals in the area (stroke rehabilitation); • Pilot study with healthy players ("*independent-measures design with two independent groups*").	1st Experiment: — 17 participants (members of the medical staff of the rehabilitation department of a French Hospital[5] 2nd Experiment: — Group 1: • 4 people (3 males, 1 female – aged 25.75±1.7); — Group 2: • 4 people (1 male, 3 females aged 25.75±3.3).	Clinical setting (Hospital in France).	This study wants to verify the pertinence of using Mixed Reality[6] for rehabilitation therapy; 1st Experiment: — The experiment was composed by different sessions (10 min/each) to test a different potential form of therapy (Mixed-Reality game developed solely for therapy purposes, videogame using a computer[7] and a mouse and Wiimote[8]); 2nd Experiment: — Group 1 used a naïve strategy of difficulty adjustment and Group 2 used the author's proposition for the difficulty adjustment strategy.	1st Experiment: — A questionnaire was conducted by the end of the last session: • Divided in two parts[9]; • Followed a 1-4 evaluation scale; 2nd Experiment: — The statistical analysis was performed and obtained through R (http://www.r-project.org – version 2.12.0); — Perceived difficulty was measured and compared between groups as well as the success/failure ratio.	1st Experiment: — Mixed Reality gets the highest score in all aspects (usability, ease of use, simplicity, usefulness) except for perceived fun (the Wii was perceived as more entertaining than the MR game); — It is suggested that MR and the Wiimote could complement each other; — Mixed Reality is perceived as intuitive in terms of human-computer interaction; 2nd Experiment: — Group 2 got better results and perceived the games as less difficult than group 1.
Saposnik et al. (2010) — Canada	Pilot randomized, single-blinded clinical trial with two parallel groups ("*designed as a feasibility study and therefore not powered*	22 randomized stroke patients in the subacute period. The mean age was 61.3. 2 groups: — Group that used the VRWii gaming	Clinical Setting (Toronto Rehabilitation Institute).	This study aimed to compare the feasibility, safety and efficacy of using VR as stroke rehabilitation therapy method; The patients participating in the study took part in 8 60-	The measured outcomes (evaluated 4 weeks after intervention) were: — Primary safety; — Primary feasibility;	— This study concluded that using VRWii was an alternative to more conventional therapy methods for stroke patients;

	to detect a difference between groups").	system (Nintendo Wii); — Group that participated in recreational therapy (used as control group); The participants were randomly allocated in a 1:1 ratio.		min intensive sessions (Wii or Recreational Therapy), scheduled in a flexible manner over a 14-day period; — VRWii: This uses COTS[10] for therapy, since they are accessible and affordable. The sessions time totaled 364 minutes; — Recreational Therapy: The participants of this group played cards, bingo or "Jenga". The total sessions time was 388 minutes.	— The level of effort necessary to complete the games; —Secondary: evaluation of the efficacy of the proposed method, following: • Wolf Motor Function Test; • Box and Block Test; • Stroke Impact Scale; — Adherence to recreational therapy was monitored using a timer.	— The participants of the VRWii group showed significant improvements in motor arm function of 7 seconds; —Because the Wii group was younger than the recreational therapy group, it might be hard to pinpoint the exact reason for the positive outcomes obtained in this study.
Thomas et al. (2017) — UK	Pilot randomized controlled trial (single-center wait-list randomized controlled study).	30 randomized multiple Sclerosis Patients that are ambulatory and relatively inactive[11]; Two groups: the participants received the intervention either immediately (for 12 months) or after a 6-month wait (for 6 months). Two participants dropped out at the beginning for medical reasons.	MS service in secondary care. The study took place in the homes of the selected participants[12]; Beforehand, the patients participated in two orientation sessions in the hospital.	This study had the objective of testing the feasibility of *Mii-vitaliSe* (effectiveness of a definitive trial and of costs); The *Mii-vitaliSe* is a home-based, physiotherapy-supported *NintendoWii* (COTS) intervention[13]; During the initial 6 months of the intervention, both groups had a mean usage time of 27 min/day, twice a week; The cost to deliver this intervention to a single patient was of £684 (~799€) per person.	— The measured (at baseline, 6 and 12 months) outcomes were self-reported physical activity levels[14], quality of life, mood[15], self-efficacy[16], fatigue[17], assessments of balance, gait, mobility[18] and hand dexterity[19]; — Interviews to 25 patients (semi-structured) were also conducted; — The adherence was measured by a daily play log; — A questionnaire was conducted (at 6 and 12 months postbaseline) in order to access self-reported healthcare.	— The use of Wii was frequent (around 2 times per week) and approached aerobic activity guideline levels; — No serious adverse events were reported; — *Mii-vitaliSe* was well received by the patients; — Physical assessments taking place in the hospital were perceived as tiring and inconvenient, because they required travelling to the intervention's location.

Ghassemi et al. (2019) — USA	Pilot Study.	20 neurologically intact subjects (adults, 7 women, 13 men, ages ranging from 21-40 years). Participants were randomly assigned to one of two groups. — Unilateral group (training with their non-dominant hand) — Bilateral group (training with both hands).	Investigation Center.	The game is played through electromyographic control and different 5 serious games were developed for this purpose (all simple point-and-click based or inspired by classic arcade games); The intervention lasted for 3 sessions, and each session had 3 phases: Calibration, Test with the system, and Training phase. The training phase lasted around 30 to 45 minutes. At the end of the training phase another test was conducted. Both groups performed the tests only using their non-dominant hand.	Factors analyzed in order to determine the success of the study: — Time of Completion (rmANOVA); — EMG patterns employed; — Cursor Kinematics.	— Improved performance using their non-dominant hand was observed in both groups and such improvement seemed to be related to better use of existing activation patterns; — The time needed to complete the test reduced over the sessions; — As this study was conducted with neurologically intact subjects, it isn't possible to apply or generalize any to actual stroke patients.
Bower et al. (2015) — Australia	Study divided in 2 phases: — Phase 1: initial feasibility testing; — Phase 2: pilot randomized controlled trial.	— Phase 1: 40 individuals (mean age 63 years)[20] were randomly assigned to trial one of the four available games during a single session; — Phase 2: 16 participants (mean age 61 years) from phase 1 were recruited and then were randomly assigned to the intervention group	Clinical setting (single rehabilitation facility in Melbourne, Australia).	— This study aimed to assess the feasibility of using motion-controlled games as a stroke rehabilitation method[21]; — 4 games (*Ball Maze*, *Fridge Frenzy*, *Tentacle Dash* and *Bubble Fish*) were developed and tested. 3 of them required torso movement and 1 was controlled by upper limb movement; — Phase 1: Participants played 1 of the 4 games (randomly selected) in a	Phase 1: — Factors analyzed in order to evaluate feasibility: 1) recruitment and willingness to participate; 2) adherence; 3) acceptability (5-point Likert scales); 4) safety (including a post-session rating of perceived exertion using the Borg scale); Phase 2: — Participants of the intervention group were	Phase 1: — The majority of the participants found the session to be enjoyable and helpful; Phase 2: — In terms of enjoyment, the participants claimed that they felt the games were a fun and fresh way to participate in therapy and they claimed to have appreciated the competitive element;

(8) or to the control group (8).		single session, under professional supervision; — Phase 2: 8 40-min sessions over the course of 4 weeks (in addition to their standard therapy), using all 4 games; — *"Participants in the control group (n=8) continued with standard care only"*.	asked which three things they liked the most about the intervention and which things they would change; — Several functional outcomes[22] were also assessed (at baseline and 4 weeks after starting phase 2).	— The intervention group improved significantly in several of the measured outcomes, such as FIM; — The control group did not show any significant improvements.

[1] According to Laamarti, Eid, & El Saddik (2014), the four big categories for Serious Games applied to health care are: health monitoring, detection and treatment, therapeutic education and prevention and rehabilitation.

[2] Serious game system that aims to enhance and promote upper arm rehabilitation of people suffering from neurological disorders, offering offered six arm rehabilitation games, featuring adjustable difficulty levels

[3] The average number of weeks after stroke was 15.71 and all participants

[4] The questionnaire had the goal of assessing the patients' perception of motivation, challenge, immersion and their opinion on the interface used for the test.

[5] 3 occupational therapists, 9 physiotherapists, 3 students in physiotherapy and 2 general doctors. The participants had an avg of 17 years of experience in the field.

[6] Mixed Reality merges *"real and virtual worlds to create a new context of interaction where both physical and digital objects co-exist and interact consistently in real-time"* (Abdelkader & Hocine, 2011)

[7] The game played on the computer was identical to that offered through Mixed Reality. This aimed to prove the relation between hardware and the efficacy of game content.

[8] The Wiimote uses sensors that are responsible to acceleration, direction and speed, which allows the possibility of tracking and interacting with the game while performing hand, arm or wrist movements.

[9] the first referred to the hardware systems and the second one addressed the use of different games for therapy

[10] The games used for Wii were Tennis, Bowling and Cooking Mama and aimed to train shoulder movements (rotation, flexion and extension), elbow movements (extension and flexion) and wrist movements (supination, pronation, flexion and extension). Thumb flexion was also involved in all activities.

[11] The majority of the participants were female.

[12] One of the selection criteria was whether they had a suitable television at home.

[13]According to Thomas *et al.* (2010), the *Mii-VitaliSe* intervention consists of "*two supervised Nintendo Wii familiarization sessions in the hospital followed by home use (Wii Sports, Sports Resort and Fit Plus software) with physiotherapist support and personalized resources."*

[14] Godin Leisure-Time Exercise Questionnaire, activPAL3 tri-axial accelerometer

[15] EuroQol-5 Dimensions-5 Levels, Multiple Sclerosis Impact Scale, The Medical Outcomes Short-Form Survey V2

[16] Spinal Cord Injury Exercise Self-Efficacy Scale, The Multiple Sclerosis Self Efficacy Scale

[17] The Fatigue Symptom Inventory

[18] Two-Minute Walk Text, Step Test, Steady Stance Test, Instrumented Timed Up and Go, Gait Stride-time Rhythmicity, Static Posturography

[19] Nine-Hole Peg Test

[20] The selected stroke patients were able to sit unsupported and showed no cognitive deficits nor visual problems.

[21] The movement was captured using depth-sensing camera named PrimeSense and the participants could play the game either sitting or standing. All the games designed were adaptable to users in order to match their levels of balance, motor control and possible perceptual problems commonly found on stroke patients.

[22] Functional Independence Measure, Motor Assessment Scale, Functional Reach, Step Test and a 6-minute walk test.

Appendix B

Serious games for healthcare

This questionnaire is a part of a student's master's thesis in Management for the Creative Industries (Catholic University of Portugal - School of Arts). Its objective is evaluating the relevance of using serious games for healthcare, as well as surveying possible cases where this methodology is already being implemented.

A serious game is a video game that is used for a serious purpose while still carrying the defining traits of video games and allowing the users to experience positive emotions, such as feelings of perceived fun. Besides, they aim to promote something called "collateral learning", which can be described as a way of acquiring certain skills through non-conventional learning methods.

The main objective of this thesis is gauging the relevance of developing personalized serious games, answering the needs of patients for specific treatments and therapies.

The methodology implemented for the development of this investigation thesis begins with a bibliographic revision of relevant authors, focusing on the serious game sub-genre and its healthcare applications.
In a second moment, various case studies where different kinds of games were used to improve the health of physically disabled or impaired people will be analyzed, in order to understand the link between game design and aesthetic, therapeutic efficacy and patient motivation. The evaluation of the efficacy of these cases will be qualitative and will take into account parameters such as the patients' conditions (pre- and post- intervention) the context, the setting where the intervention took place and the kind of game that was used. According to the results obtained in this step, if possible, a quantitative analysis will be conducted in order to gauge the efficacy of treatments resorting to video games. The next step will consist of fieldwork, resorting to interviews and questionnaires, in order to better understand the relevance, pertinence, openness, availability and receptivity to use video games as something more than a mere form of entertainment. The last step of this thesis will consist in evaluating the video game industry and the serious games' market, in order to better understand the possibility of transforming this kind of games into something worth diving into.

*Required

Free and Informed Consent for Research Participation

Confidentiality and Anonymity: The participant's anonymity and confidentiality will be safeguarded (there will be no nominal identification of the participant). Confidentiality and exclusive use of the data collected for this study are guaranteed, under conditions of anonymity (no registration of identification data). The collected data will be kept for the duration of the thesis, being deleted after i has been concluded.

For questions or concerns related to the study, the participant can contact Catarina Vieira (catarina.vieira.28@hotmail.com) or Professor André Perrotta (aperrotta@porto.ucp.pt).

I declare that I have read and understood the purposes of this study, in which I will be included. I wa given the opportunity to ask the questions I thought necessary, and I got a satisfactory answer for a of them. I became aware that, in accordance with the recommendations of the Declaration of Helsinki and the Oviedo Convention, the information or explanation given to me focused on the objectives, methods, anticipated benefits, potential risks and possible discomfort. I know that I cannot expect any direct benefits for myself, but I know that I will help research in order to understand the relevance of the use of serious games in the health sector/as therapy tools. I also know that my answers/data will not have a direct effect on the way I will be treated in the future. In addition, I am aware that I have the right to refuse my participation in the study at all times, without suffering any consequences. Therefore, I consent to the application of the proposed questionnaire. I was also informed that my name will not appear in any document used in the investigation, nor will be the subject of exposure of the results in communications.

1. Please read the following information carefully. If you think something is unclear, don't hesitate to ask for more information. If you agree with the everything, please check the respective box. *

   Tick all that apply.

   - [ ] I agree with the terms of use presented above.

2.

   Tick all that apply.

   - [ ] Tick this box if you don't wish to be contacted again in the future.

The open questions can be answered either in english or in portuguese.

3. What's your area of expertise? *

   _____

4. What's your age group? *

   Mark only one oval.

   - ◯ 18 - 34
   - ◯ 35 - 44
   - ◯ 45 - 54
   - ◯ 55 - 65
   - ◯ 65 +

5. How many years of experience do you have in the field? *

Mark only one oval.

- ◯ < 5
- ◯ 5 - 10
- ◯ 10 - 20
- ◯ > 20

6. What kind of entity do you work for? *

Mark only one oval.

- ◯ Public
- ◯ Private
- ◯ Both

7. Do you work in Portugal? *

If you work in a country other than Portugal, please specify.

Mark only one oval.

- ◯ Portugal
- ◯ Other: _____

8. How much would you agree with the following statement? *

Mark only one oval per row.

	Totally disagree	Disagree	Neutral	Agree	Totally agree
Video games are a waste of time	◯	◯	◯	◯	◯
Video games are not something I find useful	◯	◯	◯	◯	◯
Video games are not interesting for adults	◯	◯	◯	◯	◯
Video games are a contemporary form of entertainment	◯	◯	◯	◯	◯
Video games are a good multimedia tool	◯	◯	◯	◯	◯
Video games are something I enjoy	◯	◯	◯	◯	◯
Video games are a form of art	◯	◯	◯	◯	◯

9. Prior to this questionnaire, were you familiar with the concept of "serious game"? *

Mark only one oval.

◯ Yes *Skip to question 10*
◯ No *Skip to question 23*

10. Have you ever used any kind of serious games in any procedure? *

Mark only one oval.

◯ Yes
◯ No *Skip to question 23*

11. What kind of procedure? For which pathology? Which group of patients was abridged? *

12. What kind of video game did you use for the procedure? *

Mark only one oval.

- ◯ Commercial videogame (e.g.: videogames for Nintendo Wii or XBox)
- ◯ Videogame developed specifically for the purpose for which it was used
- ◯ Both

13. Briefly describe the video game.

14. In order to play the game, what device was used?

15. Do you know who developed the video game? *

In case you do, please specify by selecting the "other" option.

Mark only one oval.

- ◯ No
- ◯ Other:

16. How do you evaluate the average reaction of the patients to the use of a video game? *

Mark only one oval.

- ◯ Very positive
- ◯ Positive
- ◯ Neutral
- ◯ Negative
- ◯ Very
- ◯ No opinion

17. Where did the intervention take place? *

Mark only one oval.

- ◯ Clinical context (e.g.: clinic, hospital, rehabilitation center)
- ◯ Home of the patient
- ◯ Research center
- ◯ Other: _____

18. Was the game used for rehabilitation purposes?

Mark only one oval.

- ◯ Yes
- ◯ No *Skip to question 23*

19. How many hours per week do you spend with each patient in need of physical rehabilitation?

Mark only one oval.

- ◯ 0 - 2 hours
- ◯ 2 - 5 hours
- ◯ More than 5 hours

20. How many hours do these patients spend in physiotherapy per week?

Mark only one oval.

