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A GAME A DAY KEEPS THE DOCTOR AWAY: A SHORT REVIEW OF COMPUTER GAMES IN MENTAL HEALTHCARE

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Computer games are currently a focal topic in different research areas. One of the emerging contexts for their use is represented by healthcare. Thanks to their potentialities, they have been successfully exploited in this domain to foster motivation and to enhance cognitive processes. This paper proposes a review of existing research on computer games, exploited for prevention, support, training, rehabilitation, and particularly stressing the relationship between cognitive processes and gaming.

1. Games and Videogames

1.1 The Double Soul of Game

Playing is an activity that everyone has encountered more than once during his/her lifetime. Trying to provide a definition of games, Caillois (1957) identified some distinctive traits characterizing this activity. First of all, games are based on a free participation, and their development is circumscribed in time and place. Games are structured according to specific rules and the activity's outcome is unpredictable. Finally, players are well aware of the existence of this different reality, where norms and behaviors usually enacted in our daily life are temporarily suspended.

Developmental scientists have underlined that playing affects cognitive processes. Piaget (1945), for instance, observed that different stages in the psychological development of children correspond to different stages in play development. The perceptual play, based on perceptual and motor pleasure characterizing the first months of life, is substituted by the symbolic play, individual and subjective, focused on imagination and fantasy. Later, even the symbolic play will be gradually replaced by games with rules, involving a group of participants with different and specific roles imitating the real world. According to Piaget, the passage from symbolic to ruled games would also mark the appropriation of moral values (Piaget, 1932).

This Piagetian distinction between imagination and rules in play has been further developed by another important psychologist, Vygotskij (1967). He claimed that the effects of culture are visible even in the phase of symbolic play, as every imaginary situation includes social rules of behavior. For example, children will play Mom, reproducing the practices of what can be called a "maternal behavior".

If Piaget and Vygotskij depict children as sponges absorbing social and physical inputs from the environment, a constructivist approach to game interprets this activity as a process for the construction of meanings (Farné, 2005).

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Manipulating objects, accomplishing tasks and activities the child is also actively shaping an idea; stimulated by his/her needs and the pleasure to explore, playing the child will learn to know his/her environment.

Cognitively, different games involve different kinds of skills. For instance, games based on a limited set of rules (e.g. board games or card games) and, consequently, a constrained number of possibilities in terms of played moves, engage perception, memory and thinking processes. Differently, the fact of having to rely on luck, as in lottery games, seems to involve mainly decision-making processes (Rogers, 1998).

Even though developmental advantages supported by games could not be good reasons to make children and adults play, entertainment and fun are. In fact, games have a double soul which emerges in their being entertaining but also educational (Myers, 1999). The entertainment dimension highlights the emotional experience, which increases the attractiveness of the game beyond its educational aim, and involves every age; for this reasons games can be considered powerful tools for training and clinical settings (Hartmann, 2002; Russ, 1995; Hopkins, and Wober, 1973; Morales-Sanchez, Arias-Merino, Diaz-Garcia, Cabrera-Pivaral, and Maynard-Gomez, 2007; Carter, Mackinnon, and Copolov, 1996).

This paper aims at providing an overview about studies investigating the relationship between game activity and cognition. In particular, a specific kind of game will be taken into consideration, namely “computer games”, and linked to its application in the healthcare domain. The paper is structured as follows. Next part will be devoted to the presentation of videogames and their peculiarities. Then, in part 1.3, the relationship between video games and cognition will be discussed. In section 2, studies on computer games in healthcare will be described in terms of their potentialities for prevention, support and rehabilitation. Finally, part 3 will be devoted to a proposal for usable, low budget, neurocognitive games.

1.2 Computer Games

Games have changed in the last decades from “hide and seek” played in open-air with friends to “World of Warcraft” played in closed environments with people all over the world.

Esposito (2005a, pp. 2) proposes this definition of videogame: "A videogame is a *game* which we *play* thanks to an *audiovisual apparatus*, and which can be based on a *story*". The gameplay is "the component of the computer games that is found in no other art form: interactivity. A game’s gameplay is the degree and nature of the interactivity that the game includes” (Rouse, 2004; in Esposito, 2005a, pp. 3). Historically, Esposito (2005b) marks the beginning of the “Computer Games Era” in 1971, with the release of the first commercial game “Computer Space”. From that date on, four periods have characterized the game development: 1971-1978, pioneers’ success (first years: milestones such as “Pong”); 1978-1983, genre development (also known as the golden age, for instance: “Adventure” for story and role playing, “Defender” for shoot’em up, “Qix” for abstract action, “Pole Position” for driving simulation); 1983-1994, strong ideas (less technological limits: powerful ideas in “Tetris”, cross-genres in “The Legend of Zelda”, complex simulations as in “Sim City”); 1994-today, recent games with advanced graphics, augmented interfaces and multiplayer games (“Quake III Arena”, “Super Mario Galaxy”, “World of Warcraft”).

To introduce the main differences between computer games and traditional games, a review of games taxonomies would be useful. According to the report "Guide to Computer Games in Education for NASA" by Laughlin and Marchuk (2005), games (term interchangeably used for computer games and video games in this document) can be categorized according to the technological platforms they exploit: personal computers, consoles, cell phones and handheld devices. Alternatively, they can be classified according to the communication modalities implemented. Text-based or graphic-based games are the main categories. Games can also differ in terms of the interaction modalities they support. In this case, games can be played in single-player modality, multiplayer modality (when the game is performed in head-to-head situation, as is the case of some sport games), hot-seat modality (several players holding the control by turn-taking), network modality (several players sharing the same game environment by network), online modality (network games using the Internet as medium), massively multiplayer modality (permitting to a large range of players to share at once the same game, available online only, and constituting a persistent world).

Finally, games can vary according to the different activities the participant can carry on. Some examples can be:

- action adventure games: combining elements of problem solving and exploration;
- fighting games: two or more opponents fighting;
- management games: economic management, simulating environment;
- platform games: completing level moving and avoiding obstacles, jumping on platforms;
- racing games: riding a race vehicle like cars and motorbikes;
- real time strategy games: gathering resources and performing strategies on units;
- role-playing games: control of single or many characters, performing quests;
- simulation games: reconstructing and using an accurate historical or modern vehicle;
- world-building games: open-ended games with total control of characters and environment to manage.

The dimensions used as criteria to classify games represent the main differences between traditional games and computer games. First of all, computer games' scalability leads to a quickly disappearance of physical constraints as they can be potentially played everywhere. Secondly, contrary to traditional games, computer games can involve a large number of participants playing together. Finally, imagination is replaced by graphically advanced scenarios, where actions can now be carried out that could not be performed in the real environment. To sum up, computer games have revolutionized the spatio-temporal dimensions characterizing traditional games as well as the range of actions that can be performed while playing.

In the next paragraph the complex relationship between cognition and computer gaming will be discussed, emphasizing which new possibilities computer games offer to the development of cognitive skills.

1.3 Human-Computer Game Interaction

Playing and cognition are deeply interconnected and with the advent of computer games new scientific interests for their relation emerged.

Green and Bavelier (2006) highlighted a range of cognitive processes modifications occurring with the gaming practice. They observed the perceptual and cognitive effects of games on cognitive functions, such as general enhancement in reaction time, visuo-motor coordination, spatial skills and visual attention.

To better understand the connection between computer games and cognition, Lindley and Sennersten (2006) proposed a model based on the assumption that learning "how to play" a videogame implies different cognitive skills. First of all, players need to learn how to manage interaction mechanisms, such as using the mouse or the remote appropriately. Secondly, players need to get familiar with interaction semantics, which means associations between physical actions (such as pressing a key) and the corresponding movement in the in-game environment. Thirdly, they should acquire game expertise, which would allow them to perform the right action at the right moment. While the first two skills become unconscious and automatic in a very short period, game expertise evolves according to the new challenges proposed by the game played. Decision-making can be considered as one of the main cognitive process underlying this expertise, and it cannot be set apart from the attention paid to the context-related contingencies as well as from memory of previous experience. Scientific investigation in areas such as learning or training has also considered another important variable playing a role in the relation between game and cognition, namely motivation. Playing can be a good "motivator" for the student who has to learn a lesson. Kellar, Watters, and Duffy (2005), investigating on motivation in computer games players, highlight the relevance of some factors as:

- Possibilities for Control, (supporting self-regulation, autonomy, initiative);
- Context Awareness, (including rationale, feedback, storyline);
- Competency, appropriate and performable tasks and challenges;
- Engagement, involving personalization, role-playing, rewards, communication, social interactions. The engage ment dimension is also traditionally linked with the sense of *presence* (Lombard and Ditton, 2003) or, in other words, with the feeling of being present in the gaming environment. Consequently, Retaux (2003) underlines that also presence could be critical in enhancing motivation. According to this author, *presence* can be experi enced in virtual environments and it can reshape the context of gaming radically, providing flow and immersive sensation. As observed by Bracken and Skalski (2006), *presence* in gaming can be connected with the match between difficulty level and the player's skills, or more in general, with the possibilities of action offered by the environment and exploited by the individuals (Spagnolli & Gamberini, 2005).

