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Serious Games for Serious Problems: from *Ludicus* to Therapeuticus

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1. Introduction

Within the primate family, the members of our species are the ones that present the longest period of immaturity. Originally thought as an adaptive evolutionary strategy, since natural selection would only opt for the characteristics that are more "cost-efficient", the longer period of dependency from progenitors is now perceived as a spin-off of another trait-intelligence. As a result of the relative narrow birth canal, humans' offspring need longer time, when compared to other primates, to puff up the cranial volume compatible to the volume and complexity of the brain from where our intelligence levels arise. This means that the cost of brightness leans on the necessity of further time to allow the brain to develop. More specifically, social intelligence seems to be the driving agent. According to Alexander (1987), as humans accomplished dominance over the other species, competition was shifted to their fellow members, which boosted the need to cope with the complex systems of relationships within the group.

The long period of brain development accounts for an increased ability towards the behavioral flexibility needed to deal with such multidimensional network which, according to Bjorklund (2007) is responsible for our species success. This flexibility, and the resulting social, competence are particularly acquired during the time young humans are playing. Since they are born, babies´s senses are stimulated, learn how to use their muscles, learn how to control their body, and, develop the strategies to interact and cope with other individuals by playing games (Papalia et al., 2005). In fact (Rakoczy, 2007) states that games because of the make-believe, in one hand, and of the associate inherent rules, in the other, are the doorway to the entrance on the structured institutional adulthood reality.

Children's interaction with the surrounding elements enables them to understand that the others are potential cooperators which allows them to accept their role as persons and, specially, the opportunity of sharing the same cultural background with others from which they acquire new ways of behavior and new ways of thinking (Rakoczy, 2007). Games enable children to engage more easily in this process.

Playing games is therefore a medium for learning the complexities of human systems. Huizinga (1971) states on his book *Homo ludens*, that playing is the basis of all human societies and civilizations. According to this author, civilizations appear and developed from and through gaming. At this light all human activities emerged from gaming. Philosophy derives from playing with concepts; the language formation relies on playing with sounds and meanings; war rests upon strategy and tactics, two pillars of gaming and art is a form of interacting, or playing, with a perceived reality.

Also, gaming replicate several aspects of a certain reality through a set of pre-established rules. When playing one obey and incorporate the inherent laws of the game. And because of its playful character rules are assimilate with minor effort. Even for games that have no previous standardized rules, the formal guidelines naturally appear along the way with participant consensus.

Even the production of knowledge process is, according to Huizinga (1971), a game. Like a children's game, knowledge production is full with doubts resulting from the uncertain outcome of ones and others players' actions, being, at the same time bound to rules. And it is this duality that provides the ability for knowledge to be produced. The rules made the superstructure, defining the pathway. The uncertainty enables the ability of the player to learn from their attempts and errors, which, is according to Popper the only way to comprehend and acknowledge a certain reality. So gaming seems to be a propeller of human intellectual and social activities.

The impact of gaming as a social activity is underlined by the entertainment industry where the gaming industry is leading the way. The revenues from video games release has relegate the film industry to a supporting role. Video games industry revenues in 2007 were $ 41.9 billion, whereas the movies industry accounted for $ 27 billion (PWC, 2008). Despite most of the innovative techniques came from the military and the academy (the internet, motion detection, artificial intelligence, animation physics and collision detection, among others), video games' companies have picked up from there and open up the Pandora's box to the general public.

Nowadays, many areas of activity use off-the-shelf video games graphic engines to produce simulations. Professionals from fields like urban planning (http://wwics.si.edu/foresight/index.htm), journalism (http://eciencia.urjc.es/dspace/bitstream/10115/.../texto_final_serious_games.pdf), the military (http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.151.4796...), the police (www.dcs.shef.ac.uk/.../SeriousGames4thePolice_AhmedBinSubaih-1.pdf), education (Ritterfeld et al., 2009), or even, cultural heritage (Anderson et al., 2009) were converted to the thrilling visual and audio ascendancy of video games.

When the first goal of such games is other than entertainment they are coined as serious games (SG) (Micheal & Cohen, 2006). SG are upgrades of plain numerical simulations. One of the main goals of computing was, initially, to make possible, within a reasonable frame of time, the execution of long iterative calculi for simulation. The simulation of what-if scenarios was, and still is, a desirable path to follow every time an uncertain outcome arises. In the 60's of last century the USA Apollo program was an example. The Digital Simulation for the Verification of Apollo Flight Software was devised to emulate spaceship flight maneuver (Glick & Femino, 1970). Spaceship trajectory, gravity and sensor errors, among other features, were displayed as form of numbers and letters that were computed while the crew replied back by clicking on a 12 button keyboard (Dunbar et al, 1966). The result of simulations appeared as numerical or alphanumerical data. Nowadays, SG do the same thing. However, and on account of graphic boards and computer generated imagery (CGI) techniques, it is now possible to interact with the computer in a more fashionable way. 3D computer graphics' techniques, invented also in the 1960's, enabled that computer based simulations could be carry on more user-friendly environments.

SG are one of the most notorious off-springs of these developments. The concept behind SG rests on the ability of channeling videogames properties like graphic interfaces, animation, realism, interaction and simulation to a target other than pure entertainment. Zyda (2005, p.26) defined SG 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." But, perhaps what differentiates SG from their videogame ancestry is the ability in producing knowledge and skills that are focused within the application context (Susi et al, 2007). Under this light, Yusoff and colleagues (2009) produced a conceptual framework where learning, within a SG context, is a result of an iterative process that derives from the level of achievement of each player. According to player performance, the system should produce data or information that acknowledges every accomplishments and failures by providing feedback to the player. For each feedback, knowledge is produce enabling to move forward. It is also stressed that the SG must take into consideration its own game attributes that sustain learning and engagement, and the intended learning outcomes i.e. the major goals to attain.