- 0 - 5 hours
- 5 - 10 hours
- 10 - 15 hours
- More than 15 hours

21. In terms of serious game use as a rehabilitation tool, how many hours of use per week of serious games would you consider adequate?

Mark only one oval.

- 0 - 5 hours
- 5 - 10 hours
- 10 -15 hours
- More than 15 hours

22. By each hour of use of serious games, how many hours of conventional physiotherapy sessions do you believe that can be replaced?

Mark only one oval.

- 0 - 2 hours
- 2 - 5 hours
- Over 5 hours

23. Select some of the barriers you find relevant to the use of serious games. *

Tick all that apply.

- [ ] Too expensive
- [ ] No access to the games/technology
- [ ] Preference towards traditional methods
- [ ] Didn't know this kind of video games existed
- [ ] Lack of appropriate games to implement in my area of expertise
- [ ] They're not applicable in my area of expertise
- [ ] Issues related to the law
- [ ] Other: _____

24. What are your thoughts about using video games as therapy tools? Do you find them beneficial? If yes, why? If not, why not?

_____

_____

_____

_____

_____

25. Given the chance, would you be willing to use these video games in the future? *

Mark only one oval.

- ◯ Yes
- ◯ No

26. What features of gaming could be important to be implemented in a serious game? What features should be avoided?

_____

_____

_____

_____

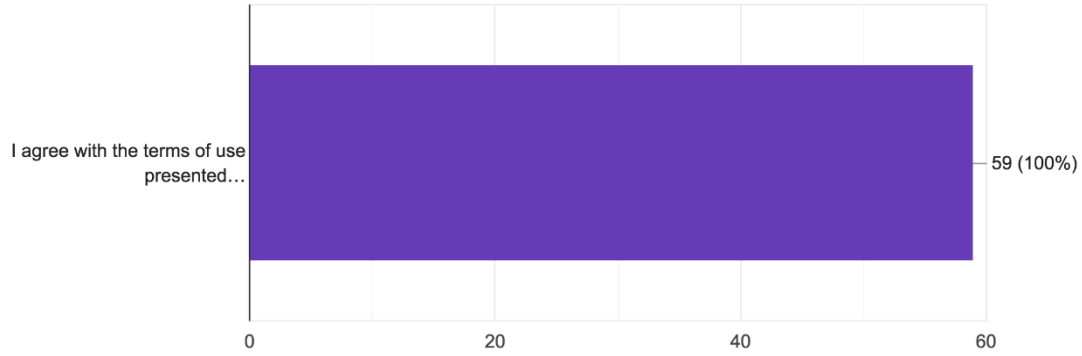
_____

Appendix C

Serious Games for Healthcare – Questionnaire targeted at healthcare professionals

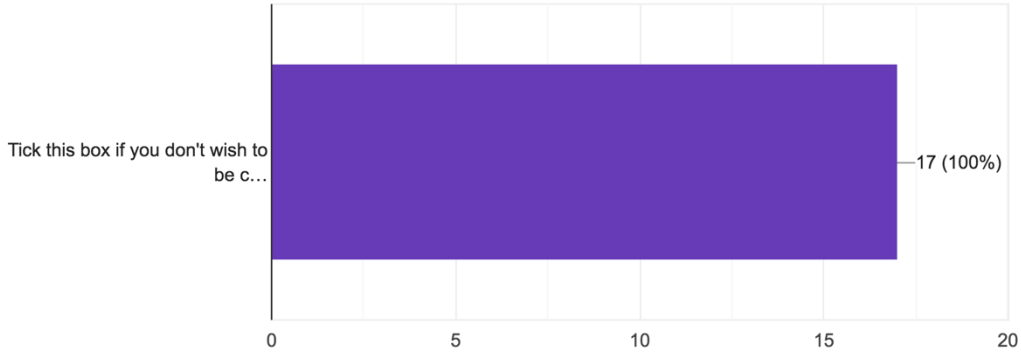
Please read the following information carefully. If you think something is unclear, don't hesitate to ask for more information. If you agree with the everything, please check the respective box.

59 responses



I agree with the terms of use presented above.

17 responses



Tick this box if you don't wish to be contacted again.

What's your area of expertise?

59 responses

Medicine

Medicina

Family Medicine

Anatomia Patológica

MEDICINA

Urology

psychiatry

Ortopedia

Upper limb hemiparesis

neuroscience

cognitive neuroscience

Physical medicine and rehabilitation

Physical and Rehabilitation Medicine

Hepatology

Respiratory Healthcare

Clinical Pathology

Neurosurgery

Medicind

Medicina Geral e Familiar

Interna de Formação Geral

Healthcare

Médico Radiologista

Physical and Rehabilitation Medicine

Finance

Fisioterapia

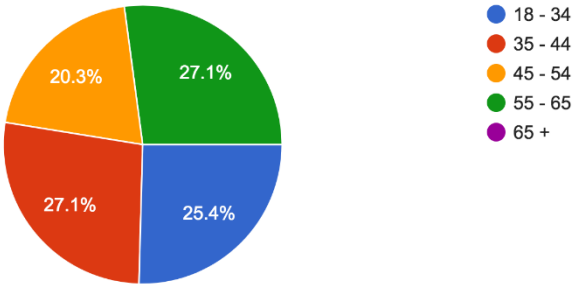
Tecnologia assistiva e reabilitação de crianças com paralisia cerebral

Interventional Radiology

Medical Doctor
Teatcher
Design
surgery
Medicine, pneumonology
Médico
Enfermagem
Medicina Geral e familiar
Nursing
Family medicine
medicina
Medicina geral e familiar
Gp doctor
MG
Medicine
Surgeon
Psicomotricidade
Psychology
terapia da fala
Speech Therapy
psicologia
Neuropsychology
allergy
Neurology

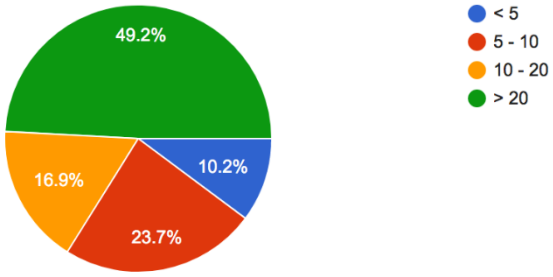
What's your age group?

59 responses



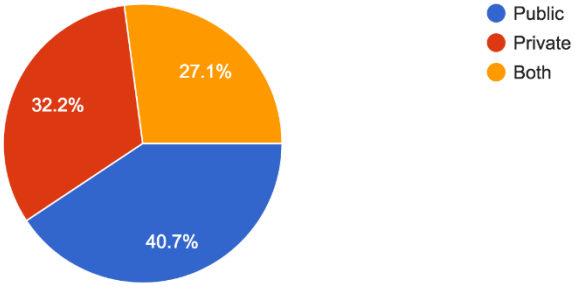
How many years of experience do you have in the field?

59 responses



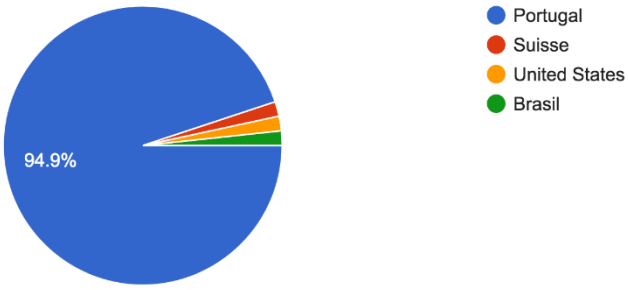
What kind of entity do you work for?

59 responses

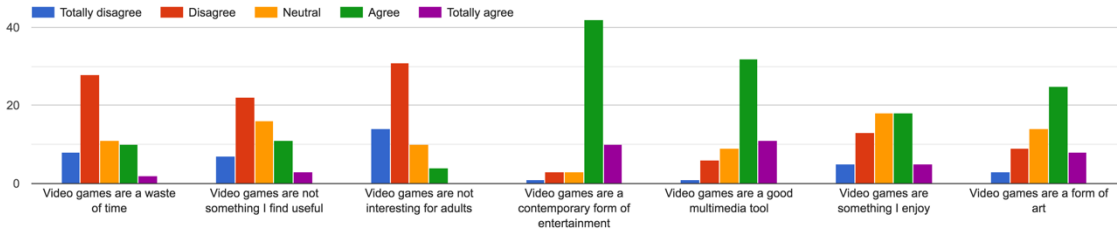


Do you work in Portugal?

59 responses

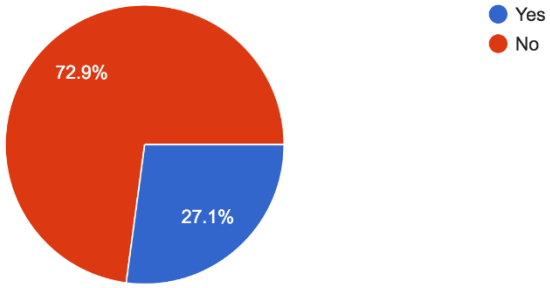


How much would you agree with the following statement?



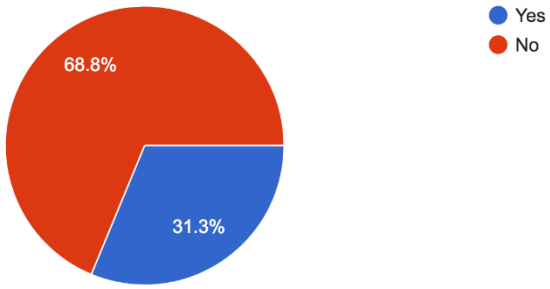
Prior to this questionnaire, were you familiar with the concept of "serious game"?

59 responses



Have you ever used any kind of serious games in any procedure?

16 responses



What kind of procedure? For which pathology? Which group of patients was abridged?

5 responses

RECUPERAÇÃO FISICA DE DOENTES COM CANCRO DE MAMA

Lesão neurologica

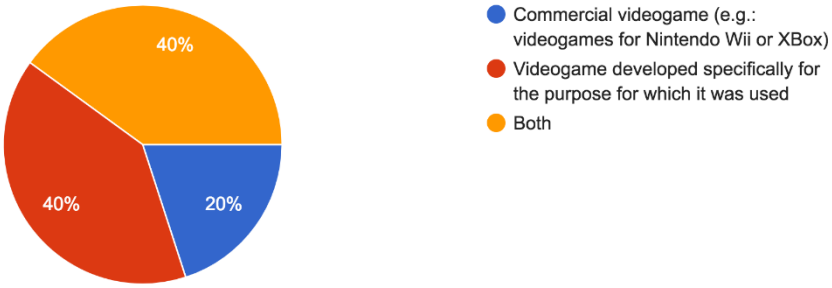
Research. N/A. N/A

Tenho usado jogos de videogame na reabilitação de crianças com para,índia cerebral, como recurso fisioterapêutico em diferentes atividades terapêuticas, por exemplo durante treino de marcha em esteira

Neurologia e Psiquiatria

What kind of video game did you use for the procedure?

5 responses



Briefly describe the video game.

4 responses

MOVIMENTOS DE COORDENAÇÃO DOS MEMBROS SUPERIORES COM APOIO DE WEE

.

I have used both: Wii and a risk assessment game for decision making assessment

Tenho usado o Wii, Xbox e jogos associados a óculos de realidade virtual durante as atividades terapêuticas para atingir objetivos específicos

In order to play the game, what device was used?

4 responses

WEE

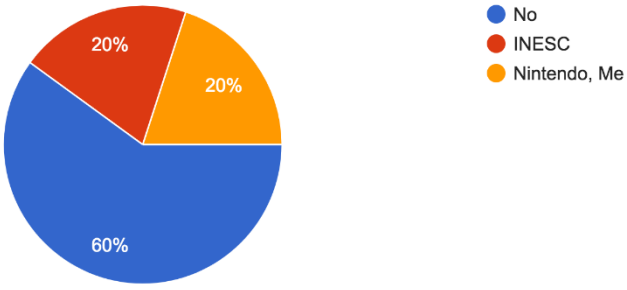
'

Wii nunchuck, mouse/cursor

Uso os games citados citados anteriormente e a escolha do equipamento e do jogo depende do objetivo terapêutico definido anteriormente em conjunto com a família ou a cricança

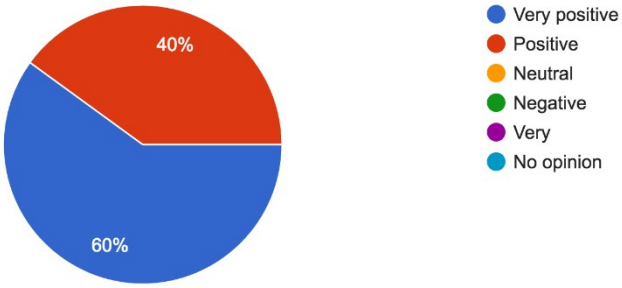
Do you know who developed the video game?

5 responses



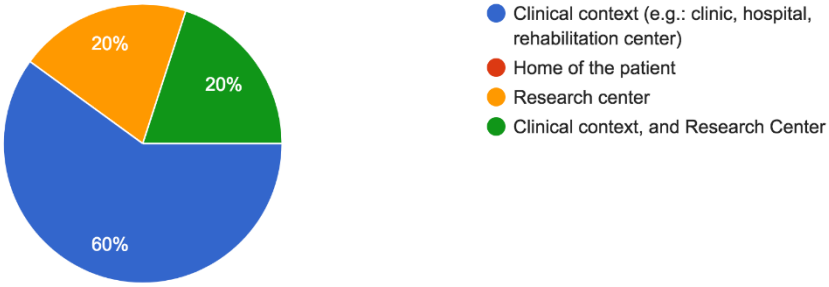
How do you evaluate the average reaction of the patients to the use of a video game?

5 responses



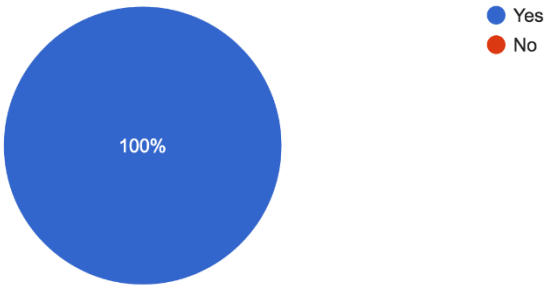
Where did the intervention take place?

5 responses



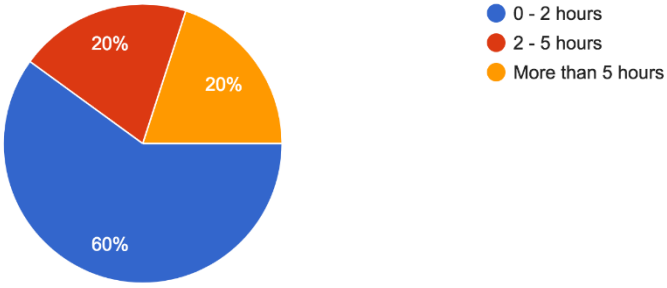
Was the game used for rehabilitation purposes?

5 responses



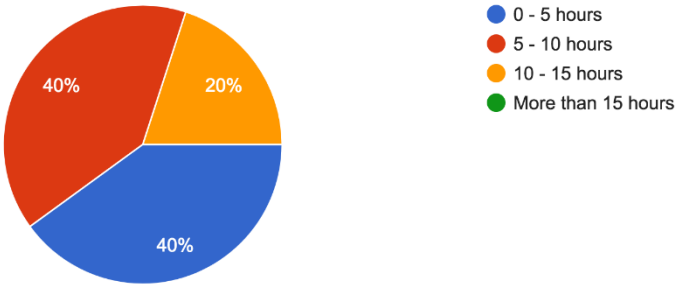
How many hours per week do you spend with each patient in need of physical rehabilitation?

5 responses



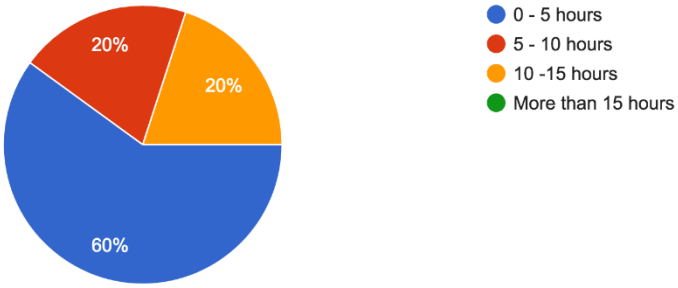
How many hours do these patients spend in physiotherapy per week?