Rambusch (2006) linked the engagement in the game to the embodied and situated nature of computer game play, highlighting the role of the interaction between players and complex settings. In particular, she defines the gaming environment as a setting composed by a real world and a virtual world connected thanks to their affordances exploited by the player. Playing can not be situated into a "virtual cyber-vacuum", but it must be interpreted as a socially embodied and situated activity, which is constantly shaped by the physical experience emerging from the interaction between player and the environment. Narrative have often the goal to drive this relation between players and socio-environmental affordances; Schneider, Lang, Shin and Bradley (2004) observing the effects of the narrative dimension on several aspects of the gaming experience found that story-based games enhanced presence and engagement as well as the psychological arousal at a unconscious level. Probably, the multiplayer possibilities offered by the Internet represent one of the most effective motivator in today's players: networked game environments offer ideal contexts to support communication among players and to develop relationships with emotional investment (Yee, 2006). Multiplayer games offer relational contexts to enact cooperative dynamics: the Computer-Supported Cooperative Play (CSCP) triggers several phenomena related to identity and sociability, as observed in the XBox Live system by Wadley, Gibbs, Hew and Graham (2003). In these environments cooperation and competition are primary factors that determinate motivation and engagement levels acting on several social extrinsic motivators related to the desire for/rejection of potential affiliations with other players (Bonk & Dennen, 2005).

2. E-Mental Health: from Virtual Reality to Computer Game

In order to be more effective, technologically-enhanced health solutions work side by side (as alternative or supportive methods) with traditional approaches (LoPresti, Mihailidis, & Kirsch, 2004). Virtual and Mixed Realities represent the possibility to create a new, immersive place functional to enhance motivation, where patients can be trained while playing. Clinically, Virtual Realities allow to implement interactive treatment and training in controlled three-dimensional (3D) environments, where movement devices can be set to record and monitor patients' physical responses (Glantz, Rizzo, & Graap, 2003; Wiederhold & Wiederhold, 2007).

The potentialities of this new approach caught the attention of the European Union which, in 2001, funded a research project for Telemedicine and Portable Virtual Environments for Clinical Psychology, called VEPSY-updated (http://www.cybertherapy.info). The aim of this project was to investigate the effects of Virtual Reality systems adopted in clinical settings.

In particular, the project aimed at facing several clinical disorders (Riva et al., 2003), such as:
- social phobia, panic disorder and agoraphobia, exploiting the combination of VR and exposure therapy;
- obesity, bulimia and binge-eating disorders, using the Experiential Cognitive Therapy (ECT) to modify body image perceptions;
- male impotence and premature ejaculation, taking advantage of the immersive virtual reality to improve the efficacy of a psychodynamic approach in treating male erectile disorders.

The project integrated the cognitive behavioral therapy (CBT) with a Virtual Reality (VR)-enhanced treatment named Experiential Cognitive Therapy (ECT), which joined VR and telemedicine to be used in eating disorders' assessment and treatment (Riva, Bacchetta, Cesa, Conti, & Molinari, 2004). This program worked on many fronts, for instance helping the patients in understanding the origins and reinforcement of negative attitudes toward their body image, redefining the concept of beauty, decreasing the restriction in activities and negative feelings, supporting motivation and self-efficacy, developing individualized treatment plans regarding eating behaviors and exercise. Results showed that ECT had a significant effect on the perception of the body image. This outcome was usually associated to a decrease in problematic eating and social behaviors.

Another field of research born from the development of VR is the emotional determinants of presence. EMMA (Engaging Media for Mental Health Applications) was another European Union funded project, realized to develop a Virtual Environment able to generate and enhance presence and emotions. This tool was successfully designed not only for users suffering from psychological problems, but also for users with acute restricted mobility or the general population (Alcañiz, Baños,_ Botella, & Rey , 2003).

Virtual City (Costa, Carvalho, & Aragon, 2000) is an example of cognitive training for stimulating cerebral plasticity changes, empowering the classical rehabilitation procedures. Authors report preliminary studies on schizophrenic patients, immersed into complex environments where several tasks and games were proposed to enhance processes of alertness (turning off the radio in a virtual house), concentration (distinguishing between sequences of stimuli in a music room), attention (solving puzzles in book and game rooms), perception (recognizing people on the street) and memory (reaching a telephone-box or reacting to signals and requests in open-air environments).

Even though the aforementioned projects have proved the effectiveness of Virtual Environments in clinical settings, their efficacy depends on a delicate balance among their components. Attracted by this issue, Rizzo and Kim (2005) performed a SWOT analysis (Strengths, Weaknesses, Opportunities, Threats) of virtual reality systems in therapy and rehabilitation, finding that:
- Strengths can be the enhanced ecological validity (degree of relevance or similarity between virtual test/training and reality), stimulus control and consistency (to support the repetitive and hierarchical delivery of stimuli according to a scale of difficulty), real-time performance feedback, cuing stimuli to avoid error learning, self-guided exploration and autonomous practice, interface adaptation to specific impairments, complete naturalistic data collecting, safe setting, gaming factors (to enhance motivation), low-cost environments that can be dupli cated and distributed.
- Weaknesses depend on degree of natural interaction, disturbs of hardware wiring and devices, immaturity of engineering process, platform compatibility, front-end flexibility (clinicians are not programmers), data visualiza tion, side effects (like cybersickness).
- Opportunities can be recognized in emerging advances in interfaces and hardware, real time data analysis, game drivers, intuitive appeal for the users, academic and professional acceptance, closeness of research and clinical professionals, integration with neuroimaging systems, tele-rehabilitation.
- Threats could be low costs/benefits ratio, after-effects, ethical challenges, and the idea that technology could

eliminate the need of clinicians, limited awareness and unrealistic expectations.
If the degree of natural interaction is a critical issue in Virtual Realities, a solution is represented by Augmented and/or Mixed Reality. Recent advances in interface technologies create semi-immersive settings for users with artificial augmentation of their experience through innovative controls and feedback visualizations, supporting and increasing the spontaneous interaction of players with the environment. The introduction of virtual elements in the real world is exploited for therapeutic reasons, as in the treatment of cockroach phobia (Botella et al., 2005). In this study insects super-imposed to real worlds allowed an exposure therapy in safe situations.

Pervasive Games represent the bridge between Augmented and Mixed reality and computer games. Extending the effective power of games across different media platforms (Lindt et al., 2005) and everyday life contexts (Benford, Magerkurth, & Ljungstrand, 2005), we can obtain information spaces for augmented experience overlapped and intersected with real spaces and objects, This physical distribution of digital information can significantly support the work of healthcare systems with the development of pervasive and portable telemedicine equipment, as in ambient intelligence (Riva & Gramatica, 2003).

An aspect that needs to be considered when discussing Virtual Realities as an alternative setting to host training activities is the possibility to *physically interact* with such environments. The development of haptic interfaces has represented a first step towards this goal. Among their various applications, in clinical settings they have been used to enhance the level of affective experience. An example is TapTap, a wearable haptic interface using its garment to produce the affective stimulation (Bonanni, Vaucelle, Lieberman, & Zuckerman, 2006). Another support to interaction is offered by tabletop technologies. Digital tables with touch-screens create the context for collaborative tasks and physical interactions, enriching the chance to share the same experience with other players, whose activity (comprising complex gestures) can be monitored in real-time on the screen (Tse, Greenberg, Shen, & Forlines, 2007). An example is provided by the ElderGames project, which aims at developing a tabletop technology exploitable by elderly people to play with their peers; the typology of games implemented and the possibility to interact with others is expected to contribute to their health and wellness in a monitored environment (Gamberini et al. 2008) .The Nintendo Wii is one of the most popular examples of ergonomic, low-budget implementation of physical interaction in Virtual or Mixed Reality; it's offering several game scenarios where inputs are provided by a system that tracks and translates position, orientation and acceleration of the players' on a remote virtual movements in the game environment (Mäyrä, 2007). The Playstation EyeToy, discussed by Kizony and Weiss (2004), eliminates the remote control by positioning the users' outline in the on-screen scenario, and allowing the player to manipulate virtual objects by mirroring gestures performed in the real environment.

