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Imaging the Future

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INTRODUCTION

According to the recent "*Telemedicine Market Shares, Strategies, and Forecasts, Worldwide, 2010 to 2016*" report, presented on March 25^{th}, 2010 by Aarkstore Enterprise Worldwide, telemedicine markets at $7 billion in 2009 are expected to reach $24 billion by 2016. Total healthcare spending worldwide will reach $8.4 trillion. In this context Cybertherapy–the provision of healthcare services using advanced technologies–has the promise of delivering care more adequately to rich and poor people.

As U.S. President Barack Obama underlined in his speech to the American Medical Association, "We are spending over $2 trillion a year on healthcare–almost 50 percent more per person than the next most costly nation. And yet, as I think many of you are aware, for all of this spending, more of our citizens are uninsured, the quality of our care is often lower, and we aren't any healthier. In fact, citizens in some countries that spend substantially less than we do are actually living longer than people in other countries."

What Obama's statement didn't address is that some portions of the population are healthier. To say that not everyone is treated is not the same as saying that the system does not treat many people very well. Cybertherapy is poised to increase the quality of healthcare delivery and spread its superior healthcare delivery system to a greater portion of the population.

Healthcare delivery systems are moving towards a quantum shift in care delivery. Technology provides new ways to sense and monitor heart disease, inflammation, infection, cancer, diabetic condition, and chronic condition status using technology. This represents a quantum shift in care diagnosis. The old methodologies of patients' verbal descriptions and in-person visual inspections are becoming less important. Monitoring technologies and blood work are being used in combination with imaging and telemetrics to provide a real time, continuous evaluation of patients' conditions.

Moreover, cybertherapy supplements information available from a physical examination by making healthcare delivery more readily available. Cybertherapy is able to supplement traditional care. Cybertherapy is extending monitoring capabilities through the concept of "Interreality" *which creates a bridge between the physical and virtual worlds.* Using Interreality, cybertherapy is bridging *virtual experiences* with *real experiences* using *advanced technologies* (virtual worlds, advanced sensors and PDA/mobile phones). Therefore, the ability to visualize patient conditions through monitors, sensors, imaging, and biometrics and by adapting their experience through the use of these capabilities changes everything.

Despite the potential of cybertherapy, its benefits and the technical maturity of the applications, the use of cybertherapy services is still limited, and the market remains highly fragmented. Although many countries–including the U.S., Europe, Korea and Japan–have expressed their commitment to wider deployment of cybertherapy, most cybertherapy initiatives are no more than one-off, small-scale projects that are not integrated into healthcare systems.

It has been recognized that integrating these new types of services into existing healthcare systems is a challenging task. The aim of this volume is to support and encourage all interested countries in this endeavor by identifying and helping to address the main barriers hindering the wider use of cybertherapy and by providing evidence to build trust and acceptance of these practices.

Because of the complexity of this goal, we have put a great deal of effort into the definition of the structure of the volume and in the sequence of the contributions, so that those in search of a specific reading path will be rewarded. To this end we have divided the different chapters in four main Sections:

1. **Critical Reviews**: These chapters summarize and evaluate emerging cybertherapy topics, including technology-enhanced rehabilitation, Interreality, and Intersubjectivity.
2. **Evaluation Studies**: These chapters are generally undertaken to solve some specific practical problems and yield decisions about the value of cybertherapy interventions;
3. **Original Research**: These chapters research studies addressing new cybertherapy methods or

approaches;
4. **Clinical Observations**: These chapters include case studies or research protocols with a long-term potential.

For both health professionals and patients, the selected contents will play an important role in ensuring that the necessary skills and familiarity with the tools available, as well as a fair understanding of the context of interaction in which they are operated.

In conclusion, this volume underlines how cybertherapy has made initial progress in treating a variety of disorders. However, there is more work to be done in a number of areas including the development of easy-to-use and more affordable hardware and software, the development of objective measurement tools, the need to address potential side effects, and the implementation of more controlled studies to evaluate the strength of cybertherapy in comparison to traditional therapies.

We sincerely hope that you will find this year's volume to be a fascinating and intellectually stimulating read. We continue to believe that together we can change the face of healthcare.

Brenda K. Wiederhold *Giuseppe Riva* *Sun I. Kim*

SECTION I

CRITICAL REVIEWS

In General, there are two reasons why cybertherapy is used: Either because there is no alternative, or because it is in some sense better than traditional medicine.

In this sense telehealth has been used very successfully for optimizing health services delivery to people who are isolated due to social and physical boundaries and limitations.

Nevertheless, the benefits of cybertherapy, due to the variety of its applications and their uneven development, are not self-evident.

However, the emergence of cybertherapy is supporting the cost-effectiveness of certain applications, such as assessment, rehabilitation and therapy in clinical psychology and neuroscience.

Wiederhold & Riva, 2004

Hands, Tables and Groups Make Rehabilitation Awesome!

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Abstract. Technology has helped improve rehabilitation programs by providing patients with engaging alternatives to otherwise monotonous and repetitive exercises. In recent years, therapists have looked towards multi-touch technologies to further enhance patient rehabilitation programs. So far, the focus has mainly been on single-user interaction, largely ignoring many of the benefits patients receive from socially interacting with therapists, caregivers and their peers. To make use of these valuable interactions, we have developed a suite of multi-touch activities for motor and cognitive rehabilitation. These applications can easily be adjusted to meet the needs of individual patients and enable therapists to quantitatively measure patient behavior and performance. We also reflect on design-related discussions we had with practicing occupational therapists and provide a set of design considerations to guide future rehabilitation activities.

Keywords. Multi-touch tabletop, occupational therapy, group rehabilitation, collaboration

Introduction

Over the last decade, interest and excitement surrounding interactive surfaces and multi-touch tabletops has increased substantially. One of the most recent applications of tabletop technologies has been for motor and cognitive rehabilitation. Multi-touch tabletops can be great tools for therapists because they can include many dynamic animations and effects, allow for the precise measurement of patient behavior and performance and encourage patients to use natural actions to complete activities (e.g., reaching or dragging virtual objects). The flexibility of tabletop activities can also allow therapists to customize activities for specific patient abilities and gradually modify the difficulty of activities throughout a patient's rehabilitation program.

Although tabletops have been used in rehabilitation, they have largely neglected an important aspect of the rehabilitation process: group therapy. Group interaction in rehabilitation settings can maximize client effort, induce positive emotional changes, increase self-understanding and provide long-term improvements in patients' quality of life [1]. It has also been demonstrated that patients are more willing to spend additional time performing rehabilitation exercises in group settings than by themselves, ultimately speeding their recovery [2].

By their very nature, traditional tabletops (e.g., coffee tables, supper tables, and meeting tables) encourage social dynamics, conversation and interaction. The fusion of tabletops and group rehabilitation has the potential to greatly improve patient confidence, give patients the motivation to work harder and persevere through difficult activities. This combination also supports multi-user group interaction (i.e., cooperation and competition) between a patient and therapists, family members and peers. We have extended our suite of rehabilitation-based software activities (AIR Touch [3]) to support cooperation and competition. We also discuss a number of recommendations that help to guide the development of future activities for multi-user tabletop rehabilitation.

1. Related Work

Due to the popularity of multi-user collaboration and tabletops, a number of researchers have developed guidelines and considerations [4] for designing multi-user interactions. While some guidelines are applicable to virtually all multi-user tabletop activities (e.g., "support interpersonal interaction" and

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"support simultaneous user interactions"), many are constrained to document and media-based applications, making them unsuitable for our patient population and activities.

There has also been research investigating ways in which tabletop activities can be used to rehabilitate behavioral and communication skills. SIDES is an interactive tabletop game that has been effective in developing social skills of children with Asperger's syndrome [5]. The use of a tabletop interface provided the children with invaluable face-to-face contact, while the game setting forced the children to collaborate and work together. Similarly, the StoryTable is an interactive tabletop application that encourages users with Autism Spectrum Disorder to work together to create a narrative story [6]. The interactions that each child experienced while creating stories increased their positive social interactions and helped to decrease the occurrences of autistic behavior. This work leads to our hypothesis that multi-user tabletop activities can be effective for motor and cognitive rehabilitation.

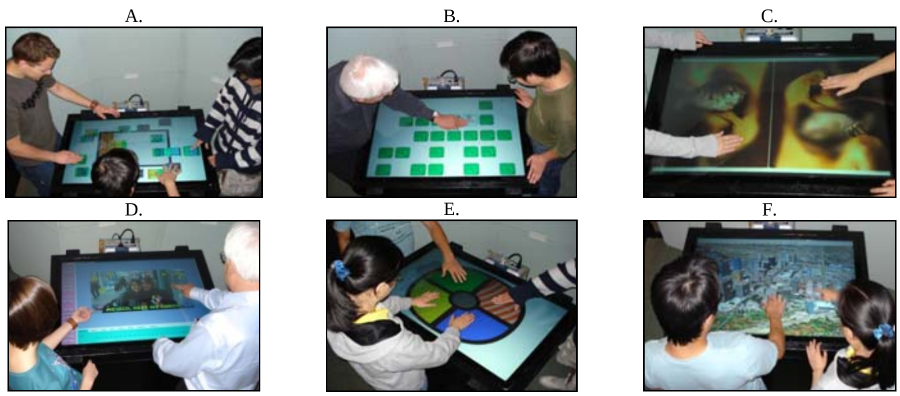

Figure 1. A) Three users assembling a Touch Tessellation puzzle, B) A user and his friend cooperatively using Match Me! to find hidden tile pairs, C) A user and family member competing to clear their Foggy Windows, D) Two users modifying a family photograph using Photo Scrapbooking, E) Three users playing Nomis Says, F) Two users exploring their hometown using Google Earth.

2. AIR Touch Design and Activities

We have created five multi-touch activities (and one AIR Touch extension) that help to induce immersion and increase perseverance. These activities enable patients to receive rehabilitative benefits by distracting them from their disabling conditions or impairments (Figure 1). Each of the activities was implemented using the AIR Touch system [3]. AIR Touch is a rear-projection, Windows XP-based and multi-touch tabletop system that uses FTIR technology to generate touch events. The AIR Touch software records a variety of behavioral and performance measurements that can be important for the identification of patient deficiencies and the tracking of patient progress.

2.1 Touch Tessellation

In Touch Tessellation, patients are presented with a number of puzzle pieces and must touch and drag each piece to complete the puzzle (Figure 1A). Touch Tessellation can test planning, decrease visual neglect, increase spatial relation skills and challenge fine and gross motor skills. To customize the activity, a therapist can specify the size and number of puzzle pieces or modify the starting location of the puzzle pieces (e.g., to encourage patients to converse or perform gross motor movements). Patient photographs can be used and meaningful sounds can be played to encourage social dialog and emotional immersion.

2.2 Match Me!

Match Me! presents patients with an array of face-up or face-down touch tile pairs that need to be matched. This activity challenges gross motor movements, can increase sustained attention and aims to improve visual neglect. To increase patient compliance and social interaction, family photos can appear on the tiles. A therapist can also choose to modify the number of touch tile pairs that are presented or change the location and pattern of the tiles. The Match Me! activity supports both cooperation and competition: a patient can work with a partner to find matching touch tiles or complete against another player to find the most touch tile pairs (Figure 1B).

2.3 Foggy Windows

In Foggy Windows, a patient is presented with a 'foggy window'. Patients must use their fingers or hands to 'defog the window' and reveal the hidden picture underneath. Foggy Windows can help patients exercise their gross motor skills and challenge figure-ground discrimination. To maintain patient engagement and compliance, therapists can modify the amount of fog that each window contains, the location of each window on the tabletop or the size and type of the hidden object that is displayed (i.e., patient photographs, emails or documents such as news stories can all be hidden). Foggy Windows can be used cooperatively, i.e., for example patients work with a partner to clean a window, or competitively, i.e., a patient and his or her partner have their own 'foggy window' and compete to clean them the fastest (Figure 1C).

2.4 Photo Scrapbooking

In the Photo Scrapbooking activity, patients are encouraged to work cooperatively with a partner to modify personal pictures and make a scrapbook page. Patients can flip through a collection of their personal photographs to decide which one to modify and add to the scrapbook. In Photo Scrapbooking, patients can crop pictures, add stickers, paint, annotate or alter picture attributes, such as brightness or contrast (Figure 1D). Once a picture has been modified, it can be added to a scrapbook page, which can be saved, printed or emailed to others. Photo Scrapbooking is an ideal collaborative activity because photographs naturally encourage emotional reactions and storytelling, and activate long-term memory. The editing of photos also challenges patients to exercise their fine and gross motor skills.

2.5 Nomis Says

Nomis Says is a virtual implementation of the classic Simon^{TM} game. In Nomis Says, a therapist can modify the number of colored quadrants that appear, change the size and location of each coloured quadrant, or change the number of times a patient can try to repeat a light-up sequence if they have made an error. Players can take turns repeating the light-up sequences, or players can be responsible for one or two quadrants and touch them at the appropriate time (Figure 1E). Nomis Says provides many cognitive and motor challenges to patients, such as sequencing, divided attention, immediate recall, gross motor skills and dexterity.

2.6 Third party application support

We have added a keyboard and mouse emulation extension to the AIR Touch system to support the use of third party applications. Interaction with Google Earth, for example, encourages patients to use their hands or fingers to navigate to places they have travelled to before or walk around their old neighborhood (Figure 1F). Third party support also allows patients to play games with their family members, such as chess or checkers, browse the internet, or send emails using a virtual keyboard. This support allows patients to continue to stay connected to the outside world and practice skills that could be valuable once they finish their rehabilitation program.

3. Rehabilitation-Based Design Recommendations

During our iterative design and implementation cycle, we consulted with a number of practicing occupational therapists. Discussions with these experts produced a number of guidelines that have influenced the design of our rehabilitation-centric activities and should be beneficial for others working in the area.

- Including positive and salient elements in multi-user activities can help patients to become '**emotionally immersed**'. This immersion allows patients to temporarily forget the pain or cognitive deficits they may have and instead focus on the activity at hand. If a patient is working on an activity that has a picture of a loved one, they are likely motivated to put in more effort and spend more time performing the activity.

- Encouraging **communication** during multi-user activities enables patient/therapist trust to increase, encourages patients to share their feelings and difficulties with their caregivers, and creates bonds with other patients over shared life or rehabilitative experiences.
- **Cooperation** is beneficial for rehabilitation because it provides patients with motivation from others who are in similar situations, such as fellow patients. Using cooperation within rehabilitation activities also encourages patients to learn from the people they are interacting with and promotes turn taking, teamwork and patience.
- If patients can become '**competitively immersed**' in an activity, they are more likely to try harder and work at an activity longer in order to beat their competitor. Patients can also receive encouragement and motivation from onlookers who are supporting them.
- Activities should be **configurable** and have elements of **uncertainty**. Configurable activities allow therapists to tailor activities to match a patient's motor or cognitive abilities, demographic, background or specific interests. Activities that contain surprises, uncertainty and variability can be reused many times throughout a patient's recovery.

4. Conclusions and Future Work

Previous tabletop rehabilitation technologies have focused on single-user interaction, neglecting the benefits of collaboration and group rehabilitation. We have addressed this issue by working with practicing therapists to create a number of multi-user activities. These activities allow patients to gain rehabilitative benefits while working cooperatively or competitively with family members, peers or therapists. We have also identified a number of design considerations that can be used to guide the development of rehabilitation-based multi-user tabletop activities.

The AIR Touch system is currently being used in a local rehabilitation hospital. A pilot study with therapists, patients and family members is underway to determine the usefulness of the system. Patient interviews are being conducted to evaluate patient enjoyment and enthusiasm towards the collaborative nature of the AIR Touch system and its software.

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Intersubjectivity as a Possible Way to Inhabit Future Cyberplaces

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Abstract. A change of perspective in online interaction research, shifts attention from technologies to what people actually do online. It's time to study how subjects interact with others and how they 'take possession' of virtual environments on a perceptive, emotional and relational plan. This paper illustrates: a) how actors 'construct' themselves as subjects facing others during online interactions; b) the relationships actors establish with virtual environments and how actors transform 'simple' cyberspaces in cyberplaces; c) how actors – on the basis of a) and b) – 'bridge the gap' between them and their interlocutors using communication as a tool to give form to intersubjectivity, intended as an effective relational structure. A research program built around these three issues – both on the theoretical and empirical plan – should become the core of Social Psychology of Cyberplaces as this paper will demonstrate.

Keywords. Intersubjectivity, Cyberplaces, Avatar, Virtual Reality, Blogs

Introduction

Subjectivity is a fluid and circumscribed image proposed by the subjects to the outside world, a portion of what the person is [1]. It is an intention based on part of the Self relevant in that context, strategically presented considering the interlocutor and the environment. To be understood by others during mediated interactions, subjects shape their subjectivities according to feedbacks and artifacts offered by the context. Subjectivity is dialogically generated and continuously adjusted by social actors during their interactions. Every social interaction is characterized by a unique combination of subjectivities created in a specific context at one moment, a combination that generates intersubjectivity. Intersubjectivity refers to a specific frame of interaction constituting a shared world for the subjects to enact in [2]. Utterance intersubjectivity indicates the process that allows actors to create a shared world within which they can interact with a good level of inter-comprehension. Such world has four specific features that are both mode of action (process) and results (product) of the actors' actions. The first characteristic of a shared world is the construction of the actors' subjectivities and their reciprocal recognition. The second one is the conjoint definition of rules regarding interaction management and the relationships between actors according to situations. The third feature is the definition of the objects involved in the interaction and the fourth one is the definition of conversational and discursive rules that allows actors to talk about the objects.

These four characteristics demonstrates that co-referring to shared worlds is a signal to a back reference to the actors themselves [3], that is: when actors talk about objects present within their world, they always give information about themselves, leaving clues, signs of subjectivity that is being elaborated during interaction [4][5].

The peculiarities of such worlds should be the conjoint definition of subjectivities and the rules to create and support relationships as well as the definition of objects and conversational rules to deal with them [6]. From a psychosocial point of view, mediated interactions are part of cyberplaces more than of cyberspaces: virtual places built thanks to new technologies, but made of relationships and of social meanings co-produced by their users.

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1. Shaping Cyberplaces: three examples

To illustrate this process, we will make reference to three of the most recent CSRPC's team studies. The first study [4] focuses on the creation of subjectivity and relational rules and therefore focuses on the first and the second features of cyberplaces. The second study [5] is explicative of the co-referring and back-referring process. The third study [6] explores the first and the third rules.

1.1. Conversational and discursive rules in VEs

Shared Virtual Environments (VEs) are potential cyberplaces where interaction between participants may take place and become predominant through negotiated action and construction of intersubjectivity.

Forty-eight conversations between 24 couples of participants placed in a VE were analyzed, in order to understand the specific structure, dynamics, and phenomenology of intersubjectivity. Participants had to negotiate assigned task to reach an objective together.

Conversational analysis of the participants' interplay highlights that actors not only co-define the virtual environment, but also its representations: when they don't share their relative positions, their mutual understanding of the situation, the interaction needs to be continuously tuned, actors have to quit the assigned task and fall back to the description of the environment, and their position in it, their actions, and their intentions. Interactions in the VE are focused on the co-construction of meaning, and are articulated on three different levels: an action level, constituted by the task, and the actions required to perform such task; an interactional level which consists in the environment surrounding the actors, in their avatars, in the affordances; a dialogical level based on the shared, reciprocal presence of actors. In order to collaborate, actors need to share their representation and relative position in each level of the interaction: they need to be aware and to make others aware of who they are, where they are, what they are doing, how to do this and the result of their action.

Results show that interactive micro-chains are used in a VE to collaborate successfully and to build a shared representation of the world, of the objects and of their position: intersubjectivity results from the actors' reciprocal sense of social presence, what they are doing, their negotiated ways of action and the outcomes of such actions.

1.2. Co-referring to shared objects and back-referring to actors

A person's subjectivity is dialogically constructed thanks to inter-actional exchanges with other people and the environment where it takes place. Subjectivity and interactivity processes are not the main aim of interactive exchanges but are a requisite to carry out any coordinated activity between actors. These actions carry hints and clues of who the actors are.

The word 'fandom' relates to a group of people, typified by a feeling of closeness to others with the same interests, sharing, and specific jargon [8]. As a community of practice, members of a fandom share a specific jargon and practices (textual, graphics and visual productions) that generate new meanings and become a space of negotiation.

In this second study [5] twenty media fandom blogs linked to two different tv-show's communities were analyzed in their structural and design elements in an ethnographic perspective to explore how people present themselves as member of a community. These descriptions were produced for each blog.

While each blog stands alone and is basically independent from the other, bloggers all use the same channels of communication to foster feeling of connection to their community: both verbal and visual-iconic jargons refer to a world that is only meaningful to the initiated. The common language made of subtle references to the focus of the community is characterized by: content of different blog features (e.g. credits, faq, images) is iterated and repeated to stress the common interest (tv-show); interactions are actively encouraged but strictly regulated by spelled-out warnings all through the blog (e.g. "friending" rules, credits for taking other people's fandom related artistic production). Blogs are socially constructed places but are home to a specific person, and therefore breaking the rules entails shunning from a specific blog and its fandom neighbors.

Blogs are also places for individual expression and this is evident by the way bloggers use common content (in this case, a tv show) and recognized blog features (e.g. header) to deliver a very personal self-presentation as member of a fandom. Through their Self Presentation, fans refer to the community thanks to the use of common clues, but within these boundaries, they use their own or other's people skills to have original content which differentiate them from other fans.

This second study shows that each element of the blog refers to a community-specific jargon and shared meanings. Through such specific manipulation of the blog structure, subjects talk about themselves as member of a specific fandom; being an intersubjective asynchronous environment, the fandom blog becomes a real cyberplace.

1.3. Co-definition of objects and subjectivities

The third study [6] explores the strategies that 10 couples of players drew together to shape a self-representative avatar in videogames (tennis and bowling) played with the Nintendo Wii console.

When online interactions are studied, offline context generally is not considered. The Nintendo Wii Console creates a blended context [9] where VE and real life (RL) are tied together so that movements acted in RL are replayed with a good degree of accuracy within the VE. Participants are represented in the VE by an avatar, called Mii. Participants play a bowling and a tennis match against another player who could be a friend or an unknown person. The interactions were audio and video recorded to analyze the visual information and the conversations among participants. Content analysis was performed. Results show that avatar construction becomes a collaborative process only if the other player is a significant other, revealing how much players feel linked to their Miis. This strong connection is also clear observing how they interact with Miis and with the partner during the game. The gaze continuously changes position depending on how Miis' movements mirror players' ones. Linguistic clues also reveal that when the Mii does not mirror the player's movements it becomes an external component: players switch from first person to third person, when there are breaking points [10] due to the technological components. Observation also shows that players tend to position themselves in RL by mirroring what happens in the VE, even if this kind of positioning is not required by the Wii.

Creation of avatars is performed as a collaborative process only when the other player is a stakeholder, a significant person to the participants. Avatars partially contribute to the definition of subjectivity that is built intersubjectively. Conversations, physical movements in RL and in VE and the medium itself help players negotiate the meaning of their actions and their subjectivities. As partial representation of the self, avatars act as a bodily representation in a virtual environment. 'Bringing the body' into the virtual environment, avatars allow the participants to invest into the environment itself, emotionally and relationally, turning 'simple' cyberspaces into cyberplaces, environments made of meanings co-produced intersubjectively.

2. Conclusion

Users use ICTs to perform old tasks in new, creative ways, and at the same time, ICTs create new possibilities and alternative solutions [11]. Users' behaviours are linked to a specific online environment and are cultural elements of digital worlds [12]. The focus is not on technology, but on the people. Cyberspace has been considered for a long time for its technological features, but for cyberspaces to become alive with people they must become Cyberplaces, where social dynamics are supported: "With the click of a mouse, people can interact with diverse others in a multiplicity of socially produced places, providing a context for the emergence of simultaneously anonymous yet personally meaningful identities situated in a geographically spaceless context […]"[13]. Only within a process of intersubjectivity is it possible for people to imbue cyberspaces with meanings and transform them into "socially produced places".

The three examples reported above respectively show: 1) how subjects create rules to define and manipulate objects by speaking about themselves, 2) how subjects speak about themselves through object manipulation, 3a) how the subjects' construction of their own face in virtual environments (avatar) is affected by the other and 3b) how this cooperation among subjects can bring about intersubjectivity and transform mere cyberspaces into 'future' cyberplaces rich in co-constructed affective investments and shared meanings. These processes are to be taken into consideration when one wants to describe, observe, study whatever people are doing in any VEs, at the crossroads of intersubjectivity and cyberplaces.

A last remark must be dedicated to the design of VEs. If one wants VEs to be successful with users, that is if one wants them to be inhabited by active people, these intersubejctive processes must be embedded in the design of VEs. This is because the cyberplaces must support the processes described in the previous paragraph to allow future users to build their intersubjectivities. Considering the cognitive and action contexts when designing VEs is not sufficient to design real cyberplaces, all the four processes must be taken into consideration and used as guidelines while projecting and implementing VEs.