5 responses



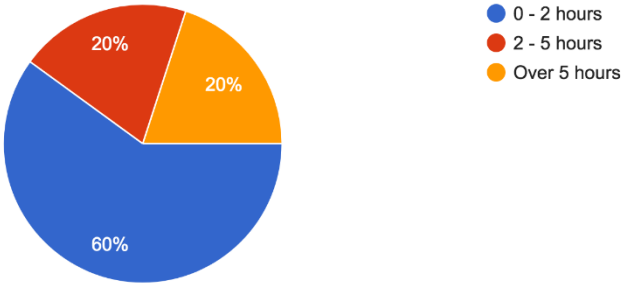
In terms of serious game use as a rehabilitation tool, how many hours of use per week of serious games would you consider adequate?

5 responses



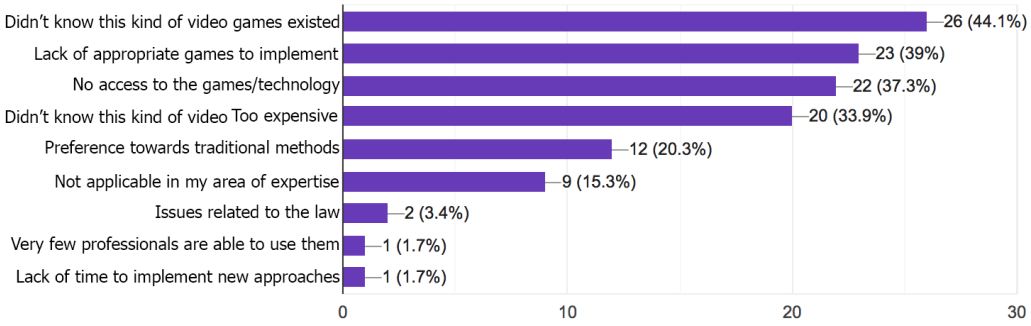
By each hour of use of serious games, how many hours of conventional physiotherapy sessions do you believe that can be replaced?

5 responses



Select some of the barriers you find relevant to the use of serious games.

59 responses



What are your thoughts about using video games as therapy tools? Do you find them beneficial? If yes, why? If not, why not?

46 responses

Yes

Sim porque permitem uma utilização individualizada e autónoma pelo paciente

Sim, são benéficos.

Unknown

Yes; as therapy cognitive comportemental.

So far, I have not tried them with inpatients

Yes, they tend to motivate patients.

I think the use of games as a therapeutic tool is beneficial, since it has been showing therapeutic effects in different pathologies.

Yes. More possibilities to stimulate the patients

I need to know more

NA

I find They may be useful when the intended effect is stronger when the subject is not focused and not in a defensive e position that could prevent him to benefit from it.

I prefere learning wth a classic model like books, make my notes.

Don't know enough to answer

Beneficial. Achieving goals, learning skills. Immediate feedback

Sim, desde que haja protocolos para a sua utilização.

Sim, pois podem oferecer uma alternativa aos métodos tradicionais e oferecem uma complementaridade neste âmbito

Yes, it may allow some other people to open up and be exposed to proper info in a more appealing way

I find them beneficial. My knowledge of the application of video games is more related to the rehabilitation of children with delayed psycho-motor development and, in my opinion, they are an interesting form of treatment in rehabilitation, whose use should also be applied in adults

Sobretudo para doentes jovens parecem-me uma forma de aplicar tramento de forma lúdica e divertida, o que poderá aumentar a adesão terapêutica e superação emocional da doença.

I have no opinion

Sim, podem ajudar a atingir objectivos terapêuticos inibindo por exemplo o reflexo antálgico pelo seu aspecto lúdico que pode ajudar a abstrair os doentes de mecanismos de proteção. Também facilitam a apredizagem pela facilidade de repeticao e correcção lara atingir o objectivo.

Considero o uso de videogame uma ferramenta/recurso importante na reabilitação de crianças com paralisia cerebral, pois aumenta a aderência ao programa de reabilitação e a motivação do paciente durante os atendimentos.

Yes. Because the time needed to perform angiography is too long and avoid radiation

Yes. To distract the people

Yes. They might be an easy way to learn something about their disease.

Use for relaxing

Maybe... i can see it as a Nice Toll for chilren

benéfico como forma de ensino de medidas ou atitudes...como terapia ocupacional de criar /desenvolver capacidades cognitivas, movimentos finos....

I don't know

Para passar tempo

Maybe. It depends on the video games

Poderá ser uma forma de terapeutica

Perhaps they're a way to communicate with people in need of therapy.

Yes, it is a interactive way to learn by experience. When playing the player will be focused, and engaged which makes learning something or any other motif of the game easier to accomplish.

Preciso de formação na área, não tenho opinião.

Sim, é mais uma ferramenta que ajuda no contacto com o doente e no melhorar da relação médico/utente

Sim, sobretudo pela sua capacidade de haver interação. A possibilidade de conjugar texto, imagem, som, etc..

Podem trazer alguns benefícios, claro, até porque se tornam metodologias fáceis de os jovens aderirem. Todavia devem ser supervisionados para terem efeitos terapêuticos. Caso contrario tornam-se apenas jogos de "estimulação". Devem ser refletidos num contexto terapêutico.

Yes, video games are an excellent and interactive tool specially when you work with teenagers

As our society is becoming more thecnological, this therapy tools are beneficial, because they allow us to do our work in presencial session, as in teletherapy sessions...And the kids nowadays prefer to use and play these kind of games.

sim.

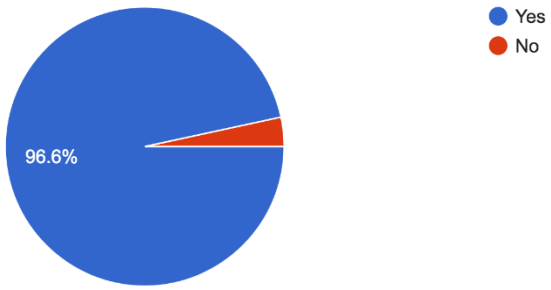
Yes, I think that video game as therapy tools are the next step in treatment by ensuring that therapeutic instruments can keep up with technological developments, as well as promoting and increasing the interaction between the user and the therapeutic tool.

I don t have enought information to respond

Yes, they be extremely beneficial

Given the chance, would you be willing to use these video games in the future?

59 responses



What features of gaming could be important to be implemented in a serious game? What features should be avoided?

37 responses

Grafismo, narrativa e facilidade de utilização

O que deve ser importante: A descontração, o divertimento e a obrigação de movimento.
O que deve ser evitado: o excesso de barulho/ruído

?

The set up should be minimal. The worst thing is for a complex set up

I believe this depends more on the personality of the individual than on my preferences.

It will be important for games to be programmed to fit personalized therapeutic goals and whoever applies the games should constantly analyze the possible level of dependence and avoidance of social interaction, as a result of the interaction with the games.

Cognitive stimulation; motor stimulation

I don't konw enough of serious game

NA
Implement: all the features that make the game popular and widespread.Also ensure a solid scientific background in every issue they envolve: data entry, algorithms and conclusions. Avoid: the main issue is the ethical frontier between pure "useless" amusement and a scientific drive.
facility; serious. Violence nad commercial thinks are not good in my perspective.
To be simple and intuitive. Avoid excess information and movement
Goals. Reliable. Avoid difficult steps
Não sei
Implementar: Técnicas de treino de memória, compreensão e destreza manual. Evitar: Uso desnecessário de violência
The functions that can be used most are cognitive stimulation and manual dexterity. Excessive stimulation, dependence and tiredness should be avoided.
Parecem-me jogos úteis para reabilitação neurológica, fisiátrica e cardio-respiratória também. Jogos violentos ou de conteúdo negativo não me parecem indicados.
I have no opinion
Devem ajudar a potenciar capacidades ativamente e nunca substituir
Os jogos devem possibilitar adaptações para que usuários de cadeira de rodas e com mobilidade reduzida tenham condições de manuseio e participação. Assim seria necessária a adequação de joysticks as habilidades da criança e o reconhecimento de crianças cadeirantes durante a configuração dos jogos
Realistic angiography ; non specific targets
Introducing the scores of risk for the different pathologies and their change with diferent treatments.
The noise
Positive form of learning. Money should not be involved
simples, colorido, claro. evitar grandes explicações e complexidade no jogo
Dependence
Não tenho opinião
Realist, avoid addiction to the game
sem opinião
Avoid violent features

Games focused on achieving a set of tasks/objectives. The difficulty or complexity is increased based on the user's results. I think that a game that creates feelings of frustration because of a steep learning curve for example should be avoided. It should be simple in the beginning and gradually more complex.
Não sei.
Não tenho conhecimentos para responder à questão
Multimedia. interacão com outros usuários. Evitar conteúdos muito exigentes do ponto de vista tecnológico e que obriguem a equipamentos muito sofisticados.
Interaction with the world and a good storytelling are important features. Features to be avoided are the use of guns, violence or any form of abuse.
security
Short and clear instructions; clear objecitives od each game

Appendix D

Informed Consent – José António Moreira

CATÓLICA
ESCOLA DAS ARTES
PORTO

Serious Games para Reabilitação Física

Este questionário integra uma dissertação de mestrado em Gestão de Indústrias Criativas (Escola das Artes – Universidade Católica Portuguesa) e tem como objetivo avaliar a relevância de utilizar *serious games* (jogos sérios) na área da saúde, assim como averiguar possíveis casos em que esta metodologia já se encontre a ser implementada.

O conceito de *serious game* pode ser definido como um videojogo que é utilizado para um fim que não apenas o entretenimento do jogador mantendo, no entanto, as características que tornam os videojogos apelativos e cativantes que permitem que o utilizador experiencie emoções e sentimentos positivos percecionados como "divertidos". Para além disso, estes videojogos também visam promover algo chamado de "*collateral learning*", isto é, uma forma de obter determinadas capacidades através de métodos de aprendizagem não convencionais.

O objetivo principal da dissertação em curso é avaliar a relevância do desenvolvimento de *serious games* personalizados que respondam às necessidades dos pacientes para tratamentos e terapias específicas.

A metodologia implementada para o desenvolvimento desta investigação começa com uma revisão bibliográfica de autores relevantes, com enfoque no subgénero dos *serious games* e as suas aplicações na área médica.
Num segundo momento, vários casos de estudo nos quais diferentes tipos de videojogos foram utilizados (para melhorar a saúde de pessoas fisicamente incapacitadas) serão analisados a fim de compreender a possível ligação entre o design dos videojogos, a estética dos mesmos, a sua eficácia terapêutica e a motivação dos pacientes. A avaliação efetuada será qualitativa e terá em consideração parâmetros como as condições do paciente (pré e pós intervenção), o contexto, o local onde a intervenção tomou lugar e que tipo de videojogo foi utilizado. De acordo com os resultados obtidos neste passo, uma análise quantitativa poderá ser levada a cabo a fim de aferir a eficácia dos tratamentos em questão. O próximo passo consistirá em trabalho de campo – entrevistas e questionários – a fim de melhor compreender a relevância, pertinência, abertura, disponibilidade e recetividade do uso de videojogos do subgénero *serious games* como algo mais do que uma simples forma de entretenimento. O último passo desta dissertação consistirá na avaliação do mercado e da indústria dos videojogos e dos *serious games*, respetivamente, para entender qual a possibilidade de transformar este tipo de videojogos algo apetecível e rentável do ponto de vista económico.

Consentimento Informado e Livre para Participação em Investigação

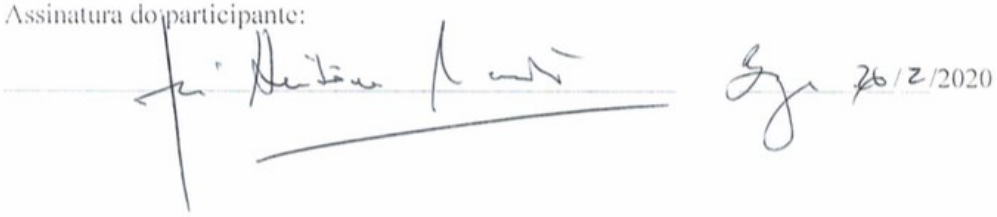
Eu declaro que li e compreendi os objetivos deste estudo, no qual serei incluído. Foi-me dada a oportunidade para fazer as perguntas que achei necessárias e recebi uma resposta satisfatória para todas elas. Estou ciente que, de acordo com as recomendações da Declaração de Helsínquia e a Convenção de Oviedo, a informação ou explicação que me

foi fornecida deu-me a conhecer os objetivos, métodos, benefícios antecipados e possível desconforto. Eu sei que não posso esperar qualquer benefício direto para mim, mas sei que irei contribuir para a investigação da relevância do uso de *serious games* na área médica. Também sei que as minhas respostas e os meus dados não vão ter um efeito direto na maneira como vou ser tratado no futuro. Além disso, estou ciente de que tenho o direito de recusar minha participação no estudo em qualquer momento, sem sofrer consequências. Deste modo, concordo com a participação na entrevista.

.....

Declaro que li e compreendi os termos propostos acima.

Assinatura do participante:



26/2/2020

Appendix E

Transcrição Entrevista – Dr. José António Moreira — Neurocirurgião – CNCV (Clínica Neurológica da Coluna Vertebral) – 26 de Fevereiro de 2020

Catarina Vieira (CV): Eu gostava de saber se acha, ou não, se os videojogos são uma perda de tempo? Qual é a sua opinião em relação aos videojogos no geral?

Dr. José António Moreira (JAM): Eu joguei videojogos. Eu acho que aumentam os reflexos e a atenção. Agora claro, aquilo pode tornar-se viciante e eu acho que o defeito deles é exatamente esse.

CV: Mas não acha que isso possa ser benéfico, se for para motivar uma pessoa para cumprir e sentir-se mais entusiasmada para participar nas sessões de reabilitação?

JAM: Sim, sim. Para sessões de terapia, acho que sim, acho que ajudam. Entusiasmam, principalmente, doentes, por exemplo, com paralisia cerebral.

CV: Já existem alguns casos em que jogos específicos foram utilizados para ajudar na reabilitação de doentes com paralisia cerebral.

JAM: Isso é ótimo. Eu não sabia disso.

CV: No entanto, ainda estão a ser aplicados principalmente a nível de investigação e não estão disponíveis no mercado.

JAM: Mas era bom que estivessem.

CV: Que tipo de pacientes é que fazem fisioterapia e o que é que eles fazem em sessões com métodos tradicionais?

JAM: Existem os pacientes neurológicos (pós-AVCs, ou com doenças neuro degenerativas) e existem os doentes que fazem fisioterapia por lesões neuromusculares. Existem os dois tipos: neurológicos e neuromusculares ou músculo-esqueléticos.

CV: Acha que o uso destes jogos seria benéfico para os dois tipos, ou mais para um do que para outro?

JAM: Seria benéfico para os dois. Sim, para os dois, embora de forma diferente. Os vasculares ficam com parésias[46] e, então, precisam mais de jogos de precisão. Precisão, atenção e até mesmo de linguagem. E os outros, os músculo-esqueléticos, por exemplo, quando é para tratar uma prótese ou um doente que foi submetido a uma prótese, não é tão útil, mas um doente paraparético, por exemplo, pós traumatismo vertebro-medular. Acho que teria mais utilidade nesses casos.

CV: Certo. A frequência das sessões a que os doentes são sujeitos é mais ou menos qual?

JAM: Uma por dia, em períodos que podem ir dos 20 dias aos 60. É habitualmente essa a média.

CV: Acha que seria benéfico substituir algumas dessas sessões por sessões só com videojogos?

JAM: Sim, porque as sessões são curtas. As sessões são de 20 a 30 minutos.

CV: Mas é aconselhável que os pacientes continuem a praticar fisioterapia mesmo para além desses 20 ou acha que é demasiado?

[46] Paralisias parciais, por exemplo, de um membro.

JAM: Sim, podiam fazer. Por exemplo, as doenças neurodegenerativas ou doenças neurológicas sim. Podem fazer mais do que uma vez por dia.

CV: Os doentes não se cansarão muito?

JAM: Se for muito tempo seguido. Mas podem fazer várias vezes.

CV: Certo. Em relação à Wii – acha que é mais eficaz usar a wii ou seria melhor um jogo mesmo específico?

JAM: Era preferível um jogo específico, orientado para a patologia, sem dúvida.

CV: Mas, dentro da Wii, acha que esta já responde a várias coisas que são necessárias ou acha que ainda precisa de evolução?

JAM: Não, não. Aqueles que eu conheço precisam de ainda muito.

CV: Que tipo de jogo é que acha que funcionaria bem, dentro daquilo que conhece e daquilo que conhece dos doentes?

JAM: Depende do que for. Por exemplo, existem testes que são feitos com animais, por exemplo, das cores, encaixe de objetos... E isso pode ser feito com videojogos. No fundo, são jogos de precisão.