The development of videogames played without remote controls has attracted the interest of research areas such as eye-tracking and Brain-Computer Interfaces. The advantages offered by eye-tracking in gaming are remarkable. Discussing the Tobii ET-17 technology, Jönsson (2005) underlined that tracking the user's gaze is highly non-invasive and fast, easy and intuitive for the user; this technique can reduce fatigue, reveal attention, be non-invasive, and connected to other input devices. Another actor operating in the field of playing and work applications of gaze-tracking technology is COGAIN, a network of excellence on Communication by Gaze Interaction, supported by the European Commission's IST 6th framework program. The project is hosting an annual conference (www.cogain.org) and is developing several solutions to support users with disabilities.

2.1 Games for Prevention

The social etiology of particular diseases or the social cause of the deterioration of already weakened or stressed conditions are emphasized by models that describe the interaction of biological, psychological, and social factors (for instance, Bruns & Disorbio, 2006). On these bases, it is games can be useful to prevent or deal with health-related problems. "Serious Games" are more than edutainment (education through entertainment) because they extend the aims of this kind of media (usually thought for preschoolers and basic learners) to train and inform a larger target, including universities and companies, about social relevant issues (Micheal & Chen, 2005), By exploiting the power of persuasion, serious games could represent an ideal tool for attitude and behavioral changes (Bogost, 2007).

2.1.1 Games for Prevention and Harm Reduction

Prevention and harm reduction represent valuable strategies to reduce the social costs connected to addiction. Videogames can support this endeavor. Videodope (Gamberini, Breda, & Grassi, 2007) is a serious game designed to enhance players' awareness of the effects that the abuse of psychoactive substances has on the body. By selecting a specific drug and a certain organ, the game displays a 3D human avatar (Figure 1) that can be zoomed in or made transparent, showing the organ and describing with images and text the short-term, medium-term and long-term effects of the selected drug on the organ as well as on the cognitive skills, and sexual ability. The description is integrated with legal and social information. At the end of this phase, a quiz starts, which allows to attribute the player a score according to his/her answers. Thanks to the provision of feedback as well as to the display of the connection between behavior and its consequences, this game represents an appealing persuasive tool (Fogg et al., 2001; Fogg, 2003) to be used in settings such as schools, discos, pubs and the web.

Another game that exploits the representation of behavioral cause and effects is called Playsafety (Purgato & Gamberini, 2005), and addressed young people's unsafe behavior; defined according to preliminary investigation of the nighttimes scenarios where dangerous behaviors most frequently occur, and to a scenario- based design, several situations were created (disco, park and restroom for drug abuse, a motorbike ride for safety driving). Players, represented by avatars, were offered different reaction options, followed by scenes depicting the consequences of their choice (Kerr, Neale, & Cobb, 2002).

2.1.2 Games for Training

Fery and Ponserre (2001) analyzed a golf game used to learn real launches. Like virtual reality tools in general, the golf game showed a positive transfer of skills from virtual to real settings. The authors reported that even the mere view of swinging movements could be enough to create a representation of force feedback in users, and let them acquire the necessary skills to improve their real performance. Players used two different learning strategies, one focused on the movements of virtual characters, another one focused on a gauge representing the force. Practice and the time spent watching and learning equal a motor control experience, useful to better orient real world actions.

Figure 1. Videodope screenshot

Virtual environments can be also exploited in safety training in emergency situations. Gamberini, Cottone, Spagnolli, Varotto, and Mantovani (2003) show that in these situations users can show a change in their behaviors, in the direction of increasing the speed of their escape at the detriment of the movements' precision. The observation of this change, in the direction in which one would have expected it in emergency situations, encourages to think that event simulated emergencies can be experienced as realistic and the that a training there would reproduce some of the aspects of a real emergency situation. Spagnolli et al. (2007), report of another system for safety training, developed by Honda, which the authors tested to find the social setting that would maximize the learning experience. The safety trainer includes motorcycle controls and offers different hazard situations in traffic conditions, designed on the basis of real accidents data involving motorcycles.

Other typical training applications of videogames are those targeting specific professional skills in the military personnel, in particular aircraft pilots. Gopher, Weil, and Bareket (1994) observed that cadets trained with Space Fortress performed significantly better in flight sessions than those trained with traditional methods. As a consequence, the Israeli Air Force incorporated that video game into the regular training program of its pilots. In this case the enhancement in perceptual and cognitive processing could induce significant differences in job performance.

Another example of professional training through videogame has been reported by Rosser et al. (2004); Laparoscopy is a surgical intervention technique based on a camera and some operating instruments introduced in the body via small incisions. The surgical instruments are steered by the surgeon who views the images transmitted from the internal camera to the screen. This type of surgery requires high levels of visual attention, manual dexterity, and hand eye coordination. The authors emphasized how video games could be successfully used as training for laparoscopic surgeons.

2.1.3 Games for Exercise and Fitness

Bogost (2005) defined this category as "exergames", namely games that promote and support the users' fitness. The users' rapid movements of the fingers activate legs or feet movements in the virtual character to simulate sprinting or running. An example of exergame is Yourself! Fitness, allowing to create a virtual personal trainer, called Maya, who proposes personalized 30-minutes daily programs. The training game is customizable according to height, weight, vital parameters (such as heart rate) and goals of the users. The interactions with Maya are frequent and she adopts a gym-professional attitude in order to improve players' participation according to the feedback received.

Bogost coins the expression "rhetoric of impulsion" to refer to score-based encouragements to engage in physical activity implemented in entertaining tools with no explicit training aims. An example is Dance Dance Revolution, where on-screen arrows at correct beats of music correspond to steps on the pad: at any missed step, a global energy meter decreases, accompanied by messages evaluating the accuracy of the players' movements (Perfect, Great, Good, Almost, or Miss).

2.1.4 Social Dialectics

There are several games helping users to deal with social issues. FearNot (Hall, Woods, & Dautenhahn, 2004) is a virtual learning environment offered to 8-11 years old children to learn dealing with bullying and mobbing in the school context. Age Invaders promotes relations (Khoo & Cheok, 2006) between elderly and young people, who are required to play all together in the same virtual environment. The game adapts itself according to the age of the player. According to Khoo and Cheok's research, elderly people benefits not only from the cognitive stimulations provided by the game, but also from familiar and social inclusion, positively affecting mood, self-expression, physical and cognitive activity.

2.2 Games for Health Support

2.2.1 Games for Special Needs

The problem of differential access to technology involves elderly people (as already discussed in the previous paragraph), and people with physical disabilities. Cognitive training tools have been successfully developed for elderly people. Gamberini et al. (2008) reviewed a series of studies showing the incidental positive effect of classic "first generation games" (reviewed by Whitcomb, 1990) and "innovative games" on cognitive functions and quality of life of elder people, both of them able to slow down age-related cognitive senescence. Åstrand (2006) proposed a user-based design process with iterative cycles to create an online word game for older people, called ACTIONPET (based on the ACTION project for healthcare: Assisting Carers using Telematics Interventions to meet Older persons' Needs). Van Schaik, Blake, Pernet, Spears, and Fencott (2008) described the design, development and testing of a VAE, Virtual Augmented Exercise tool, based on puzzles and target-hitting games. This gaming tool for older adults has been preferred to traditional physical exercises with adherence rate of 100%. A video-captureVR system, TheraGames, is supposed to enhance interaction of elderly people with rehabilitative systems exploiting the highly motivating game setting (Kizony, Weiss, Shahar, & Rand, 2006).