As seen, nowadays simulation is, in most cases, made through the help of 3D models. The 3D perspective enables a better comprehension of the phenomenon under simulation, particularly if the phenomenon presents itself on a 3D fashion, such is the case, of most aspects of our daily lives. Visual perception on human brain relies on different brain areas in the cortex that are specialized in processing different aspects of visual information. For example, color, form and depth are processed on V1 and V2 occipital areas and motion on the medial temporal cortex. This means that the fully understanding, or cognition, of a real three dimensional phenomenon summons up different areas of the brain. Consequently, the cognitive load can be reduced if the object or situation presents itself as much as real as possible. And that is why one image worse thousand words. More effort is required for analyzing and comprehending a complex structure if it is described in the form of words. The same occurs if a 3D reality is displayed in 2D. The load on our brain is higher.

Along with simulation another a pattern arises. Interaction. The user ability to freely experience the digital world is, along with the meaning of the experience, a decisive contribution for a full engagement within the gaming context. Meaningfulness and interaction are therefore responsible for tricking ones brain perception making believe that the participant is actually in the synthetic set. This sense of being there, also defined as presence, is responsible for turning a 3D experience into a virtual reality (VR) adventure. And VR is the keystone of any modern SG.

The ability of the end user to freely and easily interact with the complex synthetic world, alone, or with others have ignited a modern "gold rush". As a consequence, millions are currently engaged on online 3D/VR games. This fact boosted a brave new world. Interacting with the PC is no longer a "thing" for software engineers. In future generations it will be probably hard to find anyone with no proficiency in computing interaction. And this is the casus belli for SG. Due to their inherent characteristics, SG are probably the best option when one needs to replicate a certain reality, real or oniric. Such is the case of the treatment of several mental health disorders or the case of motor and cognitive rehabilitation.

Concerning mental health disorders, more often than not chemical and pharmacological strategies do not work. One common way out is to empower patients through cognitive and

behavioral therapies. In these therapies the patient is confronted with situations aimed at reeducating erroneous beliefs. For example, patients with arachnophobia face spider images or the spider itself as many times needed, until the disruptive fear ceases (Garcia-Palacios et al, 2002).
Regarding motor and cognitive rehabilitation, traditional exercises are more often than not, repetitive and boring, causing, after a few sessions, a break on the meaningfulness of the exercise. Setting games where patient's next action is unknown and where interaction is the keynote may engage more efficiently the patient on the rehabilitation process. Rand et al (2001), developed an augmented reality SG where paraplegic patients exercise torso posture by attempting to reach out for balls that randomly appear on a virtual screen.

2. Serious games for neuropsychological rehabilitation

2.1 Neuropsychological rehabilitation

The cognitive consequences of acquired brain injury can be very diverse and differ in their nature. Lesions can result from infectious or degenerative diseases in the central nervous system (e.g. Alzheimer, Parkinson disease), brain tumors, stroke (e.g. cerebrovascular accident) and traumatic brain injury. According to each condition, lesions can be focal or diffuse, resulting in deficits that range from cognitive impairment or attention/concentration deficits to motor disability. Cognitive impairment is defined by Cooper et al. (2008) as a limitation in the capacity for mental tasks and is often associated with deficit in executive functions. In fact, according to Wang and collaborators (2004) patients suffering from traumatic brain injuries need, in most cases, to relearn almost all daily life activities.
Brain injury can affect all human domains, such as cognitive, emotional, behavioral and social functioning, leading to selective effects in terms of motor or sensory losses, cognitive disability (e.g. memory deficits) and emotional problems, namely, anxiety and depression.
Neuropsychological rehabilitation is related with the improvement of cognitive and motor deficits caused by brain injury. In this way, the major goal of cognitive rehabilitation is to enable patients to overtake cognitive and emotional deficits and to achieve social adjustment and better quality of life (Wilson, 2003).
The scientific literature is in agreement regarding the development of new neuropsychological approaches that need to take on board the scientific knowledge from different areas of psychology. Cognitive rehabilitation can be considered as the use of cognitive theories in rehabilitation of patients with brain injury. The use of theoretical models from cognitive psychology has been quite influential on neuropsychological approaches (Sohlberg & Mateer, 2001). For example, theoretical models for working memory of Baddeley and Hitch (1974) have been critical for memory recover in cognitive rehabilitation programs, as well as the models of behavior and theories of learning (Baddeley, 1993) and cognitive behavior therapy models (Beck, 1976; 1996) for treatment of emotional consequences that are common in patients who suffer brain injury. The study of memory and attentional deficits is also important for many patients with acquired brain injury, even when they are not a primary problem. Once the patient is required to apply skills in real-world settings, demands on attention and working memory often exceed their processing and response capabilities. Patients with acquired brain injuries may find it

difficult to train both a primary task and a simultaneous secondary task. Wilson and colleagues (2006) suggest that these procedures should be supported by visual and verbal cues that can signal attention to obstacles and forthcoming events. According to Wilson (2003) the self-regulation of frustration and loss feelings is another crucial factor in rehabilitation processes. In this way, the main goals of neuropsychological rehabilitation are to promote recovery of patients through the complete understanding of the impact of cognitive and behavioral impairments in their functional disabilities (Ylvisaker et al., 1998).