CV: Mas, por exemplo, não seria mais interessante se fosse um jogo multijogador?

JAM: É difícil, é difícil. É difícil implementar isso. Acho que tem de ser um jogo por pessoa.

CV: E sem possibilidade de estarem a jogar com outra pessoa? E fosse anónimo?

JAM: Talvez. Uma pessoa contra a outra... Não sei, isso vai depender do jogo.

CV: Não quero estar a ser indelicada, mas por quanto é que normalmente fica para o doente? É comparticipada?

JAM: As fisioterapias são comparticipadas.

CV: Todas?

JAM: Não. Há privadas e comparticipadas. Um pacote de fisioterapia de 20 sessões custa ao doente 110€, portanto, são cerca de 5€ por casa sessão. Com P1, ou seja, o médico de família passa um P1. As 20 sessões pelo sistema nacional de saúde são muito mal pagas. Ficam por 180€. As pessoas levam um P1, o estado paga 70-80€, e a pessoa paga os 100€. Normalmente é assim. As pessoas isentas não pagam nada, então o estado paga os 180€. É muito mal pago para os profissionais que acompanham as sessões.

CV: Acha que uma iniciativa destas podia ser vendida para o serviço nacional de saúde?

JAM: Para os centros de fisioterapia. As sessões de fisioterapia são muito mal pagas.

CV: Como é que os *Serious Games* se poderiam adaptar aos doentes?

JAM: Depende. Podem ser jogos de treino visual, treino de linguagem, treino... Há vários jogos, depende daquilo que se pede ao doente. Movimento, precisão,... Por exemplo, para ensinar a andar, pisar certos trajetos – o doente estar a pisar e a tentar ver na televisão o trajeto e, se falhar, ouve-se um apito ou qualquer coisa... Pronto. No fundo, é incentivar. Imagine que fazem um videojogo em que há uns passos que o doente tem de seguir e, se falhar, aquilo fica vermelho e o perde pontos. O que a

pessoa quer é andar e fazer muitos pontos. É um estímulo positivo.

CV: E se fosse um videojogo inspirado, digamos assim, num daqueles títulos de muito sucesso, como o Super Mario? Funcionaria bem? As pessoas reagiriam positivamente?

JAM: Sim, acho que sim. Sem dúvida que sim.

CV: Seria melhor do que uma coisa completamente nova?

JAM: Sim, sim, sim, sim.

CV: Atualmente, dentro daquilo que já existe, o que acontece é que o desgin, a parte visual, fica muito aquém daquilo que poderia ser, se comparar um videojogo dos que são destinados ao mercado do entretenimento com um jogo feito para fins sérios, a diferença é grande.

JAM: Pois, mais, as equipas dos jogos de entretenimento também devem ser "super-equipas".

CV: Mas se essa parte fosse semelhante aos títulos comerciais, acha que poderia melhorar a capacidade de motivação dos doentes e o interesse?

JAM: Sim, sem dúvida. Como qualquer jogo. As pessoas quando fazem fisioterapia, nomeadamente os neurológicos. Eu acho que para os neurológicos isto seria ótimo. Porque isso, no fundo, é uma prova contra um computador. Estamos ali a tentar... é o tal reforço positivo, não é? Ou seja, vence-se e quer-se sempre fazer melhor, o que é ótimo. Acho que sim, acho que sim, seria bom. Se nós tivéssemos videojogos, era excelente. Se arranjarem videojogos desses, eu sou o primeiro a comprá-los. A gente o que quer é sempre dinamizar e facilitar. O que faz diferença entre os serviços é isso.

CV: E é tudo. Muito obrigada por me receber.

Appendix F

Transcrição Entrevista – Clínica De Neurologia E Fisiatria Da Póvoa De Varzim, Lda. – Dr.ª Paula Costa, Fisioterapeuta Rui Coelho, Fisioterapeuta Filipe Mendes e com uma terapeuta ocupacional – 4 de Março de 2020

Catarina Vieira (CV): Pode falar um pouco de quanto custam as sessões de fisioterapia, quer para os doentes, quer para a entidade promotora?

Dr.ª Paula Costa (PC): Como a clínica tem convenção (a convenção significa que trabalhamos para o Estado), cada paciente que vem tem de ir ao médico de família e trazer um P1 (uma credencial). A frequência das sessões é para 20 sessões e duas consultas médicas. A duração das sessões depende do tratamento de cada paciente, mas anda sempre à volta dos 45 minutos – 1 hora. Nunca excede uma hora. E tentamos ao máximo que às vezes ande entre os 45 – 50 minutos, pelo custo dessas sessões. Repare, se um paciente traz um P1, se for isento, não paga rigorosamente nada à clínica e faz as 20 sessões gratuitamente (é o Estado que as paga). Se o paciente não for isento e tiver de pagar uma taxa, esta ronda os 104€. Isso faz com que cada sessão fique mais ou menos por volta dos 3,90€. Se passar muito tempo, para a clínica, repare, um fisioterapeuta está com um paciente e esse paciente não chega a 4€. O que o doente me paga é esse valor.

CV: Eu gostava de perceber de que forma é que, a longo prazo, o uso de videojogos não seria benéfico a nível de custos.

PC: Já vieram cá, há pouco tempo, fazer uma demonstração com o iPad. A ideia realmente é essa – rentabilizar o fisioterapeuta. Enquanto o fisioterapeuta só pode estar com o doente, ... ou melhor, depende da situação, podem existir situações graves em que o fisioterapeuta só pode estar com 1-2 pessoas. Por exemplo, imagine um bebé. Se está com um bebé, não pode estar com muito mais. Mas independentemente de ser um bebé ou não, ganha o mesmo. O bebé paga os 4€, que nem chega a 4€. Eu penso que neste caso, ou nesta situação, qualquer que seja o jogo, será rentabilizar o trabalho deles. No entanto, nas situações que temos, é realmente bastante dispendioso. Temos de ter mesmo garantias que vai ser utilizado, porque se não, é um investimento muito grande para a casa, e até reaver esse dinheiro, é complicado. Agora, em termos de vantages do jogo, eu acho que não sou a pessoa indicada para conversar sobre isso.

Fisioterapeuta Rui Coelho (RC): Mas há outra coisa que às vezes, temos de ver o estrato social das pessoas que às vezes frequentam determinadas clínicas. Isto porquê, muitas das vezes nos temos doentes que já fazem fisioterapia ao longo dos anos e já está muito mecanizada a maneira de fisioterapia tradicional – aquilo que já é o habitué deles. Nós temos uma experiência com a Wii. Nós chegamos a pôr lá em baixo a Wii, para estarem a fazer jogos, principalmente para trabalhar com AVCs e tudo mais. Mas, passado uns tempos, notávamos que há ainda aquela ideia que só a mobilidade, de estar a mexer ou a massajar uma pessoa é que lhe vai trazer os benefícios. Isto não vem substituir o tratamento tradicional, percebe? É um complemento. Só que, o que acontece é que conseguir explicar isso ao paciente,... há uma certa dificuldade de ele entender. Ele depois pergunta "o que é que eu estou aqui a fazer?". Nós com a Wii tentamos mesmo com os AVCs, no lado hemiplégico, para ele tentar, mesmo jogar, mesmo a trabalhar. Temos lá em baixo a Wii e temos tudo preparado para se trabalhar. Mas notou-se isso.

PC: Acham que se o fisioterapeuta não lhes toca, não lhes mexe, acham que está a ser "enganado", que não está a dedicar-lhe...

RC: Acham que o estão a despachar... "põem-me aqui com uns joguinhos" e tal... Eu digo isto porque isto aqui tudo depende do estrato social. Se nós formos trabalhar para uma clínica ou no centro do Porto ou no centro de Lisboa ou com pessoas mais jovens, é completamente diferente. Nós aqui recebemos muita gente que é das aldeias da Póvoa. Em que está muito mecanizada aquele tipo de

fisioterapia mais tradicional. Se nós pusermos uma senhora a fazer qualquer coisa então ela vai dizer "eu vim para aqui para estar aqui"... Nós às vezes temos dificuldade a nível dos estagiários quando queremos que eles falam as avaliações, eles que estejam 20 minutos a avaliá-los em determinadas situações, eles dizem logo "Oh Rui, então eu vim hoje só para me estarem a avaliar"... Quer dizer, é um bocadinho difícil. Não quer dizer que isso não seja uma coisa engraçada, que nós também vamos tentando estar a par das coisas que vão aparecendo no mercado, e os investimentos por aqui também são feitos nesse sentido e estamos apetrechados com materiais que realmente vêm-nos ajudar imenso... Mas claro, nós equacionamos sempre consoante a situação e as pessoas que nos procuram, percebe? Porque, repare uma coisa, nós temos aqui miúdos, temos casos de pediatria, temos terapias da fala, temos terapias ocupacionais, ... Nesse âmbito, não sei se às vezes poderia haver algum interesse ou algum condicionamento para isso. Agora, em relação à fisioterapia dita, em que nós tratamos com os mais adultos, a recetividade deles com a Wii, nós vemos que não foi grande coisa. Tanto que, neste momento, está parada.

PC: Ou então tem de ser para pessoas mais jovens.

RC: Mais jovens, sim. Também isso. Nós aqui temos o estrato social, mas temos também essa questão – somos mais procurados por idosos. Temos poucos jovens.

CV: Mas se fosse um público entre os 20 e os 40, já aderiam mais?

RC: Se calhar, já aderiam. Tinham a capacidade de saber. Certamente.

PC: E provavelmente, repare: eles têm a noção que estão sozinhos, mas que estão a trabalhar.

RC: Precisamente.

PC: Tanto lhes faz estarem a fazer o movimento com um fisioterapeuta ao lado ou sem. E para nós, é bastante melhor, porque o fisioterapeuta conseguiria estar a controlar dois ou três ao mesmo tempo.

RC: Esta malta nova hoje está mais habituada a isso, porque você vê, hoje se quer tirar uma receita ou assim, vai logo aí. Agora, com estas pessoas de idade, é um bocadinho diferente.

PC: A minha opinião e, lá está, por isso é que eu disse que devia falar com o fisioterapeuta, eu acho que esse tipo de situação vai ter que entrar aos poucos neste tipo de trabalho. Assim, como a Wii... Com a Wii, há aqueles casos em que vale a pena apostar, porque é uma pessoa jovem e que vai gostar. Há outros, como o terapeuta diz e muito bem, que não vai resultar. E eu penso que é o que vai acontecer, se calhar, neste caso.

RC: Nós já tivemos cá uma fisioterapeuta que tentava com um programa de computador para AVCs. Também veio aqui demonstrar. Mas claro, nós aqui temos pessoas que não sabem ler, temos pessoas que não sabem utilizar um telemóvel. Aqui, eu acho que isso tem maior impacto em clínicas que sejam frequentadas por uma classe muito mais jovem. A recetividade será diferente.

CV: Estou a perguntar isto, porque encontrei um estudo que concluía que uma faixa etária mais idosa, perante um jogo, aderia e cumpria melhor as regras do que os mais jovens.

RC: Eu não tenho dúvidas nenhumas. Mas tem razão no que está a dizer. E eu não tenho dúvidas de que isso é uma coisa que, no futuro, irá ser implementada. Não tenho dúvidas disso. Porque acho que a saúde vai tomando umas proporções... Mas isto às vezes passa tudo por uma questão de se ter tempo, de ser ter o tempo de utilidade das coisas. E tudo funciona à base da rentabilidade. Hoje em dia, o que se quer, é a rentabilidade das coisas e, muitas das vezes, a escassez que há, é do tempo para se poder aplicar. Isto porque os ganhos das empresas são cada vez mais diminutos – cada vez existem mais impostos, cada vez as pessoas estão mais asfixiadas e, às vezes, até a querer dar a ajuda para possibilitar que uma pessoa se lance ou isso, é difícil apostar numa novidade. Porque altera logo o funcionamento das coisas e, parecendo que não, isto é uma casa que está muito mecanizada. Temos ambulâncias que chegam a uma hora específica e depois vêm para buscar o doente, depois já vem

outra para trazer outro doente... Não é a mesma coisa de uma pessoa que vem no seu carro, esteja aqui um tempo... Isto tudo são fatores que não ajudam para a aplicação de tal situação. Não se está aqui a pôr em causa a questão da utilidade dessas tecnologias.

PC: Uma coisa que não sei até que ponto é que poderia ser relevante... Se for uma clínica (como existem muitas em Braga) que trabalha só com particulares, então eu sei que tenho realmente dois fisioterapeutas, mas também sei que, por hora, só vou ter um ou dois pacientes. O fisioterapeuta realmente vai ter tempo para se dedicar, porque também estamos a falar de outro valor. É particular e a pessoa vai ter de pagar 30€ ou 40€, por exemplo. Ou, no mínimo dos mínimos, 25€. Então vou ter de dispor de outro atendimento. Mas não interprete mal, que nós tentamos atender as pessoas da melhor forma que conseguimos. Agora, com esse tipo, como o Terapeuta Rui diz, é capaz de ser verdade. Eu não consigo, se calhar, estar a mudar o programa para este doente, e depois tenho de ir se o programa do colega está adequado... Ele é autónomo e está a fazer o que o jogo à partida vai sugerindo, mas temos de estar atentos. Temos de dispor de tempo para isso.

RC: Mas o que é que você queria saber?

CV: Queria saber o que é que usavam, como é que usavam, em que dispositivos é que usavam, que tipo de jogabilidade é que os jogos utilizados têm. E depois, o que é que acha que poderia ser benéfico ou não? O que é que poderia ser implementado? Opinião sobre o impacto da parte visual, sonora de um jogo nos resultados? E da narrativa?
RC: Hoje em dia já fazem uso de tecnologias em certas clínicas. É capaz de ser mais vantajoso procurar essas casas que têm isso como utilidade frequente. Nós não temos utilidade nenhuma suficiente para você ter algum feedback. Os terapeutas ocupacionais trabalham muito com o iPad, com joguinhos de encaixe, *puzzles*, etc, o que é fantástico. A criança evolui bastante enquanto isso. Acho que a Terapeuta Ocupacional podia ajudá-la.

PC: Aqui, o nosso dia a dia, é mesmo de trabalho físico. Para nós, é difícil explicar o que é que poderíamos alterar, o que é que poderíamos melhorar, porque o nosso dia a dia não vai de encontro com os videojogos. Portanto, a única coisa que nós temos na realidade, é a Wii. Mas temos o relato do fisioterapeuta em relação ao uso da Wii.

CV: É uma opinião muito interessante que eu ainda não tinha ouvido até agora e acho que é muito relevante ter em conta o estrado social, que é algo que eu não tinha tido em conta até agora. Acho que é muito valioso.

RC: Muitas vezes passa por aí. Às vezes nós queremos inovar um bocadinho, mas está mecanizado nestas pessoas, dos 70 e dos 80, aquela fisioterapia tradicional. Mesmo nós, se às vezes utilizarmos uma técnica que seja diferente, eles reagem.

PC: Mesmo com alguns mais novos. Porque "quase que nem me tocou"... As pessoas ainda vivem muito disso. Têm que lhes mexer.

RC: Eu tive a possibilidade de trabalhar com estrangeiros e, principalmente, com Americanos. Eles ficavam muito satisfeitos com a nossa fisioterapia. Eles dizem que lá, na recuperação, "ligam-nos a uma máquina, ou metem-nos num tapete ou numa bicicleta, e dobramos e esticamos. Não há como vocês que venham aqui mexer e que venham fazer". É engraçado. E na Suíça é a mesma situação. A fisioterapia praticada pelas pessoas pela suíça não tem nada a ver com a nossa fisioterapia. Ou você tem muito dinheiro para ir a particulares, porque nas companhias e tudo mais, não fazem este tipo de fisioterapia. Nós ainda somos muito procurados porque ainda somos daqueles que utilizam muito a mão, em que há muito toque, em que se massaja, em que o dobrar e o esticar são importantes. Há sítios em que não. Nós temos pessoas que estão no estrangeiro e que estão imigradas e que, muitas vezes, têm patologias e que vêm cá tratar-se. E para os seguros é melhor. Porque levam o recibo daqui e fica-lhes mais barato. Se for uma pessoa daqui, é um trinta-e-um, porque tem de ter uma prescrição médica, porque tem de ter isto, tem de ter aquilo, ... é uma confusão. E, realmente, quem vem muitas das vezes, vem procurar. Muitas vezes, nós temos situações de pessoas que estão emigradas, mas que querem vir cá tratar-se porque é diferente.