IJsselsteijn, Nap, de Kort, and Poels (2007) proposed several suggestions for design of games for elderly people, according to the limitations and potential of the users and the opportunities offered by modern games. ElderGames (Gamberini et al., 2006) is oriented to develop games with advanced visualisation and interaction tabletop interfaces to enhance the cognitive, functional and social skills of elderly through health monitoring, mental exercise and engagement. It implements also a communication system for multiplayer entertainment from a distance. The experts involved in this project analyzed attentively the cognitive needs of the older users to design appropriate mind-engaging games to affect positively the main cognitive changes in senescence (perception, attention, executive functions, memory). The presence of cognitive decline in elderly can be identified by using as index of game performance (Jimison, Pavel, McKanna, & Pavel, 2004). Cognitive Cubes (Sharlin et al., 2002) is an augmented tactile tool for assessment of spatial constructional skills to discriminate differences in cognitive skills and tasks, and correlate the scores with standard paper-and pencil 3D spatial assessment. The authors are studying possible developments to explore this kind of augmented solutions for clinical assessment.

Another category with special needs is blind children; Lumbreras and Sanchez (2000) created a 3D audio Virtual Game named AudioDOOM for blind children. The user is required to handle a joystick to explore a maze following 3D audio cues (sound and noise of footsteps, doors, echoes), and finding enemies. After several sessions, participants showed to be able to reproduce a physical representation of the maze using Lego bricks. Therefore, acoustic interactions during the game seemed to be efficient in supporting spatial-cognitive maps. In 2003, TPB, the Swedish Library of Talking Books and Braille proposed a series of 13 computer games on their web site, specially designed for children with different visual impairments. The games were small Macromedia Flash™ applications, designed using graphics and sound in order to encourage children with partial sight to exercise visual objects recognition, and to create picture-based and sound-based games. The positive response of children to TPB games suggested that the visual design of these games is suitable for children with different visual impairments (Weiss, Rand, Katz, & Kizony, 2004).

2.2.2 Games for Clinical Adherence and Monitoring

According to Michael and Chen (2005), games can help patients in reshaping their lifestyle in adherence with the special needs caused by their conditions. Jack et al. (2001) used a virtual reality setting to increase motivation and engagement in adult patients practicing physical therapy after a stroke. An innovation, which could deeply affect the life of diabetics, has been developed by Nintendo GameBoy called Glucoboy. Glucoboy is a tool aimed at increasing awareness of young people with diabetes about their blood glucose levels, providing incentives to adopt the treatments. Similarly, Bronkie the Bronchiasaurus is designed to help children affected by asthma to acquire information about their problems and the ways to cope with them.

Watters et al. (2006) proposed digital games as a possible means for long-term treatments of children (also recognizing their power to engage adults). Their framework is based on three main goals: to offer high accessibility even on small devices, to adapt the tool to player's interests and clinical needs, to maintain games novel and interesting over time. An accessory advantage is constituted of the users' data collection and monitoring, particularly useful to healthcare operators.

2.2.3. Games for Psychological Therapy

Goh, Ang, and Tan (in press) discussed how mental health professionals can explore and take advantage of the diffusion of computer games to help the treatment of mental illness. The authors propose guidelines and strategies for psychotherapeutic games to be used with children and adolescents, highlighting for instance the need for considering the potential users' characteristics, such as gender, culture, socioeconomic status as well as needs and expectations. This remark is supported by studies such as Greenhill's (1998, in Goh, Ang, & Tan, in press), who observed that stimuli present in the environment, such as colors and sounds, captured the attention of players in different ways: children diagnosed with ADHD, for instance, focused their attention on the videogame only in the case of vibrant colors and loud sounds.

The literature reports numerous cases of video games used in psychological treatments thanks to their capability to provide alternative realities were patients could feel safe and step back from the real world. Accident phobia has been successfully treated using virtual reality driving games in exposure therapy, a traditional methodology of the cognitive-behavioral therapy approach (Walshe, Lewis, Kim, O'Sullivan, & Wiederhold, 2003). Dandeneau, Baldwin, Baccus, Sakellaropoulo, and Pruessner (2007) succeed in lowering players' cortisol levels using a videogame that decreased a perceived threat. Finally, Moore, Wiederhold, Wiederhold, and Riva (2002) proposed virtual gaming environments as settings for psychotherapy of phobia, paired with several physiological measurements derived by behavioral indexes. The combination of exposure therapy and Virtual Reality (VR exposure therapy [VRET]) has been used in several researches on specific phobias, such as acrophobia (Emmelkamp, Bruynzeel, Drost, & van der Mast 2001), claustrophobia (Botella, Banos, Villa, Perpina, & Garcia-Palacios, 2000), fear of flying (Wiederhold & Wiederhold, 2003), fear of driving (Walshe, Lewis, Kim, O'Sullivan & Wiederhold, 2003) and spider phobia (Hoffman, Garcia Palacios, Carlin, Furness, & Botella, 2003) as well as on anxiety disorders, such as social phobia , panic disorders with agoraphobia and post-traumatic stress disorder PTSD (Krijn, Emmelkamp, Olafsson, & Biedmond, 2004). Walshe, Lewis, Kim, O'Sullivan and Wiederhold (2003) investigated the effectiveness of exposure therapy for the treatment of driving phobia following a motor vehicle accident program. The program was characterised by the combination of driving games (Game Reality, GR) and Virtual Reality driving environments (VR). Participants were exposed to a Virtual Driving Environment (Hanyang University Driving Phobia Environment) and computer driving games (London Racer/ Midtown Madness/ Rally Championship). Results suggest that VR and GR have an effective role in the treatment of driving phobia.

Positive effects of Virtual Reality Exposure Therapy have also been documented for treatment of Post-traumatic stress disorders (Rothbaum & Schwartz; Wiederhold & Wiederhold, 2008). The success of virtual realities games on PTSD inspired Rizzo et al. (2006), who successfully used the Full Spectrum Warrior graphic assets as a Virtual Environment for the treatment of Iraq War military service personnel diagnosed with PTSD.

Wiederhold and Wiederhold (2007) discussed the power of virtual technology and videogames to distract patients from pain: high immersion virtual reality requires attention to be focused on virtuality, decreasing the available amount of cognitive resources devoted to other experiences. The use of immersive virtual realities has been illustrated by Hoffman, Patterson, and Carrougher (2000) to distract burn patients from pain during physical exercises. Patients reported to feel less painful when immersed in a virtual immersive reality than when they were not, highlighting the value of this non-pharmacological method for pain reduction. A further study (Sharar, 2006) exploited a virtual immersive game named SnowWorld for pain reduction during physical post-burn therapy in children. Results underlined an analgesic effect of the game also confirmed by fMRI neuroimaging.

A third use of video games in psychological treatment rests on the neuropsychological functions stimulated by gaming. Under this approach stands the treatment of schizophrenia. Han, Sim, Kim, Arenella, and Lyoo (in press) suggested that limited internet video game could be used as an adjunctive tool in the treatment and rehabilitation of schizophrenic patients. Indeed, the increased activity of the prefrontal cortex or the lead of dopamine release observed during video game playing could lead to a successful treatment of this disorder (Matsuda & Hiraki, 2006; Koepp et al., 1998).

A specific computer-based program developed for the training of cognitive skills in medicated patients with schizophrenia has been tested by Bender, Thienel, Dittmann-Balçar, Tackenberg, and Gastpar (2003) The tasks of the program were focused on specific cognitive functions, such as attention, memory, executive function, visuo-motor function and calculation. The program resulted to have significant effects both on cognitive functions and self-esteem.

2.2.4 Games for Motor and Cognitive Training

Videogames, involving the sensory-motor system and problem solving skills are more than serious candidates for neuro-rehabilitation and motor or cognitive training (Morganti, Gaggioli, Castelnuovo, Bulla, Vettorello, & Riva, 2003; Gourlay, Lun, & Liya, 2000; Cameirao, Bermúdez, Badia, Duarte Oller, Zimmerli, & Verschure, 2007). Green & Bavelier (2006) identified several improvements in gaming activity, from reaction times to spatial skills, and highlighted the chances to use this kind of media to improve cognitive functions in individuals with particular needs (as reviewed for surgeons and soldiers) or for training and retraining of individuals with special health-related problems (such as young disabled or elder people) involving the nervous system. Koepp et al. (1998) reported that the level of dopamine, a neurotransmitter involved in reinforcement and learning, seems to increase during videogame activity.