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Virtual Reality Adaptive Stimulation of Limbic Networks in the Mental Readiness Training

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Abstract. A significant proportion of severe psychological problems in recent large-scale peacekeeping operations underscores the importance of effective methods for strengthening the stress resilience. Virtual reality (VR) adaptive stimulation, based on the estimation of the participant's emotional state from physiological signals, may enhance the mental readiness training (MRT). Understanding neurobiological mechanisms by which the MRT based on VR adaptive stimulation can affect the resilience to stress is important for practical application in the stress resilience management. After the delivery of a traumatic audio-visual stimulus in the VR, the cascade of events occurs in the brain, which evokes various physiological manifestations. In addition to the "limbic" emotional and visceral brain circuitry, other large-scale sensory, cognitive, and memory brain networks participate with less known impact in this physiological response. The MRT based on VR adaptive stimulation may strengthen the stress resilience through targeted brain-body interactions. Integrated interdisciplinary efforts, which would integrate the brain imaging and the proposed approach, may contribute to clarifying the neurobiological foundation of the resilience to stress.

Keywords. Virtual reality adaptive stimulation, limbic networks, mental readiness training, stress resilience, physiological measurements, emotional state estimation

Introduction

A significant proportion of severe psychological problems in recent large-scale peacekeeping operations [1] highlights the significance of the resilience to stress. The mental readiness training (MRT) [2] as a modification of the stress inoculation training (SIT) [3] for military personnel, has been proposed as a stress resilience building approach. In comparison with the SIT, the MRT places a lesser emphasis on lectures concerning stress, but a greater emphasis on the practice of stress-coping skills in the context of a relevant military training. According to [4], an individual's stress resilience includes both an ability to retain a quality task performance under highly stressful conditions (stress resistance), as well as an ability to regain normal functioning after exposure to stressful conditions (stress recovery). The MRT based on VR adaptive stimulation may contribute to both aspects of stress resilience, but each aspect should be analyzed separately from the perspective of underlying neural mechanisms. While changes in the brain-body interaction influenced by MRT based on VR adaptive stimulation result in physiological fluctuations, a further analysis is needed with respect to a direct relevance of these processes to stress resistance and stress recovery. Existing correlates of psychotherapy treatment outcomes visible in "limbic" and "paralimbic" brain structures [5,6] suggest that neurobiological considerations of stress resilience may strengthen practical applications of the MRT.

1. Physiology-Driven Adaptive Virtual Reality Stimulation for MRT

Following the promising applications of virtual reality (VR) in psychotherapy of stress-related disorders and SIT [7], the concept of physiology-driven adaptive VR stimulation [8] is proposed as a potentially useful adjunct to the MRT. The concept involves delivery of audio-visual stimuli in a closed loop, based on the information about the participant's emotional state, which is extracted from physiological

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measurements by the neural network based emotional state estimator [9]. This approach may facilitate personalized elicitation and monitoring of potential psychophysiological correlates of the stress resilience, using the stimuli with desired semantics and emotional properties. Various control laws may be implemented in physiology-driven adaptive VR stimulation, to accomplish the goals of a specific stimulation strategy. Regardless of the control law, the control vector $\boldsymbol{u}_k = \boldsymbol{u}(kT)$ sent to the stimuli generator, where T is a basic time step and $k \in \mathbf{N}_0$, may be represented as:

$$\boldsymbol{u}_k = (stimType_k, discreteEmo_k, valence_k, arousal_k, semantics_k),$$

where $stimType_k \in StimuliTypes = \{IMAGE, SOUND, VIDEO, VR, \ldots\}$ denotes a type of the stimulus to be generated, $discreteEmo_k \in DiscreteEmotionSpace = \{JOY, SADNESS, FEAR, ANGER, DISGUST, \ldots\}$ stands for a discrete emotion to be elicited by the stimulus, $(valence_k, arousal_k) \in DimensionalEmotionSpace = [1.0, 9.0] \times [1.0, 9.0]$ represents a dimensional valence/arousal description of the emotion, and $semantics_k \in SemanticsSpace$ is the description of the content of the stimulus (e.g. by a well-formed propositional formula consisting of keywords and logical and, or, not operators). For example, the following control vectors would potentially yield a rather extreme change of the participant's emotional state after step n, with $m < n$:

$$\boldsymbol{u}_m = (IMAGE, SERENITY, 8.0, 2.0, flower \text{ or } sunset),$$

$$\boldsymbol{u}_n = (VIDEO, DISGUST, 2.0, 8.0, mutilation).$$

After the control vector $\boldsymbol{u}_k$ has been formed and sent to the stimuli generator, the stimulus that best matches $\boldsymbol{u}_k$ is found and delivered to the participant. The cascade of events triggered by the stimulus in the participant's brain produces physiological manifestations that are processed by the emotional state estimator. The estimator outputs enter the controller, vector $\boldsymbol{u}_{k+1}$ is generated, and the process continues.

2. The Neurobiology of Emotions

Complex sensory-cognitive-emotional-executive interactions between the brain and the body can be described by the "high road" and "low road" neuronal circuits [10], which connect both "limbic" and "paralimbic" cortices. These interactions give rise to the subjective and physiological components of emotion (Figure 1). Upon delivery of an audio-visual stimulus, the information from sensory organs travels to the thalamus (Th). The thalamus acts as a relay station, forwarding sensory information along the "high road" pathways to appropriate primary and secondary association auditory (Aud I, II) and visual (Vis I, II) cortices for further processing. The multimodal integration of this information is performed in the highest-level association cortex in parietal-temporal-occipital region (PTOAssoc) [11], as well as in another highest-level association cortex, i.e. inferior temporal cortex (ITAssoc), related to long-term declarative memories (e.g. [12]). This information is made accessible to the prefrontal association cortex (OFC/VMPFC and DLPFC), which is bidirectionally connected with the amygdala (Am). The amygdala is regarded as an important structure for the emotional memory, which has been experimentally tested especially in relation to the emotion of fear [10]. The "top-down" regulation of emotions by orbitofrontal and ventromedial components of the prefrontal cortex (OFC/VMPFC) is particularly important, as it involves an integration of a cognitive information loop, i.e. parietal-dorsolateral prefrontal cortex (PTOAssoc-DLPFC), long-term memories via the hippocampus (Hc), fear via the amygdala, and executive functions via the DLPFC and the premotor cortex (PMC).

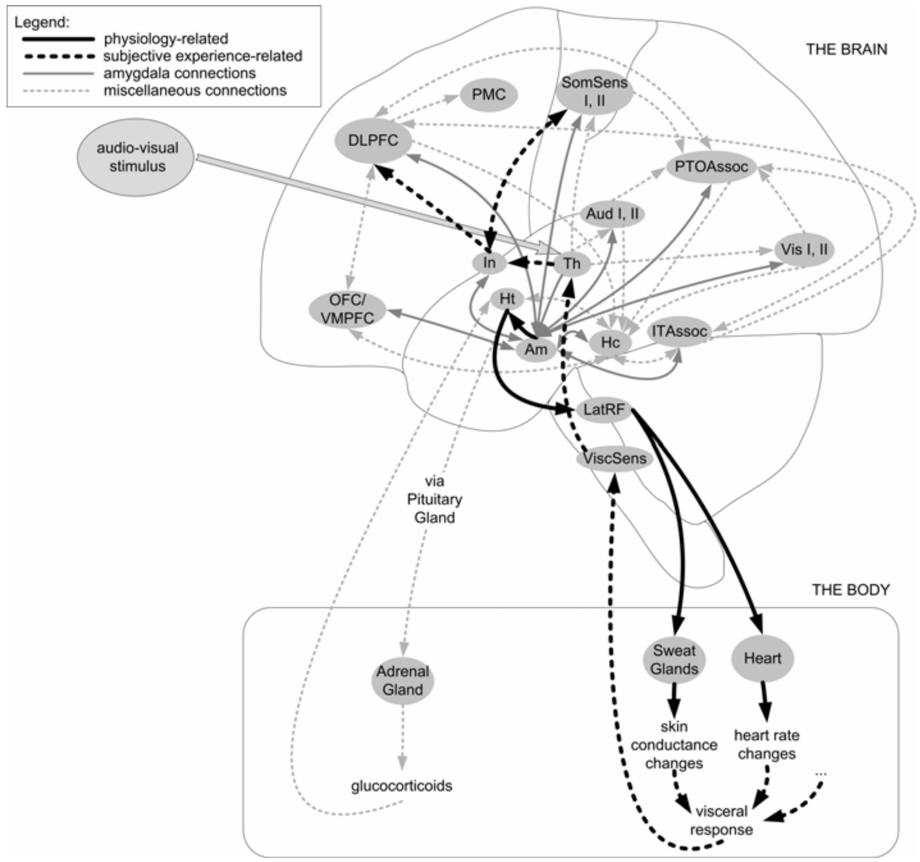

Figure 1. Pathways of the subjective and physiological components of emotion.

The "low road" circuit simultaneously transmits the audio-visual sensory information directly from the thalamus to the amygdala, where it is assessed with respect to its relevance for the organism (e.g. [13]). The information along the "low road" circuit arrives to the amygdala faster than through the "high road" circuit. This is particularly important when the stimulus is relevant for the survival of the organism. In such situations, emotional reactions will be elicited even before the stimulus has been fully processed. The net result is an "immediate" protective reaction against the fatal threat, but false alarms may also occur due to the presence of unprocessed stimuli.

Amygdala projections to the hypothalamus (Ht), which further projects to brainstem structures such as the lateral reticular formation (LatRF), lead to changes in the activity of autonomic nervous system and viscera [14]. These "low road" brain-to-body pathways produce changes in skin conductance, the heart rate, the respiration rate etc., which can be measured by physiological acquisition devices. Concurrently with changes in the autonomic nervous system, the hypothalamic-pituitary-adrenal axis regulates the amount of glucocorticoids and other hormones, which prepare the organism to cope with the current situation. Other possible manifestations may involve the emotional behavior, which relies on appropriate connections of "limbic" structures with motor circuitry.

The subjective experience of emotion, i.e. the feeling, arises as a result of the activity of body-to-brain pathways, through which visceral changes are sensed by the brain, and brain pathways that represent these changes together with the eliciting stimulus or situation [15]. Principal representational structures involved with feelings are thought to be visceral sensory nuclei in the brainstem (ViscSens), insular cortex (In) and primary and secondary somatosensory cortices (SomSens I, II) [15].

The prefrontal cortex, which is considered as an essential part of the frontolimbic system [16], displays the greatest sensitivity to the harmful effects of the exposure to stress [17]. Various parts of "paralimbic" and "limbic" cortices are known to be affected in stress-related disorders as well [5].

3. Neurobiological Considerations of the Stress Resilience

Very stressful, dangerous tasks are expected to induce a strong activation of the amygdala, which can adversely affect the stress resilience, i.e. both the stress resistance and stress recovery. For the stress resistance, the relevant neurobiological aspect is related to amygdala projections to the DLPFC, which is responsible [17] for working memory and the attentional set. These projections enable the amygdala activity to interfere with mission-related cognitive processes that rely on working memory and require sustained attention. Therefore, an approach to improving the stress resistance involves over-learning of the basic operational skills and standard operating procedures, so that they can be performed "automatically", without requiring attention. In stressful situations that demand highly cognitive abilities, the inhibition of the amygdala activity by the OFC/VMPFC may play an important role in the successful performance of stressful tasks. Based on contextual information provided by the hippocampus, the OFC/VMPFC is able to perform a selective context-dependent amygdala inhibition. Inhibitory connections from the OFC/VMPFC to the amygdala may be strengthened during the stressful training by practicing the stress-coping skills that are an integral part of MRT. A stronger inhibition of the amygdala should lead to a decreased activation of the hypothalamus and the brainstem nuclei. Therefore, one would expect to observe lowering of the physiological reactivity to stressful stimuli with improvement in the stress-coping skills. Changes in the physiological reactivity of an individual during delivery of various stressful stimuli can be longitudinally monitored by the physiology-driven adaptive VR stimulation. Stressful stimuli can also be delivered through various other forms of training, but the physiological monitoring may be more challenging if the training involves vigorous movements.

For the stress recovery, i.e. the prevention of stress-related disorders, an approach applying the physiology-driven adaptive VR stimulation presented in [8] resembles the approach from the previous paragraph. However, it may also be important to prevent a post-traumatic generalization of a specific traumatic event to a much broader, and only marginally related, innocuous context. Due to the heightened amygdala activity during the traumatic event, the neural representation of the critical aspects of the trauma is expected to consolidate quickly into long-term memory (ITAssoc). As biochemical synaptic reinforcement process is thought to underlie memory consolidation [18], it is important to block this process on synapses between the neural representation of the critical aspects of the traumatic event and the neural representation of the innocuous context. Thus, obstructing the simultaneous rehearsal of the critical aspects and the innocuous context of the trauma may be helpful in an effort to prevent strengthening of synapses between the corresponding neural representations. As memory consolidation is believed [18] to continue during the weeks after the traumatic event, a potential approach in this period may be overloading the trauma survivor's working memory with episodes of personal relevance that have a contrasting motivational basis. Another compatible approach may involve incorporating the elements of the innocuous context into nonthreatening real-life, virtual or iconic scenarios. This approach should facilitate storage of the innocuous context with strengthened nonthreatening associations and weakened associations to the critical aspects of the traumatic event. Physiology-driven adaptive VR stimulation might be helpful in this regard, when applied by an expert. The role of the expert would include choosing the stimuli that approximate innocuous context of the trauma, and then conducting the conversation to engage the trauma survivor into plausible nonthreatening situations related to the presented stimuli. Therefore, a semantically driven choice of stimuli based on the data gathered from an interview with the trauma survivor would be indicated in preference to the physiology-driven search of the stimuli database. Physiological measurements would remain useful for gauging the strength and breadth of associations between the critical aspects and the innocuous context of the traumatic event. Holmes and colleagues [19] have proposed and tested another related approach that targets the memory consolidation of traumatic flashbacks.

4. Conclusion

The inhibition of the amygdala response by the prefrontal cortex can be strengthened by MRT based on VR adaptive stimulation. This approach may significantly increase the stress resistance of trainees, in combination with a real-life exercise and training. The stress recovery may be facilitated by an immediate post-trauma VR adaptive stimulation during the process of consolidation of the traumatic event memory. The immediate post-trauma stimulation strategy, via nonthreatening scenarios that focus on the innocuous context of the individual's traumatic experience, may prevent broad associations with the traumatic event.

An interdisciplinary approach to the stress resilience is called for, which would integrate brain imaging, MRT based on VR adaptive stimulation, and psychological stress resilience research.

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Interreality in the Management of Psychological Stress: a Clinical Scenario

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Abstract. The term "psychological stress" describes a situation in which a subject perceives that environmental demands tax or exceed his or her adaptive capacity. According to the *Cochrane Database of Systematic Reviews*, the best validated approach covering both stress management and stress treatment is the Cognitive Behavioral (CBT) approach. We aim to design, develop and test an advanced ICT based solution for the assessment and treatment of psychological stress that is able to improve the actual CBT approach. To reach this goal we will use the "interreality" paradigm integrating assessment and treatment within a hybrid environment, that creates a bridge between the physical and virtual worlds. Our claim is that bridging *virtual experiences* (fully controlled by the therapist, used to learn coping skills and emotional regulation) with *real experiences* (allowing both the identification of any critical stressors and the assessment of what has been learned) using *advanced technologies* (virtual worlds, advanced sensors and PDA/mobile phones) is the best way to address the above limitations. To illustrate the proposed concept, a clinical scenario is also presented and discussed: Paola, a 45 years old nurse, with a mother affected by progressive senile dementia.

Keywords: Interreality, Virtual Reality, Biosensors, Stress, Stress Management

Introduction

According to Cohen and colleagues [1] "Psychological Stress" occurs when an individual perceives that environmental demands tax or exceed his or her adaptive capacity. In this view, stressful experiences are conceptualized as person-environment transactions, whose result is dependent on the impact of the external stimulus**.**

The *Cochrane Database of Systematic Reviews* [2-3] identified in the Cognitive Behavioral (CBT) approach the best-validated approach for stress management and stress treatment. Even if CBT is the treatment of choice for psychological stress, there is still room for improvement [42]. Specifically, there are three major issues to solve:

- The therapist is less relevant than the specific protocol used.
- The protocol is not customized to the specific characteristics of the patient.
- The focus of the therapy is more on the top-down model of change (from cognitions to emotions) than on the bottom-up (from emotions to cognitions).

1. The Interreality Approach

To overcome the above limitations, here we suggest a new paradigm for e-health – "*Interreality*" - that integrates assessment and treatment within a hybrid environment, bridging physical and virtual world [4-6].

By creating a bridge between virtual and real worlds, Interreality allows a full-time closed-loop approach actually missing in current approaches to the assessment and treatment of psychological stress:

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- The assessment is conducted continuously throughout the virtual and real experiences: it enables tracking of the individual's psychophysiological status over time in the context of a realistic task challenge.
- The information is constantly used to improve both the appraisal and the coping skills of the patient: it creates a conditioned association between effective performance state and task execution behaviors.

The potential advantages offered to stress treatments by this approach are: (a) *an extended sense of presence*: Interreality uses advanced simulations (virtual experiences) to transform health guidelines and provisions in experience; (b) *an extended sense of community*: Interreality provides social support in both real and virtual worlds; (c) *a real-time feedback between physical and virtual worlds*: Interreality uses bio and activity sensors and devices (PDAs, mobile phones, etc) both to track in real time the behavior and the health status of the user and to provide suggestions and guidelines.

To illustrate the proposed concept, a clinical scenario is also presented and discussed: Paola, a 45 years old nurse, with a mother affected by progressive senile dementia.

2. Interreality in Practice: PAOLA - A clinical scenario

Paola is 45 years old, and she works as a nurse in the hospital of her town. She has a son, Stefano, who moved three years ago to America where he works and lives with his wife and newborn baby. She does not see them very often, generally only during Christmas holidays and summer time. Her husband died last year of a heart attack, and she has been living alone since then. She believes her main resource in coping with her husband's loss has been her mother's support and she never imagined that her mother would also have gotten sick so soon.

Indeed Paola is actually the primary home caregiver of her mother, who is affected by progressive senile dementia. Since the moment her mother received the diagnosis, providing her mother with home care has become Paola's main activity after work. Specifically, she spends an average of five hours per day in caregiving-related activities. Since Paola thought she had effectively coped with both her son's departure and her husband's death, she imagined she could also successfully cope with this new negative event and now she is unable to accept its totally destabilizing effects on her.

In particular, she has difficulty accepting the true reality of her mother under these conditions and it causes her to think she has lost her, making her feel totally alone. Moreover, Paola feels like no one can help her: her son is too far away and her friends cannot understand. She thinks, "Those who have not directly experienced such a situation can never really understand that situation." Since none of her friends have dealt with such a situation Paola feels they can never truly understand.

What makes the situation even more difficult is the fact that Paola believes her coping efforts are ineffective: she believes she has no control over the situation, insufficient resources to cope with such a long-lasting event and an inability to deal with the difficulties in changing identity and acquiring the social role of caregiver the current situation requires. Paola is exposed to chronic stress and is manifesting many of the difficulties associated with psychological stress: in fact she appears to have effectively dealt with previous stressors but not the current one.

Indeed, the duration of a chronic stressor, the fact that it tends to be constantly rather than intermittently present and the changes in identity or social roles frequently associated with it may contribute to the severity of the stressor in terms of both its psychological and physiological impact.

2.1 The INTERSTRESS solution (10 biweekly sessions + 2/4 boosting sessions)

Paola will first need to accept what she is going through. This will require a cognitive restructuring activity to allow for re-appraisal of the event. This should be followed by education and training regarding useful coping responses to the type of stressors she is dealing with. In general, she has the perception that her living conditions have become exceedingly stressful and she does not know how to deal with this increasing pressure: for this reason she has decided to go to a therapist.

When she arrives, the therapist welcomes her and this gives Paola an immediate sense of being less alone and makes her begin to feel better. After a short interview and some paper-and-pencil self-report questionnaires, the therapist decides to use the INTERSTRESS system. She asks Paola to wear biosensors to monitor her physiological parameters. The therapist places the non-invasive sensors on Paola and explains their value to her, beginning the education process.

Then the therapist introduces Paola to one of the virtual worlds – the *Experience Island* - where she is exposed to a virtual situation similar to the real life one. Within this virtual environment, Paola has to help her mother with daily activities. The data fusion system allows the therapist to directly index how the various stressors are impacting Paola's psychophysiology, thus providing an objective understanding of the different stressors and their importance and impact on Paola's well being.

At the end of the clinical session, the therapist "prescribes" homework for Paola. This, she explains, will allow Paola to be an active participant in her own well being. This will also allow Paola to begin to practice the skills she has started to learn, thus making them become more readily available to her during stressful situations. The homework: first, Paola needs to expose herself to the recorded critical situation in the virtual world displayed on her PDA. Then she must expose herself to the real world situation. In real world situations, the biosensors will track her response and the Decisions Support System, according to the difference from her baseline profile, will provide positive feedback and /or warnings.

Finally the therapist tells Paola that she can press a "stress" button in the PDA if she feels more stressed: this will record her experiences and they can then speak about them in the next session, allowing the two as a team to problem solve between session difficulties and how to more effectively handle future situational stressors.

At the start of any new session, the therapist uses the compliance data and warning log to define the structure of the clinical work. Also, the Decision Support System will analyze the stressful situations indicated by Paola to understand more what happened and the context in which they occurred.

In our experience, often in the beginning of therapy, the patient is relatively "unaware" of which situations cause the most physiological arousal or stress. Their self-report measures of stress are often different than their bodily responses due to denial and other defense mechanisms. By showing them what situations caused the most physiological arousal, they often develop a new awareness, which brings on added insight and allows for self-treatment to proceed more effectively. Utilizing new skills and coping mechanisms taught by the therapist, the patient is able to employ these skills prior to stress becoming overwhelming.

This is where Virtual Worlds have an immensely beneficial advantage. In the new sessions, the virtual world is not only used for assessment but also for training and education. Within the environment, Paola has the opportunity to practice different coping mechanisms: relaxation techniques, emotional/relational management and general decision-making and problem-solving skills. For example, if Paola's real world outcome is poor (e.g., she cannot do a task without feeling irritable and impatient when with her mother) she will experience again a similar experience in the virtual environment and will be helped in developing specific strategies for coping with it. Later, in the relaxation areas she will enjoy a relaxing environment and learn some relaxation procedures. As with any new skill, Paola has the opportunity to practice the coping skills, they become second nature and these new behaviors replace the older, outdated behavior patterns which caused the initial overwhelming stress.

The therapist now prompts Paola to also visit another virtual world – the *Learning Island*. Within this world, Paola learns how to improve her stress management skills and in particular she learns about the main causes of stress and how to recognize its symptoms, learn stress-management skills, such as better planning and learn stress relieving exercises-such as relaxation training and get the information needed to succeed.

After some sessions, the therapist invites Paola to participate in a virtual community *(*under therapist supervision initially) where she will meet other individuals who are stressed like her. Within this virtual world - *Community Island* - Paola has the opportunity to discuss and share her experience with other users.

However, in some cases Paola experience new critical situations that may raise her level of stress. For example, she had to discuss with her boss in the morning and this left her feeling very upset during the rest of the day.

At the end of the workday, when she returned home to care for her mother, she felt very excited/stressed and nervous and the Decision Support System alerted Paola twice about this. Both the signals were sent also to the therapist who appeared on her PDA display as an avatar suggesting to Paola some relaxation techniques.

Paola is scheduled to see the therapist the next day. The therapist asks her if the avatar was helpful. Her answer is yes: the avatar gave her an emotional boost appearing in the exact moment she needed it and suggesting helpful relaxation techniques she had previously learned. Then the therapist asks Paola about her difficulty. In particular, the therapist wants to get information about where Paola was: what she was doing, thinking and what her reactions were.

Paola relates all the information to the therapist: she was in the hospital and was quarrelling with a colleague, causing her stress level to become higher. The therapist compares the information provided by Paola with the information provided by the Decision Support System. Any difference is explored and interpreted.

By working as a team, Paola is taught a new skill of interpretation, and her therapist is more able to understand any differences in Paola's self-perception of stress and the objective measurements shown by the DSS. This will help to more effectively individualize and guide future training and therapy sessions.

In the following sessions, Paola tells the therapist that she feels better thanks to being able to frequently experience stressful situations within safe virtual environments. She also says that meeting other people in the community has helped her to find much-needed support and to discover new strategies to manage her emotions. With regard to this, she says also the community experience has helped her with seeing the stressor in a new perspective. Moreover, by listening to other's experiences, she was facilitated in adopting new coping skills.

Indeed, Paola has developed the ability to help her mother more effectively and to find time to do other things. The therapist helps Paola to cognitively restructure the critical situation, which now she is more able to deal with through the strategies she has learned. The last session ends with advice on the prevention of relapse.

3. Conclusions

The clinical use of Interreality is based on a closed-loop concept that involves the use of technology for assessing, adjusting and/or modulating the emotional regulation of the patient, his/her coping skills and appraisal of the environment (both virtual, under the control of a clinicians and real, facing actual stimuli) based upon a comparison of that patient's behavioral and physiological responses with a training or performance criterion. Although CBT focuses on directly modifying the content of dysfunctional thoughts through a rational and deliberate process, Interreality focuses on modifying an individual's relationship with his or her thinking through more contextualized experiential processes. To discuss and evaluate the clinical use of the proposed approach we presented and detailed a possible clinical scenario: Rosa, a 55 years old nurse, involved in a major car accident.

Obviously, any new paradigm requires a lot of effort and time to be assessed and properly used. Without a real clinical trial, the Interreality paradigm will remain an interesting, but untested concept. However, a recently funded European project, "INTERSTRESS – Interreality in the management and treatment of stress-related disorders (FP7-247685) - will offer the right context to test and tune these ideas.