PC: E independentemente, se me perguntarem a minha opinião, e tendo em conta só a situação da Wii, que é a única que temos aqui, eu sou a favor. Sou a favor dos videojogos, sou a favor dos jogos, sou a favor de tudo o que é novo, porque acho que é importante. A minha opinião é que não podemos excluir o fisioterapeuta, por muito que seja autónomo, por muito que rentabilize, porque, no final, tem que ir lá o técnico. Tem de ir lá dar o jeitinho.

RC: É um complemento, uma sustentação.

CV: E se for para terem acesso em casa?

PC: Lá está, então implica que as pessoas tivessem, no mínimo, um iPad. É muito fácil hoje em dia, porque achamos que as novas tecnologias estão muito difundidas. Já estão na nossa casa e assim. Muitas das pessoas que frequentam a clínica não têm, sequer... Eu acho que muitas, hoje em dia, já têm telemóvel. Não um muito sofisticado, mas têm. Mas, mesmo que a clínica emprestasse um iPad durante uma semana a meia dúzia de pessoas. Elas provavelmente não iam usar porque é demasiado complicado entrar no jogo, etc..

RC: Veja isto: nós temos doentes que são amputados. E tivemos os colegas nossos que achavam estranho como é que nós púnhamos as próteses nos nossos doentes (isto no geral, em Portugal todo) e a maior parte dos doentes não andava com as próteses, abandonavam-nas, etc. Mas as próteses estavam mal feitas? Chegou-se à conclusão que não. Nós trabalhávamos muito bem as próteses. Em comparação com doentes de Inglaterra, puseram foi só uma coisa de contar os passos. Ou seja, eu, como profissional, faço a colocação da prótese, ensino (colocar e tirar), treino o doente para andar, para lhe dar autonomia. Até aqui é tudo muito bonito. Depois lá fora, na primeira semana, em casa, ainda vai pondo a prótese, na segunda semana já põe um dia e noutro já não põe... já não vai ao café, ... Então, era brutal a diferença. Enquanto que, num doente Inglês, mal põem uma prótese, não a tiram, é sempre a andar. Chegavam ao final do dia com uma diferença brutal de caminhar, entre um doente português e um doente estrangeiro.

PC: É a mentalidade das pessoas.

RC: Está a ver? Se eu emprestasse um iPad a um doente, um ou outro até podia aderir (podemos estar aqui a ser injustos), mas certamente não iriam aderir.

PC: Embora, lá está, às vezes as pessoas surpreendem-nos.

RC: Mas é ainda outra coisa – estamos muito habituados a que haja pouca espontaneidade nossa para fazer o que quer que seja. Só se for picado, ou se for obrigado...

CV: Portanto, uma resistência à mudança.

RC: Nós pagamos muito por isso. É por isso que todo este atraso que nós temos provém daí. E há outra coisa (a parte que eu batalho sempre), que é a parte de compreensão, de entender, de perceber. Porque nota-se nas pessoas. Quando falo do estrato social, falo até da questão de eles próprios terem capacidade de entender. Porque você, se falar com as pessoas, se tentar dizer que têm que mudar qualquer coisa, para eles é uma confusão muito grande. Porque a maior parte são pessoas que estão sozinhas, a maior parte dos seus filhos estão no estrangeiro... Isto é tudo uma costa, uma zona, em que a maioria das pessoas está muito sozinhas, e provêm de famílias de pescadores. Mas as coisas vão modificando. Mas nota-se mesmo na compreensão. A senhora pode chegar ali e estar a falar com o doente e explicar que tem que assinar... mas até isso é uma confusão. Se conseguisse dar uma palavrinha, que ela é uma pessoa que trabalha muito com esse tipo de material.

_____

Terapeuta Ocupacional (TO): Nós, com as crianças, passamos muito por isto. O iPad é um instrumento espetacular para trabalhar com muitos meninos, mas para meninos com autismo é impensável, porque depois, quando se tira aquele estímulo (que é um estímulo muito forte), ele está

tão desorganizado que vai fazer uma birra. Porque não compreende porque é que temos de desligar. Mas o iPad, a nível de trabalho, é uma das ferramentas que fazem sentido. Mas não as conseguimos utilizar com toda a população. Nos adultos, é aquela questão, é muito complicado. As pessoas querem sempre o toque e acham que é por aí que vão ter uma evolução mais significativa. Eu acho que ninguém, mesmo por sítios em que já passei, não vejo ninguém a utilizar. Mesmo os terapeutas da fala, aquilo que utilizam mais, como suporte, é o iPad. Há meninos em que ainda não se consegue, sequer, considerar colocar algo desse género. O iPad já tem, agora, um sistema que é o Grid, que dá suporte à comunicação alternativa, para meninos que não tenham comunicação verbal (ou a tenham muito reduzida), porque transforma a voz... Os miúdos falam, ou aquilo fala o que os miúdos escrevem... Mas, não temos suporte para esse tipo de situações.

PC: Para concluir, só se falar com o Terapeuta Filipe, que foi o que utilizou mais a Wii. Ele é que lhe pode dizer porque é que utiliza menos, porque foi a pessoa que esteve mais focada com a Wii.

TO: E ele como esteve especificamente naquele espaço, acaba por ser mais fácil gerir também isso. E acho que ele devia usar aquilo mais em pessoas mais jovens. Para lesões desportivas, ou pós-cirurgias. Mas uma população entre os 30-40 anos, que já está mais disponível para este tipo de apreciação.

PC: Já foi o que lhe tínhamos dito antes.

CV: Muito obrigada.

PC: O terapeuta Filipe, aqui na clínica, era quem utilizava mais a Wii, certo?

Fisioterapeuta Filipe Mendes (FM): Sim. A integração da Wii aqui na clínica foi uma novidade. Mesmo acho que noutras clínicas não existe. Logo os doentes nunca tinham visto, não estavam habituados. O feedback deles é muito positivo, porque motiva. Têm os scores a atingir, e dá-nos uma percepção da sustentação, do equilíbrio que eles têm. Aquilo tem uns parâmetros engraçados que nós conseguimos controlar e ajustar ao doente. Mas, de facto, é uma mais valia.

CV: Que jogos é que utilizam?

FM: Essencialmente os jogos de equilíbrio. Transferências de carga... Por exemplo, nos AVCs, onde há défices de equilíbrio... Usava mais nesse aspecto. Depois, também, no contexto da pediatria, para as crianças também é muito engraçado. Eles ragem muito bem.

CV: Então usavam, maioritariamente, jogos do sector comercial?

FM: São os jogos acoplados à consola, que vêm com a consola. Especificamente, para aquela consola, não conheço nenhum. Nós já temos a Wii a uns 5-6 anos, e os jogos que nós temos são aqueles jogos de reforço muscular, postura, equilíbrio. São aqueles jogos que são feitos para a Nintendo e que vêm para a consola.

CV: Acha que a parte visual e sonora do jogo interferem com os resultados?

FM: Nunca me apercebi que interferisse. Se interferir, acho que é no sentido positivo. Porque é uma espécie de guia para o utente. O utente vê a imagem e tem de repetir o que está na imagem, por isso acaba por ajudar e esclarecer o exercício. A nível de som, acho que não interfere.

CV: E a presença de uma narrativa?

FM: Com certeza era melhor. Se houvesse um diálogo com a máquina. Conhece o jogo do equilíbrio que estou a falar? Que tem um círculo e os pacientes têm de ficar no meio desse mesmo círculo. Depois, no fim do jogo, há um traçado, se diz se o doente esteve mais ou menos para um lado, mas o doente não consegue perceber aquilo. Nós é que temos de traduzir para o doente e explicar melhor.

CV: Mas acha que seria melhor utilizar um jogo desenvolvido mesmo para estes fins, ou a Wii já

responde às necessidades?

FM: Acho que podia melhorar. Através de outro software mais objetivo, mais focado mesmo para reabilitação. Nomeadamente, pelos movimentos que nós fazemos no nosso dia-a-dia. Por exemplo, uma reabilitação mais funcional do membro superior, acho que tem mais utilidade até para o membro superior. Nós usamos, por exemplo, para estes casos, o jogo do ténis, o do baseball... Ora, existem certos movimentos que podiam ser reintegrados na consola e no software, mais específicos, mais orientados, como os movimentos que nós usamos nas atividades da vida diária, como o pentear, o escovar os dentes... Esse tipo de movimentos.

CV: Acha que a Wii permite que o utilizador faça "batota"?

FM: Isso já não sei, porque isso está relacionado com o contexto domiciliário. Ou seja, nós não estamos presentes a acompanhar. A minha experiência é mesmo aqui, junto ao doente, e a corrigir ao mesmo tempo que ele faz. Forçosamente, o paciente acaba por cumprir as tarefas e ser corrigido no imediato. Por exemplo, a postura, o equilíbrio, o que for. Nunca trabalhei à distância. Sei que existem uns programas que estão a tentar integrar a fisioterapia no domicílio, através de videoconferências... Não sei até que ponto é que isso pode ter resultados eficazes. Como diz, podem fazer batota e até o neto deles pode fazer por eles. É complicado.

CV: E o que acha da eficácia da Wii versus jogos feitos mesmo para este fim?

FM: Quando nós adaptamos aqui a Wii eu também fiz um estudo. Este conceito surgiu em Israel – os isrealitas foram os primeiros a incorporar as consolas de jogo no tratamento de reabilitação. O médico fisiatra que estava cá, o Dr. Francisco Pires, também concordou imenso. Depois, quando ele saiu daqui, foi para outro hospital e, passados 5 ou 6 meses, ele ligou-me a dizer que também queria instalar lá a Wii e a perguntar pela Wii para os doentes neurológicos ou com défices neurológicos. Para a reabilitação, só se for para reforço muscular. Também existem lá alguns jogos engraçados para reforço muscular. É preciso fazer aquelas repetições, sempre coordenadas e equilibradas para atingir a maior pontuação. A motivação é essa: hoje fazem, por exemplo, 75 pontos, amanhã tentamos os 80, os 90... Ou seja, concentram-se, há um foco, mas isso claro, o fisioterapeuta tem de estar ao lado para corrigir, motivar, registar, etc.

PC: Outra coisa, Terapeuta Filipe. Não acha que a utilização da Wii tem vindo a diminuir?

FM: Por desleixo meu, também. Porque, ela está ali a mão e está tudo a funcionar, e às vezes incorporo. Mas temos de selecionar bem os doentes para o fazer. Eu, às vezes, olho para um doente e tenho medo que ele se frustre porque não consegue fazer. Às vezes, nas primeiras tentativas, aquilo é um bocadinho confuso e eles acabam por ficarem desanimados. Eu acabo sempre o jogo com uma pontuação alta para motivar o doente e para ele não se frustrar. Para não sentir que não é capaz de o fazer. O candidato tem de ser o certo para trabalhar na Wii. É um caminho que se vai fazendo, tentar uma, duas vezes, encorajar o doente... Mas, nos grupos que eu pertenço de fisioterapia, a integração das consolas na fisioterapia não é muito falada. Fala-se no uso no domicílio. Eu tenho uma ideia que querem projetar a fisioterapia para o domicílio – as pessoas fazerem em casa, sem a necessidade de se deslocarem. Eu acho que é um erro. As pessoas devem estar acompanhadas. Nós tivemos aqui um caso de uma prótese de um joelho em que a senhora tinha uns vídeos. Foram a casa colocar um aparelho próprio e, através dos vídeos, ela fazia as repetições, x vezes por dia. Mas depois acabou por vir para aqui, talvez porque os resultados não foram os esperados.

PC: Terapeuta Filipe, obrigada.

CV: Obrigada pela atenção e participação.

Appendix G

Informed Consent – Paula Costa

CATÓLICA
ESCOLA DAS ARTES
PORTO

Serious Games para Reabilitação Física

Este questionário integra uma dissertação de mestrado em Gestão de Indústrias Criativas (Escola das Artes – Universidade Católica Portuguesa) e tem como objetivo avaliar a relevância de utilizar *serious games* (jogos sérios) na área da saúde, assim como averiguar possíveis casos em que esta metodologia já se encontre a ser implementada.

O conceito de *serious game* pode ser definido como um videojogo que é utilizado para um fim que não apenas o entretenimento do jogador mantendo, no entanto, as características que tornam os videojogos apelativos e cativantes que permitem que o utilizador experiencie emoções e sentimentos positivos percecionados como "divertidos". Para além disso, estes videojogos também visam promover algo chamado de "*collateral learning*", isto é, uma forma de obter determinadas capacidades através de métodos de aprendizagem não convencionais.

O objetivo principal da dissertação em curso é avaliar a relevância do desenvolvimento de *serious games* personalizados que respondam às necessidades dos pacientes para tratamentos e terapias específicas.

A metodologia implementada para o desenvolvimento desta investigação começa com uma revisão bibliográfica de autores relevantes, com enfoque no subgénero dos *serious games* e as suas aplicações na área médica.
Num segundo momento, vários casos de estudo nos quais diferentes tipos de videojogos foram utilizados (para melhorar a saúde de pessoas fisicamente incapacitadas) serão analisados a fim de compreender a possível ligação entre o design dos videojogos, a estética dos mesmos, a sua eficácia terapêutica e a motivação dos pacientes. A avaliação efetuada será qualitativa e terá em consideração parâmetros como as condições do paciente (pré e pós intervenção), o contexto, o local onde a intervenção tomou lugar e que tipo de videojogo foi utilizado. De acordo com os resultados obtidos neste passo, uma análise quantitativa poderá ser levada a cabo a fim de aferir a eficácia dos tratamentos em questão. O próximo passo consistirá em trabalho de campo – entrevistas e questionários – a fim de melhor compreender a relevância, pertinência, abertura, disponibilidade e recetividade do uso de videojogos do subgénero *serious games* como algo mais do que uma simples forma de entretenimento. O último passo desta dissertação consistirá na avaliação do mercado e da indústria dos videojogos e dos *serious games*, respetivamente, para entender qual a possibilidade de transformar este tipo de videojogos algo apetecível e rentável do ponto de vista económico.

Consentimento Informado e Livre para Participação em Investigação

Eu declaro que li e compreendi os objetivos deste estudo, no qual serei incluído. Foi-me dada a oportunidade para fazer as perguntas que achei necessárias e recebi uma resposta satisfatória para todas elas. Estou ciente que, de acordo com as recomendações da Declaração de Helsínquia e a Convenção de Oviedo, a informação ou explicação que me

foi fornecida deu-me a conhecer os objetivos, métodos, benefícios antecipados e possível desconforto. Eu sei que não posso esperar qualquer benefício direto para mim, mas sei que irei contribuir para a investigação da relevância do uso de *serious games* na área médica. Também sei que as minhas respostas e os meus dados não vão ter um efeito direto na maneira como vou ser tratado no futuro. Além disso, estou ciente de que tenho o direito de recusar minha participação no estudo em qualquer momento, sem sofrer consequências. Deste modo, concordo com a participação na entrevista.

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Declaro que li e compreendi os termos propostos acima.

Assinatura do participante:

Paula Tinoco de Castro Marco, 4/2/2020

Appendix H

Informed Consent – Rui Coelho

CATÓLICA
ESCOLA DAS ARTES
PORTO

Serious Games para Reabilitação Física

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Declaro que li e compreendi os termos propostos acima.

Assinatura do participante:

Rui Pedro da Costa Pereira Coelho .4/2/2020

Appendix I

Informed Consent – Filipe Mendes

CATÓLICA
ESCOLA DAS ARTES
PORTO

Serious Games para Reabilitação Física

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Declaro que li e compreendi os termos propostos acima.

Assinatura do participante:

R. Utinga, 4/3/2020

Appendix J

Informed Consent – Professor Nuno Sousa

CATÓLICA
ESCOLA DAS ARTES
PORTO

Serious Games para Reabilitação Física

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Eu declaro que li e compreendi os objetivos deste estudo, no qual serei incluído. Foi-me dada a oportunidade para fazer as perguntas que achei necessárias e recebi uma resposta satisfatória para todas elas. Estou ciente que, de acordo com as recomendações da Declaração de Helsínquia e a Convenção de Oviedo, a informação ou explicação que me

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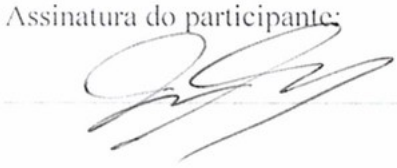
.....

Declaro que li e compreendi os termos propostos acima.

Assinatura do participante:



26 /3/2020

Appendix K

Transcrição Entrevista – Professor Doutor Nuno Sousa – 5 de Março de 2020

Catarina Vieira (CV): Qual é a sua principal função?

Professor Nuno Sousa (NS): Eu sou médico, sou professor de medicina e, nesta altura, sou presidente da Escola de Medicina da Universidade do Minho, por isso, essa é a minha principal função. Para além deste componente mais pedagógico e clínico, tenho obviamente, atividades na área da investigação.