Virtual Reality technology is widely used in post-stroke rehabilitation. (Broeren, Georgsson, Rydmark, and Stibrant Sunnerhagen, 2002; Wiederhold and Wiederhold, 2006), for instance, investigated the influence of a training with 3D-computer game (3D-Bricks), combined with the PHANToM haptic device (SensAble Technologies Inc., Woburg, MA, US) on motor relearning in a patient suffering from a left arm paresis after stroke. The authors observed an improvement in grip strength, manual dexterity and kinematic patterns (like the trajectory and the motion direction). A similar project is currently in progress at the Rutgers University, aimed at combining an Xbox-based physical rehabilitation system with the assistance of a P5 glove (made by Essential Reality) connected to the console (Morrow, Docan, Burdea, & Merians, 2006). Video games have also been involved in physical therapy for balance. Betker, Szturm, Moussavi, and Nett, (2006) used a coupling foot center of pressure (COP) which controlled a video game on dynamic balance control. The authors observed that the COP-controlled video game–based exercise caused a significant improvement in dynamic balance control. Moreover, the training program, increasing the level of motivation, had a positive affect on subjects' desire to exercise and complete the rehabilitation program. Motivation has also proved to be enhanced by the use of EyeToy (a game disc and a USB camera plugged into a Sony PlayStation) in the training of the upper limb in children with cerebral palsy (CP) (Jannink et al., 2008).

Spatial cognition has also been investigated with the use of video games. Green and Bavelier (2003) investigated the effect of video games on visual selective attention. Results showed that playing action-video-games alters visual skills. They observed the difference in performances of players and non-players after action game practice: non-players showed marked improvement considering their pre-training abilities. Furthermore, Lager and Bremberg (2005) showed a cognitive enhancement regarding spatial skills and reaction times, and Green and Bavelier (2007), observed an improvement in the spatial resolution of attention in videogame players.

Another category of special players are young people affected by *Attentional Deficit Hyperactive Disorder*, syndrome of disattention and hyperactivity. McGraw, Burdette, and Chadwick (2005) investigated the effects of Dance Dance Revolution game on reading disorders of children affected by ADHD to verify that matching visual and rhythmic auditory cues could strengthen performance on particular aspects assessed by Receptive Coding and Finger Sense Recognition subtests.

Another example is Play Attention®, (http://www.playattention.com) which is a feedback-based training program designed to train attention. In particular, it seems to increase concentration, task completion, visual tracking, short-term memory, and the ability to ignore distractions: these results are due to the increasing strength of high-frequency beta waves and decreasing low-frequency theta waves. Feedback-based technology has already been used by NASA to increase astronauts' and pilots' attention in training with flight simulators. Play Attention is an adaptation of this NASA technology for educational needs. The user can make videogame respond to his or her own brainwaves in order to control the game action.

Even though computer games have been successfully involved in rehabilitation, several problems concerning their use in this specific area have been discussed by Green and Bavelier (2006). First of all, game difficulty varies with the specific game and the individual characteristics of the participant (education, computer skills, age, health). Secondly, arousal (increased by the gaming) can be a critical factor for the analysis of the performance as it can by itself induce the desired neuropsychological changes. Finally, the discomfort of using certain tools such as virtual environments should be considered (Stanney, Hale, Nahmens, & Kennedy, 2003). This is especially true for games that are not designed for mental enhancement, but that are anyway able to improve cognitive skills incidentally (as reported in the studies by Whitcomb, 1990).

3. Proposals for Augmented Neurotraining Games

Engagement has been widely considered as one of the main factors inducing motivation. Berthouze, Kim, and Darshak (2007) observed that, after the efforts made by game designers in enhancing players' engagement by improving characters' credibility and environmental appearance, the attention of professionals is now focusing on input devices and controllers. In one of their first studies they considered "Guitar Hero" for Sony Playstation, and compared players using the gamepad with players using the guitar-like control that allows gestures mirroring the guitar-playing acts. Outcomes led them to suppose that an increasing corporeal involvement should affect the feeling of presence even in absence of total immersion in the virtual environment. In particular, they concluded that a full-body experience contributes to facilitate the emergence of a presence feeling in the virtual environment. Lindley, Le Couteur, and Berthouze (2008) arrived to a similar conclusion by testing the effects of movements on bongos controls (enabled by body movements), in the Donkey Konga Game, compared to standard controls. Results showed that the first condition increased not only involvement in the virtual environment, but also social behaviors in the real environment.

Physical interactions cannot only enhance the sense of presence, but has also several cognitive benefits, as observed by Colcombe and Kramer (2003) in the elderly. Fabre, Chamari, Mucci, Masse-Biron, and Prefaut (2002) observed that combination of fitness training and cognitive training is able to enhance memory performance more than individual training. Physical interaction in the improvement of cognitive processes has been recently addressed by Eng et al. (2007), who realized a visuo-motor rehabilitation virtual system for stroke patients with upper arms impairment. In this case patients were required to physically interact with items in a virtual environment. The theoretical framework of the authors refer to the evidences of "mirror neurons" for imitation in motor control imagery, with the hypothesis of facilitation in cortical plasticity and functional recovery through processes of motor observation, planning and execution.

In fact, commercial gaming technology is now focusing on physical interactivity, as in the control system of Nintendo DS®, and Nintendo Wii®, which involves the whole body in the game activity (http://www.touchgenerations.com). Both systems allow the manipulation of virtual objects on the screen, through the performance of intuitive gestures handling real tools (the pen on the touch screen for DS, the Wiimote for Wii). These potentialities of the Nintendo Wii body-based game system have inspired some interesting projects. Pearson and Bailey (2007), for instance, proposed to analyse the effects of this console system in supporting learning processes in cognitively and physically disabled people. The physical nature of interaction can be particularly appealing for these individuals, facilitating their acceptance of computer-mediated learning programs. The Wiimote offers a force-feedback system with a rumble effect that is triggered by a collision of the cursor or the avatar against a virtual object. Force-feedback has been used in rehabilitation procedures (Popescu, Burdea, Bouzit, & Hentz, 2000), and it is also able to support presence in collaborative gaming environments (Salläs, Rassmus-Gröhn, & Sjöström, 2000). Feedback technologies have been useful in past to increase dexterity (Prisco et al., 1998), as well as problems of motor coordination or representation (like apraxia).

The authors are working on Wii-based technology to implement tasks involving and training specific cognitive processes. The advantage of using Nintendo Wii for treatment depends not only on its specific game potential, but also on the cheap price of the tool, which allows home training, and the involvement of the family in the patient's rehabilitation (as observed by Burdea, Popescu, Hentz, & Colbert, 2000). Furthermore, Nintendo Wii is a handy device that could also be used in settings such as clinics or retirement houses.

4. Conclusions

The present paper has reported a review of studies about computer games exploited in the healthcare domain. Besides their proved relations between playing games and training cognitive abilities, video games' added value with respect to other solutions resides on two aspects. First they are entertaining. In contexts where health rehabilitation or health support processes can be painful or boring, computer games act as motivators. Secondly, computer games provide alternative worlds, which can be shaped on the target's needs, facilitating the development of adequate behaviors transferable into the real world.

Probably, most possibilities have not yet been explored. For instance, as emerges from the majority of the studies reported, results on the improvement of cognitive functions due to the use of computer games have been mostly accidental. In other words, if the effects of computer games on cognitive processes have been widely confirmed, the possibility to develop specific tasks targeting specific cognitive processes has received relative little attention. Likewise, interfaces reacting to the users' physical movements are emerging now, as evidenced by the increasing interest for haptic devices. In addition to training certain motor skills, physical interaction can further enhance the sense of presence, engaging even more deeply the player with the game and, consequently, further fostering motivation.

Figure 2. Nintendo Wii setting

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References

Alcañiz, M., Baños, R., Rotella, C., & Rey, B. (2003). The EMMA Project: Emotions as a Determinant of Presence. *PsychNology Journal,* 1(2), 141-150.

Åstrand, H. (2006). *Design and development of an online game for older people from a usability perspective.* Master's thesis, Chalmers University of Technology, Department of Signals and Systems, Göteborg, Sweden.

Bender, S., Thienel, R., Dittmann-Balçar, A., Tackenberg, A., & Gastpar, M. (2003). Training effects of computer-based cognitive training in patients with schizophrenia. *Schizophrenia Research,* 60(1), 124-124.

Benford, S., Magerkurth, C., & Ljungstrand, P. (2005). Bridging the physical and digital in pervasive gaming. *Communications of the ACM,* 48(3), 54-57.

Berthouze, N., Kim, W. W., & Darshak, P. (2007). Does body movement engage you more in digital game play? And Why? *Proceedings of the Int. Conf. of Affective Computing and Intelligent Interaction,* Lisboa, Portugal, 102-113.