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SECTION II

EVALUATION STUDIES

To date, some cybertherapy applications have improved the quality of health care, and later they will probably lead to substantial cost savings.

However, cybertherapy is not simply a technology but a complex technological and relational process.

In this sense, clinicians and health care providers that want to successfully exploit cybertherapy need a significant attention to clinical issues, technology, ergonomics, human factors and organizational changes in the structure of the relevant health service.

Wiederhold & Riva, 2004

Neuropsychological Testing Through a Nintendo Wii® Console

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Abstract. In recent years, videogames have demonstrated their positive effects in the psychological treatments and cognitive training of the old population. In this paper we present a pilot study in which a group of elderly people in an old people's home was requested to play a set of cognitive tasks administered through a popular videogames console, the Nintendo Wii®. The results obtained by comparing the Wii® cognitive games with traditional paper and pencil tests are described and discussed to orient further improvements.

Keywords. Cognitive training, elderly, videogames

Introduction

The worldwide growth of the old population is expected to increase rapidly until 2050 and over [1]. This expansion highlights the need to elaborate simple, quick and low-cost solutions in order to intervene and delay the natural cognitive decline connected with aging [2,3], and then keep the elderly population as much independent and self-sufficient as possible. Side by side with classic cognitive training, new methodologies adopting digital technologies have emerged, to help reach this goal on a large scale. Several researches have focused the attention on the analysis of the effects produced by the interaction with computerized applications, such as videogames [4,5], on different populations. Overall, results show a positive impact on several cognitive functions (executive control functions, attention, visual processing and reaction times) both in young [6-9] adults and elderly people [10-14].

Normally videogames are developed for young people [19], when trying to develop games for the elderly population special attention should be paid to their needs in terms of usability [15,16] in order to prevent boredom and anxiety to increase at the expense of motivation and concentration [17,18]. Nintendo Wii®Mote controller provides a new interface rationale for videogames that involves natural physical interactions, along with the normal cognitive functions stimulation, and could then prove more usable than other input techniques, such as joystick, pen or keyboard, to unfamiliar users.

This paper focuses on a set of videogames developed for the Nintendo Wii® platform in order to test and exercise the cognitive skills of the elderly person. Differently from other applications of Nintendo Wii® to elderly care centers, which usually employ the videogames licensed by Nintendo® [20-22], the cognitive games included in the software presented here are entirely developed by us. Our aim was to validate these cognitive games measuring their correlation with traditional and standardized paper and pencil (PP) neuropsychological tests, and then gain some insights on the kind of improvements needed.

1. Games

The cognitive games developed for this study address three main cognitive functions: attention, memory and motor control. The first game addresses attention and requires identifying a target shape in a set of shapes. The second game, testing short-term digit memory, requires to memorize a series of numbers and then to repeat the series in the correct order. The third one, testing working memory, consists of memorizing some letters (consonants) and then reminding them; between memorizing and reminding users are given an interference task, which lasts ten seconds and consists of performing two additions. The final game, testing visual-motor skills requires to hit some target points avoiding at the same time to hit other

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objects (Figure 1). All games are built using Adobe® Macromedia® Flash® Professional 8.0 with ActionScript 2.0 code and include several incremental difficulty levels.

2. Method

For the pilot validation described here, the games were compared with standardized PP neuropsychological tests measuring respectively sustained and selective attention (“Deux Barrages” [23]), short term digit memory (“Digit Span” (DS) [24], working memory (“Memory with Interference” (MI) [24]), and visual-motor skills (“Trail Making Test A” (TMT) [24]).

Figure 1. Screenshots from the Wii®Tests: Attention (1a), Memory DS (1b), Memory MI (1c), Motor Control (1d).

d (M=77; SD=9.92;

In the first session elderly were administered the Wii® games (see Figure 1); they sat comfortably and games were video projected on a wall in front of them. The experimenter sat at their left, providing instructions and helping in case of trouble. After one week, the same participants were requested to take the series of PP neuropsychological tests, administered according to the manual.

Performance measures were collected and compared in order to measure convergent validity with

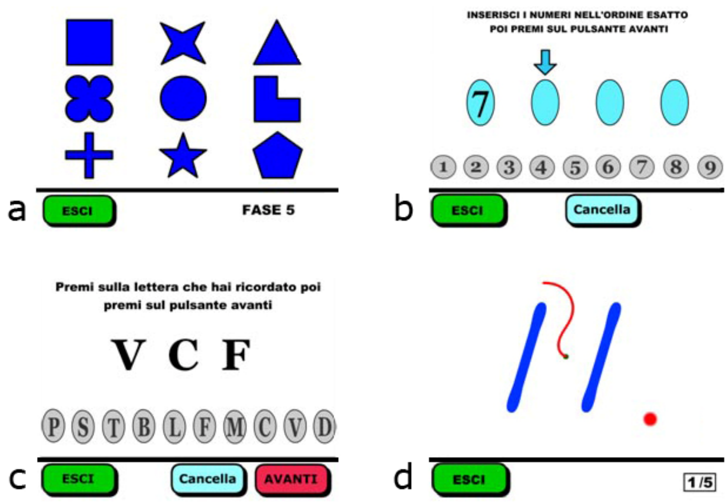

Figure 1. Screenshots from the Wii®Tests: Attention (1a), Memory DS (1b), Memory MI (1c), Motor Control (1d).

Pearson’s correlation coefficient.

3. Results

The results show a significant correlation between the electronic and PP versions of all tests, except for the Digit Span (see Table 1).

Table 1. Pearson coefficient values between Wii® tests and corresponding paper and pencil tests (PP Tests); *. Correlation is significant at the 0.01 level (2-tailed); **. Correlation is significant at the 0.05 level (2-tailed).

		Wii Tests			
		Attention	Memory (DS)	Memory (MI)	Motor Control
PP Tests	Deux Barrages	,777*			
	Digit Span		,263		
	MI			,689**	
	TMT				,464**

For sustained and selective attention two measures were correlated, given that in the Wii® the task started over in case of mistakes and then each level could be executed more than once. Thus the measures were the sum of the average time taken to complete each difficulty level in the Wii®, and ratio between error and speed rate in the Deux Barrages test. The correlation was significant (*r* = .777) (see Figure 2).

Regarding the working memory test, the errors at the Wii® and memory correlated significantly (0.689) (Figure 3a). Although significant, this value is still pretty low probably because of some additional difficulties in the input modality in the Wii® version of the test: the elderly met some difficulty in pointing at the object on the screen while pressing the "A" button on the Wii®Mote; facilitating the input entry could permit to obtain a higher correlation. The same issue could explain the results of the short-term memory

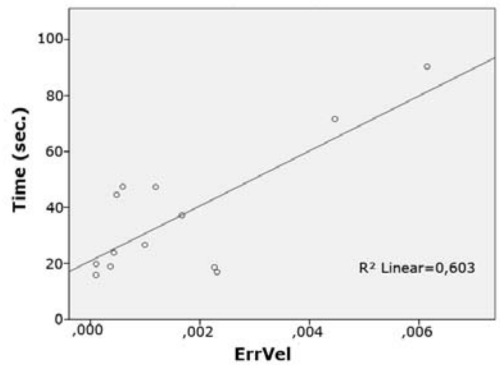

Figure 2. Y axis, time spent to solve Wii® cognitive game; X axis, ratio between error and speed rate recorded in paper and pencil test.

test whose, correlation with the Digital Span was not significant (r=.263).

Finally, the correlation between all the difficulty levels of the Wii® cognitive game with TMT-A was calculated, finding a significant correlation with the first difficulty level (r = .464); with a broader sample it could be possible to balance the performance of extreme values, in order to reduce their influence on the sample (Figure 3b).

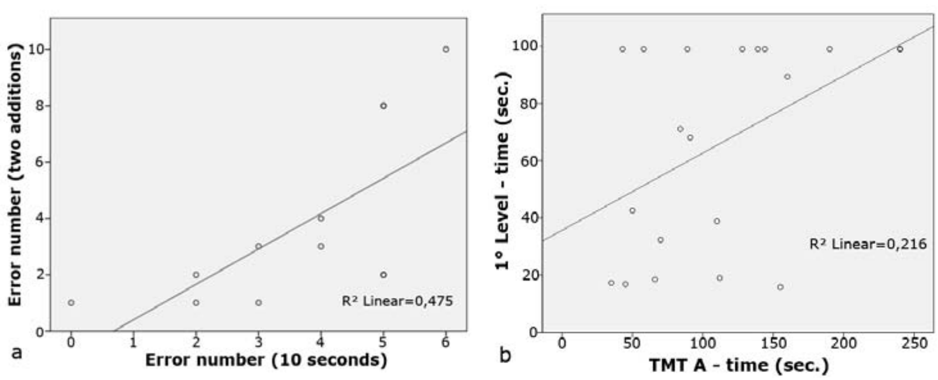

Figure 3. a) Y-axis, number of error doing an interference of two additions on Wii® Test; X-axis, number of error doing an interference of count forward by twos for 10 seconds on *x* axis. **b)** Y-axis, time of execution of 1° Difficulty Level of Wii® Game; X-axis, TMT A score.

4. Conclusion

The results of this pilot study encourage pursuing in this direction, while at the same time pointing at the way in which the games can be improved. Our primary goal was to develop games that make neuropsychological tests more attractive to the elderly people and exploiting Nintendo Wii® ergonomic features. Moreover, being small, financially affordable and portable, Nintendo Wii® can be used not only in elderly care centers but also at home, allowing the participation to the rest of the family. On the other hand, adding physical interaction could worsen the performance at some tasks, adding some unexpected difficulties. Some adjustments are then needed, for instance to the input modality, by enlarging the targets. This consideration will be the ground for future studies, in order to find a good fit between task requisites and their implementation in the Wii® interface.

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Influence of Tracking Feedback in User Motor Response in Rehabilitation Therapy

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Abstract. In this experimental study, we present the results of user motor responses with and without the use of Tracking Feedback to complete correct movements in Virtual Rehabilitation Therapy. To carry out this study, we used a VRT system for standing balance rehabilitation. We applied it under two different conditions to twenty patients (with and without tracking feedback). We then analyzed their motor responses. By means of this analysis, we have confirmed the importance of Tracking Feedback in the achievement of rehabilitation goals. We also tested the possibility of eliminating the tracking components from the system to lower cost to make the integration of Virtual Rehabilitation systems available to more patients. Our results indicate that is currently not feasible.

Keywords. Virtual Rehabilitation Therapy, Motor Response, Tracking Feedback

Introduction

Currently, Virtual Motor Rehabilitation (VMR) is providing new directions in the field of motor rehabilitation. This technology is being used in patients with major injuries and illnesses, such as stroke, cerebral palsy, paralysis and Parkinson's disease [1-2] Specifically, people with cerebral palsy suffer from balance disorders due to many factors, including alterations in mechanical components, sensory organization or motor coordination systems.

In numerous studies, it has been proven that VMR systems are very effective as clinical tools [3-6]. In addition, the use of VMR technologies increases motivation in patients, generating better results than without VMR technologies. These, technologies reduce the recovery time needed by patients and provide physical therapists with new tools to help them do their jobs more efficiently.

Most VMR systems provide patients with feedback of their movements and actions. This requires the systems to integrate a tracking component. Since this tracking component is generally expensive and limits environments where the system can be used, it can be an obstacle to their use in rehabilitation. It is well known that there are many influential factors in patient rehabilitation: early intervention, task-oriented training and repetition intensity [7]. Rehabilitation programs are based on task-oriented training and repetition intensity; therefore, many sessions are required to achieve the expected results.

This paper analyzes the influence of Tracking System Feedback on the achievement of the movement goals of the subjects. In order to achieve the correct movements, a VMR system, called REHABTRACK, is applied in two different ways: first, the system shows the movements that the subject is doing in real time; second the same system is used without showing the subject's movements.

1. Methods

In our experimental design for REHABTRACK, we analyzed three parameters: "Response Time" (the time necessary for the first response); "Completion Time" (the time needed to accomplish the goal); and "Movement Precision" (the accuracy in hitting the target). In addition, we used a usability questionnaire,

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VRUSE [10], which is specifically designed to evaluate the virtual reality applications. We eliminated three subsections of this questionnaire from testing: functionality; user guidance; and help; flexibility. The questionnaire was composed of 80 questions to assess the subject's user experience with the system.

1.1 Subjects

Twenty subjects ranging in age from 19 to 38 years-old, with a mean age of 28.5, were selected from a total of 40 candidates to participate in this study. Most of the subjects (seven males and thirteen females) were university students, with no disabilities. The subjects were explained the purpose and the procedures of the study. Each subject was paid 10€ for their participation once the study had been completed. Reasons for a subject's exclusion from the study were the following: cognitive and motor deficits; previous experience with VMR systems; a high level of knowledge in the area of computer graphics, computer games and/or three-dimensional virtual environments.

We divided the subjects into two groups:

Group A: Ten users who first used the system without movement feedback and afterwards with movement feedback.

Group B: Ten users who first used the system with movement feedback and afterwards without movement feedback.

1.2 System Components

1.2.1 Hardware system

The system hardware consisted of: a standard PC; a 47" LCD TV; an optical tracking system (six *Natural Point* Optitrack cameras without infrared led ring); two small spheres (four centimeters in diameter) coated with catadioptric tape; a Velcro strip to attach the spheres to the subject; five speakers transmitted sound cues through a Dolby 5.1 system (three were placed in front of the subject and two were placed behind the subject).

1.2.2 Software system

The software used to design the virtual environment was programmed in lite-C (GameStudio [9]). Additionally, (ARENA™ Motion Capture Software) was used as the tracking software to calibrate the Optitrack cameras [8] and to monitor the position of the subject´s foot movements. The Optitrack cameras tracked the spheres using the Hue Saturation Value (HSV) color space.

1.3 Procedure / Protocol

In this study, we used a VMR system (REHABTRACK) for standing balance rehabilitation with and without tracking feedback components. The objective was for the subject to step on the virtual target with their foot and return to the central area while being challenged with a cognitive task to choose among the many items that appear (an egg plant, a tomato, a potato, etc.). Each subject had a session that lasted approximately thirty-minutes. At the beginning of the session, the researcher explained the process to the subject in order to familiarize him/her with the Virtual Environment system. The researcher placed a sphere on each ankle of the subject (see Fig. 1, right) to track his/her movements. The subject was then given a few minutes to practice with the system.

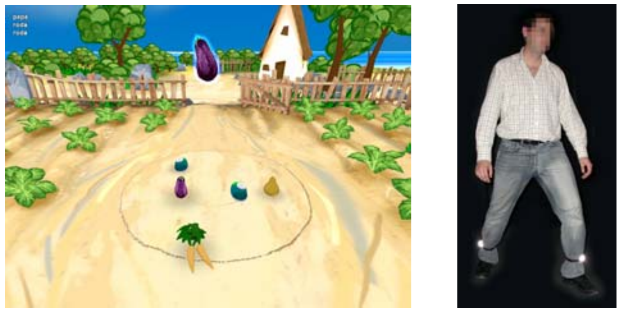

Figure 1. Left: screenshot of the system; right: subject using the system.

After practicing, each subject completed a ten-minute testing session with 30 targets. The target placements in the Virtual Environment, which were random to the subject, were actually pre-determined for evaluation purposes. The targets appeared at four-second intervals, one after another, and then disappeared when the subject either hit or missed the target. The subject was given one second between intervals before the next item appeared.

The REHABTRACK system showed the subjects with feedback a virtual foot on the TV screen. When they stepped on a target, the system gave them a sound cue and the target exploded and the item disappeared. The subjects without feedback had no virtual foot and no sound cue or explosion when they stepped on a target. Since the item continued to be visible, the subjects did not know whether or not they had hit the target. The tracking feedback was monitored by the spheres attached to the ankles of each subject. Each movement was captured and later analyzed. After the testing was complete, each subject completed an abridged version of the VRUSE usability questionnaire. This questionnaire was used to test the accuracy and reliability of the system.

2. Results

The consistency of the obtained results was analyzed using descriptive statistics (mean, standard deviation and Student's t-test, and 10th, 25th, 75th and 90th percentiles as shown in Table 1). The stability of the t-test was evaluated with 99% limits of agreement ($p<0.01$).

Table 1: Student's t-test for subject results: mean, standard deviation and 10th, 25th, 75th and 90th percentiles for time(s) and distance.

	Without Tracking Feedback			**With Tracking Feedback**		
p value: Response Time <0.001; Completion Time <0.001; Movement Precision<0.001						
	Response Time	**Completion Time**	**Movement Precision**	**Response Time**	**Completion Time**	**Movement Precision**
Mean	1.1	2.03	0.22	0.91	2.04	0.09
Standard deviation	0.37	0.57	0.13	0.24	1.00	0.05
Percentiles						
10	0.80	1.55	0.09	0.72	1.10	0.09
25	0.92	1.70	0.13	0.78	1.31	0.13
75	1.20	2.35	0.27	0.97	2.45	0.27
90	1.49	2.57	0.39	1.14	3.69	0.39

As Table 1 shows, there was a significant difference between subjects without feedback and subjects with feedback in both Response Time and Movement Precision; however, there was no significant difference in Completion Time.

3. Discussion & Conclusions

For this study, we designed REHABTRACK, a Virtual Motor Rehabilitation system, to evaluate a subject´s response with and without tracking feedback in a Virtual Environment. The purpose of this study was to evaluate the importance of tracking feedback in rehabilitation therapy. Of the twenty subjects who participated in the study, eight successfully completed the test. Their results were analyzed and our conclusions are presented as follows:

Response Time: As Figure 1 shows, the Response Time using for subjects using feedback were faster than the response time for subjects without feedback. However, we did find that as the subjects without feedback became more familiar with the system, their response time got faster and their results tended to converge with the subjects with feedback.

Completion Time: As Figure 2 shows, the completion for subjects with feedback were stable, but, for subjects without feedback, the completion time decreased. This may be due to the fact that when there is feedback, a training effect is produced.

Movement Precision: As Figure 3 shows, the criterion that we used was that if the movement of the subject was less than 20 cms it was considered to be a target hit. The data for subjects with feedback were stable, and the data for subjects without feedback were dispersed.

The results of our study indicate a faster response time and greater movement precision in subjects with feedback. Therefore, we can conclude that in systems where these parameters are critical, tracking feedback systems must be maintained. Otherwise, if these parameters are not critical factors, tracking systems might possibly be eliminated. In future work, we plan to study whether by lengthening the training sessions and adding more targets, the results for subjects without feedback would eventually converge with the results for subjects with feedback.

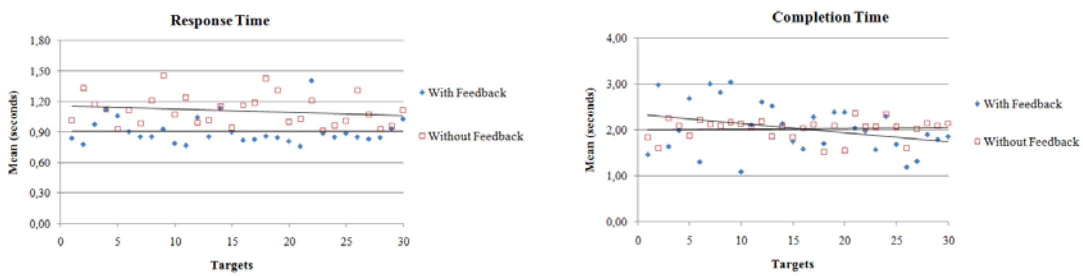

Figure 2. Results for Response Time and Completion Time during testing sessions for 30 targets.

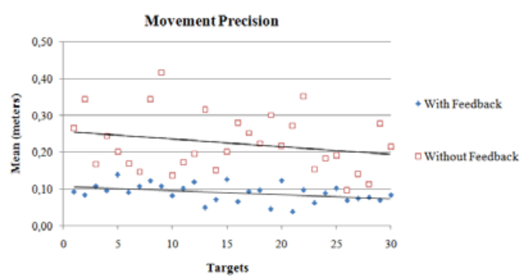

Figure 3. Movement Precision during testing sessions for 30 targets.

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Virtual Reality in the Treatment of Generalized Anxiety Disorders

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Abstract. Generalized anxiety disorder (GAD) is a common anxiety disorder characterized by 6 months of "excessive anxiety and worry" about a variety of events and situations. Anxiety and worry are often accompanied by additional symptoms like restlessness, being easily fatigued, difficulty concentrating, irritability, muscle tension and disturbed sleep. GAD is usually treated with medications and/or psychotherapy. In particular, the two most promising treatments seem to be cognitive therapy and applied relaxation. In this study we integrated these approaches through the use of a biofeedback enhanced virtual reality (VR) system used both for relaxation and controlled exposure. Moreover, this experience is strengthened by the use of a mobile phone that allows patients to perform the virtual experience even in an outpatient setting. This paper describe the results of a controlled trial (NCT00602212) involving 20 GAD patients randomly assigned to the following groups: (1) the VR and Mobile group (VRMB) including biofeedback; (2) the VR and Mobile group (VRM) without biofeedback; (3) the waiting list (WL) group. The clinical data underlined that (a) VR can be used also in the treatment of GAD; (b) in a VR treatment, patients take advantage of a mobile device that delivers in an outpatient setting guided experiences, similar to the one experienced in VR.

Keywords: Generalized Anxiety Disorder, virtual reality, biofeedback, relaxation, portable devices, mobile phones, new technologies.

Introduction

Generalized Anxiety Disorder (GAD) is a psychiatric disease characterized by long-lasting anxiety that is not focused on a specific object or situation.

Within the treatment of GAD, physical (relaxation and controlled breathing), behavioral (visualization and controlled exposure) and cognitive control strategies (challenging negative thoughts) represent a key part of the treatment, even if they are hard to learn.

To overcome this limitation the EU funded INTREPID research project (IST-2002-507464) proposes to improve the treatment of GAD using some advanced technologies: virtual reality, biofeedback and mobile phones.

1. The Approach of the INTREPID project: a controlled study

1.1. The clinical approach

The INTREPID research project proposes to improve the treatment of GAD through the use of a biofeedback enhanced virtual reality (VR) system used both for relaxation and controlled exposure [1, 2]. The virtual experience, described in detail in the *Protocol* paragraph, was developed by ESIEA Réalité Virtuelle et Systèmes Embarqués (RVSE – http://www.esiea.fr) using 3DVIA Virtools 4.1.

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Moreover, this experience is strengthened by the use of a mobile phone that allows patients to perform the virtual experience even in an outpatient setting. To study the efficacy of the proposed approach, a between subjects design was used with three experimental conditions and repeated measurements (pre and post-treatment). The study received ethical approval by the Ethical Committee of the Istituto Auxologico Italiano and was recorded in the Clinicaltrials.gov database with the official trial number "NCT00602212" [3].

1.2. The sample

Twenty-one consecutive patients with a diagnosis of GAD (DSM-IV-TR criteria) were included in the trial. Criteria for participation in the study included age between 18 and 50 years, no psychotherapy treatment received for their GAD, in case of taking pharmacotherapy, the type and amount of medication had to remain consistent during the experimental period, no history of neurological diseases, mental retardation, psychosis, alcohol or drug dependence, and no migraine, headache, or vestibular abnormalities.

1.3. Assessment tools

A semi-structured interview was used to identify relevant DSM-IV-TR diagnostic criteria for GAD in the sample.

The following psychometric questionnaires were also administered to each patient at pre-treatment and upon completion of the clinical trial:

- Penn State Worry Questionnaire (PSWQ [4]);
- Beck Anxiety Inventory (BAI [5]),
- State-Trait Anxiety Inventory Form Y-2 (STAI-Y [6]),
- Hamilton Anxiety Rating Scale (HAM-A[7]).

1.4. Protocol

The patients were randomly assigned to the following groups: (1) the VR and Mobile group (VRMB) including biofeedback – 4 subjects; (2) the VR and Mobile group (VRM) without biofeedback – 8 subjects; (3) the waiting list (WL) group – 8 subjects:

1. *Virtual Reality + Mobile Phone without Biofeedback Condition (VRM).* In this experimental condition patients received an eight-session VR-based treatment including both relaxation and exposure and techniques supported by HR biofeedback. In sessions 1 to 6, the patient explored a beautiful tropical island (experienced with a head-mounted display and head-tracking) following a predefined path leading to different relaxing areas: Campfire, Beach and Waterfall. In these areas the patients started to relax by observing the flickering campfire, watching waves lapping gently on a shore, or looking to the waterfall and fish pond. Each experience was supported by an audio narrative based on progressive muscle relaxation and/or autogenic techniques. To improve the efficacy of the training and to increase the effects of relaxation, patients experienced at home, using a mobile phone, on a non-navigable version, the same virtual reality environment experienced during the therapy. The patient was asked to train relaxation abilities at least once a day for the entire duration of the treatment following the treatment plan provided by the therapist. In session 7 and 8 the patients explored again the island reaching a Gazebo in which they are exposed to pre-selected words or images related to their personal stressful events. The patients were then asked to use the learned relaxation techniques to cope with them.