CV: Certo. Tem quantos anos de experiência?

NS: Eu formei-me em 1992 e comecei a dar aulas em 1990. Portanto, dou aulas há cerca de 30 anos e faço investigação há cerca de 32.

CV: Trabalha para que tipo de entidades? Pública? Privada? Ambas?

NS: Ambas. Iminentemente públicas, mas também tenho atividades para entidades privadas.

CV: Qual é a sua opinião, de uma forma muito geral, em relação aos videojogos?

NS: Acho que são como qualquer outro produto humano. Rigorosamente igual a qualquer outro produto humano. Pode ser extraordinariamente positivo, se for usado de uma forma inteligente, pode ser extraordinariamente nefasto, se for abusado de uma forma malévola.

CV: Costuma jogar alguma coisa?

NS: Sim, mas não particularmente videojogos.

CV: Estava familiarizado com o conceito de Serious Games antes desta entrevista?

NS: Muito. Porque faço investigação no seu uso como ferramenta de enhancement cognitivo e de intervenção terapêutica?

CV: Para que tipo de pacientes é que acha que este tipo de jogos se adequaria?

NS: Para muitas condições. Aquela que eu uso com mais frequência são em indivíduos que têm défice cognitivo – idealmente, défice cognitivo ligeiro – e como forma de os ajudar a mitigar o handicap que têm. Mas, os videojogos podem ser usados em muitas outras condições, algumas das quais estive hoje aqui a falar.

CV: Então, já utilizou? Que tipo de jogos é que normalmente utiliza?

NS: Nós usamos tipicamente videojogos bastante simples no seu constructo, com tarefas de dificuldade incremental, que nós queremos associar a ganhos de controlo cognitivo e emocional, nomeadamente no controlo da atividade elétrica do cérebro, portanto, tendencialmente, por este motivo, usamos videojogos de baixa complexidade pois permite-nos, do ponto de vista da investigação, controlar melhor as variáveis. Reconheço que retira uma parte significativa daquilo que podem ser os ganhos associados, mas como nós temos de controlar as variáveis, é isso que fazemos.

CV: Normalmente, que tipo de dispositivos é que usam? Consolas? Computadores? Tablets?

NS: Varia. Aí somos bastante agnósticos. Depende, às vezes, das condições que temos para os aplicar.

CV: O que é que acha – seria mais eficaz utilizar a Wii ou um jogo especificamente desenvolvido para a patologia em questão?

NS: É sempre melhor um jogo específico desenvolvido para aquele fim. Sempre. O problema é que o tempo de desenvolvimento e o esforço associado ao desenvolvimento pode não ser eficiente e eficaz. E portanto, aqui é melhor ir à procura do melhor compromisso para o contexto. Se se tiver uma grande equipa que possa desenvolver o videojogo da forma que se entende que se adequa a uma patologia em particular ou, melhor ainda, a um indivíduo em particular, portanto uma coisa muito customizada, isso é perfeito. Mas, como de uma maneira geral, no caso da fisioterapia, se um fisioterapeuta recebe múltiplos indivíduos na sua clínica diária, ele obviamente que não consegue customizar o videojogo para aquele indivíduo, mas a verdade é que usa um produto, que eu diria, de banda larga. Mas a resposta a isto é a mesma que veio do ganho do Personal Trainer. Quem faz exercício com alguém que, para além de ser um especialista, consegue adaptar o exercício àquela pessoa, tem obviamente, um ganho maior, do que aquele que vai para uma aula onde estão 30 ou 40 pessoas a fazer exercícios que se ajustam de maneira diferente a cada indivíduo.

CV: Mas não acha que, por exemplo, a nível de design, os Serious Games ficam aquém daquilo que existe? Não acha que se fosse possível desenvolver um videojogo para fins de reabilitação, com design idêntico ao dos jogos comerciais, não teria um resultado superior?

NS: Claro que acho.

CV: Ou seja, estamos a pecar a nível de resultados por abdicarmos do design.

NS: Claro que estamos. Eu não sei qual é a perda, nunca fiz um estudo que me permitisse dizer "a perda é de x%", mas é óbvio que estamos a perder. O problema é sempre o mesmo, quando temos de desenhar uma coisa from scratch, demora mais tempo, é mais... Aqui é sempre à procura do compromisso ideal.

CV: No entanto, acha que a Wii já responde a várias coisas que são necessárias para reabilitação física ou...?

NS: Eu não um especialista nessa área, mas dizem-se que sim, porque o constructo da Wii permite que o próprio movimento da pessoa seja analisado e seja ajustado àquela pessoa porque é um efeito espelho. Se depois se estabelecerem as métricas daquilo que é o ganho e o objectivo, eu acho que é uma estratégia interessante.

CV: Acha que a narrativa no jogo podia influenciar, ou acha que depende do contexto.

NS: Depende do contexto, mas ajuda sempre.

CV: Que tipo de videojogo acha que funcionaria bem?

NS: Depende dos doentes e da sua patologia, não é? Por exemplo, repara, para um doente com um défice cognitivo, fazer jogos com a Wii tem provavelmente menos interesse terapêutico do que fazer um jogo que os obriga a ter algum exercício cognitivo onde eles estão particularmente deficitários, ok? Tendo dito isto, também é verdade que o exercício físico é fundamental para ter uma boa atividade cognitiva, por isso, existem sempre ganhos laterais – são aquilo a que eu chamo os efeitos laterais positivos.

CV: Se tiver dois indivíduos, com exatamente as mesmas características físicas e cognitivas, acha que pode ser benéfico para os dois ou vai depender de outros fatores?

NS: Primeiro, isso é uma situação limite que não existe. Segundo, é claro que pode ser benéfico para os dois. No entanto, o benefício que vai desencadear num e noutro pode variar de acordo com a motivação, com o contexto em que o jogo é apresentado, com a compreensão, com a atenção, com o cansaço... Estás a ver? Há um sem número de variáveis que podem influenciar o ganho de cada

indivíduo. Aliás, o mesmo indivíduo, em dois momentos distintos vai beneficiar de formas distintas daquele estimulo.

CV: Das características dos videojogos que conheça, o que é que acha que podia ser implementado num jogo com fins de reabilitação física?

NS: Vamos lá ver, se tu conseguisses ... Repara, eu tenho um défice na articulação do joelho. A seguir, aparece uma pessoa que tem um défice num tornozelo. Repara, são dois défices distintos. Se houvesse a capacidade de ajustar o videojogo para o défice de um determinado indivíduo, isso era uma mais-valia tremenda. Agora, tu sabes que o meu défice é no joelho e, portanto, tu podias estimular um conjunto de exercícios que iriam mitigar o défice que eu tenho no joelho. Iria trabalhar muito mais esta articulação do que o tornozelo, ou a articulação coxofemoral. E isso é o que é ter um videojogo inteligente – que se customiza, que se personaliza, ao indivíduo que está à frente. Esse, para mim, seria um ganho absolutamente extraordinário.

CV: O que é que pensa dos jogos multiplayer?

NS: São muito interessantes do ponto de vista cognitivo (em muitas dimensões cognitivas), são muito interessantes do ponto de vista social. Porque é que eu digo isto? Porque estimulam a interação com outros indivíduos, sobretudo se o sucesso do jogo depender do sucesso de mais do que um elemento. E, portanto, tem aqui um componente social que muitas vezes é criticado nos videojogos, porque é visto exclusivamente como uma forma de estar antissocial, de grande isolamento, quando na realidade existem muitos contextos que até promovem o contacto social. Isto, obviamente, não exclui que existem outros tipos de contactos sociais que devem ser privilegiados. Portanto, é uma questão de bom senso e do uso dos diferentes contextos sociais. Mas eu gosto da ideia de que as pessoas percebam que o outcome, em determinados casos, pode não ser um outcome exclusivamente determinado pelo indivíduo, mas determinado por múltiplos indivíduos. Já me parecem menos interessantes as situações em que há confronto entre indivíduos. Eu favoreceria muito mais atividades sinérgicas do que competição.

CV: Que barreiras é que considera as mais relevantes para o uso de Serious Games cá em Portugal?

NS: O estigma. Há, de facto, uma percepção negativa dos videojogos. Sobretudo, mais uma vez, do abuso do ambiente de videojogos, em particular em adolescentes, com estudos já muito elaborados que mostram perdas marginais em algumas dimensões da função cerebral. Portanto, nós temos que estar atentos a isso e temos de saber dosear, não só o tempo, mas também a intensidade, com que se está nesses jogos, ainda que isso esteja relativamente afastado do conceito de Serious Games. Mas atenção que às vezes há alguma sobreposição. A questão, da percepção, do estigma... E depois, sobretudo, quando o teu alvo são populações que estão menos confortáveis com o digital, quando tu começas a querer trabalhar com indivíduos mais idosos, que têm menos à vontade com consolas, etc, obviamente que estás a criar aí um factor de afastamento, de distanciamento... E isso é algo importante. Para pessoas mais novas, de uma forma geral, isso não causa nenhum desconforto.

CV: Mais alguma coisa a acrescentar?

NS: Não. Foi um gosto conversar contigo (...)

Appendix L

Development of Serious Games for Healthcare

This questionnaire is a part of a student's master's thesis in Management for the Creative Industries (Catholic University of Portugal - School of Arts). Its objective is evaluating the relevance of using serious games for healthcare, as well as surveying possible cases where this methodology is already being implemented.

A serious game is a video game that is used for a serious purpose while still carrying the defining traits of video games and allowing the users to experience positive emotions, such as feelings of perceived fun. Besides, they aim to promote something called "collateral learning", which can be described as a way of acquiring certain skills through non-conventional learning methods.

The main objective of this thesis is gauging the relevance of developing personalized serious games, answering the needs of patients for specific treatments and therapies.

The methodology implemented for the development of this investigation thesis begins with a bibliographic revision of relevant authors, focusing on the serious game sub-genre and its healthcare applications.
In a second moment, various case studies where different kinds of games were used to improve the health of physically disabled or impaired people will be analyzed, in order to understand the link between game design and aesthetic, therapeutic efficacy and patient motivation. The evaluation of the efficacy of these cases will be qualitative and will take into account parameters such as the patients' conditions (pre- and post- intervention), the context, the setting where the intervention took place and the kind of game that was used. According to the results obtained in this step, if possible, a quantitative analysis will be conducted in order to gauge the efficacy of treatments resorting to video games. The next step will consist of fieldwork, resorting to interviews and questionnaires, in order to better understand the relevance, pertinence, openness, availability and receptivity to use video games as something more than a mere form of entertainment. The last step of this thesis will consist in evaluating the video game industry and the serious games' market, in order to better understand the possibility of transforming this kind of games into something worth diving into.

*Required

Free and Informed Consent for Research Participation

Confidentiality and Anonymity: The participant's anonymity and confidentiality will be safeguarded (there will be no nominal identification of the participant). Confidentiality and exclusive use of the data collected for this study are guaranteed, under conditions of anonymity (no registration of identification data). The collected data will be kept for the duration of the thesis, being deleted after it has been concluded.

For questions or concerns related to the study, the participant can contact Catarina Vieira (catarina.vieira.28@hotmail.com) or Professor André Perrotta (aperrotta@porto.ucp.pt).

I declare that I have read and understood the purposes of this study, in which I will be included. I was given the opportunity to ask the questions I thought necessary, and I got a satisfactory answer for all of them. I became aware that, in accordance with the recommendations of the Declaration of Helsinki and the Oviedo Convention, the information or explanation given to me focused on the objectives, methods, anticipated benefits, potential risks and possible discomfort. I know that I cannot expect any direct benefits for myself, but I know that I will help research in order to understand the relevance of the use of serious games in the health sector/as therapy tools. I also know that my answers/data will not have a direct effect on the way I will be treated in the future. In addition, I am aware that I have the right to refuse my participation in the study at all times, without suffering any consequences. Therefore, I consent to the application of the proposed questionnaire. I was also informed that my name will not appear in any document used in the investigation, nor will be the subject of exposure of the results in communications.

1. Please read the following information carefully. If you think something is unclear, don't hesitate to ask for more information. If you agree with the everything, please check the respective box. *

   Tick all that apply.

   ☐ I agree with the terms of use presented above.

2.

   Tick all that apply.

   ☐ Tick this box if you don't wish to be contacted again in the future.

The open questions can be answered either in english or in portuguese.

3. What's your area of expertise? *

   Mark only one oval.

   ◯ Game designer
   ◯ Programmer
   ◯ Character Artist
   ◯ Animator
   ◯ Sound designer
   ◯ Concept artist
   ◯ Game tester
   ◯ Scenery/Background Artist
   ◯ 3D Artist
   ◯ Level Designer
   ◯ UI artist
   ◯ Producer
   ◯ Writer
   ◯ Other

4. What's your age group? *

Mark only one oval.

- ◯ 18 - 34
- ◯ 35 - 44
- ◯ 45 - 54
- ◯ 55 - 65
- ◯ 65 +

5. How many years of experience do you have in the field? *

Mark only one oval.

- ◯ < 5
- ◯ 5 - 10
- ◯ 10 - 20
- ◯ > 20

6. Do you work in Portugal? *

If you work in a country other than Portugal, please specify.

Mark only one oval.

- ◯ Portugal
- ◯ Other: _____

7. Do you or the company that you work for play a part within the Serious Games industry? *

Mark only one oval.

- ◯ Yes *Skip to question 8*
- ◯ No

8. Have you ever participated in the development of a serious game for medical purposes?

Mark only one oval.

- ◯ Yes *Skip to question 9*
- ◯ No

9. In which medical context was the game developed for? *

Mark only one oval.

- ◯ Physical Rehabilitation *Skip to question 10*
- ◯ Education *Skip to question 11*
- ◯ Fitness and wellness *Skip to question 11*
- ◯ Raising population awareness for certain medical conditions *Skip to question 11*
- ◯ Other: _____

10. What pathology / condition was the game for? *

Mark only one oval.

- ◯ Post-stroke rehabilitation
- ◯ Multiple sclerosis
- ◯ Cerebral Palsy
- ◯ Other: _____

11. How long did it take to develop the game? *

Mark only one oval.

- ◯ Less than 1 year
- ◯ Between 1 and 3 years
- ◯ Between 3 and 5 years
- ◯ Over 5 years

12. What was the development budget of the full game? *

Mark only one oval.

- ◯ < 5.000 €
- ◯ 5.000 € - 10.000 €
- ◯ 10.000€ - 50.000€
- ◯ > 50.000€

13. Did the development of the game embody the use of a game engine? *

If yes, please pick the "Other" option and specify.

Mark only one oval.

- ◯ No
- ◯ Other: _____

14. What was the programming language used?

_____

15. What kind of device/OS was the game developed for?

_____

16. How big was the team? Which jobs did it abridge? *

_____

_____

_____

_____

_____

17. What creative challenges did you encounter during the game's development? *

18. What were the technological challenges encountered during the game's development? *

19. What are the difficulties to enter the video game market? *

20. From the initial briefing and the final delivered product, how can you rate the engagemen of the client with the development team of the game? *

Mark only one oval.

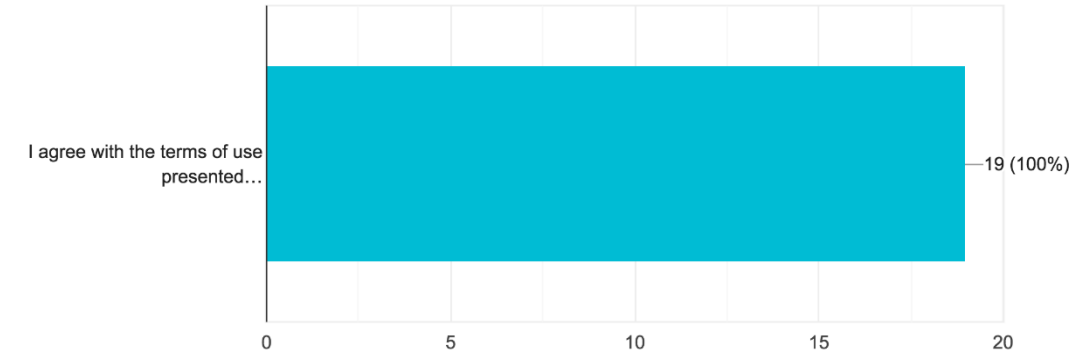
	1	2	3	4	5	
Low	◯	◯	◯	◯	◯	High

Appendix M

Development of Serious Games for Healthcare – Questionnaire targeted at developers

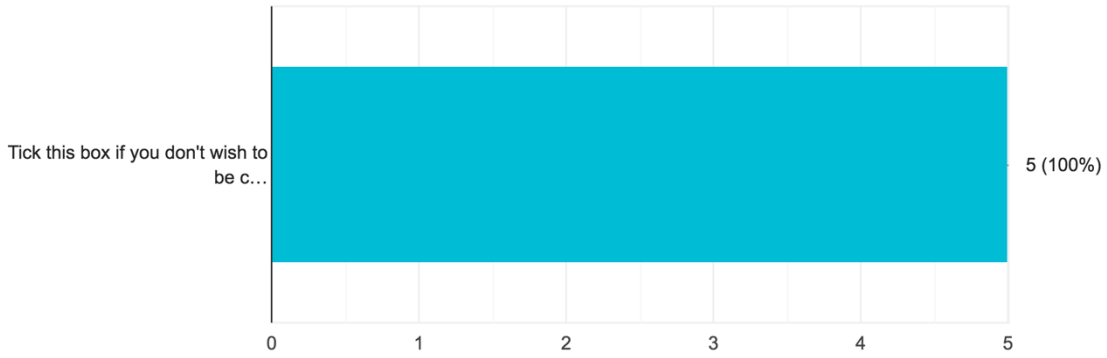
Please read the following information carefully. If you think something is unclear, don't hesitate to ask for more information. If you agree with the everything, please check the respective box.