Betker, A. L., Szturm, T., Moussavi, Z. K., & Nett, C. (2006). Video game-based exercises for balance rehabilitation: a single-subject design. *Archives of Physical Medicine and Rehabilitation, 87(8),* 1141-1149.

Bogost, I. (2005, December). *The Rhetoric of Exergaming.* Paper presented at the Digital Arts and Cultures conference, Copenhagen, Denmark.

Bogost, I. (2007). Persuasive Games. *The Expressive Power of Videogames.* Cambridge, Mass.: MIT Press

Bonanni L., Vaucelle, C., Lieberman, J., & Zuckerman, O. (2006). TapTap: A Haptic Wearable for Asynchronous Distributed Touch Therapy. *Ext. Abstracts CHI 2006,* ACM Press (2006), 580-585.

Bonk, C J., & Dennen, V.P. (2005). Massive Multiplayer Online Gaming: *A Research Framework for Military Training and Education.* (Technical Report 2005-1). Washington, DC: Advanced Distributive Learning Initiative.

Botella, C., Banos R.M., Villa., H., Perpina, C., & Garcia-Palacios, A. (2000).Virtual reality in the treatment of claustro phobic fear: a controlled, multiple-baseline design. *Behavior Therapy*, 31, 583–595.

Botella, C. M., Juan, M. C., Banos, R. M., Alcaniz, M., Guillen, V., & Rey., B. (2005). Mixing realities? An application of augmented reality for the treatment of cockroach phobia. *CyberPsychology and Behavior,* 8(2), 162-171.

Bracken, C. C., & Skalski, P. (2006). Presence and video games: The impact of image quality and skill level. *Proceedings of the Ninth Annual International Workshop on Presence. Cleveland,* OH: Cleveland State University.

Broeren, J., Georgsson, M., Rydmark, M., & Stibrant Sunnerhagen, K. (2002) Virtual Reality in Stroke Rehabilitation with the assistance of Haptics and Telemedicine. In Sharkey, P., Sik Lányi, C., Standen, P. (Eds.), *Proceedings of The 4th International Conference on Disability, Virtual Reality and Associated Technologies* (pp. 71-76). Reading, UK: University of Reading.

Bruns, D., & Disorbio, J. M. (2005). Chronic pain and biopsychosocial disorders: The BHI 2 approach to classifica tion and assessment. Practical Pain Management, 5(7), 52-61.

Burdea, G., Popescu, V., Hentz, V., & Colbert, K. (2000). Virtual Reality-Based Orthopedic Telerehabilitation. *IEEE Transactions on Rehabilitation Engineering,* 8(3), 430-432.

Caillois (1957). Les jeux et les hommes. Gallimard.

Cameirao, M. S., Bermúdez i Badia, S., Duarte Oller, E., Zimmerli, L., & Verschure, P. F. M. J. (2007). The Rehabilitation Gaming System: A virtual reality based system for the evaluation and rehabilitation of motor deficits. Proceedings of Virtual Rehabilitation, Venice, Italy.

Carter, D. M., Mackinnon, A., & Copolov, D. L. (1996). Patients' strategies for coping with auditory hallucinations. Journal of Nervous and Mental Disease, 184, 159–164.

Colcombe, S., & Kramer, A. F. (2003). Fitness effects on the cognitive function of older adults: a meta-analytic study. Psychological Science, 14, 125–130.

Costa, R., Carvalho, L., & Aragon, D. (2000). Virtual city for cognitive rehabilitation. In Sharkey, P., Cesarani, A., Pugnetti, I. and Rizzo, A. (Ed.), *Proceedings of the Third ICD-VRAT* (pp. 305-313). Reading, UK: University of Reading.

Dandeneau, S. D., Baldwin, M. W., Baccus, J. R., Sakellaropoulo, M., & Pruessner, J. C. (2007). Cutting stress off at the pass: Reducing vigilance and responsiveness to social threat by manipulating attention. *Journal of Personality and Social Psychology,* 93(4), 651-666.

Emmelkamp, P. M., Bruynzeel, M., Drost, L., & Van Der Mast, C. A.. (2001).Virtual reality treatment in acrophobia: a comparison with exposure in vivo. *Cyberpsychology and Behavior,* 4(3), 335–339.

Eng, K., Siekierka, E., Pyk, P., Chevrier, E., Hauser, Y., Holper, L., et al. (2007). Interactive Visuo-Motor Therapy System for Stroke Rehabilitation. *Medical and Biological Engineering and Computing,* 45(9), 901-907.

Esposito, N. (2005a). A Short and Simple Definition of What a Video Game Is. Proceedings of DiGRA 2005 Conference: Changing Views - Worlds in Play, Vancouver, British Columbia, Canada.

Esposito, N. (2005b). How Video Game History Shows Us Why Video Game Nostalgia Is So Important Now. Playing the Past. Retrieved 6 May, 2008, from *http://www.utc.fr/~nesposit/publications/esposito2005history.pdf*

Fabre, C., Chamari, K., Mucci, P., Masse-Biron, J., & Prefaut, C. (2002). Improvement of cognitive function by mental and/or individualized aerobic training in healthy elderly subjects. *International Journal of Sports Medicine,* 23, 415–421.

Farné R. (2005). *Pedagogy of Play.* Topoi, 24(2), 169-181.

Fery, Y. A., & Ponserre, S. (2001). Enhancing the control of force in putting by video game training. *Ergonomics,* 44(12), 1025-1037.

Fogg, B.J. (2003). *Persuasive technology.* San Francisco, CA: Morgan Kaufmann.

Fogg, B. J., Marshall, J., Kameda, T., Solomon, J., Rangnekar, A., Boyd, J., & Brown, B. (2001). Web credibility research: A method for online experiments and early study results. *Proceedings of CHI'01, Extended Abstracts on Human Factors in Computing,* 295-296.

Gamberini, L., Alcaniz, M., Barresi, G., Fabregat, M., Ibanez, F., & Prontu, L. (2006). Cognition, technology and games for the elderly: An introduction to ELDERGAMES Project. *PsychNology Journal,* 4(3), 285–308.

Gamberini, L., Alcaniz, M., Barresi, G., Fabregat, M., Prontu, L., & Seraglia, B. (2008). Playing for a Real Bonus: Videogames to Empower Elderly People. *Journal of CyberTherapy and Rehabilitation,* 1(1), 37–48.

Gamberini, L., Breda, L., & Grassi, A. (2007). VIDEODOPE: applying persuasive technology to improve awareness of drugs abuse effects. *HCI'07,* Beijing, July 22-27.

Gamberini, L., Cottone, P., Spagnolli, A., Varotto, D., & Mantovani, G. (2003). Responding to a fire emergency in a virtual Environment: Different patterns of action for different situations. *Ergonomics,* 46(8), 842-858.

Gee, J. P. (2007). Video Games and Embodiment. *AERA* 2007, Chicago.

Gifford, B. R.(1991). The learning society: Serious play. *Chronicle of Higher Education*, 7.

Glantz, K., Rizzo, A., & Graap, K. (2003). Virtual Reality for Psychotherapy: Current Reality and Future Possibilities. *Psychotherapy: Theory, Research, Practice, Training,* 40(1-2), 55-67.

Goh, D. H., Ang, R. P., & Tan, H. C. (In press). Strategies for designing effective psychotherapeutic gaming interventions for children and adolescents. *Computers in Human Behavior.*

Gopher, D., Weil, M., & Bareket, T. (1994). Transfer of skill from a computer game trainer to flight. *Human Factors,* 36(3), 387-405.

Gourlay, D., Lun, K. C., & Liya, G. (2000). Virtual reality and telemedicine for home health care. *Computers and Graphics,* 24, 695-699.

Green, C. S., & Bavelier, D. (2003). Action video game modifies visual selective attention. *Nature,* 423, 534-537.

Green, C. S., & Bavelier, D. (2006). The Cognitive Neuroscience of Video Games. In Messaris, P. and Humphreys, L. (Eds). Digital Media: *Transformations in Human Communication,* 211-224. New York, Peter Lang.

Green, C. S., & Bavelier, D. (2007). Action video game experience alters the spatial resolution of attention. *Psychological Science,* 18(1), 88-94.

Hall, L., Woods, S., & Dautenhahn, K. (2004). Research Findings from Synthetic Character Research: Possible Implications for Interactive Communication with Robots. Proceedings of *13th IEEE W. on Robot and Human Interactive Communication,* RO-MAN 2004, 53–58.