Figure 1. The Mobile Phone used in the trial (HTC Touch Pro)

Figure 2. The Campfire Virtual Environment (3DVIA Virtools 4.1)

2. *Virtual Reality + Mobile Phone with Biofeedback Condition (VRMB*). The patients experienced the same protocol described above, but with the biofeedback support. Specifically, in the sessions with the therapist, HR variations were used to modify specific features of the virtual environment:
    a. *Campfire (sessions 1-2).* HR controls the fire intensity: a reduction of the patient's physiological activation reduces fire intensity until it disappears;
    b. *Beach (sessions 3-4).* HR controls the movement of the waves: a reduction of the patient's physiological activation reduces the movement of the waves until the ocean becomes completely calm;
    c. *Waterfall (sessions 5-6):* HR controls the movement of the water: a reduction of the patient's physiological activation reduces the movement of the water until the water flow becomes completely still;
    d. *Gazebo (sessions 7*-8): HR controls the size of a stressful image or video: a reduction of the patient's physiological activation reduces the size of the stimulus until it disappears;

Figure 3. GSR/HR Sensor Module: a) the control box; b) the Skin Conductance Response sensors; c) the Blood Volume Pulse sensor (developed by Aurelia)

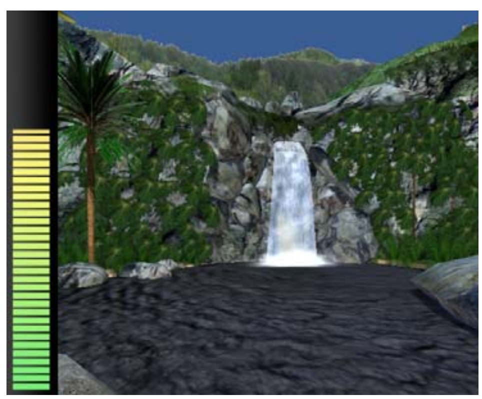

Figure 4. The Waterfall Virtual Environment with the relaxation bar in the left (3DVIA Virtools 4.1)

3. *Waiting List Condition (WL).* This was a control condition, in which patients were included in a waiting list and not received any kind of relaxation training.

2. Results

Given the limited size of the sample, we used non-parametric analyses to analyze the treatment effects (pre vs post treatment) on the psychometric variables within the 3 groups. Results show:

- *VRMB group*: a significant decrease in the BAI ($Z=-1.826$; $p<.05$) and STAI-Y2 ($Z=-1.826$; $p<.05$);
- *VRM group*: a significant decrease in the BAI scores ($Z=-2.383$; $p<.05$) and PSWQ scores ($Z=-2.103$; $p<.05$);
- *WL group*: a significant decrease in the PSWQ scores ($Z=-2.103$; $p<.05$).

Non-parametric K-Independent Tests were used to analyze the between subjects differences in the pre and post treatment anxiety questionnaires. No significant differences were found for $p<.05$.

The GSR, the HR, as well as the STAI-Y1 and the VAS-A were recorded at the beginning and at the end of each training session in the VRMB and in the VRM groups. Regarding the physiological responses, we observed that the mean of the differences of HR and GSR before and after each session tended to be higher in the VRMB group than in the VRM group. Nevertheless, the difference between the two experimental groups was not statistically significant. Regarding the psychometric variables, we observed that the mean of the differences of STAI-Y1 and VAS-A before and after each session tended to be higher in the VRMB group than in the VRM group.

3. Discussion

The study offered two interesting results. First, it confirmed the possibility of using VR in the treatment of GAD. Both experimental groups improved their clinical outcomes after the end of the treatment. Second, it supports the clinical use of a mobile phone to re-experience and anchor the contents of the VR sessions at home. The study also suggests a possible added value through the use of biofeedback: only in the VRMB group we found a significant reduction in the anxiety scores (STAI) after the treatment. Regarding the patients' physiological responses, we found a tendency indicating a decrease in HR and GSR between the pre and post sessions measurements in the VRMB group, higher than in the VRM.

In conclusion, this study showed that (1) VR can be used also in the treatment of GAD; (2) in a VR treatment, patients take advantage of a mobile device that delivers in an outpatient setting guided experience, similar to the one experienced in VR. It also suggested – but further analysis are needed – that with these patients the effectiveness of an immersive virtual relaxing environment may be improved by using physiological data to modify in real time specific features of the virtual environment.

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The virtual environments used in the study were developed by the ESIEA INTREPID team (J.L. Dautin, J. Ardouin, F. Crison and M. Le Renard - http://www.esiea.fr) using 3DVIA Virtools 4.1.

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Effect of the mood produced by virtual reality exposure on body image disturbances

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Abstract. Previous research suggests that negative mood increases body image disturbances. The aim of this study was to examine whether the mood produced by virtual reality exposure had any influence on such disturbances. As expected, dysphoric mood increased body image disturbances in patients with eating disorders.

Key words. Body image, eating disorders, virtual reality, mood

Introduction

Previous research has provided evidence about the ability of virtual reality (VR) exposure to produce emotional responses (anxiety and depression) [1-2] and fluctuations in body image disturbances, especially as regards body image distortion and body image dissatisfaction in patients with eating disorders (ED) [3-4]. Furthermore, several studies have shown a strong relationship between dysphoric mood and increased body image disturbances [5-6].

The data reported here comes from a broader research project whose main objective is to study the instability of body image disturbances in ED patients by means of VR exposure. In the first stage of this research, VR was shown to be capable of eliciting different levels of anxiety and depressed mood [7]. Subsequently, the effect of VR on the level of body image distortion and body image dissatisfaction experienced by participants was also assessed [8]. The results showed that ED patients felt more anxiety, a more depressed mood, greater body image distortion and increased body image dissatisfaction when eating high-calorie food, both alone and with other people, than when eating low-calorie food. In contrast, controls showed similar responses in all situations.

Having demonstrated the ability of VR to produce changes in mood and body image disturbances in ED patients, the aim of the present study was to examine whether the anxiety and depressed mood produced by virtual reality exposure has any influence on body image distortion and body image dissatisfaction in patients with ED and in controls.

It was hypothesised that participants with ED would experience various virtual environments, especially those involving high-calorie food, as more stressful and depressing than would the control group, since these environments are emotionally significant for people with ED. In addition, as dysphoric mood is considered to be highly related with body image disturbances in ED patients but not in controls, only in the first group would anxiety and/or depression be good predictors of body image distortion and/or body image dissatisfaction.

1. Method

1.1. Participants

Eighty-five patients diagnosed with ED and 136 non-ED students from the University of Barcelona participated in the study. They were all female and their participation was voluntary.

Twenty-eight participants from the control group were excluded based on the following criteria: suffering or having previously suffered from an eating disorder or similar symptoms (assessed by self-report); being at risk of suffering from an ED (Eating Attitudes Test-26 > 20) [9]; and being overweight (body mass index

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(BMI) > 25; WHO, 1998) [10] or underweight (BMI < 18; WHO, 1998) [10]. This yielded a final control group of 108 students.

1.2. Assessment measures

- Eating disorder symptomatology: *Eating Attitude Test-26* (EAT-26) [9]
- Anxiety: *State and Trait Anxiety Inventory* (STAI-S) [11]
- Depressed mood: *Barcelona Depression Questionnaire* (CDB: *Cuestionario de Depresión Barcelona*) [12]
- Body image disturbances: *Body Image Assessment Software* (BIAS) [13]

1.3. Procedure

First, all participants were measured and weighed in order to obtain their body mass index (BMI). They were then requested to complete the EAT-26.

In the next step, participants were exposed to four virtual environments (Figure 1) which were randomly displayed: the kitchen with low-calorie food (VE1), the kitchen with high-calorie food (VE2), the restaurant with low-calorie food (VE3), and the restaurant with high-calorie food (VE4). In the kitchen, participants were asked to eat either salad and fruit or pizza and ice-cream (depending on their experimental condition) while being alone. In the restaurant, participants were asked to eat either salad and fruit or pizza and ice-cream (depending on their experimental condition), but this time while being with other people who made comments about the food. Virtual reality environments were developed on the basis of the literature and using the information obtained from an ad hoc questionnaire; the latter was administered to 68 ED patients and compiled data about the situations and stimuli which produced the greatest discomfort in terms of body image.

Anxiety, depressed mood, body image distortion and body image dissatisfaction were assessed in the interval between the presentations of each virtual situation.

1.4. Statistical analysis

In order to study the strength of the relationship between mood and body image disturbances, several correlations were calculated. Standard multiple regression was also performed in order to determine which emotions were the best predictors of body image distortion and body image dissatisfaction.

Figure 1. Images of the low-calorie kitchen and the high-calorie restaurant

2. Results

Table 1 shows that correlations between anxiety or depressed mood and body image distortion were higher in ED patients than in controls, both when considering virtual environments separately and for the overall means.

Table 1. Correlations between mood and body image distortion

			VE1	VE2	VE3	VE4	Mean
Body image distortion	Anxiety						
		Control	.083	.189*	.265**	.226**	.224**
		ED	.430**	.468**	.464**	.517**	.511**
	Depressed mood						
		Control	.113	.176*	.267**	.139†	.175*
		ED	.405**	.467**	.496**	.516**	.511**

† $p < .10$ (marginally significant); * $p < .05$; ** $p < .01$

Similar results were obtained when the depressed mood and anxiety experienced in the virtual environments were correlated with body image dissatisfaction (Table 2). Correlations in the ED group were higher than those in the control group, both when considering virtual environments separately and for the combined means. The strongest relationship was that between mood and body image dissatisfaction.

Table 2. Correlations between mood and body image dissatisfaction

			VE1	VE2	VE3	VE4	Mean
Body image dissatisfaction	Anxiety						
		Control	-.099	-.344**	-.294**	-.205*	-.278**
		ED	-.593**	-.583**	-.549**	-.638**	-.672**
	Depressed mood						
		Control	-.179*	-.297**	-.338**	-.200*	-.235**
		ED	-.575**	-.606**	-.582**	-.653**	-.678**

† $p < .10$ (marginally significant); * $p < .05$; ** $p < .01$

Standard multiple regression was then performed to determine the best predictors of body image disturbance in both the control and ED groups. As Table 3 shows, neither anxiety nor depressed mood seems to be a good predictor of body image distortion, neither among controls nor for the ED group. It can also be seen that the interaction between anxiety and depression predicted higher levels of mean body image distortion in ED patients than in controls.

Table 3. Anxiety and depressed mood as predictors of body image distortion

			VE1	VE2	VE3	VE4	Mean
Body image distortion	Anxiety[a]						
		Control	.024	.131	.161	.213†	.185
		ED	.289†	.262†	.170	.286†	.279†
	Depressed mood[a]						
		Control	.098	.101	.167	.025	.064
		ED	.183	.259†	.355*	.280†	.280†
	Anxiety + Dep. Mood[b]						
		Control	.144	.206†	.295**	.228†	.229†
		ED	.445**	.493**	.505**	.541**	.535**

[a] R; [b] Beta; † $p < .10$ (marginally significant); * $p < .05$; ** $p < .01$

Overall, depressed mood was the best predictor of body image dissatisfaction in ED patients. In contrast, neither anxiety nor depression alone had a significant influence on body image dissatisfaction among controls (Table 4). However, when anxiety and depressed mood were considered together, dysphoric mood was a good predictor of body image dissatisfaction in both the control and ED groups, the best results corresponding to the latter group.

Table 4. Anxiety and depressed mood as predictors of body image dissatisfaction

			VE1	VE2	VE3	VE4	Mean
Body image dissatisfaction	Anxiety[a]						
		Control	-.080	-.259*	-.138	-.137	-.214†
		ED	-.369**	-.275†	-.210	-.310*	-.351*
	Depressed mood[a]						
		Control	-.031	-.149	-.252*	-.127	-.106
		ED	-.292*	-.388**	-.408**	-.398**	-.386**
	Anxiety + Dep. Mood[b]						
		Control	.102	.365**	.355**	.231†	.291**
		ED	.621**	.629**	.594**	.667**	.706**

[a] R; [b] Beta; † $p < .10$ (marginally significant); * $p < .05$; ** $p < .01$

3. Discussion

Both the depressed mood and anxiety produced by virtual reality exposure are highly related with body image disturbances in patients with ED. As previous research has shown[5,6] the presence of a dysphoric mood is related with increased body image disturbances, especially body image dissatisfaction, in both controls and ED patients, although the relationship is much stronger in the latter group.

As expected, ED patients showed higher correlations between mood and body image disturbances in the virtual environments involving high-calorie food. These situations are experienced as highly stressful and depressing for people with ED, both in real life[14] and in the virtual world[2,7]. Furthermore, general dysphoric mood is considered to be strongly related with body image disturbances in ED patients[5,6]. It was therefore expected that those virtual environments which elicited higher levels of anxiety and depression would be the ones that also produced greater body image disturbances. The results partially support this hypothesis. Depressed mood was indeed the best predictor of body image dissatisfaction in ED patients, although no good emotional predictor of body image distortion was found. It is interesting to note that anxiety and depression considered together did become a good predictor of both body image distortion and body image dissatisfaction for all participants, although the effect was stronger for the ED group.

Future research should focus on the relationship or interaction between anxiety and depression which enhances the power of mood as a predictor of body image disturbances. Likewise, it would be necessary to study which explanatory model best fits the relationship between the mood produced by VR and the body image distortion and body image dissatisfaction experienced by participants.

4. Conclusions

The mood experienced by ED patients in virtual environments, especially depressed mood, influences their body image disturbances (mainly body image dissatisfaction). In contrast, the body image of participants without ED is not influenced considerably by the mood experienced in virtual environments. This is probably due to the fact that the virtual situations used in this study are not emotionally significant for people without ED. The results support previous research conducted in this field.

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PDA Self-Register System for Eating Disorders: A Study on Acceptability and Satisfaction

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Abstract: Self-monitoring techniques, such as the use of dietary registers, are considered to be central to cognitive-behavioral treatment of Eating Disorders (ED). This information allows the clinician to identify the triggers of the behaviors associated to ED as purges and/or binges, and the associated thoughts and emotions, helping to carry out a more accurate assessment. Traditionally these registers are made with paper and pencil mode, where the patient has to register every eating and the emotions/thoughts associated; but this system has some problems, as low portability, low adherence or methodological difficulties. The use of PDA for self-registers can help to solve these problems. The aim of this study is to study the levels of acceptability and satisfaction with PDAs self-register system specifically designed for assessment and treatment of ED. Samples of 30 subjects diagnosed with ED are receiving a PDA with software specifically designed for recording type and amount of food, emotions before and after eating and other behaviors. The participants are completing self-register daily during a week, and afterwards answer an acceptance and satisfaction questionnaire. This work is in progress at the moment. It is expected that the PDA system will show high levels of acceptance and satisfaction.

Keywords: Eating Disorders, Personal Digital Assistant, Self-registers.

Introduction

The self-register technique is an important tool for the diagnosis, functional analysis and evaluation of treatment in Eating Disorders (ED). The self-register is an assessment semi-structured technique that measures behavior in natural settings (home, work, school, etc). Also, it is useful to know the monitoring of therapeutic guidelines and assess the effects of treatment and patient outcomes. Traditionally the patient receives a paper where the patient must record every eating, and also the thoughts and emotions before and after the eating. This information allows the clinician to identify the triggers of purges and/or binges, and the associated thoughts and emotions, helping to carry out a more accurate assessment. But the traditional self-register system has several problems, as situational constraints, missing reports because of lapses of motivation and memory [1], difficulties to identify if the information has been recorded in real time [2] and poor rates of adherence to the treatment [3]. It is necessary to design more efficient methods to simplify the process of self-monitoring and to improve the consistency and completeness of self-reports [4]. Information and Communication Technologies (ICT) can help achieve this goal. In recent years, new mobile technologies, such as personal digital assistants (PDAs) and mobile phones have become more readily available, thus generating new interest in developing systems adapted for these tools. The aim of this study is to explore the levels of acceptability and satisfaction with PDAs self-register system specifically designed for assessment and treatment of ED.

1. Method

The sample is composed of 30 patients diagnosed with Anorexia Nervosa (purging type), Bulimia Nervosa or Binge Eating disorder (according to DSM-IV-TR). Exclusion criteria are major depression, schizophrenia or other psychotic disorders and severe physical illness. The participants have entered into the study voluntarily and have signed informed consent (if the participant is underage, consent has been

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signed by parents or guardians). The sample is receiving a PDA with software specifically designed for recording type and amount of food, emotions before and after eating [Fig.1], thoughts before and after intake, the intensity of hungry and in general, the environmental circumstances that are surrounding their eating behavior [Fig. 2], frequency of binge eating, vomiting and laxative use. The participants are completing self-register daily, after each intake during a week. The degree of acceptance and satisfaction is being evaluated with scales specifically designed at the end of the recording time.

2. Results

This study is currently a work in progress. It is expected that the PDA system will show high levels of acceptance and satisfaction.

3. Conclusion

The use of electronic PDA diaries offers important advantages and may enhance weight loss treatments and assessment of ED. It is expected that in this study the PDA system will show good levels of Acceptance and Satisfaction in the participants. The software designed and the technology used will help participants find it easy to use and user-friendly. It is expected that due to the portability and novelty of the system, the adherence will improve rather than allowing users motivation to deteriorate over time. These improvements will interact allowing the system to show good acceptance in ED patients. All these advantages of PDA recording systems are also anticipated to increase therapeutic efficiency in ED treatment. Electronic diaries using PDAs are likely to become routine tools in clinical psychology, as mobile technologies become ubiquitous, more robust and less expensive, new software programs to meet the needs of the clinicians will be developed [1].

Figure 1.

Figure 2.

Acknowledgments

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Development of a Computer Based Symmetry and Arrangement Symptoms Measures in Obsessive-Compulsive Disorder

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Abstract. *Background:* Epidemiological studies indicated that compulsive ordering and arranging, and a preoccupation with symmetry are common presentations of obsessive-compulsive disorder (OCD). *Objective:* The goal of the current study was to develop and obtain preliminary psychometric data for the objective and quantitative measurement of symmetry and arrangement symptoms in OCD. *Method:* Twenty-eight normal volunteers were administered computer based assessment tasks with 4 different conditions with or without target and distraction. Primary dependent variables included several indices of time and click of arranging behaviors. Construct validity for the task was examined by comparing the novel behavioral measures with standardized measures such as Symmetry, Ordering and Arranging Questionnaire (SOAQ), Obsessive Compulsive Inventory-Revised (OCI-R), Beck depression Inventory (BDI), Beck Anxiety Inventory (BAI) and Quality of life scale (QOL). *Result:* We found significant positive correlation between behavioral parameters and standardized scales for OCD (total time and SOAQ: $r^2=0.623$, $P<0.001$; total number of clicks and 'ordering' subscore of OCI-R: $r^2=0.541$, $P<0.01$). There was no significant correlation between behavioral parameters and other scales measuring constructs less relevant to ordering and arranging. A main effect of target only was observed on behavioral parameters. *Conclusion:* This study therefore provides preliminary data to support the use of this task as a novel behavioral measure of compulsive symptoms related with symmetry, ordering and arranging.

Keywords. Symmetry, ordering, obsessive-compulsive disorder

Introduction

Obsessive–compulsive disorder (OCD) is a severe psychiatric disorder associated with considerable impairment [1]. Although in research settings the diagnosis of OCD can be reliably obtained using structured clinical interviews in private practice and other community-based treatment settings, the diagnosis is often reached through idiosyncratic clinical interviews and, at best, self-report inventories. However, this approach is problematic, given that reliance on one method of assessment (e.g., patient self-report) may inadequately capture clinical phenomena. Further, such an approach may be associated with poor reliability, as evaluations may differ across even expert observers. In light of the need to develop additional assessment measure for OCD that extend beyond self-report inventories and clinical interviews, Kim et al. (2008) developed a computer-based behavioral assessment of checking behavior in OCD and examining the validity of a novel behavioral assessment [2].

Given the results of epidemiological data indicating that ordering and arranging is one of the most common presentations of OCD [3], in adults and in children[4], negligence of this issue is surprising. The purpose of the present study was to develop and obtain preliminary psychometric data for a computer-based behavioral measure of symmetry and arrangement symptoms.

1. Methods

The virtual environments of task were designed to elicit symmetry and arrangement symptoms; the subject was asked to rearrange the objects on the desk until they felt their task was complete. The virtual

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environments and objects were constructed using 3D–MAX (Discreet, USA), and were converted for rendering in the A6 GameStudio Engine (Conitec, Germany).

Twenty-eight normal volunteers were enrolled with 4 different conditions with or without target and distraction (see Figure 1 for several screenshots from the virtual Environment). Primary dependent variables included several indices of time and click of arranging behaviors. Construct validity for the task was examined by comparing the novel behavioral measures with standardized measures such as SOAQ, Obsessive OCI-R, BDI, BAI and QOL.

Figure 1. Screenshots of the instruction panel (left) and the virtual environments and objects of the task with target (right)

2. Results

There was significant positive correlation between behavioral parameters and standardized scales for OCD (total time and SOAQ: r^2=0.623, P<0.001; total number of clicks and ‘ordering’ subscore of OCI-R: r^2=0.541, P<0.01). There was no significant correlation between behavioral parameters and other scales measuring constructs less relevant to ordering and arranging.(see table 1).

Table 1. Correlations between behavioral parameters and other variables in normal subjects

Variable	Total time	Total numbers of clicks
SOAQ	0.623†	0.536†
OCI-R(ordering subscore)	0.495*	0.541†
OCI-R(total score)	0.401	0.541†
BDI	0.145	0.157
BAI	0.095	0.020
QOL	-0.247	-0.347

*:p<0.05, †:p<0.01

There was significant main effect of target only on total time (F=22.00, p<0.001) and number of clicks (F=4.66, p<0.05).

3. Discussion

To our knowledge, this is the first study utilizing VR technology in a behavioral measure of symmetry and arrangement symptoms regarding OCD.

Construct validity was demonstrated by the significant positive correlations between task performance and both self-reported measures for obsessive-compulsive symptoms. We think no significant correlation between behavioral parameters and other scales represent the discriminate ability of this instrument for compulsive symptoms related with symmetry, ordering and arranging. Using these kinds of instruments, we will measure abnormal behavioral patterns that only correspond with certain targeted symptoms in the heterogeneous symptoms of OCD.

4.Conclusions

In summary, the findings from this study provide a promising step towards targeted behavioral measure of OCD. With appropriately designed and lager studies that replicate and extend the current study, we believe that these behavioral measures may be able to improve the assessment and, ultimately, treatment of OCD, by augmenting the standard battery of self-report and clinical interviews assessments used in usual practice to assess pretreatment symptoms and treatment outcomes.

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Using Virtual Humans to Alleviate Social Anxiety: Preliminary Report from a Comparative Outcome Study

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Abstract. Empirical studies have consistently shown the effectiveness of a multicomponent CBT treatment of social anxiety disorder (SAD). Previous outcome studies on virtual reality and SAD have focused on people suffering from fear of public speaking and not full blown SAD. In this study, 45 adults receiving a DSM-IV-TR diagnostic of social anxiety were randomly assigned to traditional CBT treatment (with in vivo exposure), CBT-VR combined treatment, or a waiting list. Results show significant reduction of anxiety on all questionnaires as well as statistically significant interactions between both treatment groups and the waiting list.

Keywords. Social anxiety, virtual reality, anxiety

Introduction

Social anxiety disorder (SAD) is characterized by marked and persistent fear of being judged negatively or humiliated in social or performance situations and leads to avoidance of social situations [1]. According to Statistics Canada, SAD affected 750,000 Canadians in 2002 [2] and its lifetime prevalence is estimated at 13.3% [3]. SAD often results in a diminished quality of life, considerable emotional suffering, and significant impairment in personal, occupational and social experiences.

Empirical studies over the past 20 years have consistently shown the effectiveness of a multi-component cognitive-behavior intervention in the treatment of SAD [4-9]. CBT treatment package typically includes exposure to the feared situation(s), social skills training and cognitive-restructuring.

One significant limitation of the traditional *in vivo* exposure is the difficulty for the therapist to get adequate and controlled social interactions (e.g., audience to conduct the exposure, control on people's reactions, variety of social situations appropriate for exposure) in order to make progress in a continuous and soft way for the participant. Virtual reality (VR) overcomes many of the shortcomings of *in vivo* exposure; in addition of providing a treatment that is more readily accepted by clients [10, 11] and allows the client to interact with a phobic scenario in the safety and confidentiality of the office.

Outcome studies for VR and SAD are more recent than those on specific phobias, the later having confirmed repeatedly the efficacy of *in virtuo* exposure [12]. Few studies have been published so far, most of them focusing on the fear a public speaking, a less severe form of SAD [13]. Also, a previous study conducted by Klinger and colleagues [14] showed a significant effect of VR on SAD. Despite the limitations of that early study [14], we can safely propose that using virtual humans to conduct *in virtuo* exposure would be a useful alternative to traditional CBT in the treatment of SAD. This present study aims to compare very similar CBT treatments that differ only by the use, or non-use, of *in virtuo* exposure versus a waiting list control condition. Our hypothesis is that both treatments will be superior to the waiting list.

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1. Method

Forty-five adults (mean age 34.9 years old; 71% female) receiving a DSM-IV-TR diagnosis of social anxiety have completed the study and were randomly assigned to one of these three conditions: (1) traditional individual CBT treatment (CBT; n=16); (2) individual CBT combined with *in virtuo* exposure (CBT-VR; n=14); (3) waiting list (WL; n=15). CBT group and CBT-VR group participants received a 16 individual session of therapy. WL group were measured "pre and post" and, for ethical reasons, were later treated for their condition.