All validated approaches of cognitive rehabilitation start from a neuropsychological assessment. The complete neuropsychological assessment is important to determine and estimate the impact of each intervention. Cognitive rehabilitation has two different perspectives: internally and externally focused interventions. Regarding the internally focused protocols, interventions aim at training a specific function, whereas externally focused interventions are more related to the environmental adjustment of these patients.

Despite the nature of each intervention protocol, meaningful improvement in patient's everyday life activities is one critical aspect of neuropsychological rehabilitation. However, the focus on function has supported the development of more structured protocols and tools that may benefit the overall adjustment of these patients.

Sohlberg and Mateer (1989) claim that neuropsychological rehabilitation should be based on a theoretical background. For instance, cognitive retraining suggested by Sohlberg and colleagues (2001) is based in the assumption that stimulation of affected functions may help to recover from disability, which can be the case of using computer games to assist neuropsychological rehabilitation.

2.2 Serious games and IT in neuropsychological rehabilitation

Serious games (SG) can be defined, as seen, as games that do not have the entertainment as a primary goal and can contribute to a specific purpose.

Research with videogames has focused mainly in the negative effects of video games at an individual and social level, while other perspectives suggest that videogame play can help to develop cognitive abilities, such as visual and spatial skills.

Early in 1984, Greenfield has suggested that video games could enhance visuo-motor and cognition skills. Later, Green and Bavelier (2003) showed in a controlled study that playing videogames improves the overall capacity of the attentional system measured by the number of objects that can be attended in specific task.

Green and Bavelier (2006a) also studied spatial distribution of attention with video game play. These authors carried out a controlled study to test whether gamers have more attentional resources than non-gamers. The results showed that gamers attend more effectively to stimuli presented in the periphery and in central vision, revealing higher visuospatial attention.

The latest videogames are very challenging and can promote visuospatial attention resources by training task-related attention or vision skills (Green & Bavelier 2006b). For example, "heavy" gamers can train visual skills in an unusually challenging situation, since they are daily exposed to very demanding visual tasks that require visual processing of multiple items. Green and Bavelier (2007) also suggest that videogames could require, in a great extent, the efficient neglect of distracting items, which can enhance visual processing and, thus allocation of attentional resources.

One of the most common procedures in rehabilitation is the repeated and systematic training of the impaired functions, where patients need to practice and relearn lost cognitive and motor functions (Allred et al., 2005). In this way, the study of neural mechanisms involved in learning is a key component for the understanding of video-game practice in rehabilitation.

A study of Koepp and collaborators (1998) found that videogame play may change the release of neurotransmitters (e.g. dopamine) in the brain. Dopamine is a neurotransmitter involved in many functions with important roles in cognition and behavior through reward and learning modulation. The authors studied dopamine levels with positron emission tomography scans during an action video game play and actually observed an increase in dopamine levels during videogame play.

In agreement with these assumptions and according to Sohlberg and colleagues (2001) theory, cognitive retraining is one crucial aspect for neuropsychological rehabilitation. Virtual environments in terms virtual reality SG can provide training environments where repetition, visual and auditory feedback can be systematically manipulated according to each individual differences.

Levin and collaborators (2005) argued that using SG applications in rehabilitation may benefit training purposes, mainly through the 3D spatial correspondence between movements in the real world and movements in the virtual worlds, which may facilitate real-time performance feedback. As stated before, the repetitive practice is an important aspect in motor and cognitive training as it improves performance in disabled patients (Chen et al, 2004). For example, these authors used SG environments in children with cerebral palsy and observed that the repetitive practice of a particular motor aspect enables the coordination of a specific muscular system. While, repeating the exercises, patient's senses are provided with feedback on the accomplishments achieved during each task.

Another example of SG contribution in rehabilitation is the study of Viau and colleagues (2004). The authors studied movements performed by participants with hemiparesis with virtual objects in VR and real objects in real life and found no differences between conditions, suggesting that this VR can be effective as training technique for rehabilitation

Another important issue with neuropsychological rehabilitation is the patient's motivation to perform the predetermined exercises. Mainly because SG and VR are usually presented on a multimodal platform with several sorts of immersive cues, such as images and sounds, patients may be more willing to engage and pursue with the exercise when are performed within a SG or VR setups. In agreement with this notion, Bryanton and collaborators (2006) claim that children with cerebral palsy had more fun and tended to repeat more often at home the exercises in the virtual environments than the conventional exercises.

The wideband technology provides mobile and remote application of the SG virtual environments and brought about a new area of application, the telerehabilitation. Due to the disability characteristics or to the distance from the rehabilitation clinic, or both, an important part of the patients neglect training sessions (Sugarman et al., 2006). The neuropsychological telerehabilitation may take the cognitive and motor exercises to the patients. Lewis and colleagues (2006) developed a telerehabilitation application that enables therapist to communicate, control and monitoring patient's exercises remotely. This system comprises rehabilitation devices such as gloves and head-mounted display on the patient's side and a web camera and headphones on the remote therapist side. Although, it requires the effective participation of the therapist on rehabilitation procedure, this limitation may be overcome by the replacement of the therapist by an avatar. This synthetic person, armed with artificial intelligence, can coach the patient throughout the rehabilitation exercises dismissing therapist's involvement. However, there is lack of information regarding the effectiveness of this approach and the results are unclear at this point.