19 responses



I agree with the terms of use presented above.

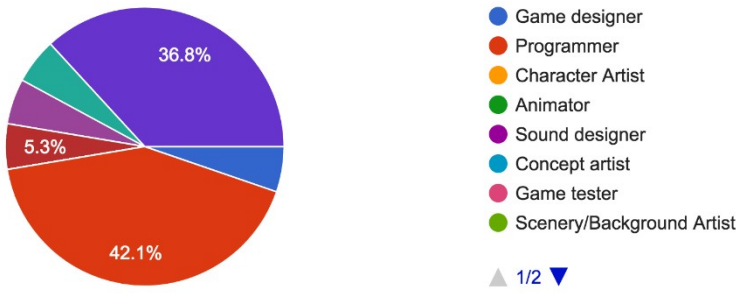
5 responses



Tick this box if you don’t wish to be contacted again.

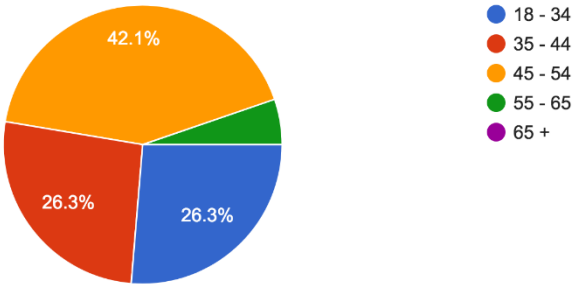
What's your area of expertise?

19 responses



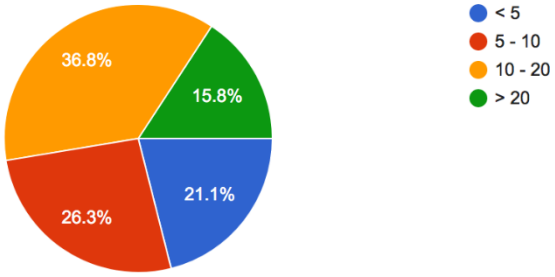
What's your age group?

19 responses



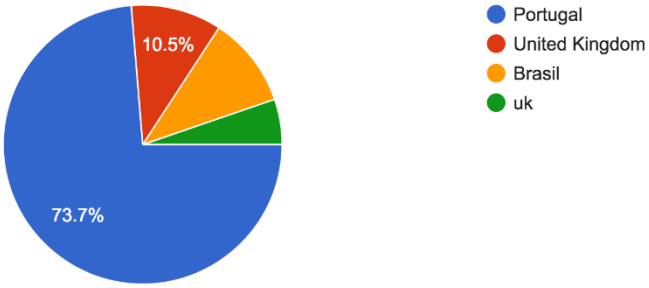
How many years of experience do you have in the field?

19 responses



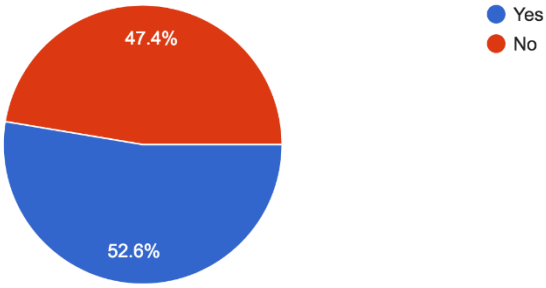
Do you work in Portugal?

19 responses



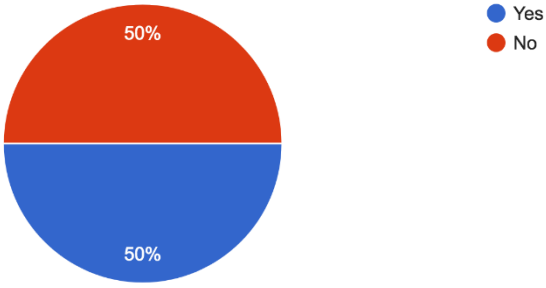
Do you or the company that you work for play a part within the Serious Games industry?

19 responses



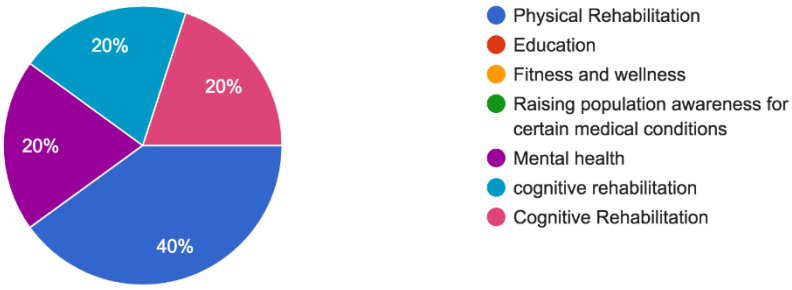
Have you ever participated in the development of a serious game for medical purposes?

10 responses



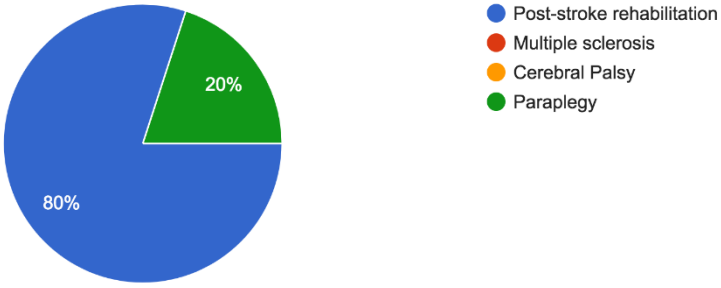
In which medical context was the game developed for?

5 responses



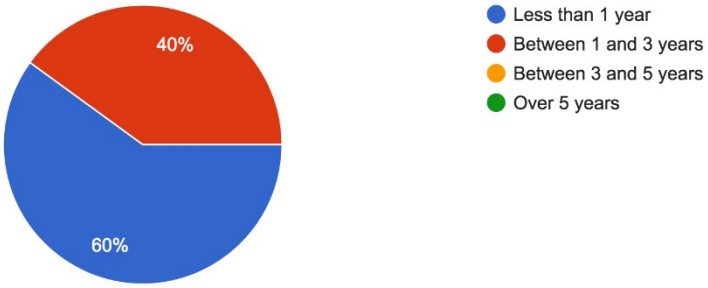
What pathology / condition was the game for?

5 responses



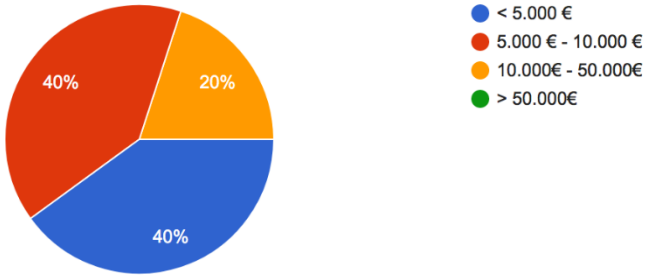
How long did it take to develop the game?

5 responses



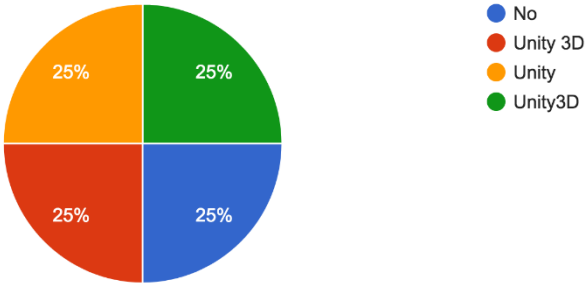
What was the development budget of the full game?

5 responses



Did the development of the game embody the use of a game engine?

4 responses



What was the programming language used?

4 responses

C#

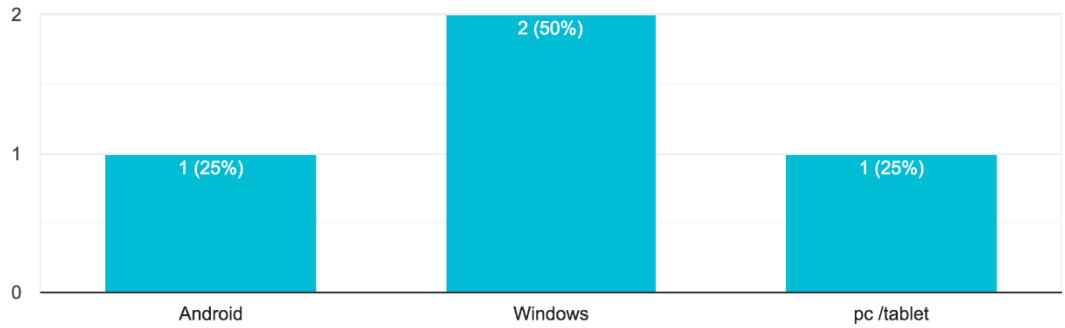
javascript and html & CSS

Unity

c#

What kind of device/OS was the game developed for?

4 responses



How big was the team? Which jobs did it abridge?

5 responses

1 programmer/designer, 1 medical, 1 neuroscience, 1 signal analysis

5

myself - the game was a small prototype for concept demonstration

3

1

What creative challenges did you encounter during the game's development?

5 responses

Create a game constrained by the medical protocol requirements

N/A

to choose a story or goal for a game to be played in cooperative mode by several users; feedback and interface design suited for patients in rehab/senior people; choose interactions mechanisms and game mechanics that could be suited and motivating for patients in cognitive rehab so that they could keep playing

xxx

content development, tracking technology limitations

What were the technological challenges encountered during the game's development?

5 responses

Synchronization of EEG, VR and Thermal-tactile feedback device

N/A

create games that are acessible online so that patients can play at home without having to go to the hospital or rehab clinical; create competitive and collaborative games so that patients can play with others (patients in rehab, family, friends), contributing to augment their motivation to keep playing; create games that can adapt to the patient performance/difficulties

xxx

requirement analysis to define games and gestures helpful in the rehabilitation context

What are the difficulties to enter the video game market?

5 responses

nothing to report

Market's maturity

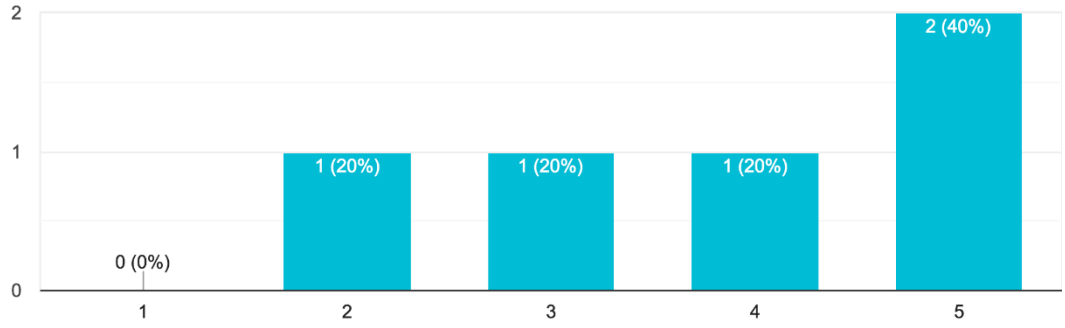
not applicable in my case

xxx

Worke develop within a Mastre thesis -- No intention to enter game market

From the initial briefing and the final delivered product, how can you rate the engagement of the client with the development team of the game?

5 responses



Appendix N

Informed Consent – Professor Carlos Vaz de Carvalho

CATÓLICA
ESCOLA DAS ARTES
PORTO

Serious Games para Reabilitação Física

Este questionário integra uma dissertação de mestrado em Gestão de Indústrias Criativas (Escola das Artes – Universidade Católica Portuguesa) e tem como objetivo avaliar a relevância de utilizar *serious games* (jogos sérios) na área da saúde, assim como averiguar possíveis casos em que esta metodologia já se encontre a ser implementada.

O conceito de *serious game* pode ser definido como um videojogo que é utilizado para um fim que não apenas o entretenimento do jogador mantendo, no entanto, as características que tornam os videojogos apelativos e cativantes que permitem que o utilizador experiencie emoções e sentimentos positivos percecionados como "divertidos". Para além disso, estes videojogos também visam promover algo chamado de "*collateral learning*", isto é, uma forma de obter determinadas capacidades através de métodos de aprendizagem não convencionais.

O objetivo principal da dissertação em curso é avaliar a relevância do desenvolvimento de *serious games* personalizados que respondam às necessidades dos pacientes para tratamentos e terapias específicas.

A metodologia implementada para o desenvolvimento desta investigação começa com uma revisão bibliográfica de autores relevantes, com enfoque no subgénero dos *serious games* e as suas aplicações na área médica.
Num segundo momento, vários casos de estudo nos quais diferentes tipos de videojogos foram utilizados (para melhorar a saúde de pessoas fisicamente incapacitadas) serão analisados a fim de compreender a possível ligação entre o design dos videojogos, a estética dos mesmos, a sua eficácia terapêutica e a motivação dos pacientes. A avaliação efetuada será qualitativa e terá em consideração parâmetros como as condições do paciente (pré e pós intervenção), o contexto, o local onde a intervenção tomou lugar e que tipo de videojogo foi utilizado. De acordo com os resultados obtidos neste passo, uma análise quantitativa poderá ser levada a cabo a fim de aferir a eficácia dos tratamentos em questão. O próximo passo consistirá em trabalho de campo – entrevistas e questionários – a fim de melhor compreender a relevância, pertinência, abertura, disponibilidade e recetividade do uso de videojogos do subgénero *serious games* como algo mais do que uma simples forma de entretenimento. O último passo desta dissertação consistirá na avaliação do mercado e da indústria dos videojogos e dos *serious games*, respetivamente, para entender qual a possibilidade de transformar este tipo de videojogos algo apetecível e rentável do ponto de vista económico.

Consentimento Informado e Livre para Participação em Investigação

Eu declaro que li e compreendi os objetivos deste estudo, no qual serei incluído. Foi-me dada a oportunidade para fazer as perguntas que achei necessárias e recebi uma resposta satisfatória para todas elas. Estou ciente que, de acordo com as recomendações da Declaração de Helsínquia e a Convenção de Oviedo, a informação ou explicação que me

foi fornecida deu-me a conhecer os objetivos, métodos, benefícios antecipados e possível desconforto. Eu sei que não posso esperar qualquer benefício direto para mim, mas sei que irei contribuir para a investigação da relevância do uso de *serious games* na área médica. Também sei que as minhas respostas e os meus dados não vão ter um efeito direto na maneira como vou ser tratado no futuro. Além disso, estou ciente de que tenho o direito de recusar minha participação no estudo em qualquer momento, sem sofrer consequências. Deste modo, concordo com a participação na entrevista.

.....

X Declaro que li e compreendi os termos propostos acima.

Assinatura do participante:

Porto, 28/02/2020

Appendix O

Transcrição Entrevista – Professor Doutor Carlos Vaz de Carvalho — Vice-diretor do GILT (Games, Interaction and Learning Technologies), ISEP – 28 de Fevereiro de 2020

Catarina Vieira (CV): Há quantos anos é que trabalha com os Serious Games e qual é a sua principal função?

Professor Carlos Vaz de Carvalho (CVC): Estou a trabalhar nesta área dos jogos sérios talvez há 15-20 anos. Primeiro de uma forma menos sistemática e depois, a partir de 2005, de uma forma mais sistemática. Neste momento trabalho nos jogos sérios de duas perspetivas: de um ponto de vista mais de investigação/letivo aqui no Instituto Superior de Engenharia, porque eu sou o vice-diretor aqui do GILT, que trabalha nas áreas que têm a ver com os jogos sérios, e o meu trabalho de investigação é aqui. Depois leciono também disciplinas relacionadas, no mestrado em engenharia informática aqui no instituto, nomeadamente uma disciplina específica de jogos sérios e, para além disso, sou diretor de uma empresa chamada Virtual Campus cuja principal função é desenvolvimento de software educativo, no qual nós incluímos também a parte dos jogos sérios.