Both treatment groups had individual exposure sessions every week that were done in various public speaking and social situations (virtual or not, depending on the participant group condition). For the CBT-VR group, the software used for exposure were created by E. Klinger in the European VEPSY Updated project or by Virtually Better Inc. The hardware used was a HP xw4600 Workstation Intel® Core™2 Duo CPU E6850 @ 3.00 GHz, 3.48 GB of RAM, with a NVidia GeForce 8800 GTX graphic card, running on Windows XP Professional (version 2002). An eMagin z800 3D Visor was used as the virtual helmet.

2. Results

This study compared 16 individual therapy sessions of traditional CBT with *in vivo* exposure, CBT with *in virtuo* exposure and a waiting list control condition. Results on anxiety rated scales and self-report questionnaires showed a significant improvement in both treatment conditions compared to the waiting-list (see Table 1). The ANOVAs revealed significant Time effects on all measures ($p < .001$) and no significant Group main effects. Most importantly, statistically significant Group by Time interactions were found, confirming that treatments were superior to the waiting list. Further analyses of treatment X contrast interactions revealed that <u>both</u> active treatments were superior to the waiting list condition. First, for those receiving CBT with *in vivo* exposure, the interactions contrasts between traditional CBT and the WL have been found to be significant on the Liebowitz scale ($F= -2.53$, $p<0.05$), the Social Phobia Scale ($F= -3.07$, $p<0.01$), the Appraisal of Social Concerns (probability $F= -2.53$, $p<0.05$; consequence $F= -2.54$, $p<0.05$), the Fear of Negative Evaluation ($F= -2.42$, $p<0.05$), a Self-efficacy single-item measure ($F=2.34$, $p<0.05$), the Beck Depression Inventory II ($F=-2.97$ $p<0.01$) and the Trait-anxiety subscale of the STAI ($F= -2.56$, $p<0.05$). Significant interaction contrast was also found for the CBT-VR Group and WL Group on the Liebowitz Scale ($F= -4.06$, $p<0.001$), the Social Phobia Scale ($F= -5.12$, $p<0.001$), the Appraisal of Social Concerns (probability $F= -3.67$, $p<0.001$; consequence $F= -3.38$, $p=0.001$), Fear of Negative Evaluation ($F= -3.36$, $p=0.001$), the Self-efficacy single-item measure ($F= 2.59$, $p<0.05$), the Beck Depression Inventory II ($F=-3.17$, $p<0.01$) and the Trait-anxiety Inventory ($F= -4.44$, $p<0.001$).

These significant interaction contrasts confirmed our hypothesis that both treatment conditions were superior to the waiting list condition. This is the first randomized controlled study that includes a large sample of people suffering from severe social anxiety (DSM-IV-TR criteria) using CBT treatment combined with *in virtuo* exposure and compared to a waiting list. This study is part of a broader project that will determine whether the effects of the two treatments are sufficiently similar to be considered equivalent and exploratory analyses will assess variables that may contribute to the process of change such as the therapeutic alliance, the sense of presence, immersive tendency and cognitive variables.

Table 1. Descriptive results and repeated measures ANOVA for pre post data. N = 45.

	CBT Mean (SD) – Pre/Post	CBT-VR Mean (SD) – Pre/Post	WL Mean (SD) – Pre/Post	Interaction F
LSAS	72.44 (23.91) 50.38 (23.87)	82.93 (32.23) 47.50 (17.83)	79.60 (25.90) 77.93 (22.23)	8.40***
SPS	30.25 (14.84) 20.19 (10.51)	38.29 (16.65) 18.07 (10.87)	33.53 (13.40) 37.47 (15.28)	13.31***
ASC-P	46.22 (24.49) 26.88 (20.24)	53.39 (16.99) 23.84 (17.08)	49.25 (12.89) 50.24 (14.60)	7.06**
ASC-C	62.40 (22.42) 34.92 (24.43)	70.32 (18.58) 33.70 (23.63)	55.15 (18.07) 53.57 (15.71)	6.06**
FNE	23.69 (6.23) 18.50 (7.66)	25.64 (6.13) 18.00 (8.21)	24.27 (4.51) 24.73 (4.51)	6.02**
SESM	50.31 (20.61) 70.63 (14.59)	46.79 (19.48) 69.57 (13.25)	42.83 (17.24) 46.00 (19.48)	4.08*
BDI-II	14.19 (12.88) 7.75 (9.16)	11.57 (7.35) 4.07 (4.32)	12.40 (7.48) 16.13 (13.33)	6.30**
STAI-Y2	49.40 (10.78) 43.33 (10.71)	53.71 (9.55) 42.43 (11.22)	49.33 (9.19) 50.07 (9.96)	9.94***

Note. LSAS= Liebowitz Social Anxiety Scale; SPS = Social Phobia Scale; ASC-P=Appraisal of Social Concerns – subscale probability; ASC-C= Appraisal of Social Concerns – subscale consequence; FNE= Fear of Negative Evaluation; SESM= Self-efficacy single measure; BDI-II=Beck Depression Inventory II= STAI-Y2= State-Trait Anxiety Inventory – form Y2 (Trait). *p<0.05; **p<.01, **p<0.001

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eBaViR, Easy Balance Virtual Rehabilitation System: a Study with Patients

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Abstract. eBaViR is a virtual rehabilitation system, which has been developed for balance rehabilitation for patients suffering from acquired brain injury. It is a game-based system that uses a low-cost interface, the Nintendo Wii Balance Board. The games have been specifically designed with the help of experts in the rehabilitation of balance disorders and can be adapted to patients according to their needs. We present an experimental study that has been carried out using the system. The aim of the study is to determine whether this setup could be applied as a Virtual Rehabilitation System for balance rehabilitation in Acquired Brain Injury. We randomly divided patients into two groups: a trial group and a control group. The trial group used eBaViR system during the rehabilitation sessions, and the control group followed traditional rehabilitation sessions. We obtained encouraging results.

Keywords. Virtual Rehabilitation Therapy, Wii Balance Board, Stroke, Balance

Introduction

The causes of Acquired Brain Injury (ABI) may be multiple, such as Traumatic Brain Injury (TBI) or stroke. Its consequences are disabling and complex, resulting in motor, sensory and neuro-cognitive problems for the patients, which entails the loss of functional independence. In order to maximize the independence of people with ABI, a rehabilitation process that requires the treatment of physical, psychological and cognitive problems is carried out.

In patients with neurological damage of the central nervous system, postural disorders represent one of the most significant disabilities, and many patients do not recover the ability to maintain an upright stance [1]. Among other biological and functional characteristics, postural control could be the best indicator of independent living. The recovery of postural control by the patient can be considered to be essential for independent living, as well as for social participation and general health. Thus, balance training is a critical therapeutic procedure for walking and training patients to care for themselves [2].

The use of virtual reality techniques and the latest innovations in technology can be of great assistance when applied to rehabilitation procedures [3]. The benefits of rehabilitation following ABI are all too often disrupted by a lack of patient engagement in the process [4]. One of the advantages of virtual reality systems are that they increase the motivation of the patient, thereby improving continuity, which has an impact on recovery.

In this paper, we present the results of a clinical trial for evaluating a low cost virtual rehabilitation system. The development of the system and a subsequent clinical study were carried out jointly by LabHuman from the Universidad Politécnica de Valencia and Nisa Valencia al Mar Hospital, both located in Valencia (Spain).

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1. Methods

1.1. System Description

The eBaViR system is a game-based system that uses a low-cost interface device, the Nintendo Wii Balance Board. The system hardware components are a conventional PC, a 42” LCD Screen and a Nintendo Wii Balance Board (WBB).

The Nintendo WBB is composed of four pressure sensors located in its vertices. These sensors allow it to detect the pressure distribution on the board. Therefore, a profile of the balance motion can be achieved by measuring the weight distribution in each of the sensors over time. A wireless communication between the PC and the Wii Balance Board is established via Bluetooth. The balance board also has the advantage of being portable, easy and comfortable to handle, thanks to its small size and weight.

The software system is composed of three sensors. These games have been specifically developed with the help of experts in the field of rehabilitation of balance disorders. The games are designed to improve the static balance rehabilitation of the patients. These games are simple and have targets and modes that can be easily understood by the ABI patient.

All these games require the transfer of body weight while maintaining standing balance. These weight displacements are part of the conventional rehabilitation procedures of ABI patients. The patient stands on the balance board and performs movements on both the sagittal and frontal planes, while attempting to control the game target element that appears on the screen. All the games have an initial configuration interface. This initial screen allows the physiotherapist to parameterize the game to suit the needs of each patient. There are two sets of parameters: a set that configures the rehabilitation session, such as the length of the session and the number of breaks per session; and a set that configures the game level with parameters such as the size or the speed of the game elements.

ABI patients frequently have hemiparesis. One of the most characteristic consequences of incomplete recovery from hemiparesis is that there is a weight-bearing asymmetry in favor of the non paretic leg as well as increased spontaneous postural sway[5][6]. Because of this, the next step after configuration is to automatically adjust the sensitivity of the WBB to each patient’s limitations. The system is designed to record the resting position of the patient and his/her range of motion in both the frontal and sagittal planes, which adapts the game environment to the patient’s movement.

Once the rehabilitation session and the game have been configured and the platform automatically adjusts itself, it is time to begin the rehabilitation session. During this session, the system gives the patient auditory feedback with a “negative sound” when the patient performs an incorrect action and a “positive sound” when the patient accomplishes his/her goal throughout sessions. The patient’s score is continuously displayed and points are accumulated to calculate a final score. At the end of the rehabilitation session, the system shows the patient percentage of hits and errors made during the game. Game results and sounds serve as a motivational element.

1.2. Protocol

The clinical trial was carried out in the facilities of the Valencia al Mar Hospital, which is located in the city of Valencia (Spain). It was developed by a team of neurologists and physiotherapists from the Brain Injury Service of the Hospital. A sample of twenty patients from those under treatment at the Brain Injury Service was selected. The participants were randomly divided into a control group and a trial group.

Our evaluation consisted of a comparison of these two groups. Each subject participated in a total of 20 rehabilitation sessions. Their balance was evaluated using the following quantitative measures: ordinal scales, timed scales and a feedback questionnaire filled out by the patients. These measures were collected right before the first rehabilitation session (T0); at the end of the last rehabilitation session (T20); and twenty days after the last rehabilitation session(T20+20).

1.3. Subjects

All the participants were patients with ABI, causing hemicorporal weakness and without the cerebellum-trunk structure being affected. Most of the patients’ diagnoses were either isquemic stroke or hemorrhagic stroke. However, three of the patients suffered from TBI, and three suffered from other types of ABI.

At the beginning of the study, all the patients had been affected by ABI for over eight months. The patients ranged in age from 15 to 76 years old.

Of the total, 64.7% of the participants were men, and 35.3% were women. According to the Berg scale, at the beginning of the study, ten patients had a risk of falling and ten had no risk of falling. In addition, all the participants had a normal cognitive function and were able to walk 10 meters indoors with or without technical orthopedic aids. None of the participants had had previous experience with virtual rehabilitation therapies.

2. Results

Until now, five patients from the control group and five patients from the trial group have completed the rehabilitation process. We analyzed the results obtained according to the Berg Scale using repeated measures ANOVA. Patients were assessed at the beginning and end of treatment. A post-evaluation after 20 days is currently underway, and we will include the results in future works.

Table 1 shows the inter-subject results. The results show that there was no significant difference between the participants in the two groups (p = 0.393).

Table 1. Inter-subject effects.

Source	Sq Sum tipoIII	gl	Mean sq	F	Sig
Intersection	39961.800	1	39961.800	240.734	.000
Group	135.200	1	135.200	.814	.393
Error	1328.000	8	166.000	5.7	

Table 2 shows the intra-subject results. *factor1* refers to the Start or End of the treatment and *Group* refers to Control or Trial group. These results show that there were significant difference when comparing Berg scores obtained by the patients before and after treatment, regardless of the groups that they were assigned to (p = 0.002). The intra-subject results also indicates that both, *factor1* and *Group* had a statistically significant influence on the patients scores (p = 0.020). Patients from different groups have different evolution over time.

Table 2. Intra-subject effects.

Source	Factor1	Sq Sum tipoIII	gl	Mean sq	F	Sig
factor1	Lineal	39.200	1	39.200	20.103	.002
factor1*Group	Lineal	16.200	1	16.200	8.308	.020
Error(factor1)	Lineal	15.600	8	1.950		

Figure 1 shows the evolution of each group according to the Berg Scale. The trial group had a better evolution than the control group.

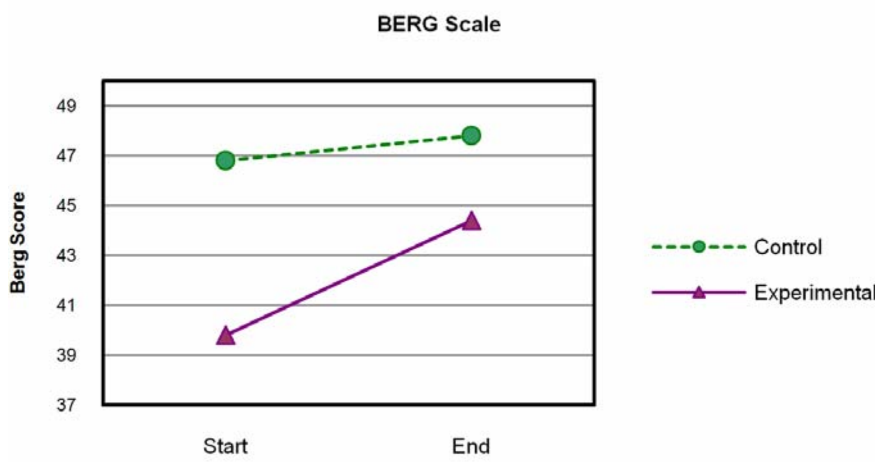

Figure 1. The graphic shows the evolution of the control and trial groups according to Berg Scale

All other tests used show no significant difference in the evolution of the groups.

The feedback questionnaire filled out by the patients of the trial group, shows influence of the system in patient motivation, since they declared to have enjoyed the rehabilitation sessions. In addition, patients thought the treatment was very useful for their rehabilitation.

3. Discussion and Conclusions

Among the factors that influence the total costs of a virtual rehabilitation system, an important one is the tracking system that is used. The system that we present has the advantage of being an inexpensive system, thanks to the interface used (WBB) which decreases the total cost of the system. Even though eBaViR is not immersive, we consider that an immersive environment is not necessary for the purpose for which it was designed. Moreover, this might even be an advantage because the system does not require a high performance visualization system, and therefore, the cost is lower.

Also, thanks to the characteristics of the Wii Balance Board (its small size and its light weight), the system does not require large spaces for installation and use, nor special environmental conditions as might be necessary with other tracking systems. This makes it a fully mobile interface that is easy to install in a clinical environment, since it does not require a large area for use or storage.

These characteristics make eBaViR a low-cost system that is easily adaptable to rehabilitation centres, also easily extended to patients' homes, and can even be part of a tele-rehabilitation system.

The results obtained in the clinical study show significant improvement of static balance in patients trained with the eBaViR system over the control group. However, there was no difference in the dynamic balance tests between the trial group and the control group.

In this study we worked with patients who had chronic brain damage for over eight months. Since their evolution is slower than recently injured patients, and taking into account the duration of the study (20 sessions), a longer study would be desirable in order to obtain further information on the evolution of both groups.

Also, the results of this evaluation should be verified with a post evaluation after 20 days. This post-evaluation is currently underway.

Another point that must be studied further is whether the use of eBaViR system would improve the dynamic balance of patients when executing more dynamic exercises than those already tested. Furthermore, physiotherapists have shown a great interest in testing the system for improving static equilibrium in earlier stages of rehabilitation.

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Multimedia Holistic Rehabilitation Method for Patients After Stroke-Efficiency Analysis

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Abstract. The article presents the results of post-stroke rehabilitation of patients with brain dysfunctions causing cognitive impairments such as problems with concentrating, reasoning, logical thinking, and memory. Some of those patients suffered from various forms of aphasia as well. The holistic rehabilitation of the stroke patients was aided by specially designed computer systems offering an array of varied multimedia tasks. The research results presented below confirm the usability of the suggested method.

Keywords. stroke, aphasia, rehabilitation, multimedia rehabilitation, cognitive function, cognitive rehabilitation.

Introduction

Stroke may have a clear-cut negative impact on patients' psychosocial functioning. There are common disabilities that result from a stroke:

- Decline in attention
- Selective attention deficits
- Decline in logical thinking, planning and reasoning tasks, comprehension, synthesis and analysis
- Weakening of short-term as well as long-term, verbal and visual memory
- Speech disorders (aphasia, dysarthria).

It makes it difficult or even impossible for a stroke patient to lead a normal everyday life (they are often unable to fulfill one's family or professional duties). As a result, they might suffer from mood disorders such as anxiety, irritability and apathy. Physical limitations following a stroke make patients dependent on others. Their lack of self-reliance and reduced intellectual abilities hinder them from achieving their former goals, and contribute to patients' depression.

Rehabilitation plays a vital role as it helps the stroke survivors partly or fully recover their functions lost after brain injury. The research presented below shows that the implementation of computer systems specially designed for rehabilitation purposes speeds up stroke patients' recovery [1-5]. Using multimedia tools as a complementary rehabilitation method lets us rehabilitate stroke patients in a holistic and polysensorial way. The reported results reflect enhancement of our previous development in this field [6].

1. Method

The suggested post-stroke rehabilitation method consists of four stages:

- Stage 1: Diagnostics. Types and levels of disability are estimated on the ground of neurologic examination and psychological tests. The standard examination lets us assess the handicap in quantitative and qualitative ways.

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- Stage 2: The main rehabilitation stage. On the basis of the results obtained from stage 1, patients perform specifically chosen exercises within approximately three months' time. Many of these tasks, among other things, involve the exercises performed on a specially designed and created computer system (see section 2).
- Stage 3: Goal attainment scaling. A patient undergoes diagnostic evaluation that lets assess the patient's progress.
- Stage 4: An optional stage of remote rehabilitation. Chosen patients might continue rehabilitation at home – an individualized computer application is prepared for them that let doctors monitor the patients' exercises via the Internet. Doctors might also make some changes in the performed tasks [7, 8].

2. The Main Rehabilitation Stage

Various rehabilitation exercises have been prepared to target at different disabilities:

- Logopedic exercises for patients affected by various forms of aphasia [9]
- Exercises that help retrain stroke-impaired limbs
- Exercises improving cognitive functions (comprehension, association, concentration, memory, etc.)

Some of the exercises take into account more than one disability at a time.

As the result of a diagnostic stage, an individual rehabilitation program (called "training") is prepared by a doctor. This rehabilitative therapy consists of clearly designed exercises – the exercise quantities as well as the order of exercises are strictly designated by the training program. The difficulty level might be controlled by exercise parameters (each exercise consists of one or more of them). However, the parameters are suited in such a way so that the exercises are neither too difficult (in order not to discourage the patients), nor too easy. All the computer exercises are to improve brain plasticity by a polysensorial interaction. During the therapy the computer system stores all the parameters and patient results (e.g. the duration of exercise, the number of mistakes). It lets a doctor supervise a patient's progress and, if necessary, modify the exercises and training.

Figures below show patients practicing sample logopedic exercises (Fig. 1a), developing dexterity and attention (Fig. 1b), concentration and balance (Fig. 1c) and verbal memory (Fig. 1d).

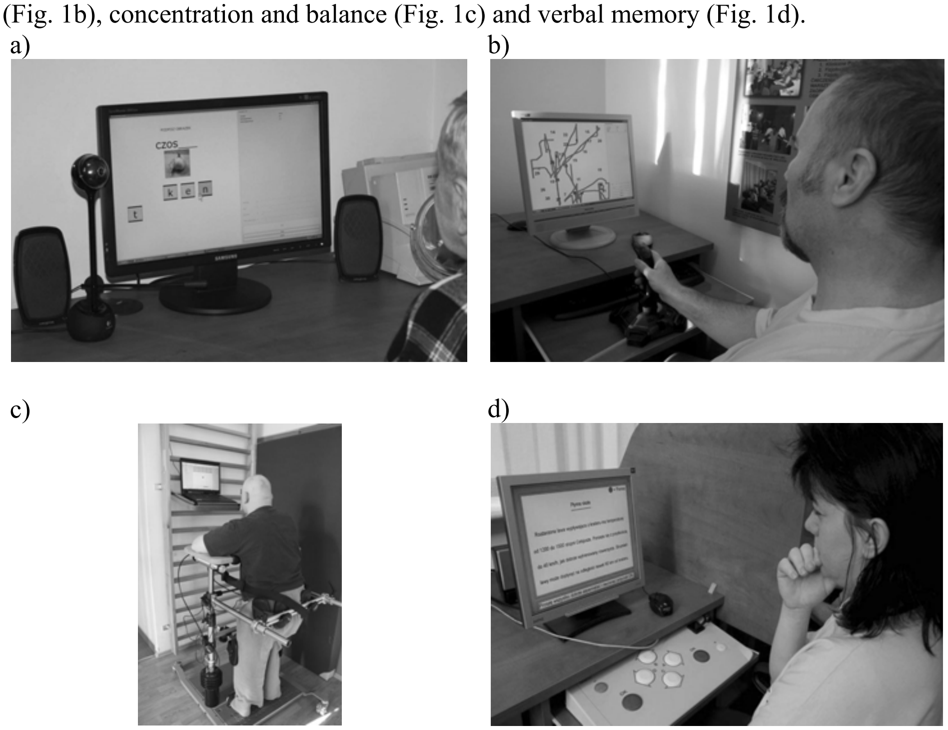

Figure 1. Patients during computer aided rehabilitation exercises.

3. Results

The results presented below are based on rehabilitation of 63 stroke survivors. 33 of them (22 men and 11 women) suffered from aphasia, the remaining 30 (19 men and 11 women) had other brain dysfunctions.

3.1. Patients with Aphasia

Before starting a rehabilitation program, stroke patients must undergo a series of tests to assess their cognitive functions. Some elements of Włodzimierz Łucki's package of cognitive tests [10] are used. Various language tasks are performed such as naming common objects, activities or parts of the body, repeating syllables, words and sentences, enumerating days of the week, names of the months, consecutive numbers, comprehension of simple and more complex sentences, reading words and sentences, writing letters, syllables and sentences.

The receptive and expressive components of the test provide an opportunity to learn the patient's main dysfunction – whether they have receptive or rather expressive speech problems.

Table 1 presents the results of cognitive tests that categorized the aphasic patients.

Table 1. Types of aphasic patients.

Major symptoms/sort of aphasia	Number of patients
Expressive (non-fluent, motor) aphasia	4
Receptive (fluent, sensory) aphasia	13
Mixed (sensorimotor) aphasia	16

Table 2 shows the rehabilitation outcome. The data given shows the results before and after a three-month therapy. One point scored means that one word or a sentence has been correctly understood, spoken, read or written by a patient.

Table 2. Effects of speech rehabilitation – patients with mixed aphasia.

Comprehension	Expression	Reading	Writing
30.78 / 40.08	45.21 / 61.30	13.81 / 16.49	7.18 / 9.3

An increase of 10 points on the comprehension test was observed, whereas verbal expression scores grew by 16 points. Improvement scores in writing and reading were much lower. The observed outcome seems to be in line with the main goal of the rehabilitation process – thus the therapy appeared to be successful. The tests examining reading and writing skills were treated as an additional scope of the therapy.

3.2. Patients with Concentration and Memory Dysfunctions

These patients were also examined before and after the rehabilitation that lasted approximately three months (see Table 3). Mini Mental State Examination (MMSE) [11] test was used to assess the outcome of the rehabilitative therapy. The maxium points possible on this test is 30 points. A score of 0-23 indicates cognitive disturbance. The MMSE attempts to quantify the patients' capabilities in five fields: orientation, registration, attention and calculation, recall, language.

Also, some elements of Włodzimierz Łucki's package of cognitive tests were used to examine the stroke patients' cognitive functions (in that case visual and auditory memory were taken into account).

Aleksander Łuria's learning curve [12] was used as well.

Table 3. Effects of rehabilitation - patients with concentration and memory dysfunctions.

Mini Mental State Examination		Memory (W. Łucki set)		
General score (max 30)	attention (max 5)	visual memory (max 15)	auditory memory (max 16)	learning curve (max 10)
24.9 / 26.1	3.1 / 3.5	8.3 / 11.0	5.4 / 6.4	3.4 / 4.6

One point increase in total MMSE score and a half-point increase on the attention scale were observed. MMSE is at most a diagnosing test, so we did not expect any significant difference.

As far as Łucki's package of tests is concerned, there was an increase of 3 points in visual memory, which is a statistically significant change, as well as a rise of 1 point in auditory memory.

Aleksander Łuria's learning curve indicates one point recovery, which is also a statistically significant score.

4. Conclusions

The presented results of the post-stroke therapy prove that traditional and modern approaches cannot be treated separately. Moreover, it seems that they should be applied simultaneously to obtain the best possible results.

Using multimedia in post-stroke rehabilitation is supposed to make the therapy process more interesting. It is also believed to motivate patients and make them deeply involved in the rehabilitative therapy as it provides additional stimuli for their hard and long work. All of those factors are extremely important in the long-lasting post-stroke rehabilitation process.

In our future research we will concentrate mainly on the remote rehabilitation that will allow patients to continue supervised therapy at home. Utilization of VR gloves as a device for improving hand dexterity is also taken into consideration.