More recently, Gamito and collaborators (in press) have addressed this issue and studied an online portal to train memory and attention in patients with traumatic brain injury (Figure 1). The study was carried out on single 20 years old male patient with traumatic brain injury where the he had to complete a set of 10 online VR sessions. The patient was assessed before, during and after training with neuropsychological measures for working memory and attention. In this case study, the authors found an improvement in cognitive abilities suggesting that this online VR platform can be effective for cognitive rehabilitation of TBI patients.

Fig. 1. Online VR platform for cognitive telerehabilitation of TBI patients (Gamito et al. in press).

The same authors suggest that on a virtual environment, training can be perceived more as a game and less than a task, engaging the patients in the rehabilitation process more than the conventional methods.

In the future, the dissemination of these procedures may benefit with the development of game platforms, such as Wii, Xbox, Playstation that may also contribute to enhanced and more user-friendly training environments, where systematic training and real-time feedback can occur, as can be seen on the last section of chapter.

The principles of rehabilitation are grounded in different theories, however, it appears that the common procedure to all different approaches is that stimulation of impaired functions can promote faster recovery of the affected cognitive or motor skills and, as consequence, may contribute also to self-esteem, emotional well being and the overall social adjustment of these patients. Within the cognitive retraining perspective of (Sohlberg et al., 1989) and with virtual environments derived from SG and VR applications, training can be more effective since it provides a more ecologically valid technique which will ensure the transfer of learned skills to real-life situations.

3. Serious games for mental disorders

3.1 Mental diseases: facts, numbers and traditional treatments

One may think that mental disorders affect just a small part or specific layers of society; however, they are widespread in the population (Kessler, et al., 2005a), being the leading cause of disability in the U.S. and Canada (WHO, 2003). It has been shown that around 57.7

million people have diagnosable mental disorders (U.S. Census Bureau, 2004), according to a reliable established criteria (APA, 2000). Around 26 % of the Americans suffer from a mental disorder in any given year and 45 % of those meet the criteria for two or more disorders, usually related to co-morbidity (Kessler et al., 2005b).

Under the *mundus* of mental illness, a wide range of psychopathologies can be found. The most common type of mental disorders in psychiatric population are the anxiety disorders (AD) with a 18,1% of incidence and a lifetime prevalence of 28,8%, (Kessler et al., 2005b). AD is a supra category which include panic disorder, obsessive-compulsive disorder, post-traumatic stress disorder, generalized anxiety disorder, and phobias (social phobia, agoraphobia, and specific phobia) (APA, 2000). It is estimated that nearly 40 millions of American adults have an AD in a given year, representing 18 % of the American population (U.S. Census Bureau, 2004; Kessler et al., 2005b). Furthermore, AD commonly co-occur with others mental disorders and normally lead to relapses (Kessler et al., 2005b).

Another very common type of mental disorders are the mood disorders, which include the depression disorders and the bipolar disorders (APA, 2000). The unipolar depression and bipolar affective disorders are on the top ten of the leading causes of disability worldwide (Murray & Lopez, 1996). It is estimated that major depression affects approximately 14.8 million American adults (U.S. Census Bureau, 2004; Kessler et al., 2005b). Moreover, major depression is the leading cause of disability in the U.S. for ages 15-44 (WHO, 2004).

Although, not so common, schizophrenia is known to be a highly disabling disorder. In a 1999 a study conducted in 14 countries, schizophrenia was ranked as the third-most-disabling condition just after quadriplegia and dementia (Üstün et al., 1999). A meta-analyses study conducted by Bhugra (2005) revealed that the median prevalence of schizophrenia was 4.6/1,000 for point prevalence, 3.3/1,000 for period prevalence and 4.0/1000 for lifetime prevalence.

The typical treatments for mental disorders can be categorized in pharmacological or nonpharmacological (Gazzaniga & Heatherton, 2006). Pharmacological treatment includes several main groups. In mood disorders, Tricyclic antidepressants (TCAs), Selective Serotonin Reuptake Inhibitors (SSRIs) and Serotonin and Norepinephrine Reuptake Inhibitors (SNRIs) are the mostly employed (Hirschfeld & Vornik, 2004). Anxiolytics are used, generally shorter-term, for AD (APA, 2000). A sort of anxiolytics, like benzodiazepines prescribed for short-term relief, azapirones, barbiturates, meprobamate and non-cardioselective beta-receptor blocker are the mostly applied for AD (Goodman, 2004;). On other hand, antipsychotics are usually prescribed in schizophrenia (Davis & Adams, 2001). However, antipsychotics may provoke extrapyramidal reactions with a range of side effects like dystonias, akathisia, parkinsonism, tardive dyskinesia, tachycardia, hypotension or even impotence (Bellack, 2006).

Among nonpharmacological treatments, cognitive–behavioural therapy (CTB) is the most frequent in AD (Hofmann & Smits, 2008) , mood disorders (Gloaguen et al., 1998) and schizophrenia (Wykes et al., 2008). Interpersonal psychotherapy is also commonly applied, with positive outcomes in depression (Weissman et al., 2000).

Indeed, a larger body of literature suggests that CBT for AD are the non-pharmacological most effective approach (Craske, 1999), with an effectiveness relatively similar across AD and most efficacious that non-CBT treatments (e.g., Abramowitz, 1997; Fedoroff & Taylor, 2001;). These findings are not surprising, since that most treatments consist of therapeutic techniques of education, self-monitoring, cognitive restructuring and exposure therapy.