CV: Em que tipo de projetos é que participa ou já participou?

CVC: Os nossos projetos são na área da investigação, quando são aqui mais pelo instituto. Quando é pela empresa, são projetos mais de desenvolvimento. Na empresa, obviamente, também temos contratos ligados com esta área.

CV: Está, então, principalmente na área da educação?

CVC: Sim, da tecnologia aplicada à educação.

CV: Já fez alguma coisa destinada à área médica?

CVC: Sim e não. Isto da área médica permite considerar muitas coisas. Por exemplo, nós temos jogos para a área cognitiva, para a área mental, que também é uma área médica, embora normalmente quando se referem a área médica, as pessoas pensam logo na parte física. Temos jogos também nessa área.

CV: Que tipo de jogos? Como é que funcionam? Quais é que são os objetivos? Qual é o tipo de gameplay?

CVC: São jogos muito diferentes porque dependem dos públicos a que nos destinamos. Por exemplo, nós temos jogos destinados quer a adolescentes, quer a público sénior e, portanto, os tipos de jogos são muito variáveis. Nós já fizemos jogos de aventura, já fizemos RPGs, já fizemos jogos arcade de ação. É em função do desafio que nós temos em concreto, dessa tal componente séria,... Em função da avaliação que fazemos do público alvo é que depois decidimos qual é o tipo de jogo que vamos implementar.

CV: Utilizam alguma game engine?

CVC: Utilizamos sobretudo o Unity. Neste momento é a nossa ferramenta principal.

CV: Ou seja, a linguagem usada é o C#?
CVC: Sim, sim.

CV: Acha que a parte visual e sonora do jogo pode alterar consideravelmente os resultados?

CVC: Mais uma vez, depende do jogo, ou seja, existem jogos que especificamente dependem muito

da parte visual, do design gráfico do jogo. Mas existem jogos que funcionam mais pela vertente do desafio que é criado ao jogador e, portanto, dependem muito do jogo.

CV: Não se deveria, então, pegar em características dos jogos do sector comercial e transferi-las para os Serious Games?

CVC: O problema principal não passa por aí. A questão são os orçamentos. Nenhum jogo sério, excetuando eventualmente um ou dois, tem os orçamentos dos jogos mais difundidos comercialmente. E obviamente que quanto temos um jogo que tem um orçamento, digamos, de 100 milhões de dólares, em termos de design espera-se que seja muito melhor. E muitas vezes esses jogos até pecam pelo outro lado, que é a parte das mecânicas. Fazem investimento na parte do design e não na parte das mecânicas. Portanto, obviamente às vezes há assim um "deixa andar" porque se focam demasiado na parte séria e às vezes deixa de ser um jogo para passar a ser uma ferramenta educativa ou qualquer coisa do género, do que propriamente um jogo. Este tipo de jogos, neste momento, está muito divulgado na área para o treino físico, mas não são jogos de computador. São jogos físicos, mesmo. Isto é, eu tenho um ecrã à minha frente e tenho de clicar numa determinada posição que vai aparecendo iluminada, mas obriga-me a mexer. Ou seja, é como aquele "Dance Dance Revolution", que tem um tapete e eu tenho de me estar ali a mexer. A mecânica é muito simples – saber onde é que tenho de tocar num determinado momento. Embora, o "Dance Dance Revolution" e esse tipo de jogos depois têm música. Mas, lá está, esse jogo é muito simples em termos de mecânica, mas, para esse fim específico, funciona.

CV: E em relação à narrativa? Acha que é essencial ou também depende do propósito para o qual o jogo é desenvolvido?

CVC: Depende do propósito, naturalmente. Por exemplo, os jogos para o desenvolvimento mental... Nós temos duas versões: temos aqueles jogos tipo brain training, que são jogos quase casuais, sendo jogos muito simples que praticamente não têm narrativa. Mas depois há um trabalho muito interessante que foi feito por uns colegas nossos da Universidade de Vigo, juntamente com a Universidade de Santiago de Compostela, em que eles têm jogos que são equivalentes aos testes psicológicos que fazem para avaliar a questão da demência. O que eles fizeram foi criar um jogo que é um misto de aventura e RPG em que as pessoas têm de executar determinadas ações e aí a narrativa é importante pois é esta que leva as pessoas a criar um contexto que é familiar. Ou seja, são as suas próprias atividades que depois são reconvertidas no jogo. E aí a narrativa é importante. Portanto, mais uma vez, depende muito do propósito.

CV: E no caso dos jogos Multi-player?

CVC: Eu acho que qualquer jogo multiplayer cria um fenómeno de competitividade que é um factor motivador muito interessante. Mas nem toda a gente gosta da competição. Eu, pessoalmente, acho que é um factor motivador muito interessante e funciona muito bem quer em jogos, quer em jogos sérios. Nós criamos um jogo chamado Transforma que é um jogo para desenvolvimento de competências de empreendedorismo. É um jogo de tabuleiro, mas funciona online e aquilo que nós verificamos é que podemos jogar individualmente (standalone) ou podemos jogar multiplayer. No standalone temos uns bots e o computador tem personagens que controla. E a motivação das pessoas é muito maior quando jogam contra outros adversários humanos do que quando estão a jogar com o computador, portanto, é muito interessante. Mas nem toda a gente reage muito bem à competição.

CV: Não será pelo receio de se sentirem expostos ou receio de falhar?

CVC: É isso. Nem toda a gente gosta desse mecanismo da competição.

CV: Em média, quanto tempo é que demora a desenvolver um jogo?

CVC: Depende do jogo. Nós tivemos este aqui *(CVC mostra um jogo no telemóvel destinado a alunos do secundário - Examinator).* Isto basicamente é um jogo quiz com versões diferentes, em que nós temos perguntas e a ideia disto foi criar o jogo para os alunos que tinham o exame do 12º ano porque o

12º ano é um ano complicado e isto serviu para eles estudarem enquanto estão no metro ou no autocarro. Tinham questões e tinham respostas e as respostas também tinham um feedback... Entretanto o jogo está a ser usado desde o 8º ano até ao 12º... Este tipo de jogo demorou 3 meses a desenvolver. Agora temos jogos que demoram mais de um ano. Por exemplo, temos aqui outro *(CVC mostra outro jogo no telemóvel)*... Este foi um jogo que fizemos para prevenção do cyberbullying. Este já é mais tipo RPG.

CV: Então estes jogos são feitos maioritariamente para dispositivos móveis?

CVC: Não, temos jogos para dispositivos móveis, mas temos jogos também para desktop. O jogo que nós temos com "mais saída" é o jogo chamado o eCity, que é um jogo de simulação de cidades. Mas o objetivo do jogo, na realidade, era despertar nos alunos do secundário, o interesse e motivação para vir para engenharia. Dentro desse contexto de jogo, nós criamos uma série de desafios que estão ligados à engenharia. O jogo acabou por funcionar muito bem como jogo. Inclusivamente, no Youtube, há pessoas que pegaram no jogo e fizeram demos de como usar o jogo, e esse jogo existe apenas para Mac e Windows, ou seja, para desktop. Não temos para mobile. Desenvolvemos para todos os ambientes.

CV: E a nível de orçamentos?

CVC: Os orçamentos também variam muito. Por exemplo, aquele primeiro que lhe mostrei, o Examinator, custou 50.000€. Este Geo-Geo, que é um puzzle que fizemos para alunos do secundário, mas que pode ser usado por qualquer pessoa porque é um puzzle geográfico, que, em função de determinadas pistas, tenho de identificar a localização no globo de um país ou de uma cidade, etc...Este também custou cerca de 75.000€. O outro que eu lhe mostrei do cyberbullying já foi no âmbito de um projecto europeu e o valor total do projecto foi cerca de 500.000€, mas esse valor não corresponde exclusivamente ao desenvolvimento do jogo. A parte da análise de necessidade, ou seja, falar com os utilizadores, os custos com a parte de validação do jogo... Quando estamos a falar de projeto, já envolve outras etapas. Essencialmente, os nossos jogos variam entre 50.000€ até 500.000€.

CV: E quanto ao tamanho da equipa e as suas funções?

CVC: Cerca de 10 pessoas - dois designers, 3 da equipa de desenvolvimento, uma ou duas pessoas para fazerem a parte de levantamento de necessidades e fazer o teste e uma pessoa para gerir isto. A equipa foi variando ao longo dos últimos anos mas, em termos médios, é mais ou menos isto que nós temos.

CV: Quais é que foram os principais desafios criativos que foram sendo encontrados?

CVC: O principal desafio é sempre perceber, em função do problema e em função do público alvo, qual é o melhor jogo para essa questão. E já falhamos algumas vezes. Às vezes achamos que, em função do levantamento de necessidades e em função dos gostos das pessoas, há um determinado tipo de jogo que se adapta, e depois, quando o jogo está pronto...Bem, normalmente, não chega a estar pronto porque começamos a falar com os utilizadores antes, como é lógico, fazemos um processo de teste para acompanhar os utilizadores. Mas já nos aconteceu chegar a um estado muito avançado do desenvolvimento do jogo e perceber que, afinal, a solução técnica que tínhamos adoptado não era a melhor. Por exemplo, num jogo que fizemos para a área do empreendedorismo (a ideia do jogo era desenvolver competências de internacionalização para gestores de pequenas empresas, ou seja, para eles perceberem como é que podiam pegar na empresa deles, que era uma empresa geralmente pequena, e levá-la para o exterior) que fizemos para a europa e para a américa do sul, adoptamos um ambiente 3D e depois chegamos ao fim... Os primeiros testes correram muito bem, as pessoas estavam muito interessadas... Mas, se calhar, o problema foi que os primeiros testes foi com pessoas de empresas que estavam muito na área da tecnologia e, portanto, elas reagiram favoravelmente mas depois quando fomos para o mercado com o jogo, percebemos que, afinal, o ambiente não era muito interessante para a maior parte dos nossos utilizadores.

CV: E em relação aos desafios tecnológicos?

CVC: Os desafios tecnológicos, talvez porque somos dessa área, não são assim muitos... Ou seja, os desafios tecnológicos passam por identificar as melhores plataformas para a distribuição do jogo – se é melhor distribui-lo num dispositivo móvel ou para um desktop. Com o Unity, embora possamos fazer desenvolvimento simultâneo para várias plataformas, sabemos que, no final, as coisas não funcionam assim. Portanto, há determinadas restrições a nível de interação com um dispositivo móvel e com um computador. Há restrições a nível de processamento e tudo isso. Nós temos sobretudo de fazer essa identificação de qual é o melhor dispositivo para trabalhar. A nível de desenvolvimento, não temos tido assim muitos problemas. Às vezes até usamos algumas ferramentas que estão um pouco fora do normal, mas não temos tido problemas com isso.

CV: Na sua opinião, quais é que são as principais dificuldades para entrar no mercado dos Serious Games, ou dos videojogos no geral?

CVC: São dois mercados muito diferentes... É assim, o mercado dos Serious Games... Temos duas áreas muito interessantes a nível de jogos sérios: o mercado empresarial e o mercado da saúde, precisamente aquele que está a trabalhar. O problema é que a utilização de jogos, quer num contexto, quer noutro, ainda não está muito bem estabelecida. Ainda existem muitas pessoas que olham para isto com muita suspeição. Portanto, as pessoas que têm o poder de decisão ainda reagem um bocadinho mal quando alguém propõe alguma coisa baseada num jogo. Normalmente, não identifico muito isto em termos de faixa etária, mas acredito que possa influenciar. Mas isto, às vezes, é bem mais da formatação mental das pessoas. Também conheço jovens da sua idade que também dizem que jogos são uma perda de tempo. Mas, eventualmente pessoas com mais idade, terão mais alguma dificuldade em aceitar isto. Neste momento, em fase de introdução no mercado dos jogos sérios, o principal problema é esse: as pessoas com poder de decisão serem um bocado reativas à utilização de jogos e preferirem modelos tradicionais. O que, às vezes, nem são muito eficazes em termos das competências adquiridas.
Depois, também é preciso dizer que, do meu ponto de vista, jogos sérios são interessantes no desenvolvimento de competências e habilidades e não tanto no fornecer conhecimento. Nós conseguimos ter bons jogos sérios a fornecer conhecimento, mas são normalmente muito difíceis de construir. Enquanto que, se nós olharmos para as competências, por exemplo, algo que está verificado e validade cientificamente nos Estados Unidos é que... os médicos agora trabalham muito, quando fazem operações, fazem sobretudo laparoscopias – aquela operação em que eles fazem um furinho e metem para lá um tubo... basicamente, o médico já não trabalha sobre o corpo do paciente. Trabalha com joysticks. E o que eles já verificaram nos EUA é que os médicos que tinham uma prática regular de videojogos tinham muito mais habilidade e destreza física. Inclusivamente, eles recomendam, no ensino superior da medicina, que eles joguem para ganhar essa destreza. Portanto, eu acho que esse tipo de habilidades e competências, bem como outras competências mentais (de resolver problemas, de olhar para um problema e perceber onde é que vou buscar a informação para resolver esse problema, ...) tudo isso se consegue muito bem jogando jogos e, às vezes, nem precisam de ser jogos sérios. Os jogos sérios funcionam muito bem em termos empresariais para as competências sociais – por exemplo, desenvolvimento de competências de negociação, de relacionamento, de liderança de reuniões, de trabalho em grupo... tudo isso funciona muito bem com os jogos sérios. Mas, lá está, estamos a falar de competências e habilidades mais do que propriamente desenvolver um determinado conhecimento.
A principal dificuldade é, então, fazer com que as pessoas que têm poder de decisão reconheçam que isto é uma ferramenta válida. Se calhar, mais difícil na área da saúde do que no mercado empresarial que, neste momento, já está a reconhecer a validade desta abordagem.
Em termos de videojogos puros, é uma questão comercial. Mais do que a ideia, é conseguir um bom *pitch*. Nós vemos aí jogos que tiveram orçamentos gigantescos e que
São, francamente, fraquinhos, porque tiveram um excelente *pitch*. Não basta, de facto, ter uma excelente ideia, não basta ter um excelente jogo. É preciso saber distribuí-lo e saber competir, porque o mercado já está muito estabelecido em torno de determinados conjuntos e grandes companhias. Os jogos *indie* podem ter umas saídas interessantes, as nunca passam de uns milhares de vendas.

CV: Como é que classifica a participação e o envolvimento do cliente? Eles participam ativamente?

CVC: Sim, sim. O cliente tem de estar sempre envolvido. Desde o momento em que fazemos o levantamento de necessidades, seja com o cliente, seja com os eventuais utilizadores finais, acompanhar o processo de desenvolvimento. Como já disse há pouco, nós cometemos um erro num jogo por atrasar o processo dos utilizadores entrarem em cena (e os primeiros utilizadores que entraram em cena se calhar não eram os ideais) e, portanto chegamos a uma fase muito avançada do desenvolvimento do jogo quando percebemos que a solução técnica não era a ideal. Esse erro foi interessante porque nos permitiu perceber que não podemos fazer isso dessa forma, ou seja, o cliente e o utilizador têm de estar sempre envolvidos no processo.

CV: Tem conhecimento da reação dos utilizadores e de quais os resultados obtidos?

CVC: As reações têm sido genericamente positivas. Geralmente, os utilizadores gostam. Às vezes gostam mais pela parte do jogo do que pela parte séria. Os processos de validação que temos feito também levam a concluir que, de alguma forma, os jogos, de facto, contribuem, em fim de série, para o que foi preestabelecido. Por isso é que continuamos a trabalhar na área. Por isso é que continuamos a fazer coisas, porque os resultados têm sido bons.

CV: Havendo possibilidade, compensaria mais utilizar jogos já feitos e disponíveis no mercado (desde que se adaptem à finalidade em questão) ou acha sempre preferível desenvolver jogos específicos para o fim pretendido?

CVC: Se existem jogos que já estão feitos e que nós podemos reaproveitar de alguma forma, e que são bons, porque não utilizá-los? E nem precisam de ser jogos sérios, podem ser videojogos, mas que têm determinadas características que potenciam o desenvolvimento das competências que nós esperamos. Porque não utilizar? Não precisamos de criar a roda mais uma vez.

CV: Mais alguma coisa que acha que possa ser importante saber ou acrescentar?

CVC: Não.

CV: Mais uma vez, muito obrigada por me receber!