Han, D. H., Sim, M. E., Kim, J. I., Arenella, L. S., & Lyoo, I.K. (in press). The effect of internet video game play on clinical and extrapyramidal symptoms in patients with schizophrenia. *Schizophrenia Research.*

Hartmann, W. (2002). Toy culture in preschool education and children's toy preferences in Viennese kindergartens (Austria) and in German-speaking kindergartens in South Tyrol (Italy). *Symposium of Toy Culture in Preschool Education and Children's Toy Preferences: Common Features and Differences in Europe and Across the World.* World Congress, London. In Singer, D., Golinkoff, R.M. and Hirsh-Pasek, K. (Eds.) (2006). *Play=Learning: How play motivates and enhances children's cognitive and social-emotional growth.* New York, NY: Oxford University Press.

Hoffman, H. G., Garcia-Palacios, A., Carlin, A. S., Furness, T. A., & Botella, C. (2003). Interfaces that heal: coupling real and virtual objects to treat spider phobia. *International Journal of Human Computer Interaction*, 16, 283–300.

Hoffman, H. G., Patterson, D. R., & Carrougher, G. J. (2000). Use of Virtual Reality for Adjunctive Treatment of Adult Burn Pain During Physical Therapy: A Controlled Study. *Clinical Journal of Pain,* 16(3), 244-250.

Hopkins, B., & Wober, M. (1973). Games and Sports: Missing Items in Cross-Cultural Psychology. *International Journal of Psychology,* 8(1), 5-14.

IJsselsteijn, W. A., Nap, H. H., de Kort, Y. A. W., & Poels, K. (2007). Digital Game Design for Elderly Users. *Proceedings of Futureplay 2007,* Toronto, Canada, 17-22.

Jack, D., Boian, R., Merians, A., Tremaine, M., Burdea, G., Adamovich, S., Recce, M., & Poizner, H. (2001). Virtual reality-enhanced stroke rehabilitation. *IEEE Transactions on Neurological System and Rehabilitation Engineering,* 9, 308-318.

Jannink, M. J. A., Van Der Wilden, G. J., Navis, D. W., Visser, G., Gussinklo, J., & Ijzerman, M. (2008). A Low-Cost Video Game Applied for Training of Upper Extremity Function in Children with Cerebral Palsy: A Pilot Study. *Cyberpsychology and Behavior,* 11(1), 27-32.

Jimison, H. B., Pavel, M., McKanna, J., & Pavel, J. (2004). Unobtrusive monitoring of computer interactions to detect cognitive status in elders. *IEEE Transactions on Information Technology in Biomedicine,* 8 (3), 248-252

Jönsson, E. (2005). *If Looks Could Kill – An evaluation of Eye Tracking in Computer Games.* Master's Thesis, Royal Institute of Technology, Stockholm, Sweden.

Kellar, M., Watters, C., & Duffy, J.(2005). Motivational Factors in Game Play in Two User Groups. *Proceedings of DiGRA 2005 Conference: Changing Views - Worlds in Play,* Vancouver, British Columbia, Canada.

Kerr, S., Neale, H., & Cobb, S. (2002). Virtual environments for social skills training: the importance of scaffolding in practice. *ASSETS* 2002, 104-110.

Khoo, E. T., & Cheok, A. D. (2006). Age Invaders: Inter-generational Mixed Reality Family Game. *The International Journal of Virtual Reality,* 5(2), 45-50.

Kizony, R., & Weiss, P. L. (2004). Virtual reality rehabilitation for all: Vivid GX versus Sony PlayStation II EyeToy. *Proceedings of the 5th International Conference on Disabilities, Virtual Reality, and Associated Technologies,* Oxford, UK, 87-94.

Kizony, R., Weiss, P. L., Shahar, M., & Rand, D. (2006). TheraGame: A home based virtual reality rehabilitation system. *International Journal on Disability and Human Development,* 5(3), 265-269.

Koepp, M. J., Gunn, R. N., Lawrence, A. D., Cunningham, V. J., Dagher, A., Jones, T., et al. (1998). Evidence for striatal dopamine release during a video game. *Nature,* 393(6682), 266–268.

Krijn, M., Emmelkamp, P., Olafsson, R. P., & Biedmond, R. (2004). Virtual reality exposure therapy of anxiety disorders: a review. *Clinical Psychology Review,* 24, 259–281.

Lager, A., & Bremberg, S. (2005) Health Effects of Video and Computer Game Playing. *A Systematic Review of Scientific Studies.* National Swedish Public Health Institute.

Laughlin, D., & Marchuk, N. (2005). A Guide to Computer Games in Education for NASA. Retrieved 6 May, 2008, from *http://learners.gsfc.nasa.gov/NLT/files/NASAGamesGuideLaughlin2005.pdf*

Lindley, C.A., & Sennersten, C.C. (2006). Game play schemas: from player analysis to adaptive game mechanics. *Proceedings of the International Conference on Game research and development, Perth, Australia,* 47-53.

Lindley, C. A., Le Couteur, J., & Berthouze, N (2008). Stirring up experience through movement in game play: effects on engagement and social behavior. *CHI 2008*, 511-514.

Lindt, I., Ohlenburg, J., Pankoke-Babatz, U., Ghellal, S., Oppermann, L., & Adams, M. (2005). Designing cross media games. *Proceedings of the 2nd International Workshop on Gaming Applications in Pervasive Computing Environments* (PerGames, Munich).

Lombard, M., & Ditton, T. (2003). At the heart of it all: The concept of presence. *Journal of Mediated Communication,* 3(2).

LoPresti, E. F., Mihailidis, A., & Kirsch, N. (2004). Assistive technology for cognitive rehabilitation: State of the art. *Neuropsychological Rehabilitation,* 14(1-2), 5-39.

Lumbreras, M., & Sanchez, J. (2000). Usability and cognitive impact of the interaction with 3Dvirtual interactive acoustic environments by blind children. In Sharkey, P. Cesarani, A., Pugnetti, L. and Rizzo, A (Eds.), *Proceedings of the 3rd International Conference on Disability, Virtual Reality, and Associated Technology,* (pp. 129–136). Reading, UK: University of Reading.

Matsuda, G., & Hiraki, K. (2006). Sustained decrease in oxygenated hemoglobin during video games in the dorsal pre frontal cortex: a NIRS study of children. *NeuroImage,* 29(3), 706–711.

Mäyrä, F. (2007). The Contextual Game Experience: On the Socio-Cultural Contexts for Meaning in Digital Play. *Proceedings of DiGRA 2007 Conference: Situated Play,* Tokio, Japan, 810-814.

McGraw, T.M., Burdette, K., & Chadwick, K. (2005). The Effects of a Consumer-Oriented Multimedia Game on the Reading Disorders of Children with ADHD. *Proceedings of DiGRA 2005 Conference: Changing Views - Worlds in Play,* Vancouver, British Columbia, Canada.

Michael, D., & Chen, S. (2005). *Serious Games: Games That Educate, Train, and Inform.* Publisher: Course Technology.

Moore, K., Wiederhold, B.K., Wiederhold, M. D., & Riva, G. (2002). Panic and agoraphobia in a virtual world. *Cyberpsychology And Behavior,* 5, 197-203.

Morales-Sanchez, A., Arias-Merino, E., Diaz-Garcia, I., Cabrera-Pivaral, C., & Maynard-Gomez, W. (2007). Effectiveness of an educative intervention on operative memory through popular games in the elderly. *Alzheimer's and Dementia,* 3(3), 127-127.

Morganti, F., Giaggioli, A., Castelnuovo, G., Bulla, D., Vettorello, M., & Riva, G. (2003). The Use of Technology-Supported Mental Imagery in Neurological Rehabilitation: A Research Protocol. *CyberPsychology and Behavior,* 6(4), 421-427.

Morrow, K., Docan, C., Burdea, G., & Merians, A. (2006). Low-cost Virtual Rehabilitation of the Hand for Patients Post-Stroke. *Proceedings of Virtual Rehabilitation, International Workshop,* 6-10.

Myers, D. (1999). Simulation as play: A semiotic analysis. Simulation and Gaming: *An International Journal,* 30(2), 147-162.

Pearson, P. and Bailey, C. (2007). Evaluating the potential of the Nintendo Wii to support disabled students in education. *Ascilite 2007*, 2-5 December, Singapore.