For treatment of AD, exposure therapy is the most common and effective psychotherapeutic technique (Foa et al., 2000). This efficacy in AD, may be explain by the common denominator for all AD, that is, a distinctly and abnormal increased fear response. When fear becomes more disproportionate than what is justified by the external threat and there is a clearly interference with the ability to function optimally, then the criteria for an anxiety spectrum disorder is met (APA, 2000).

This fear response has been related to an amygdalar dysfunction (Williams et al., 2006). The amygdala consists of 13 nuclei located in the anterior medial temporal lobe and has a key role in fear regulation (Hamm & Weike, 2005). Three of these nuclei, the basal amygdala, lateral amygdale, and central nuclei, are implicated in the pathways of fear response (Paré et al., 2004). Threatening cues are received by the sensory thalamus, sent to the lateral amygdale, and subsequently transmitted to the central nucleus. This circuit is known as "short loop" pathway. The long information processing circuit (long loop pathway) sends signals to the lateral amygdale from the sensory cortex, insula, and prefrontal cortex (LeDoux, 2000). From there, the information is projected to the effector spots in the brain stem and hypothalamus, which produce the autonomic and behavioral expressions of fear response.

Similarly, a number of studies reported an increase in amygdalar activity in specific phobias (Larson et al., 2006). According to Ledoux (2000), a threatening cue representing a potential danger, causes an automatic, quick protective response that occurs without the need for conscious thought. Despite the influence of neurobiological aspects, some models refer the weight of cognitive factors on AD development and maintenance.

Exposure therapy as a therapeutic technique involves the exposure to the feared stimulus or context without any danger while the psychotherapist relieves patient's anxiety (Rothbaum & Schwartz, 2002). Traditionally, exposure therapy adopts two different paths: imagination or *in vivo*. In imagination exposure, the patient will be exposed himself/herself to all the scary parts of ansiogenic situation – but just mentally. *In vivo* exposure consists on direct confrontation to feared objects, activities, or situations by a patient (Leahy, 2003). However, new forms of treatment (with preference low-priced, fast, creative and effective) are being been wished for not only for patients but for therapists as well. The advance of technology brought new approaches and new therapeutic techniques.

3.2 Serious gaming: a new iceberg peak is emerging

Exposure therapy, within in CBT context is the most reliable intervention type when it comes to treat AD. In some of these disorders, *in vivo* and in imagination exposure fails to deliver sound results (Parsons & Rizzo, 2008).

For example, imagination exposure is somewhat ineffective in PTSD and *in vivo* exposure is far from being cost efficient in fear of flying. It is difficult to compel patients with PTSD that had suffered traumatic events to re-experience or relive those events through imagination (i.e. War PTSD, Motor Vehicle Accidents, sexual abuse). And regarding fear of flying, the amount of time spent and the associated costs of *in vivo* exposure narrows down the number of possible patients.

VR-based SG can replicate almost in perfection any of these ansiogenic situations, with less costs and in less time, given a better solution (ratio cost/efficacy) in AD treatment.

To bypass impediments such as these, SG were developed as a reliable and alternative therapeutic technological technique (TTT). The increasing accessibility to powerful personal computers and 3D visualization techniques made the development of SG and its use on psychotherapy, a tool for treating most AD. VR is actually one of the fields that, within the SG application content, yields a more promising future since it allows an even greater immersive experience and a more realistic approach.

VR holds a set of important features that, allied to the characteristics of SG, ensure a fruitful solution for many situations. One of these characteristics is the rich interactive simulation that VR encloses. The interactivity on a full sensory environment created to a specific end ensures that the objectives of exposure (in whatever field of application) are met in an easier and more controlled way than in traditional imagination exposure. In this way, VR-based SG might be an adequate technique due a better approximation to the real word (Vincelli & Molinari, 1998; Vincelli & Riva, 2002), inducing higher levels of immersion when compared to imagination exposure (Botella et al., 2000; Rothbaum et al., 1995; Vincelli & Riva, 2002).

Furthermore, VR allows the development of settings that ensure that ecological validity is taking in consideration. For instance, in cases of fear of subway, before getting in the railway carriage, patient should enter in the subway station; buy the traveling ticket, stamp it and then wait for the train to come (Figure 2).

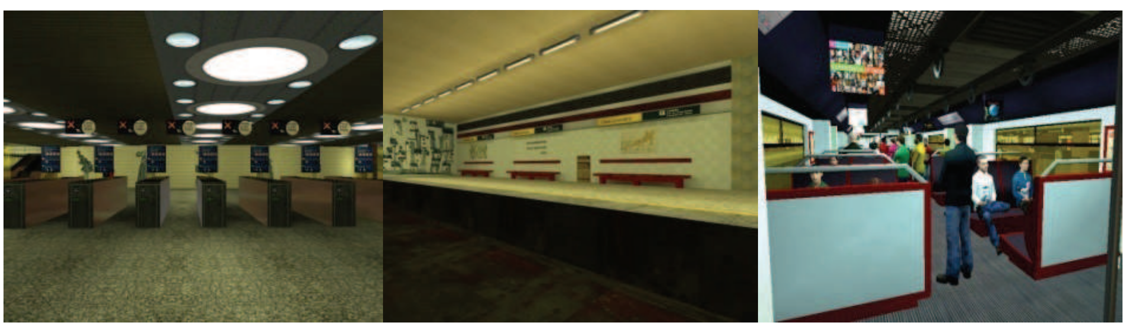

Fig. 2. Screenshots of VR-based Serious Game for Agoraphobia Treatment developed by the Psychology Computional Laboratory of the Universidade Lusófona de Humanidade e Tecnologias, Lisbon, Portugal.