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Internet Delivered Images for Exposure in Specific Phobia, Design Considerations for Self-directed Therapy

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Abstract. Exposure to phobic stimuli in subjects with specific phobia typically results in increased anxiety, ranging from mild to severe, followed by gradual habituation. The Internet is a candidate medium for the delivery of phobic stimuli to phobic subjects, such as pictures, video clips or computer animations. Delivery of such images in home settings warrants careful attention to the range and time course of anxiety responses elicited, and to tailoring of progression through hierarchies of images. The agency of the user is paramount, they need to have the final say at all stages of exposure as to whether to proceed or not. We have incorporated solutions to these requirements in the design of an internet-based exposure program (*FEARDROP*). This employs a database repository of pictures and videos of phobic stimuli. Images are called up by the user engaging a tracking circle with their mouse and following it around the screen. The image fades out if the circle is not followed, a form of 'dead man's brake'. Anxiety responses are measured at intervals on a visual analogue scale and graphed for the user. Initial results show substantial habituation to spider pictures within minutes, with a controlled comparison to video images in progress.

Keywords. Specific phobia, exposure, anxiety, design, spider

Introduction

Exposure to phobic stimuli is a standard component of treatment of specific phobias. The most common method of exposure is systematic desensitization, using a graded hierarchy ranging from lower to higher fear-eliciting stimuli. Exposure is typically preceded by anticipatory anxiety and followed by a peak of anxiety that reduces with continued or repeated exposure, a process referred to as habituation. This anxiety response can be conveniently assessed by asking the subject to rate their subjective distress on a visual analogue scale, at intervals.

The Internet contains millions of images and mentions of phobic stimuli, easily located using a search engine (for example by Googling "spider") but lacks the structure, assessments and outcome evaluation that anchor systematic desensitization. A person undertaking self-exposure and using the Internet to locate images that may assist this purpose is to an extent taking pot luck and their responses and outcomes go unreported.

Instructional programs have been developed that guide participants through the requirements of home-based self-exposure, including formulating self-exposure homework routines and reinforcing the completion of these [1]. Virtual reality research delivers exposure to virtual phobic stimuli but is not as readily available for home-based exposure [2].

In order to investigate the utility of internet delivery of phobic stimuli in the treatment of specific phobias we have incorporated the methods of systematic desensitization in the design and implementation of an internet program for home-based exposure (www.feardrop.com).

1. Method

1.1 Presentation of the stimulus

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A database repository is used to store image files, pictures and videos, which are downloaded to the user interface and shown in a screen window. These images may be assigned as individual stages in a systematic desensitization hierarchy by the investigator, with optional tailoring algorithms determining progression. Depending on the choice of images used, stimuli and hierarchies relevant to diverse phobias may be delivered in this way. Further, stimuli may be attenuated, realistic, hyper-realistic, stationary or moving and so forth, essentially any aspect of a phobic stimulus that can be conveyed by images, with enabling sound as a further option.

1.2 Measurement of anxiety

A standard rating, the Subjective Units of Distress Scale (SUDS)[3], is presented on the screen at intervals for self-rating of current anxiety level. This is a visual analogue scale, scored from 0 to 100. The time interval schedule is designated by the investigator, for example a rating immediately before exposure begins (designated ‘anticipatory anxiety’), and at 2-minute intervals during exposure. SUDS scores are uploaded to the database and graphed for feedback online to the user after each stage of exposure. The use of repeated measures at relatively brief intervals is of particular interest in Internet delivery since it secures pertinent information about the treatment process and potential mediating outcomes, such as reduction of SUDS that suggests habituation, in short term or ‘casual’ users.

1.3 Self-directed exposure

The program has been designed on the premise that the user has the ability to direct whether they wish to continue or not at all times. Three features achieve this: preview and selection of the image for the next exposure stage, initiation of exposure by engaging a tracking circle and continuation of exposure by following the tracking circle.

Each stage in the desensitization hierarchy is selected by clicking with the computer mouse on a thumbnail preview image. The current and any previously completed stages are presented in a list, each with a thumbnail preview so that the user has the option of repeating a stage or starting the next stage. A ‘tracking circle’ then appears on the screen. The tracking circle is a see-through ring, 44 pixels in diameter (approximately 10mm on a fifteen inch monitor). The investigator can preset the size of the circle. When the user moves the computer mouse over the tracking circle the program is ‘engaged’ and the phobic stimulus appears, thus the user initiates exposure. The tracking circle moves around the screen window, criss-crossing the phobic stimulus on random straight paths. The user is required to follow the tracking circle with the computer mouse, if they fall more than a set amount behind the circle the phobic stimulus fades. This device serves two purposes. First, it is an indication of treatment adherence; it confirms that the user is observing the screen containing the phobic stimulus. In other words the stimulus is being delivered to the user and not merely their computer. Second, it acts as a safety device. Panic symptoms may be anticipated in some users and the addition of the tracking circle means that the phobic stimulus does not remain on the screen unless continuously called up by the user through tracking the circle. This is a form of ‘dead man’s brake’ that senses that the driver or user remains in control or stops the train or exposure. These methods respect the agency and autonomy of the user.

1.4 Treatment process and outcome measures

An aim of this approach is to permit continuous process-outcome research within the constraints of online-treatment delivery. All users register and give informed consent. Session data including exposure stages, SUDS scores and tracking circle accuracy are stored in the database for analysis. Questionnaires are administered online for pre- post- follow-up measures of symptom change. Randomization to different online conditions, such as a comparison of still versus moving phobic stimuli, can be setup by the investigator using a research interface.

2. Results

In an online trial of self-directed home-based exposure, 78 high spider-fearful subjects who viewed a still picture of a single spider for three minutes and completed SUDS scores every 60 seconds, showed the following anxiety responses. The mean (SD) anticipatory anxiety assessed by SUDS immediately before exposure to the first spider image was 35.9(28.3). These ratings rose following exposure to 45.6(28.5) after one minute of exposure, and then showed evidence of habituation, falling to 25.8(26.6) after three minutes of exposure.

However adherence rates were low, of 220 participants in this sample who completed the anticipatory SUDS, on their first attempt the numbers completing SUDS ratings after one, two and three minutes were 140, 108 and 78 respectively.

3. Conclusions

Internet delivery of phobic stimuli is a practical proposition and can be designed to support self-directed exposure, using measures such as those outlined above. Currently the internet can only deliver a limited range of sensory inputs to most users – visual and auditory – and online phobic stimuli are limited to those which are symbolic, that is they represent but are not the real thing, for example a video of a spider is not a real spider. Accordingly therapeutic effects are likely to be circumscribed, although internet delivery may play a useful and definable role as a component or step in therapy. However, with the enhanced precision of stimulus presentation and the many possible variations in stimulus type, stimulus timing and tailoring of progression, enhancement of efficacy can be rigorously pursued. The internet also accesses a segment of the population that has not previously sought treatment, and such programs may form a useful step in their pathway of care. As with all internet interventions, adherence rates are a key issue [4], in principle this can be addressed systematically in future research, including randomization to different motivational conditions and/or different exposure tasks.

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Virtual Reality Interoceptive Exposure for the Treatment of Panic Disorder and Agoraphobia

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Abstract. The efficacy of cognitive-behavioral therapy for panic disorder and agoraphobia (PDA) has been widely demonstrated. The exposure technique is the main component of these programs; interoceptive exposure also plays an important role. The virtual reality (VR) program for treating PDA developed by Botella's group can simulate physical sensations in a controlled manner while the user is immersed in the VR environments in the consultation room. These include audible effects, such as rapid heartbeat and panting, as well as visual effects, such as blurry vision, double vision and tunnel vision. This work examines the efficacy of the interoceptive exposure (IE) component in two treatment conditions: 1) *VR Interoceptive Exposure Simultaneous Condition* (VRIE-sim; N=14), and 2) *Interoceptive Exposure Traditional Condition* (IET; N=15). Results obtained showed that both treatment conditions significantly reduced the main clinical variables at post-treatment; these results were maintained or even improved at three month follow-up. Simultaneous VR interoceptive and VR external stimuli exposure is a new and effective way to apply PDA treatment.

Keywords. Cognitive-behavioral therapy, Panic Disorder and Agoraphobia, Interoceptive exposure, Virtual Reality.

Introduction

Panic disorder with agoraphobia (PDA) is a significant health problem that causes serious interference in the daily life of those who suffer from it. The efficacy of cognitive-behavioral therapy (CBT) programs for PDA has been widely demonstrated [1]; they are recommended as the treatment of choice for PDA by the American National Institute of Health. The main component of these programs is the exposure technique. In addition, several studies highlight the importance of applying interoceptive exposure (IE) specifically as well as the need to study the contribution of this component in treating PDA in a controlled manner [2-5]. In traditional CBT programs, the exposure component is applied *in vivo* to both the agoraphobic situations and the bodily sensations feared by patients. Virtual Reality (VR) is an alternative and effective tool for applying the exposure component, which has demonstrated efficacy in the treatment of anxiety [6]. In the case of PDA, VR treatment efficacy has been found in controlled studies [7-9]. However, in all of these studies, the IE component was applied in the traditional manner (*in vivo*). The VR program for PDA developed by Botella et al. [10] enables therapists to simultaneously use virtual reality interoceptive exposure (VRIE) to present bodily sensations, including audible rapid heartbeats and panting as well as visual effects, while the patients are immersed in various VR environments (e.g., a bus, a mall) in the consultation room. In a previous controlled study developed by our team [11], we compared three conditions: *in vivo* exposure (wherein both exposure to agoraphobic situations and IE were conducted *in vivo*), VR exposure (wherein exposure to agoraphobic situations was conducted using virtual scenarios and IE was conducted using the effects offered by the VR program as well as traditional exercises), and a waiting list control. Results revealed that both treatment conditions showed similar efficacy, and that each was more effective than the control group. In spite of the efficacy of VRIE reported by the participants in this study, the VR condition did not use VRIE alone, traditional exercises were also used; thus, this component was not studied in a controlled manner. The main purpose of the present work is to clarify the

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effects of using VRIE versus traditional methods for IE. We do this by comparing the efficacy of a single CBT program in two applications: one in which VR is used for both the situational exposure and IE components and another in which VR is used for situational exposure, but the IE component is applied in a traditional manner.

1. Method

1.1. Participants

Twenty-nine participants were included in this study. All of them met DSM-IV-TR [12] criteria for the diagnoses of PDA (N=27) or Agoraphobia without PD (N=2), 23 participants were women (79.3%) and the remaining 6 were men (20.7 %). The mean age was 32.79 (SD=8.28), and ranged from 21 to 53. Exclusion criteria included having current alcohol or drug dependence or abuse, psychosis and severe organic illness or being currently treated by a similar treatment program.

1.2. Assessment protocol

- *Anxiety Diagnostic Interview Schedule IV (ADIS-IV-L)* [13]. This is a semi-structured interview designed to carry out a differential diagnosis of the anxiety disorders included in the DSM.
- *Fear and Avoidance Scales* [14]. The participants and therapists identified the situations and physical sensations that caused the participants the most fear and distress, as well as the negative thoughts associated with them. Next, they assessed, on a scale of 0-10, the degree of fear (0="no fear"; 10="extreme fear") and avoidance (0="never avoid"; 10="always avoid") for each feared situation and sensation. In addition, the degree of belief in the negative thoughts related with the target behaviors and sensations was also assessed, using a scale ranging from 0 ("I do not believe the content of the thought at all") to 10 ("I believe the thought is totally true"). For this work, the most significant target behavior and sensation chosen by each participant was used.
- *Anxiety Sensitivity Index* (ASI) [15]. This is a self-report questionnaire on which each of 16 items measuring fear of anxiety-related symptoms is rated by the participant. Each item, rated on a 5 point scale ranging from 0 ("very little") to 4 ("very much") expresses a concern about the possible adverse consequences of the anxiety symptoms.
- *Panic Disorder Severity Scale* (PDSS) [16]. This is a clinical scale that assesses important features of panic disorder and agoraphobia. Specifically, the scale rates frequency and distress for panic and panic-like sensations (limited symptom episodes), severity of anticipatory anxiety, severity of situational avoidance, and severity of impairment or interference in work and in social areas.

1.3. Design and treatment

The present work is a between-group design with two experimental conditions: 1) VR Interoceptive Exposure Simultaneous Condition (VRIE-sim; N=14), and 2) Interoceptive Exposure Traditional Condition (IET; N=15).

The treatment included application of a CBT program adapted from Barlow's group, Clark's group and Botella's group [11] with a maximum of eight individual sessions: two psychoeducation sessions and a maximum of six exposure sessions, depending on the participants' needs. The therapeutic components included: (1) psychoeducation about anxiety and PDA, (2) cognitive restructuring and, (3) exposure to internal and external stimuli. The main component was exposure; it was applied in various ways, depending on the treatment condition. Participants in the VRIE-sim condition were simultaneously exposed to audio and visual effects (i.e. rapid heartbeat, panting, blurred vision, double vision and tunnel vision) and agoraphobic scenarios in virtual settings (for approximately 50 minutes). In the IET condition, after exposing the participants to the agoraphobic scenarios using VR (for approximately 25 minutes), the interoceptive exposure was carried out in a traditional way; namely, relevant physical sensations were elicited using standard exercises, such as hyperventilation, head shaking and spinnin (for approximately 25 minutes). For VR exposure sessions, we used the Panic-Agoraphobia program developed by Botella et al. [10].

1.4. Procedure

A screening was applied to the 36 people who came to seek help at the Emotional Disorders Clinic. Next, all participants meeting the inclusion criteria underwent a deep assessment and signed the consent form for the study. The assessment protocol included two sessions of one and a half hours each. In the first session, the ADIS-IV was applied to establish the diagnosis and the participants completed the self-report questionnaires. In the second assessment session, the main target behaviors and sensations were established. After the assessment, participants were randomly assigned to one of the two treatment conditions (VRIE-sim versus IET). Finally, after completing the treatment program, all participants were assessed at post-treatment and at the three month follow-up.

2. Results

At pre-treatment T-tests showed no differences between the groups for any of the demographic variables (gender, age and education level) or clinical variables. Means and standard deviations obtained in each treatment condition for all outcome measures at pre-treatment, post-treatment and the three month follow-up are shown in Table 1. Repeated measures analyses of variance (ANOVAs) revealed that time effects were significant for all outcome measures at post-treatment (see Table 1). Both treatment conditions significantly reduced all clinical variables; however, no significant differences were found between the two treatment conditions. Comparisons between post-treatment and the three month follow-up revealed that treatment gains were maintained; furthermore, patients continued to improve significantly in six of the outcome measures for both treatment conditions (see Table 1).

Table 1. Means, standard deviations and time effects for pre-post and post-3-month follow-up comparisons.

		PRE		**POST**		**FU**		**F time-1**	**F time-2**
		VRIE-sim	IET	VRIE-sim	IET	VRIE-sim	IET	Pre-Post	Post-FU
MTB	F	9.21(1.31)	8.33(1.80)	3.28(3.22)	3.67(3.18)	1.75(1.36)	1.36(1.86)	88.409**	7.950*
	A	8.14(3.06)	8.47(1.55)	2.71(3.34)	3.40(3.29)	0.67(1.07)	1.27(1.68)	73.162**	11.215**
	B	8.28(1.68)	8.67(1.59)	3.00(3.04)	2.40(2.29)	1.17(1.03)	0.82(1.25)	130.603**	9.783**
MTS	F	8.71(2.37)	8.67(2.02)	1.93(1.44)	1.80(1.74)	1.25(1.54)	1.00(1.41)	239.607**	3.066
	A	8.50(2.68)	8.50(2.85)	1.78(1.31)	1.50(1.74)	0.50(2.52)	0.90(1.29)	175.672**	13.910**
	AC	2.36(3.36)	2.93(2.73)	8.07(1.54)	7.14(2.93)	9.25(0.75)	9.00(1.49)	44.275**	9.732**
	B	7.50(2.41)	7.47(2.26)	0.86(1.03)	1.60(2.32)	0.67(0.78)	1.09(1.81)	129.126**	0.155
	ASI	31.31(10.06)	33.36(13.29)	15.46(8.43)	12.71(6.95)	11.82(6.76)	11.30(8.94)	68.681**	2.530
	PDSS	12.61(2.60)	12.28(2.13)	5.77(4.22)	4.93(3.38)	3.36(2.01)	3.10(3.31)	73.440**	8.617**

*ρ<0.05; **ρ<0.01; MTB=Main Target Behavior; MTS=Main Target Sensation; F=Fear; A=Avoidance; B=Belief; AC=Acceptance; ASI=Anxiety Sensitivity Index; PDSS=Panic Disorder Severity Scale; F time-1=F Pre-Post time effects; F time-2=F Post-Follow-up time effects.

3. Discussion

Results obtained in this study offer data concerning the efficacy of applying IE using VR to treat PDA with a between-group design. The efficacy of IE carried out with VR was similar to the efficacy of a program that included the gold standard IE for this disorder (*in vivo* exposure). Participants included in both treatment conditions improved similarly at post-treatment for all clinical variables. In addition, these gains were maintained at the three month follow-up; furthermore, participants continued to improve in most of the outcome measures. These data are consistent with previous controlled studies that use VR to apply the exposure component to the agoraphobic situations feared by panic disordered patients [7-9, 11]. Furthermore, our results are also consistent with those obtained in previous works that show the efficacy of IE in the absence of anxiety control techniques for the treatment of PDA [2] [4-5].

Our work with VR in treatment also contributes to the improvement of CBT programs. For example, the use of VR to apply exposure might make the treatment more available (VR exposure might be better accepted by participants); hence, the treatment could reach more individuals. However, this hypothesis remains to be tested. Furthermore, applying IE and situational exposure simultaneously (using

VR to apply both) can be advantageous. For example, the therapeutic situation is more realistic (e.g., experiencing rapid heart beats immediately upon entering a mall) making the exposure situations more ecological. In addition, although VR cannot evoke all sensations feared by PDA patients, it enables therapists to simulate certain sensations that might be difficult to provoke by the standard exercises (e.g., blurred vision or double vision). Additionally, it may create a more intense IE experience overall to combine VRIE (e.g., evoking blurred vision) simultaneously with traditional *in vivo* IE, such as hyperventilating. Other advantages of applying VRIE include the increased therapeutic confidentiality that is possible because IE is conducted inside the consulting room. Finally, VRIE is likely to be preferred by patients who find some of the traditional exercises, such as spinning, too aversive.

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Use of Immersive Virtual Reality for Treating Anger

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Abstract. Poorly managed anger responses can be detrimental to one's physical and psychosocial well-being. Cognitive behavior therapies (CBT) have been found to be effective in treating anger disorders. A key component of CBT treatment is exposure to the anger arousing stimuli. Virtual reality (VR) environments can elicit potent reactions and may facilitate the treatment of anger. An anger VR environment with six video vignettes was developed by this study to examine the anger arousal potential of VR. Outcome measures included assessment of emotional reactivity, state anger, and presence. The results showed that significant anger arousal occurred during exposure to the VR environment, and arousal was greater when viewed in an immersive HMD than a non-immersive flat screen. In addition, presence was found to moderate the effects of VR. Low presence resulted in low reactivity regardless of the display modality.

Keywords. Virtual reality, anger treatment, cue arousal, presence.

Introduction

Anger is a powerful human emotion that has serious health, social, and psychological consequences when not appropriately managed. Research has documented its adverse effects on cardiovascular disease [1], domestic violence [2], and posttraumatic stress disorder[3]. Strong empirical support was reported by a meta-analysis of the efficacy of CBT in the treatment of anger [4]. CBT involves relaxation training, exposure to anger arousing stimuli, cognitive re-framing, and rehearsal of adaptive thoughts and behaviors during imaginal or role play exposure to anger provoking situations. Reactivity to anger stimuli during exposure is critical to successful treatment outcomes that will generalize to real life situations. Studies have shown that VR environments can elicit potent reactions to the stimuli that are experienced [5-6]. This suggests a very useful role for VR in the treatment of anger by exposing participants to realistic virtual anger provoking scenarios. VR technology allows treatment providers to immerse participants into a virtual environment, assess their responses in a structured, systematic manner, and promote the development of self-regulatory skills using realistic VR cues. Recent innovations in VR technologies enable the production of panoramic video environments, which provide a more realistic immersive experience than computer-generated images, and may improve exposure treatment interventions to manage the expression of uncontrolled anger.

The current investigation utilized a VR 360° panoramic video environment with six anger provoking video vignettes to examine the anger reactivity potential of VR. The effect of the display modality, i.e., immersive and non-immersive, on anger arousal was also examined to determine if there is a comparative advantage of presenting the VR stimulus cues in a head-mounted display helmet (HMD) as compared to flat-screen images to elicit anger reactivity in study participants.

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1. Methods

1.1. Participants and Procedures

Sixty normal, healthy soldiers and military retirees (33 males, 27 females), ages 18-75 years (Mean=40.05) participated in this study. An equal number of participants were randomly assigned to either a head-mounted display (HMD) or a flat-screen monitor (FSM) condition. All participants viewed the identical six brief video vignettes depicting anger-provoking situations in an office setting, e.g., supervisor criticizing work performance or firing the individual. Participants in the immersive HMD condition viewed the brief vignettes in a 360° panoramic format through a high resolution HMD equipped with headphones and a head tracking sensor. The panoramic format allowed the participant to see any aspect of the office, including co-workers, on a horizontal dimension when the participant turned in that direction. FSM participants viewed the vignettes on a standard 17" computer monitor and wore headphones. They did not have panning capabilities and viewed the critical scenes in the video from a single camera perspective. Each video vignette was approximately 15 seconds, and the order of presentation of the videos was counterbalanced to control for sequencing effect.

1.2 Relevant Outcome Measures

The following outcome measures were administered before and after viewing the videos, except for the Presence Visual Analog Scale which was completed only after viewing the video:

- *State-Trait Anger Expression Inventory 2 (STAXI-2)* is 57-item inventory that includes six scales including state anger, trait anger, anger expression in, anger expression out, anger control in, and anger control out. The coefficient alphas for the scales range from r=.73-.94[7].

- *Emotional Assessment Scale (EAS)* is a 24-item scale using 100mm visual analog responses where "0" represents "least possible" and "100" represents "most possible". The scale measures eight fundamental emotional states (happiness, sadness, fear, anger, surprise, guilt, anxiety, and disgust) and has a split-half reliability of r=0.94[8].

- *Presence Visual Analog Scale (P-VAS)* is a 100mm visual analog scale where "0" represents "I did not feel like I went into the virtual world at all" and "100" represents "I went completely into the virtual world". The measure has been used in prior research on VR, but reliability data are not available[5].

1.3 Statistical Analysis

Emotional reactivity and presence were compared between the two study conditions using repeated measures and paired samples tests ($p<.05$) of the STAXI-2, EAS, and P-VAS.

2. Results

An independent samples t-test between the HMD and FSM groups on the presence ratings (P-VAS) revealed a significant difference ($t[58]=-2.131$; $p<.04$) between the two groups with the HMD group reporting greater presence than the FSM group.

Paired samples t-tests for the HMD and FSM groups on the pre-post scores of the anger reactivity measures, STAXI-2 and EAS, yielded significant differences within the HMD group, but not the FSM group (see Table 1).

Table 1. T-Test Results for Differences between Pre-Post Anger Scores by Display Type

Anger Reactivity Measure	Flat-Screen Monitor (N=30)	Head-Mounted Display (N=30)
STAXI-2: State Anger Subscale	-1.94	-2.89**
EAS: Anger Subscale	-1.90	-2.52*

*p<.05
**p<.01

Comparisons of the mean EAS anger subscale pre-post viewing scores for the HMD and FSM groups by presence level (high/low) found significant differences (p<.04) between the HMD-high presence group and the FSM-low presence groups (see Figure 1).

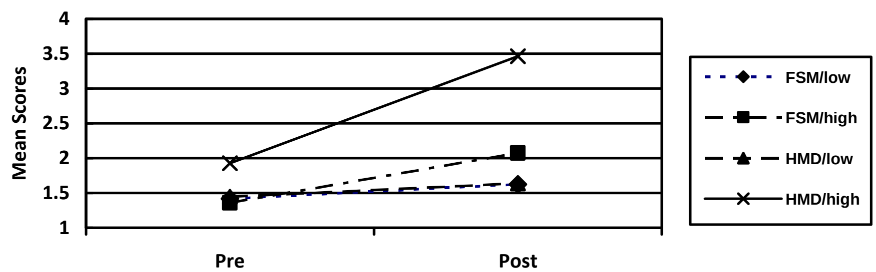

Figure 1. EAS Mean Pre-Post Anger Scores by Display Type and Presence Level

A significant difference (p<.03) was also found on the STAXI-2 pre-post anger-verbal subscale mean scores between the HMD-high presence and the HMD-low presence groups (see Figure 2).