Piaget J., (1932). *Le jugement moral chez l'enfant.* Paris: Alcan.

Piaget, J. (1945). *La Formation du Symbole chez l'enfant.* Neuchatel: Delachaux et Niestle.

Popescu, V. G., Burdea, G. C., Bouzit, M., & Hentz, V. R. (2000). A virtual-reality-based telerehabilitation system with force feedback. *IEEE Transactions on Information Technology in Biomedicine,* 4(1), 45-51.

Prisco, G. M., Avizzano, C. A., Calcara, M., Ciancio, S., Pinna, S., & Bergamasco, M.(1998). Virtual environment with haptic feedback for the treatment of motor dexterity disabilities. Proceedings of the *IEEE International Conference on Robotics and Automation,* 3721-3726.

Purgato, A., & Gamberini, L. (2005). Play Safety: Virtual Environments as a persuasive tool to contrast risky behaviors in youth. *Annual Review of CyberTherapy and Telemedicine,* 3, 243-245.

Rambusch, J. (2006) The embodied and situated nature of computer game play. *Workshop on the cognitive science of games and game play.* Vancouver (Canada), 26th July 2006.

Retaux, X. (2003). Presence in the environment: theories, methodologies and applications to video games. *PsychNology Journal,* 1(3), 283 – 309.
Riva, G., & Gramatica, F. (2003). From stethoscope to ambient intelligence: the evolution of healthcare. *International Journal of Healthcare Technology and Management,* 5, 268 - 283.
Riva, G., Alcañiz, M., Anolli, L., Bacchetta, M., Baños, R.M., Buselli, C., Beltrame, F., et al. (2003). The VEPSY UPDATED project: Clinical rationale and technical approach. *Cyberpsychology and Behavior,* 6, 433-440.
Riva, G., Bacchetta, M., Cesa, G., Conti, S., & Molinari, E. (2004). The use of VR in the treatment of Eating Disorders. In Riva, G., Botella, C., Légeron, P. and Optale G. (Eds.), *Cybertherapy: Internet and Virtual Reality as Assessment and Rehabilitation Tools for Clinical Psychology and Neuroscience.* Amsterdam: IOS Press.
Rizzo, A., & Kim, G. J. (2005). A SWOT analysis of the field of virtual-reality rehabilitation and therapy. *Presence: Teleoperators and Virtual Environments,* 14(2), 119-146.
Rizzo, A., Pair, J., Graap, K., Manson, B., McNerney, P.J., Wiederhold, B., Wiederhold, M., & Spira J. (2006). A Virtual Reality Exposure Therapy Application for Iraq War Military Personnel with Post Traumatic Stress Disorder: From Training to Toy to Treatment. In Roy M. (Ed.), *NATO Advanced Research Workshop on Novel Approaches to the Diagnosis and Treatment of Posttraumatic Stress Disorder* (pp. 235-250). Washington D.C: IOS Press.
Rogers, P. (1998). The Cognitive Psychology of Lottery Gambling: A Theoretical Review. *Journal of Gambling Studies,* 14(2), 111-134.
Rosser Jr., J. C., Lynch, P. J., Haskamp, L. A., Yalif, A., Gentile, D. A., & Giammaria, L., (2004). Are video game players better at laparoscopic surgical tasks? *Proceedings of Medicine Meets Virtual Reality Conference,* Newport Beach, CA.
Rothbaum, B.O., & Schwartz, A.C. (2002). Exposure therapy for posttraumatic stress disorder. *American Journal of Psychotherapy,* 56, 59–75.
Rouse, R. (2004). Game Design: Theory and Practice (2nd edition). Wordware Publishing.
Russ, S. (1995). Play psychotherapy research: State of the science. In Ollendick, T. and Prinz, R. (Eds.), *Advances in clinical child psychology* (pp. 365–391). New York: Plenum.
Salläs, E.L., Rassmus-Gröhn, K., & Sjöström, C. (2000). Supporting presence in collaborative environments by haptic force feedback. *ACM Transactions on Computer-Human Interaction (TOCHI),* 7(4), 461 - 476.
Schneider, E. F., Lang, A., Shin, M., & Bradley, S. D. (2004). Death with a store: How story impacts emotional, motivational, and physiological responses to first-person shooter video games. *Human Communication Research,* 30, 361-375.
Sharar, S. (2006). *Virtual Reality Distraction Analgesia.* Paper presented at the SPA Annual Meeting, Chicago, IL.
Sharlin, E., Itoh, Y., Watson, B. A., Kitamura, Y., Sutphen, S., & Liu, L. (2002). Cognitive Cubes: a tangible user interface for cognitive assessment. *Proceedings of the Conference on Human Factors in Computing Systems* (CHI 2002), 347-354.
Spagnolli, A., Bertoli, L., Chalambalakis, A., Scottini, R., Turra, P., & Gamberini, L. (2007, June). *Maximizing the effectiveness of the Honda Riding Trainer: the role of the social context.* Poster presented at CHItaly'07, Padova, Italy.
Spagnolli, A., & Gamberini, L. (2005). A Place for Presence. Understanding the Human Involvement in Mediated Interactive Environments, *PsychNology Journal,* 3,(1), pp. 6-15.
Stanney, K. M., Hale, K. S., Nahmens, I., & Kennedy, R. S. (2003). What to expect from immersive virtual environment exposure: Influences of gender, body mass index, and past experience. *Human Factors,* 45 (3), 504-520.
Tse, E., Shen, C., Greenberg, S., & Forlines, C. (2007). How Pairs Interact Over a Multimodal Digital Table. *Proceedings of the Conference on Human Factors In Computing Systems (SIGCHI)*, 215-218.
Van Schaik, P., Blake, J., Pernet, F., Spears, I., & Fencott. C. (2008). Virtual Augmented Exercise Gaming for Older Adults. *CyberPsychology and Behavior,* 11(1), 103-106.

Vygotskij, L. S. (1967). Play and its Role in the Mental Development of the Child. *Soviet Psychology,* 5(3), 6-18.

Wadley, G., Gibbs, M., Hew, K., & Graham, C. (2003). Computer Supported Cooperative Play, "Third Places", and Online Videogames. In Viller, S. and Wyeth, P. (Eds), *Proceedings of the 13th Australian Conference on Computer Human Interaction (OzChi 03)*, University of Queensland, 238-241.

Walshe, D. G., Lewis, E. J., Kim, S. I., O'Sullivan, K., & Wiederhold, B. K. (2003). Exploring the use of computer games and virtual reality in exposure therapy for fear of driving following a motor vehicle accident. *Cyberpsychology and Behavior,* 6(3), 329–334.

Watters, C., Oore, S., Shepherd, M., Abouzied, A., Cox, A., Kellar, M., Kharrazi, H., Liu., F., & Otley, A. (2006). Extending the Use of Games in Health Care. *Proceedings of the 39th Hawaii International Conference in System Sciences (HICSS39)*. Hawaii.

Weiss, P. L., Rand, D., Katz, N., & Kizony, R. (2004). Video capture virtual reality as a flexible and effective rehabilitation tool. *Journal of NeuroEngineering and Rehabilitation,* 12, 1.

Whitcomb, G. R. (1990). Computer games for the elderly. *ACM SIGCAS Computers and Society,* 20 (3), 112-115.

Wiederhold, B. K., & Wiederhold, M. D. (2003). Three year follow-up for virtual reality exposure for fear of flying. *Cyberpsychology and Behavior,* 6(4), 441–446.

Wiederhold, B.K., & Wiederhold, M.D. (2006). Evaluation of Virtual Reality Therapy in Augmenting the Physical and Cognitive Rehabilitation of War Veterans. Intl Conf. Disability, Virtual Reality & Assoc., 92.

Wiederhold, B.K., & Wiederhold, M.D. (2008). Virtual Reality for Posttraumatic Stress Disorder and Stress Inoculation Training. *Journal of CyberTherapy & Rehabilitation* 1(1), 23-29.

Wiederhold, M. D. & Wiederhold, B. K. (2007).Virtual Reality and Interactive Simulation for Pain Distraction. *Pain Medicine,* 8(3), 182–188.

Yee, N. (2006). The psychology of MMORPGs: Emotional investment, motivations, relationship formation, and problematic usage. In Schroeder, R. and Axelsson, A. (Eds.), *Avatars at Work and Play: Collaboration and Interaction in Shared Virtual Environments* (pp. 187-207). London: Springer-Verlag.