This element, in conjunction with the increased engagement that VR brings to any (serious or not) videogame, is an important feature for every multimedia application, and was taken into consideration since the beginning of the development of these tools. In some situations, namely psychotherapy, the novelty of the situation in which the participant is involved also ensures that the objective of SG is pursued in an easier way.

The impact VR-based SG has been felt in a far-reaching range of fields over the last years, being effective on treatment for anxiety, phobia, PTSD, stress inoculation training, pain and drug and alcohol addiction (Wiederhold & Wiederhold, 2008). More specifically, VR-based SG are being used to in clinical populations with acrophobia (Emmelkamp et al., 2001), arachnophobia (Garcia-Palacios et al., 2002), claustrophobia (Botella, 2000), fear of flying (Rothbaum et al., 2000), fear of driving (Saraiva et al., 2007) or PTSD (Gamito et al., 2008, 2009, 2010).

The hyper realistic threatening stimuli provided by SG lead to higher attention (Vincelli, 2000), and subsequent encapsulation, which means, once the fear system is activated it is difficult to control fear response by verbal instructions or stimulus consciousness (Hamm & Weike, 2005). According to Vincelli and Riva (2002) SG reduce then, the gap between reality and imagination, by diminishing potential distraction or cognitive avoidance to the threatening stimuli.

These and other studies revealed that this type of gaming enables patients to be immersed in the virtual world creating the so called "sense of being there". This sense, also coined as presence as mentioned in the introductory section of this chapter, allows patient to interact with virtual world like if he or she were truly in a real environment (Ditton et al. 1997). In addition, in SG, therapist may also have full control on the virtual world, being able to add, or withdraw, threatening cues according to patient and treatment requirements (Gamito et al., 2008).

SG can be thought in the prior terms as a masked exposure therapy technique with specific features embedded like novelty, playfulness, control and security that rely on the key process – the desensitization (Wolpe, 1973). Controlled studies have continuously shown that this combination of SG with traditional therapies results in more successful outcomes (Hoffman et al. 2000; Gamito et al., 2008, 2009, 2010).

The potentialities and benefits of SG have been demonstrated specially in PTSD studies (Rizzo and et al., 2006; Gamito et al., 2008; 2009). PTSD is a special case of AD, characterized by unique symptoms (e.g. dissociation, nightmares, flashbacks) which are not present in other AD, suggesting either different or deep emotion deregulation. (Ethin & Wager, 2007). PTSD patients typically re-experience the disturbing incident and engage the avoidance to stimuli linked to the traumatic scenario. These patients also present an impairing recall of events connected to traumatic scene and an autonomic hyper reactivity (APA, 2004). It has been also suggested that PTSD patients tend to have abnormal levels of key hormones implicated in fear response, namely lower cortisol levels and higher levels of epinephrine and norepinephrine when compared to non-patients (Yehuda, 1998).

Now is possible to reproduce in SG cues of events that are not replicable in a real life situation (Rizzo et al., 2006). SG appears to promote the visual, auditory and olfactory memory, activating other related memories and experiences such as cognition, affect, and physical sensation. Under SG, PTSD patients report physical (sweating, shaking knees) and emotional symptoms (feeling scared or uncomfortable) associated with the stored memories of the traumatic events. In general, SG provide a link between the patient's reality formed by his or her memories of the traumatic event and the objective world. The current studies with VR-based SG revealed that gaming aspect of the treatment also helps to reduce the stigma associated with getting therapy (Gamito et al., 2008, 2009, 2010).

In the field of specific phobias (e.g. snakes, spiders, dogs, pigeons, etc.), SG may become the first option for exposure therapy, in the way that is safer, less embarrassing, and less costly than reproducing the real world situations. The traditional exposure therapy can be, more often than not, a barrier to treatment. It is known, that only about 20% of phobic individuals seek treatment because they are too stressed by the thought of being exposed to the feared/avoiding stimuli (Bender, 2004).

In traditional exposure therapy, patient engagement in the therapeutically process is sometimes compromised. Phobic individuals tend to have difficulty in imagining, visualizing or describing the phobic situations, which, eventually, makes it hard to reproduce *in vivo* or to assess the level of avoidance in imagination exposure. This is the point that VR-based SG can be of distinctive help, by immersing phobic patients into a not-so-virtual world, in which they can live and relive as their own.

Regarding patients with fear of flying (Rothbaum et al., 2000), and acrophobia (Emmelkamp et al., 2001), SG can offer a superb visual and auditory cuing, allowing simultaneously therapists to generate and control the entire virtual world via computer. The virtual worlds allows then a simultaneous delivery of trigger stimuli including visual, auditory and tactile (bass shaker or vibration platform) originating an immersive and multimodal experience (Gorini & Riva, 2008).

SG has improved the chances of recovery in wide range of AD. Therapeutic benefits of SG not just take place in PTSD or specific phobias. The effectiveness of SG has been also tested with non-specific phobias.

A non-specific phobia is a more generalized fear, similar to specific phobias, but where the fear appears to be associated to something less discrete (APA, 2000), such as the fear of open spaces or agoraphobia.

Agoraphobics were exposed to VR-based SG, in which virtual open spaces were presented, revealing that the negative attitudes toward agoraphobic situations decreased significantly (North et al., 1996, Botella et al., 2004).