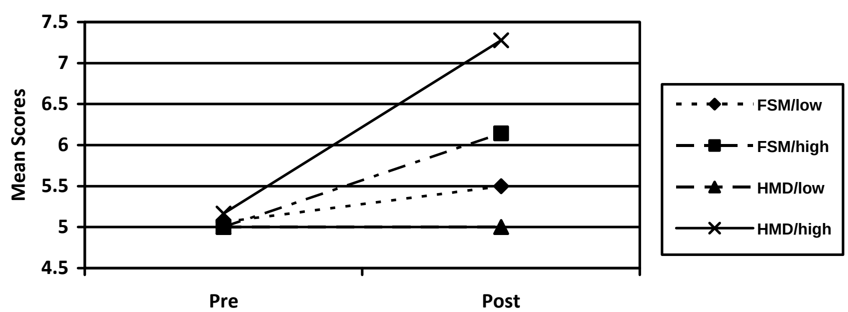

Figure 2. STAXI-2 Mean Pre-Post Anger-Verbal Scores by Display Type and Presence Level

3. Discussion and Conclusions

The panoramic anger video vignettes viewed in an immersive VR environment (HMD) produced significantly higher levels of presence than when the same videos were viewed on a non-immersive flat screen monitor. When the interaction between display type and presence level was examined anger arousal reported within the HMD panoramic video group was greater among participants who reported a high level of presence compared to HMD viewers who experienced a low level of presence. Interestingly, if presence was low, reactivity to anger stimuli was low regardless of display type, i.e., HMD or flat screen. These findings suggest that panoramic videos of anger-provoking scenarios presented in an immersive display type, e.g., stereoscopic HMD, are more effective in creating a sense of presence in the virtual environment than when presented on non-immersive display device such as a flat screen monitor. More importantly, anger stimuli experienced through immersive displays elicit greater anger reactivity to the anger stimuli than non-immersive displays. However, the effectiveness of the immersive virtual environment to produce anger reactivity varies with whether or not the viewer experiences a high level of presence while in the virtual environment. Viewers with a high sense of presence are more likely to experience greater emotional reactivity to anger-provoking stimuli than those with a low sense of presence.

Based on results of this study, presence appears to moderate the effects of VR on emotional reactivity. This has implications for the use of immersive virtual environments in anger management interventions and when evaluating the effectiveness of VR to elicit emotional cue response. Immersive VR environments are potentially useful tools in simulating real life experiences when learning to better manage reactions to anger-provoking stimuli. They may also improve the generalization of newly acquired behaviors to the real life situations. It is important to assess the individual's level of presence in a virtual environment prior to utilizing the VR environment in an anger management intervention program as presence level may affect the likelihood of benefiting from the VR intervention. While the results of this study are promising, more research is needed to evaluate the effectiveness of immersive VR environments to produce anger cue responsivity, and to determine if VR may contribute to the development of efficacious anger management treatment interventions.

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Accessible Virtual Reality Therapy Using Portable Media Devices

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Abstract. Simulated immersive environments displayed on large screens are a valuable therapeutic asset in the treatment of a range of psychological disorders. Permanent environments are expensive to build and maintain, require specialized clinician training and technical support and often have limited accessibility for clients. Ideally, virtual reality exposure therapy (VRET) could be accessible to the broader community if we could use inexpensive hardware with specifically designed software. This study tested whether watching a handheld non-immersive media device causes nausea and other cybersickness responses. Using a repeated measure design we found that nausea, general discomfort, eyestrain, blurred vision and an increase in salivation significantly increased in response to handheld non-immersive media device exposure.

Keywords. Non-immersive portable media device, cybersickness, virtual reality exposure therapy

Introduction

Virtual Reality Exposure Therapy (VRET) [1] has immense potential; however, it inherently has the drawback that it can be expensive to establish and requires specially trained counselors and technicians to efficiently run a clinic and is not always accessible for all clients due to distance or work/study or family commitments.

In Australia, in 2007 anxiety disorders affected approximately 14%, and depression 6% of the population [2]. Comparably, in America during 2007 anxiety disorders affected 18% and major depressive disorder affected about 6.7% of the population over one year [3]. The task of providing clinical options to clients is one that challenges health professionals. Access to treatment in a virtual environment (VE) could be improved for greater sections of the community if safe, reliable, mobile and relatively inexpensive tools were available.

Although virtual reality anxiety treatment studies [4,5] are reporting significant client improvement, and with ever improving technology [6] that is more compact, health and safety concerns still need to be addressed in order that practitioners are not unwittingly confounding research results.

Cybersickness is a collection of symptoms that are reported in response to simulated immersive environments [7]. The Simulator Sickness Questionnaire (SSQ) [8] is a standardized sixteen symptom questionnaire that is used to identify the severity of responses specific to exposure to immersive computer generated environments. Previously, our studies have suggested that moderate simulated motion in an immersive VE can significantly increase a client's reports of anxiety [9], as well as a range of unpleasant cybersickness symptoms, such as nausea and general discomfort [10].

This study proposes that use of a small, inexpensive apparatus, such as a handheld non-immersive media device, may be an alternative to using well equipped clinics for VRET. It is hypothesized that there will be no reports of cybersickness in response to simulated movement on a handheld non-immersive media device.

Our aim is to identify whether handheld non-immersive media devices have the potential to be used as a safe, reliable, easily transportable and cost effective treatment tool.

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1. Method

Forty (Experimental condition: 13 male, 16 female; Control condition: 4 male, 7 female) healthy Macquarie University students (18 – 35 years of age) voluntarily participated in the Macquarie University Human Ethics Committee approved experiment. Participants had normal or corrected to normal vision.

A within-subject design was used to compare self reported measures of cybersickness using the SSQ. Participants completed the SSQ before and after watching a six-minute video [9] on a handheld non-immersive device. Participants were either shown the control or the experimental condition. The control condition showed a video of a flight over a snow scene with low-simulated movement. The experimental condition presented a video of a rollercoaster ride with substantial simulated movement. In order to compare participant's responses, we used the same video environments that were used in our previously reported studies in a CAVE virtual reality environment [9,10].

Students were invited individually to sit at a desk in a quiet office opposite the experimenter. First, the participants were asked to complete the SSQ and to report on how they were feeling at that moment. The participant was then given the handheld non-immersive device to hold, and asked to watch a video for six-minutes. The participant was informed that if they wished to stop there would be no penalty. After the hand held non-immersive device video finished the participant completed another SSQ and reported how they were feeling after viewing the video. Each participant was given a chocolate bar as an acknowledgement of their participation.

2. Results

The hypothesis was tested using a Wilcoxon Matched Pairs Signed Rank Test. The prediction that there would be no significant difference between the Pre-Test SSQ and the Post-Test SSQ scores for the experimental condition (high-simulated motion) was not supported on five SSQ symptoms (Table 1), thereby suggesting that participants did experience some level of discomfort when viewing high levels of simulated motion on the handheld non-immersive device. Eleven of the sixteen symptoms did not however appear to cause an increase in symptoms in response to high levels of simulated motion. The control condition did not identify any significant changes in symptom severity, confirming our previous research findings [10].

The results indicate that exposure to a handheld non-immersive device can cause significant discomfort for individuals exposed to considerable simulated movement.

Table 1. Wilcoxon Matched Pairs Signed Rank Test

SSQ Symptoms	Experimental (n = 29) (High simulated movement)	Control (n = 11) (Low simulated movement)
General Discomfort	z = -2.000, p = 0.046*	z = -1.000, p = 0.317
Eyestrain	z = -3.000, p = 0.003*	z = -1.414, p = 0.157
Salivation	z = -2.449, p = 0.046*	z = 0.000, p = 1.000
Nausea	z = -2.121, p = 0.034*	z = 0.000, p = 1.000
Blurred Vision	z = -2.121, p = 0.034*	z = 0.000, p = 1.000
Fatigue	z = -1.890, p = 0.059	z = 1.000, p = 0.317
Headache	z = 0.000, p = 1.000	z = 0.000, p = 1.000
Difficulty in Focusing	z = -1.667, p = 0.096	z = -1.633, p = 0.102
Sweating	z = -0.577, p = 0.564	z = 0.000, p = 1.000
Difficulty in Concentrating	z = -1.890, p = 0.059	z = -1.890, p = 0.059
Fullness of Head	z = -1.667, p = 0.096	z = -1.414, p = 0.157
Dizziness Eyes Open	z = -1.000, p = 0.317	z = -1.732, p = 0.083
Dizziness Eyes Closed	z = -1.000, p = 0.317	z =-1.414, p = 0.157
Vertigo	z = 0.000, p = 1.000	z = 0.000, p = 1.000
Stomach Awareness	z = -1.667, p = 0.096	z = -1.000, p = 0.317
Burping	z = 0.000, p = 1.000	z = 0.000, p = 1.000

*Significant p<0.05

3. Discussion

The results indicate that a portable non-immersive media device can cause cybersickness symptoms when the client is exposed to significant simulated motion. The participants reported a significant increase in General Discomfort, Eyestrain, Salivation, Nausea and Blurred Vision; however, the symptoms were not severe.

Interestingly, in our previous study with an immersive CAVE virtual reality environment using three dimensional spectacles [10] we reported ten of the sixteen symptoms to have increased in symptom severity. In common with both the CAVE and the handheld device are four symptoms: General Discomfort, Nausea, Eyestrain and Blurred Vision suggesting that the perceived motion was producing the feeling of general unwellness in high-simulated motion environment by similar physical mechanisms. It would appear that the illusion of motion on the screen, known as vection [11], is as robust on a non-immersive handheld screen as on an immersive CAVE setting and thus able to invoke the symptoms of nausea and general discomfort. Increased eyestrain and blurred vision may be an indication that the participants felt they needed to watch the screen intently for six minutes, and this might account for the increased reports of changes in visual acuity, as corroborated by other researchers [12, 13]. Although previously reported findings [10,12] did not report significant changes in salivation in response to a VE, our data indicated participants experienced increased salivation, an autonomic nervous system symptom associated with an increase in nausea [14].

Appreciating which elements of the environment influence the health of the client continues to be a major question for clinicians and researchers [13]. Despite recently published works [15] including meta-analysis studies [1,5] finding cybersickness not to be a problem in the newer generation of hardware and software, our studies are reporting mild, but statistically significant increases in symptoms associated with the experience of vection.

Vection induced cybersickness symptoms may be explained by the sensory conflict theory [16]. Dual axis virtual motion has been reported to increase the scale of the cybersickness symptoms [17] when self-motion and a pseudo-Coriolis effect is perceived in response to vection in a virtual reality environment. Although, we did not specifically design our experiment to assess the effects of observing the changing axis of the scene, the fact that the central axis of the VE's in the experimental condition was significantly rotating, as compared to the control condition, may be one cause for the increase in symptom severity associated with general discomfort associated with nausea and an increase in salivation. Future experiments are needed to investigate the effect of rotation around an axis on non-immersive handheld devices.

Access to safe, reliable, valid and economical treatment with well qualified, clinically experienced therapists, who have expertise in VR treatments may be one part of the solution to providing psychological assistance in communities disadvantaged by distance or economic adversity, through mobile equipment. Furthermore, as Wiederhold [18] advocates, the use of VR handheld devices may offer therapists and ultimately bureaucracy an effective tool that could also be used for pre-disaster preparedness and post-impact recovery.

Further work is required to determine whether exposure to less capricious simulated movement would provide a more comfortable experience, and to test whether these results are applicable to a clinically diverse population. The advantage of mobile, cost effective equipment in conjunction with competent counselors may offer greater accessibility of treatments to a broader community. Therapists will forever remain the most important element in any therapeutic situation, for it is their expertise that will ultimately determine the quality of the treatment.

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Executive Functions in a Virtual World: a Study in Parkinson's Disease

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Abstract. In Parkinson's disease executive functions are altered. We used a Virtual Reality version of the Multiple Errand Test in order to evaluate decision-making ability in 12 patients and 14 controls. Patients with Parkinson's disease, even if not-demented, showed strategies full of errors, suggesting that impulse control disorder, very frequent in course of disease, could precede cognitive dysfunctions.

Keywords. Executive functions, Virtual Reality

Introduction

Even if Parkinson's disease (PD) is primarily known as a movement disorder due to a dysfunction of the nigrostriatal dopaminergic system, in the last years, many scientific studies, supported by clinical evidences, have revealed also an alteration of executive functions. This includes difficulty in planning, concept formation, working and visual memory, lexical and attention deficits, difficulty in dual and sequencing tasks.

Virtual Reality (VR) immersion works as an experimental model where "real" motor symptoms are eliminated or attenuated, and thus focusing on findings by evaluating the cognitive component of strategy.

The scope of our study was to evaluate planning, memory and attention abilities in PD non-demented patients by using a virtual version of a neuropsychological test, the Multiple Errand Test (VMET) [1, 4].

The MET is an assessment of executive functions in daily life originally developed by Shallice and Burgess [4] specifically for high-functioning patients and adapted into the simple version [5] and the hospital version [6]. It consists of three tasks that abide by certain rules and is performed in a mall-like setting or shopping center.

After the tasks and the rules have been explained, patients are able to plan and choose the sequence of actions to complete the tasks. In this way the executive functions stimulated are numerous, from the ability to plan a sequence of actions, to problem solving and to cognitive and behavioral flexibility.

Being a "real-life" multitasking test requiring the performance of very common daily actions, the MET has good ecological validity [7]. It also has good psychometric properties [8].

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1. Methods

We evaluated 12 PD not-demented patients and 14 controls. Patients were selected according to the severity of the impairment. Exclusion criteria were:

- Severely impaired mental status: according to neuropsychological assessment;
- Presence of severe difficulties in visual discrimination skills and in language comprehension and presence of spatial neglect;
- Severely impaired motor function: according to physiatrist assessment.

In particular, patients were excluded from the study who had a severe cognitive impairment (MMSE < 19), a severe motor impairment which did not allow subjects to perform the procedure, auditory language comprehension difficulties (score at the Token Test < 26.5), object recognition impairments (score at the Street Completion Test < 2.25), spatial hemi-inattention and neglect as assessed by the Behavioral Inattention Test (score < 129/146), excessive state and trait anxiety (score at the State and Trait Anxiety Index > 40) and excessive depression state (score at the Beck Depression Inventory > 16).

Evaluation was based on clinical scores (Unified Parkinson’s disease Rating Scale, Hoehn & Yahr stage), neuropsychological battery (Minimental state, Token Test, Corsi’s memory span, Digit span, Short Story recall, Word recall Test, Tower of London Test, Frontal Assessment Battery, Trail Making Test, Street Completion Test) and virtual version of MET (VMET), which was presented within a virtual supermarket. This is an assessment of executive functions in daily life, which consists to perform tasks according predefined rules, so that there are items to be bought and information to be obtained. Specifically, subjects were requested to select and buy various products presented on shelves with the aid of a joy pad. The analyzed variables were the execution times for the entire task; errors in executing the tasks, with a scoring range from 11 (the subject has correctly done the tasks) to 33 (the subject has totally omitted the tasks); inefficiencies, with a scoring range from 8 (more inefficiencies) to 32 (no inefficiencies); rule breaks, with a scoring range from 8 (more rule breaks) to 32 (no rule breaks); strategies, with a scoring range from 13 (more strategies) to 52 (no strategies); interpretation failures, with a scoring range from 3 (more interpretation failures) to 6 (no interpretation failures) and partial task failures, with a scoring range from 8 (no errors) to 16 (more errors). Specific items of partial task failures were the following:

- “Searched item in the correct area”;
- “Maintained task objective to completion”;
- “Maintained sequence of the task”;
- “Divided attention between components of task and components of other VMET tasks”;
- “Organized materials appropriately throughout task”;
- “Self-corrected upon errors made during the task”;
- “No evidence of perseveration”;
- “Sustained attention throughout the sequence of the task (not distracted by other stimuli)”.

As to the procedure, participants were included in the study after the neuropsychological evaluation. After a training session, they were asked to complete the Virtual Multiple Errands Test procedure. Two sessions of about 90 minutes were scheduled for each patient; during the first session they underwent the complete neuropsychological assessment, while during the second session (held the following day) the virtual reality Multiple Errands Test procedure within the virtual supermarket was administered. A training period was first provided in a smaller version of the virtual supermarket environment in order to familiarize participants with both the navigation and shopping tasks. With the healthy adults population, the evaluation phase was concluded in a single session of about 30 minutes and consisted of the administration of the MMSE (as the criterion for excluding not eligible subjects), a training phase in VR and the presentation of the virtual version of the Multiple Errands Test.

2. Results

Neuropsychological tests resulted correlated with VMET findings: Short Story recall with inefficiencies ($r = .72$, $p = .02$); Word recall test with Rule Breaks ($r = .68$, $p = .02$); Corsi's memory span and time ($r = -.58$, $p = .05$).

Descriptive statistics were used to summarize the mean values and standard deviations for the VMET outcomes of PD patients and healthy subjects, as shown in Table 1.

Table1. Group statistics

	Group	N	Mean	Std. Deviation
Errors	Healthy subjects	14	17.64	3,895
	Patients	12	25.08	4,757
Searched item in the correct area	Healthy subjects	14	8.86	1,512
	Patients	12	11.92	2,314
Maintained task objective to completion	Healthy subjects	14	8.86	1,351
	Patients	12	11.83	2,368
Maintained sequence of the task	Healthy subjects	14	8.93	1,328
	Patients	12	12.08	2,234
Divided attention	Healthy subjects	14	9.29	1,437
	Patients	12	12.25	2,379
Organized materials appropriately throughout task	Healthy subjects	14	9.50	1,990
	Patients	12	12.25	2,454
Self corrected upon errors made during the task	Healthy subjects	14	9.86	1,834
	Patients	12	12.50	1,931
No evidence of perseveration	Healthy subjects	14	8.50	1,160
	Patients	12	11.92	2,429
Sustained attention throughout the sequence of the task	Healthy subjects	14	9.43	1,342
	Patients	12	12.17	2,082
Buying a chocolate bar	Healthy subjects	14	9.29	2,555
	Patients	12	13.25	3,888
Buying toilet paper	Healthy subjects	14	9.07	2,165
	Patients	12	13.33	3,939
Buying a sponge	Healthy subjects	14	9.07	2,556
	Patients	12	13.33	3,939
Buying two products from the refrigerated products aisle	Healthy subjects	14	9.64	2,590
	Patients	12	12.83	3,326
Going to the beverage aisle and asking about what to buy	Healthy subjects	14	10.50	2,312
	Patients	12	15.17	1,992
Rule breaks	Healthy subjects	14	28.50	2,378
	Patients	12	24.92	3,423
Strategies	Healthy subjects	14	37.36	8,608
	Patients	12	47.33	3,339

The Mann-Whitney Test was employed to evaluate the VMET procedure with the clinical and control group.

The mean rank for patients was significantly higher for *errors* in executing the task than for control subjects (Asym. Sig. = 0.001) and the same result was also found for the *partial errors of the 7 tasks*.

Moreover, the mean rank for *rule breaks* was higher for control subjects than for patients (Asym. Sig. = 0.01) while *strategies* inferior than patients (Asym. Sig. = 0.000): this means, on the basis of the scoring key employed, that control subjects make less rule breaks and use more strategies than patients.

Finally, patients have a significantly higher mean of partial errors of specific tasks than the control group and in particular of the tasks of *buying a chocolate bar* (Asym. Sig. = .01), *buying toilet paper* (Asym. Sig. = .006), *buying a sponge* (Asym. Sig. = .007), *buying two products from the refrigerated products aisle* (Asym. Sig. = .01) and of *going to the beverage aisle and asking about what to buy* (Asym. Sig. = .000), which require a change in the primary task and the ability to respond simultaneously to multiple task demands.

3. Conclusions

If we exclude clinical forms of atypical Parkinsonism, such as for instance Lewy Body Disease, the course of mental dysfunction in PD usually starts from symptoms included in disexecutive syndrome [2] till the so-called subcortical dementia.

During this time, patients can frequently show behavioral symptoms included in an impulse control disorder, such as pathological gambling, hypersexuality, compulsive shopping and compulsive eating.

Actually, it is still controversial the existence or not of a clear relationship between cognitive and behavioral disturbances.

In our study, patients, appropriately selected in order to exclude presence of dementia, showed strategies full of errors comparing with controls, suggesting an impulsive decision-making. These data can support the hypothesis that behavioral disturbance might precede cognitive dysfunctions in PD.

Moreover, as a whole, the results provide support for the feasibility of using the Virtual Multiple Errands Test (VMET) as an assessment tool of executive functions in PD patients. However, due to the small sample size these results should be considered preliminary. Further research using the VMET with larger groups and in additional populations is recommended. In fact, employing larger groups of both healthy adults and patients will provide additional support for the use of the Virtual Multiple Errands Test in assessment and rehabilitation intervention.

Acknowledgments

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Presence, Involvement and Efficacy of a Virtual Reality Intervention on Pain

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Abstract. We explored the impact of an interactive VR environment on pain cognitions (in vivo catastrophizing and pain self-efficacy) and pain-related measures: pain threshold, pain tolerance, Pain Sensitivity Range (PSR), pain intensity and time estimation in a sample of healthy students. Sense of presence is essential to conduct a psychological treatment; if patients are not able to involve themselves in a virtual world they cannot experience relevant emotions, and the desired processes that are necessary for most psychological treatments will not occur. However, some authors argue that presence must be distinguished from the degree of engagement, involvement in the portrayed environment. The results obtained in our study are consistent with this view, since the Involvement scale of the IPQ did not correlate with any of the measures related with the treatment's efficacy.

Keywords. Virtual Reality, presence, involvement, pain.

Introduction

The use of virtual reality (VR) for pain management is a relatively new approach that has been proved useful with specific populations and acute medical procedures[1.] The efficacy of this technique for pain reduction has been attributed to attentional distraction. In fact, to be processed, pain needs attention. Therefore, if attention is distracted, it could be hypothesized that pain would be perceived with less intensity. Other alternatives would be to explore the use of this technology to change cognitions associated with pain adjustment in chronic pain patients. Although therapeutic mechanisms underlying the process of the pain patients' improvement in VR, besides its attention diversion effects, are posited to be changes in patient cognitions and behaviors, little research has systematically tested this. Both clinical studies conducted with patients receiving painful medical procedures[2-3] and laboratory-induced pain studies with healthy populations[4-5] have explored the changes that VR produces on pain-related measures such as the perceived pain intensity, pain threshold and pain tolerance, yet little is known about VR effects on cognitive variables associated with pain. Specifically, two important cognitions that have accumulated evidence of this relation with pain adjustment are catastrophizing and self-efficacy. There is growing evidence suggesting that especially catastrophizing and self-efficacy for pain management mediate some of the relationships between pain and adjustment[6-7-8-9-10]. Our research group is working to test if a VR experience specifically designed to modify catastrophizing and pain self-efficacy in a controlled laboratory environment can be developed. Given the importance of these two constructs, it is interesting to explore if VR can have an effect changing these two kinds of cognitions. If this is the case, this could be a strategy to use VR for chronic pain patients. In fact, results obtained recently in our laboratory show that this is possible. We explored the impact of an interactive VR environment on pain cognitions (in vivo catastrophizing and pain self-efficacy) and pain-related measures: pain threshold, pain tolerance, Pain Sensitivity Range (PSR), pain intensity and time estimation in a sample of healthy students. The virtual environment consisted of a stereoscopic figure that appeared in the center of the screen with a black background (fig.1) to test the hypothesis that the experience of control over the parameters that defined the

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virtual geometric figure that represents the pain, would be transferred to the expectation of control that the subject has over a painful experience.

This VR experience showed to decrease pain cognitions and to increase pain threshold, pain tolerance and PSR in a cold-pressor task. Moreover, VR reduced the subjective ratings of the duration of the task[11].

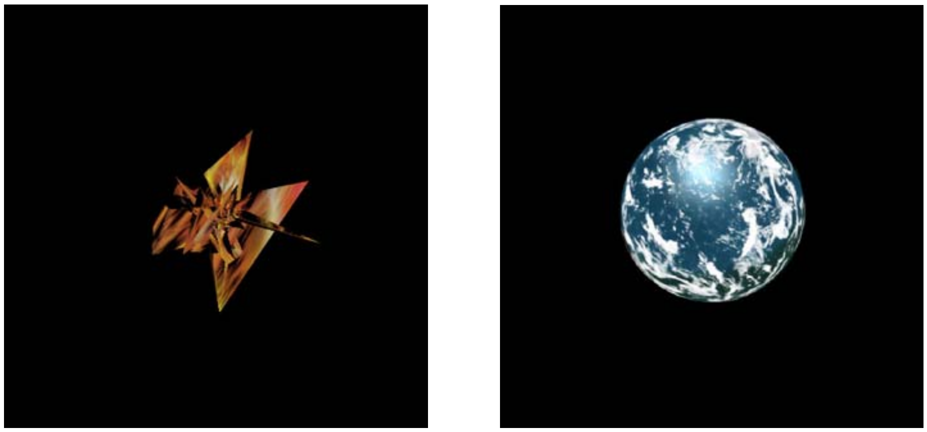

Figure 1. The initial figure and the sound represented an unpleasant pain sensation. The figure and the sound could be manipulated in the virtual environment so it could gradually be converted into a pleasant and quiet environment (analogue to a situation of no pain).

There are several factors that modulate the effect of any VR intervention. In this presentation we will offer some data regarding the contribution to the efficacy of our VR intervention on pain of one of the most important of those intermediary variables: presence.