Also in claustrophobia, SG proved its efficacy. A VR-based SG was played throughout several sessions, in which patients were exposed to a customized hierarchy of feared situations. The results showed that anxiety was reduced and maintained at one month follow-up (Botella et al., 2004). It is also important to stress, that the previous claustrophobic related SG were enough real to produce a significant level of anxiety in patients. Another advantage found in SG derives from the possibility to return to lesser anxiogenic level every time the anxiety level becomes overwhelming. Similar to a remote control, a gameover order is at a click distance. The SG also gives an additional benefit to recreate physical sensations that agoraphobics or claustrophobics feel during their panic attacks, such as shortness of breath or blurred vision. (Botella et al., 2004). In a gastronomic analogy, SG allows therapists "to serve" à la carte anxiogenic scenarios, depending on the severity and specificity of each client.

SG benefits may also be spread to other range of psychopathology like schizophrenia. SG developed for social phobia, claustrophobia, and other AD are likely to be applicable to psychosis (Freeman, 2008). VR-based SG can be used with schizophrenic patients, where some complex deficits are able to be measured. It looks like that SG can be also a promising TTT for the understanding of schizophrenia and other brain disorders. SG in schizophrenia is not only a TTT, but a methodology that helps the understanding of functioning of schizophrenia and a new form of diagnostic as well (Josman et al, 2009). According to Freeman (2008), there are some SG applied on schizophrenia treatment, which can teach about the factors that make symptoms better or worse by indicating how emotional state affects hallucinations, or by helping the schizophrenics to learn about the effects focus of attention or style of reasoning.

Regarding mood disorders, SG has not been applied as a TTT itself, but rather, as a method to understand depression. VR-based SG are seen as new tools for assessing the link between depression and the hippocampus. According to Gould and colleagues (2007), when the spatial memory is challenged by a VR-based SG, patients with depression perform poorly on game compared with non-patients, suggesting that their hippocampi were not working appropriately.

The employment of SG in mental illness does not stop here. The VR-based SG are frequent applied on eating disorders (Perpiña et al., 2003) or in sexual disorders (Optale et al., 2004). A VR-based SG, including a cognitive behavioral therapy (in order to have an influence on the sensations of displeasure) and a visual-motor therapy (to mediate the body perception levels) showed effectiveness in the eating behaviors (Riva et al., 2003, 2004). Furthermore,

SG cannot be only a TTT, but also can be used as a method in the evaluation process, in order to assess the body image perception (Riva et al., 1998).
In relation to sexual disorders, SG were applied by Optale and colleagues (1998, 2004) in several studies. All of them revealed that SG increase the positive outcomes. The results suggest that SG when combined with psychotherapy may accelerate the therapeutic process, leading to a satisfactory sexual performance.
Not so related with mental illness, but still an important topic, is pain distraction. It is common during medical procedures patients feeling excessive pain (Melzack, 1990), especially during severe burn injuries care (Carrougher et al., 2003). Hoffman and colleagues (2001) found that VR-based SG can perform as a virtual nonpharmacological analgesic. The patients who played SG reported significant decreases in their pain ratings during the game as an important part of the patient's attentional focus was shifted away from the pain. These results are corroborated with large range of studies in pain, which point out SG as a reliable method for use as an adjunct to medication in pain control (e.g. Gerson, 2003; Stelle, 2003).

4. A shining and bright new future

The future of SG technology and its fields of applications is intimately related to the development of traditional videogames, medical science and military industry. SG have evolved at the same pace traditional videogame industry have, following however some other strategies to ensure that their specific demands are met.
This is the case, as discussed before, of virtual reality (VR), which has been one of the most used technologies in SG and constitutes an important leap towards the full implementation of these type of games as a valuable resource in many issues.
One of the most important technologies associated with VR, the Head Mounted Displays (HMD), which are supposed to promote an engagement experience through head tracking and stereoscopy, have been developing at a good pace. In the early days of VR in SG, most of the fields concerning VR applications were centered along the constraints, such as cybersickness, equipment ergonomy and image definition of these equipments, in a pursuit of a fully immersive experience, without compromising comfort and usability.
Recent developments in multimedia industry, such as high definition (HD) and 3D TV sets may contribute for bridging the gap between reality and the virtual reality exhibit on HMD. High definition and 3D displays improves the sense of realism and provide stereoscopic perception, reducing discomfort for the user.
If interactivity in SGs is an important feature, one can state that motion detection is a very interesting technology concerning SG, and more specifically, neurological/physical rehabilitation. This technology has suffered a dramatic evolution in the last 10 years, and its use is now widespread in the videogame industry. Nintendo was the first big company to tackle this issue, and most of the attention being drawn upon this technology can be attributed to the Japanese manufacturer. This success had to be met by their competitors, and both Playstation 3 (Sony) and Xbox 360º (Microsoft) now offer similar solutions on this engaging technology, that allows that real movements on the user to be recognized as virtual movements by the console and, therefore, a substantial increase in the level of interaction and meaningfulness can be achieved. This is an important resource for the professionals of both motor and neurorehabilitation, and even though some studies have proven the efficacy of SG as a method of rehabilitation (Rizzo, A. & Kim, G., 2005; Broeren,

et al. 2006), there are still some bumps to cross, concerning this technologies. The major issue is that Wii games (which are the ones currently in sale worldwide) were not created to this specific end. These games were created to deliver entertainment and in order for them to work as SG, investments in some of the available applications must be made, or a ground-up development of new ones, must be done, including, of course, the involvement of neurorehabilitation professionals. Even though Wii is a closed system, in the sense that all the development of new applications have to be approved by Nintendo, some game development tools, like Unity 3D, offer the possibility of developing new products for neurorehabilitation by third-party development teams. These projects, frequent in the Personal Computer (PC) scene, would clearly benefit with a parallel development in this particular system due to its almost unique features.

Another prospective feature that will increase the level of realism in this sort of applications will be the continuous development of graphic engines used in videogames. In the last five years, the increased power of both development and end-user equipments has brought up a surge of more realistic features in most videogames, which can, in the long run, allow for more sophisticated applications especially in the areas where SG are still unable to achieve the desired results, such as Post-traumatic Stress Disorder (Rizzo et al, *in press*), depression (Baños et al, 2006) or autism (Strickland, 1997). It is important however to affirm, that in some pathologies, the problem is not merely related to technological issues. In fact, and considering PTSD, the problem may reside much more in the inadequacy of therapeutic approaches than in the technological development. Nevertheless, the so called new generation videogames consoles and PC that use Direct X 10.0 and 11.0 still have an enormous margin for improvement, and the most pressing issue is to create synergies with the videogame industry, in order to get the most out of current and future videogames in a "more serious" perspective.

SG will also amplify its presence in the educational context, as more and more solutions are being found to increase the appeal and effectiveness of teaching. The main reason is that traditional formats of teaching find it hard to reach children that are getting more and more used to rich-media contents. Therefore, SG are a fun and integrated way to maximize the educational potential at school or at home, giving learning the same resources that entertainment has for competing for children's attention. An interesting experience being implemented using SG is the Magellan Initiative in Portugal, which is a similar project to the One Laptop per Child (OLPC) initially developed in the US. Both includes a series of applications that attempt to conjugate the potential of videogames with the learning process of early years. The initial results where a little off what was initially expected, especially because of some issues regarding the updates and configuration of the software. However, most teachers considered it a valuable resource for years to come, if the abovementioned issues can be resolved quickly. This is just an example of the role that SG can have in education, but in this case, the development of the application was specifically made to this purpose.

Furthermore, online collaborative 3D environments, especially taking into account the massive success of MMORPG (Massive Multiplayer Online Role-Playing Game), can also pose as an excellent tool for online and distance learning. In fact, many universities offer distance learning solution in some of their courses, and some online 3D communities have developed far beyond their initial role. One the most compelling examples is Second Life.

This online community has allowed, in the last few years, a sound display of the potential of Internet and online communities as places of knowledge and information exchange. Many universities and even some individuals scholars have used this platform to give some conferences and lectures, where hundreds and even thousands of people can gather, from all over the world, and watch is for free. This platform was conceived to work as similar videogames (like The Sims series, one of the most successful videogame in history), but allowing oneself to interact fully with others, living a virtual "second life".

Some other applications are now being tried. Governments of countries, like USA and the UK, are turning to SG in order to find a way to make people understand the consequences of social and political issues that are changing the geopolitical landscape after the financial crisis that started in 2008. Furthermore, and in a more holistic approach, some of these games (which are still in development in some of the world's most well known software houses) intend to ask players some out-of-the-box solutions for these "serious" problems. Therefore, SG are beginning to play an important role as a liaison between politicians and the people they represent. This can also be seen in the attempt that the British Government is doing to use Facebook as a tool for feedback and solution discussion for some of the most pressing issues concerning this financial and economic crisis.

Some other less conventional forms of SG have been developed in the last years. Some of these games can be employed as propaganda, using an apparent form of entertainment to get some message across. One of the clearest examples is Full Spectrum Warrior. This is a war simulation videogame that was used, by the United States Army, to display its military prowess and technological edge over other nations (Dgansetheman, 2005). This game, however, was not developed with this objective, but was then adapted to fit the US Army's agenda. This is just a new way to reach people with a specific political agenda, and it is no different than other forms used in the past (like comic books or cinema). But the most prolific example of the extraordinary reach of SGs and the investment being made in this format is America's Army (AAs) videogame (Becker D., 2004). As is a videogame developed by Virtual Heroes for the US Army as a traditional videogame. However, its scope goes far beyond entertainment since its major goal was to create an online platform for recruitment. The enormous success of the videogame (even though there are no clear numbers as far as the efficacy of this recruitment method) is very clear, since there are more than 5 million registered users and is one of the top five most played online videogames. Results like this are evidence enough to support similar endeavors in the future and probably other military forces will develop similar applications for the same end.

SG are also playing a role on a community with a diverse agenda. Advertisements on videogames is now a reality turning entertainment games into platforms that have other than the cheerful objective of playing (Susi et al. 2007). Nevertheless, like political propaganda or army recruitment, advergaming is a strategy being used by many companies to achieve a greater connection with its audience, but most of all, to ensure that a specific brand or product builds its base of consumers of the younger generations. The most troubling issue is that most of these products are very similar to traditional videogames which can be a bit of a problem to some consumers. Moreover, it is important that the "intrusion" of advertisement in videogames, that is becoming a more serious investment for major companies, does not "backfire", as there is still a high level of resistance to these sort of advertising strategies.

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Technological advancement in graphics and other human motion tracking hardware has promoted pushing "virtual reality" closer to "reality" and thus usage of virtual reality has been extended to various fields. The most typical fields for the application of virtual reality are medicine and engineering. The reviews in this book describe the latest virtual reality-related knowledge in these two fields such as: advanced human-computer interaction and virtual reality technologies, evaluation tools for cognition and behavior, medical and surgical treatment, neuroscience and neuro-rehabilitation, assistant tools for overcoming mental illnesses, educational and industrial uses In addition, the considerations for virtual worlds in human society are discussed. This book will serve as a state-of-the-art resource for researchers who are interested in developing a beneficial technology for human society.

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