One of the core features in VR treatment of psychological disorders is the sense of presence. The term "presence" is used to describe the illusion of "being there" in a virtual environment. One of the most important consequences of this illusion is that a virtual environment can evoke the same reactions and emotions as the experience of a similar real-world situation[12]. This implies that sense of presence is essential to conduct a psychological treatment; if patients are not able to involve themselves in a virtual world they cannot experience relevant emotions, and the desired processes of habituation and extinction that are necessary for most psychological treatments will not occur. Although there is no generally accepted definition of presence, and in spite of the difficulties involved in its measurement, most researchers agree to define it as a multi component construct. Thus, some factor analysis studies[13-14] suggest a multidimensional structure for presence based on three factors: *Sense of Physical Space* (the sense of being located in a contiguous spatial environment), *Engagement/Involvement* (attention devoted to the virtual environment) and *Ecological Validity/Realism* (the participant's sense of believability and realism of the content). However, some authors argue that presence must be distinguished from the degree of engagement or involvement in the portrayed environment[15]. Presence and involvement may belong to different logical levels. One can be present but not involved, as in many situations in everyday life. Listening to some quadrophonically broadcast music you might feel like being in the theatre listening to the orchestra but without any interest for the music itself. This is high presence, low involvement (or interest). Conversely, one can be involved but not present (e.g., watching a soap opera on TV)[15].

1. Method

In order to explore the contribution of presence to the effect of our VR intervention on pain, the ratings of presence were measured by means of IPQ (Igroup Presence Questionnaire; Schubert, Friedmann & Regenbrecht, 2001) in a sample of 45 healthy participants who underwent two consecutive cold pressor trials, one using VR and one without VR exposure, in counterbalanced order. The VR intervention encouraged participants to actively search the correspondence between the experienced pain and a VR stereoscopic figure, which could be interactively manipulated with the mouse. IPQ contains three subscales, assessing involvement (awareness of the VE), spatial presence (relation between the VE and the subject's own body) and realness (sense of reality attributed to the VE). It also contains a general item that assesses the “sense of being here”. Since the environment used in the current study was not a simulation of a “real” world, items of the realness factor were removed.

2. Results

Presence, as measured by the IPQ, obtained medium ratings (sense of being, mean = 2.40, SD = 1.66; spatial presence, mean = 2.78, SD = 1.25; involvement, mean = 2.42, SD = 1.34; total, mean = 2.60, SD = 1.17). Concerning the item that assessed the general "sense of being there", 46.67% of participants reported moderate or higher ratings. The relationship between the IPQ subscales and the different measures used was investigated using Pearson product-moment correlation coefficients. The amount of VR “spatial presence” reported correlated significantly and positively with threshold and tolerance, and negatively with ratings of most pain intensity, time estimation, and catastrophizing. A similar pattern of correlations was found for the single item of “sense of being there”. No significant correlations were found with the “involvement” subscale (table 1).

Table 1. Pearson correlation coefficients between pain and presence measures

	Presence		
Measures	Sense of being there	Spatial presence	Involvement
Threshold	.23	.35*	.09
Tolerance	.38*	.30*	.20
PSR	.33*	.16	.20
Most pain intensity	-.07	-.34*	-.14
Time estimation	-.37*	-.30*	-.15
In vivo catastrophizing	-.31*	-.30*	-.01
Self-efficacy to tolerate pain	.20	.29	.09
Self-efficacy to reduce pain	.11	.08	-.05

* $p < .05$

3. Conclusions

Since the Involvement scale of the IPQ did not correlate with any of the measures related with the treatment's efficacy, these results indicate that the relationship between involvement and treatment's efficacy may not be the same as the one between presence and treatment's efficacy. The questions of whether or how involvement is related to the sense of presence have interested many researchers, and some of them[15] claim that presence is a response to media form while involvement is a response to media content, throwing an interesting twist into the general assumption about the relationship between presence and involvement. In fact, some studies[16] have found that involvement may not necessarily be a dimension of presence.

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SECTION III

ORIGINAL RESEARCH

Health care is one of the areas that could be most dramatically reshaped by these new technologies.

Distributed communication media could become a significant enabler of consumer health initiatives. In fact they provide an increasingly accessible communications channel for a growing segment of the population.

Moreover, in comparison to traditional communication technologies, shared media offer greater interactivity and better tailoring of information to individual needs.

Wiederhold & Riva, 2004

Analysis of Visual Perception Aspects of the Virtual Reality Experience with Transcranial Doppler Monitoring

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Abstract. Transcranial Doppler is a tool to measure blood flow velocity (BFV) in the main arteries of the brain that has been used in previous studies to analyze brain activity during virtual reality (VR) experiences. Increments in BFV were found during the exposure to virtual environments in comparison with baseline periods. However, due to the complexity of VR experiences, there are several factors that can be having an influence in these variations, so it is necessary to separately analyze those different aspects. In this work, we summarize our results related to visual perception. A method based on spectral analysis was used to analyze the magnitude and temporal evolution of the maximum BFV signal. Results showed that, in the presence of visual stimuli, BFV quickly rises to a maximum that is achieved after a few seconds. The contribution of the visual stimuli factor to the observed BFV variations during a VR experience can be estimated from the results of the developed work.

Keywords. Visual perception, Virtual Reality, Transcranial Doppler Monitoring

Introduction

Transcranial Doppler Monitoring (TCD) is a tool used to measure blood flow velocity (BFV) from the Middle Cerebral Arteries (MCA), Anterior Cerebral Arteries (ACA) and Posterior Cerebral Arteries (PCA). When the neurovascular coupling is adequate, the velocity variations that are detected in an artery using TCD reflect changes in regional cerebral blood flow due to brain activation in the areas supplied by that vessel [1]. The technique has a low spatial resolution (limited by the size of the cortical areas supplied by the arteries under study), but it is non-invasive and has a high temporal resolution.

TCD has been widely used to analyze brain activity during the performance of cognitive tasks in psychophysiological research [2-3]. It has also been proposed as a tool for monitoring brain activity in VR settings during clinical therapy sessions [4] and it has been used to study brain activity of participants in Virtual Reality (VR) experiences [5-6]. In these studies, different experimental conditions were proposed to analyze the influence of immersion (CAVE-like vs. single projection screen) and navigation factors (user-controlled vs. system-controlled navigation). Percentage variations between the mean BFV value during the baseline previous to an activation period, and the mean BFV value during the activation period itself were calculated and compared. These percentage variations were positive in all the experimental conditions, and differences were found between conditions.

The increment in BFV that is observed during the exposure to a VE can be explained by several factors, for example, the complex interaction between visuospatial interaction and attention tasks, and the creation and execution of a motor plan, which cannot be observed during the baseline. Emotions and presence can also vary between the baseline and the exposure to a VE, so they may also be having an influence in the observed BFV variations.

The analysis of these previous studies has two limitations:

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- First, although TCD has a high temporal resolution, the temporal variations inside the different experimental conditions were not analyzed: mean BFV values for each whole period were considered for the analysis.
- Second, there are several aspects that change between baseline and the exposure to the VE including visual perception, motor tasks, attention, emotions and presence, which complicate the interpretation of the BFV variations that are observed.

In order to improve the analysis of BFV signals during VR experiences, simpler experiments have to be proposed to analyze the individual variables that contribute to the VR experience. Furthermore, the kind of analysis that is applied to the BFV signal should be modified to also study the temporal evolution of the signal.

In a recent study [7], we have analyzed BFV responses to one of the main issues that contribute to the VR experience: visual perception. In the present work, we discuss the implications that the results from this study have in the VR field and how they may contribute to the interpretation of BFV variations during VR experiences.

1. Method

Visual perception is one of the main issues that contributes to the VR experience. Previous TCD studies have analyzed BFV responses to visual perception using experimental designs with different degrees of complexity [8-14].

In our recent study about visual perception aspects [7], we proposed a new methodology to analyze BFV that isolated the slow variations caused by the visual stimuli from any BFV variation caused by other factors, so it was possible to analyze the temporal evolution of the signal in a more reliable way. Maximum BFV data in both PCAs was monitored during a simple visual perception task (ten cycles of alternating darkness -20 s- and illumination -20 s-) for 23 subjects. The visual stimuli were generated by projecting white and black slides on a big screen (2.40 x 1.80 m) using a Sony VPL-CX5 projector (Sony, Minato, Tokyo, Japan). In the following paragraphs, a summary of the signal processing methods that were proposed in the study to analyze the maximum BFV signal during the different experimental periods (darkness versus illumination) is included:

- Firstly, a spectral analysis of the maximum BFV was performed separately for the repose and activation periods. It was found a peak located in the low-frequency band of the spectrum of each subject both during visual stimulation and repose periods.
- Then, the component of the maximum BFV signal at this frequency, which is associated with the slow variations caused by the visual stimuli, was estimated. In the low-frequency periodic component estimation, the variations in BFV caused by the experimental stimuli are isolated from the variations caused by other factors.
- The low-frequency periodic component estimation was used to obtain parameters about the temporal evolution and the magnitude variations of the BFV. The percentage variation was calculated as the percentage difference between the peak value of the low-frequency estimation signal during its temporal evolution inside the period (which can be a maximum or a minimum) and its initial value. The response time was calculated as the elapsed time between the beginning of the period and the moment in which the peak value of the low-frequency estimation signal was achieved.

2. Results

Main results from the study [7] are summarized now.

The frequency of the peak found in the spectrum was in the range between 0.037 and 0.098 Hz, depending on the subject, the vessel and the experimental condition. A spectral estimation of the low frequencies from one of the subjects, where the detected peak can be observed, is represented in Figure 1.

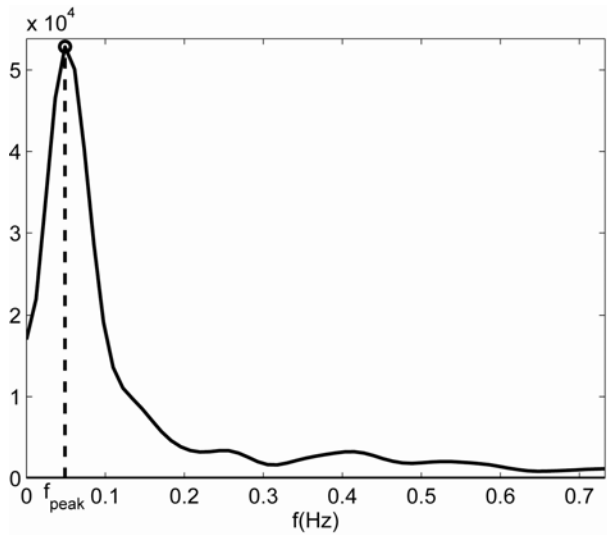

Figure 1. Spectral estimation of the low frequencies during the activation periods from one of the subjects that participated in the study. The maximum value in the low-frequency band and the frequency of the peak have been indicated graphically.

In Figure 2, the maximum BFV signal and the component of this signal at the peak frequency are represented for one of the subjects. Percentage variations and response times were calculated from the low-frequency estimation signal, as graphically shown.

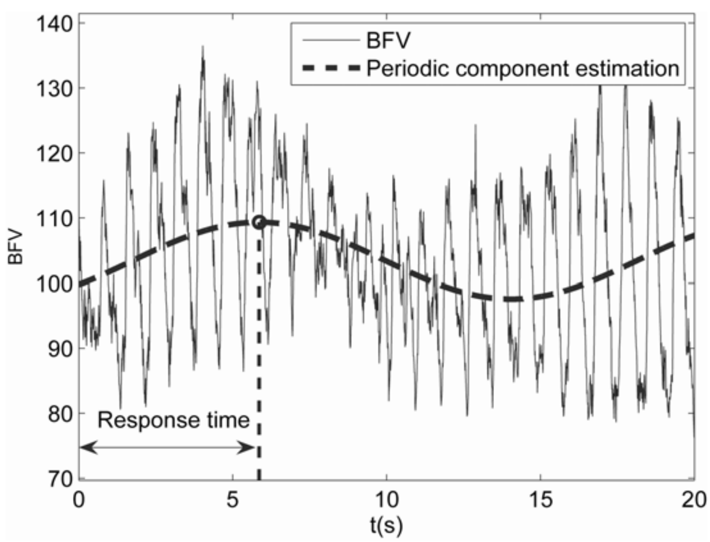

Figure 2. Representation of the maximum BFV during visual perception in a sample subject, with the low-frequency periodic component estimation. The peak value of this estimation and the response time are represented graphically.

Percentage variations were positive in the periods corresponding to visual stimulation. A mean BFV percentage variation of 4.572% was observed in the left PCA and 4.114% in the right PCA. Negative percentage variations were observed in repose periods. A significant effect was found for the presence of visual stimulus factor. No significant differences were found in percentage variations in the different vessels.

Mean response times ranged between 8.544 s to 10.726 depending on the vessel and the experimental condition. No significant differences were found between response times in the different vessels and periods.

3. Conclusions

The study has shown that in the presence of visual stimuli, BFV quickly rises to a maximum that is achieved after a few seconds. This increment in BFV has its origin in the brain activity that appears in the occipital lobe regions in response to visual perception, as long as PCAs are the vessels that supply this part of the brain.

With the proposed methodology the percentage variation and the response time can be estimated from the maximum BFV signal in an automatic way. These values can be helpful to characterize the velocity of the arteriolar vasomotor reactivity in subjects in response to visual perception tasks.

This study is a contribution to the research line that has analyzed the possibilities of TCD to monitor brain activity in VR settings. One of the aspects that is common to all VR configurations is the presence of visual stimuli of different complexity that are shown to the participant using different techniques. In this work, the visual stimulation was provided as a projection in a big screen, as occurs in many VR settings. That way, the variations in PCAs maximum BFV that are generated by a simple visual stimulation in this VR setting have been analyzed.

In future studies using TCD, the contribution of the visual stimuli factor to the observed BFV variations during a VR experience can be estimated from the results of the developed work. This is a first step in the analysis of the different factors that are needed to generate a complete VR experience. The separate influence of each of the factors has to be analyzed to achieve a better understanding of the BFV variations that occur during VR experiences. Further studies will be required to analyze visual stimuli with greater complexity and other individual factors that contribute to the VR experience, such as motor movements to control the joystick or emotional aspects. These studies will help to advance in this field of research.

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Using Robotics Construction Kits as Metacognitive Tools: a Research in an Italian Primary School

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Abstract. The present paper is aimed at analyzing the process of building and programming robots as a metacognitive tool. Quantitative data and qualitative observations from a research performed in a sample of children attending an Italian primary school are described in this work. Results showed that robotics activities may be intended as a new metacognitive environment that allows children to monitor themselves and control their learning actions in an autonomous and self-centered way.

Keywords. Educational Robotics, Metacognition, Learning.

Introduction

Robotics kits are *high tech* toys that allow users to build and to program small mobile autonomous robots into the physical environment [1]. During the game with such kits, children first build the robot body and then create a program in order to assign it an artificial intelligence (e.g., create a robot able to move into a maze). Finally, children test the robot performance into the physical environment in order to verify its success/failure. The final test is quite important because users can instantaneously see what they have planned for the robot and verify if they behave the way they were planned to.

A large amount of theoretical studies and empirical researches have showed that playing with robots allows students of different ages to improve their planning, reasoning and problem-solving abilities [2, 3, 4] as well as social skills related to peer conflict resolution, group decision-making and so on [5]. Moreover, children with mental retardation and autism seem to have benefits from rehabilitative activities based on robotics [6, 7]. However, there are no studies, according to our knowledge, which have analyzed the possibility to use robotics kits as metacognitive tools. In general, metacognition consists of two basic processes occurring simultaneously; the first is monitoring the progress of learning; the second is making changes or adapting learning strategies when subjects perceive that they are not successful [8]. Specifically, metacognitive skills include monitoring the progress of learning, correcting errors and changing strategies when it's needed [9]. From this perspective, the whole experience of playing with robots may be intended as a metacognitive process that leads users to becoming more aware and conscious of the way they think, learn and organize the game itself. With the aim to analyze the metacognitive strategies related to the error analysis and retrieving, we performed a research in a sample of children attending a primary school participating in a robotics laboratory.

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1. Method

1.1 Participants

Twelve children (6 Male and 6 Female; mean age: 9 *yrs*; range: 8-10 *yrs*) were randomly selected from all the third, fourth and fifth forms of the primary School of Palermo. The whole group was then divided in three subgroups (four children each, 2 Male; 2 Female) according to forms and ages.

1.2 Materials and procedure

In line with our previous researches [2, 3, 4], each group was provided with a robotic kit and was involved in an extra-curricular hands-on laboratory based on robotics activities (10 meetings; two hours each, once a week). After the familiarization with the hardware and software elements of the kit, all the children were given four construction and programming tasks with an increasing level of difficulty, as measured by the number of bricks, which had to be manipulated for constructing the robot body and by the number of drives, which had to be linked to create a specific robot behavioral repertory.

Specifically, children were first assigned with the following construction tasks aimed to build a small mobile robotic vehicle:

- Build the light sensor (it requires 12 LEGO bricks and 5 assembling sequences);
- Built the single bumper (it requires 32 LEGO bricks and 8 assembling sequences);
- Built the double bumper (it requires 37 LEGO bricks and 12 assembling sequences);
- Built the chassis and the wheels (it requires 100 LEGO bricks and 21 assembling sequences).

Once the robot was built, participants were then involved in programming it by using the software interface. Each group was provided with a desktop computer and a USB infrared tower to download the software program into the robot, and assigned with the following four programming tasks, having an increasing level of difficulty measured by the number of commands necessary for programming the robot:

- Program the motors – Create a robot able to move along a linear route (1 command);
- Program the motors and the light sensor - *Create a robot able to move and change trajectory if there is a black stain along its route* (4 commands);
- Program the motors and the single bumper: - *Create a robot able to move and change trajectory if there is an obstacle along its route* (5 commands);
- Program the motors and the double bumper - *Create a robot able to move and change trajectory if there is an obstacle along its route* (9 commands).

During all the construction and programming sessions children metacognitive strategies were registered using two observational grids that provided quantitative and qualitative indicators.
The first grid, named *Searching and Assembling Grid* [10] measured metacognitive abilities employed during the construction of the robot using the following indicators:

- Number of searching errors related to search and select a wrong brick;
- Number of visual-spatial assembling errors related to difficulties in orienting the robot in the space;
- Number of eye-hand coordination errors related to difficulties in motor coordination;
- Frequency of checks made by subjects to verify if the correct bricks were taken and assembled.
- Frequency of spontaneous self-corrections
- Frequency of trough-other corrections made by the experimenters.

The second grid, named *Robot Behavioral Programming Grid* [10] measured metacognitive abilities used during the programming phase, following these indicators:

- Frequency of using the Trial command, the button that allows users to test before the robot performance as planned by children;
- Number of programming commands that users eliminated;

- Number of programming commands that users changed after the download (such indicators are quite similar to self-corrections in the Searching and Assembling Grid);
- Number of downloads;
- Frequency of trough-other errors corrections.

On the basis of previous indicators two indexes were also calculated that measure metacognitive skills based on control, named respectively: 1) *Index of construction self-correction*, which was based on the ratio between the total number of self-corrections and the total number of construction errors; and 2) *Index of programming self-correction*, which was based on the percentage rate between the total numbers of programming commands that users changed and the total number of downloads.
Other two indexes that measure of the claim for external aids, during construction and programming sessions, named respectively: 1) *Index of construction help requests*, which was based on the ratio between the total number of trough-other corrections and the total number of construction errors; and 2) *Index of programming help requests* that was calculated on the ratio between the total number of trough-other corrections and the total number of download made by user were also calculated.

Finally, both the *Searching and Assembling Grid* and the *Robot Behavioral Programming Grid* collected qualitative indications about causal attributions and self-efficacy statements made by users during the robotics activities.

2. Results

As showed in Table 1, the third-form children made more metacognitive actions based on controlling and retrieving errors than the other two groups during the whole game action.

Table 1. Results at *Observational Grids*

	Searching and Assembling Grid				***Robot Behavioral Programming Grid***		
	Third form group	**Fourth-form group**	**Fifth-form group**		**Third form group**	**Fourth-form group**	**Fifth-form group**
Searching errors	13	0	6	Frequency of using the Trial command	2	0	0
Visual-spatial assembling errors	50	14	24	Number of eliminated commands before the download	2	2	5
Eye-hand coordination errors	10	6	5	Number of changed download after the download	116	64	63
Frequency of checks	14	6	8	Number of downloads	90	68	58
Frequency of self-corrections	15	5	14	Frequency of trough-other corrections	0	1	0
Frequency of trough-other corrections	40	10	17				
Construction self-correction index	**21%**	**25%**	**40%**	**Programming self-correction index**	**53%**	**38%**	**45%**
Construction help requests index	**55%**	**50%**	**48%**	**Programming help request index**	.		

However, during the construction phase they prefer to request help from experimenters rather than using self-corrections and tended to attribute their failures to external causes (e.g., “It’s very difficult!”).

On the contrary, during the programming phase, they made a higher number of self-corrections and they were more focused on their performance than on the robot, also emphasizing their own success (e.g., “I know it” or “I’m able to program the robot!”).

3. Conclusions

The present study is a first attempt to investigate the possibility of using robotics activities as a metacognitive tool. From this perspective, our results allow us to describe the action of playing with robots as a kind of “thinking with robots” which creates an autonomous and self-centered learning environment and motivates children both at monitoring and at controlling their own actions. However, further researches with a large sample should be done in order to confirm these preliminary results.

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Implementation of the Multiple Errands Test in a NeuroVR-supermarket: a Possible Approach

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Abstract. Our goal was to develop a tool for the assessment of executive functions by customizing a virtual reality (VR) version of the Multiple Errands Test (MET) [Shallice & Burgess, 1991; Fortin et al., 2003]. The MET is an assessment of executive functions in daily life which consists of tasks that abide by certain rules. It is performed in an actual shopping mall-like setting where there are items to be bought and information to be obtained. The specific goal of this study was to conduct a pilot study using the virtual version of MET (VMET) with both control subjects and patients with cognitive impairment derived from stroke.

Keywords. Virtual reality; executive functions; Multiple Errands Test (MET)

1. Executive functions impairments on a theoretical and methodological level

The "*dysexecutive syndrome*" refers to a collection of deficits in executive functions including planning, problem solving, multitasking and behavioral control [1-2]. The most common causes of executive functions impairments are neurological conditions including frontal lobe damage due to traumatic brain injury, pervasive CNS damage such as stroke [3] and those with specific pathologies such as Parkinson's disease (PD).

On a methodological level, besides the traditional paper and pencil tasks such as the Stroop Test [4], the WCST [5], the TOL [6], the Progressive Matrices [7] and Elithorn's Labyrinth, there are also tools developed to measure executive deficits in situations similar to daily ones, such as the Behavioral Assessment of Dysexecutive Syndrome, the Dysexecutive Questionnaire (BADS & DEX) [8] and the *Multiple Errands Test (MET)* [2]. The MET is an assessment of executive functions in daily life originally developed by Shallice and Burgess specifically for high functioning patients and then later adapted into the simple version [9] and the hospital version [10]. It consists of three tasks that abide by certain rules and is performed in a mall-like setting or shopping centre. Being a "real-life" multitasking test requiring the performance of very common daily actions, the MET has good ecological validity [11]. It also has good psychometric properties [12].

1.1. The Multiple Errands Test and virtual reality

As Rand et al. [13] underline, there is no doubt that the assessment of executive functions in real life settings has the advantage of giving a more accurate estimate of the patient's deficits than is possible within laboratory conditions [11, 13]. However, it is time consuming and not always feasible in typical clinical settings [14-15].

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The use of *simulated environments*, perceived by the user as comparable to real world objects and situations, can overcome the limits of the traditional MET, by keeping intact its several advantages. The realism and engagement of virtual reality tools may also help to transfer learning to the real world [16].

Rand, Rukan, Weiss and Katz [13] have developed the first version of the Virtual Multiple Errands Test (VMET) as an assessment tool for executive functions, within the Virtual Mall (VMall), a new functional video-capture virtual shopping environment [17]. It consists of a large supermarket, which was programmed via GestureTek's IREX video capture virtual reality system. This system includes a single camera, which films the user and displays his or her image within the virtual environment and interaction is done using active movements [18-19].

For the study presented in this paper we developed another VR based Multiple Errands Test, using the NeuroVR software, a free virtual reality platform based on open-source software.

Figure 1. Two screenshots of the virtual supermarket.

The MET procedure was modified according to the structure and the features of the system involved in the study. In particular, subjects were invited to buy some items following a defined shopping list and to obtain some information (e.g., the closing time of the supermarket) following specific rules (e.g., you are not allowed to go into the same aisle more than once). While completing the MET procedure, the time of execution, total errors, inefficiencies, rule breaks, strategies, interpretation failures and partial tasks failures (e.g., maintained task objective to completion; maintained sequence of the task; divided attention between components of task and components of other VMET tasks and no evidence of perseveration) were measured.

2. Method

The clinical sample consisted of 6 patients with cognitive impairment derived from stroke (mean age = 63 years, std.dev = 8.05; mean number of school years = 15.33 years, std.dev. = 2.58; MMSE = 28.13, std.dev. = 1.38), recruited from the Stroke Unit of the San Luca Hospital (Istituto Auxologico Italiano, Milan) and were selected according to the severity of their impairments. In particular, patients were excluded from the study who had a severe cognitive impairment (MMSE < 19), a severe motor impairment which did not allow subjects to perform the procedure (Barthel index, Stroke scale and the National Institute of Health Stroke Scale (NIHSS), auditory language comprehension difficulties (Token Test<26,5), object recognition impairments (Street Completion Test<2,25), spatial hemi-inattention and neglect as assessed by the Behavioural Inattention Test (<129/146), excessive state and trait anxiety (State and Trait Anxiety Index>40) and excessive depression state (Beck Depression Inventory>16).

The control group consisted of 14 healthy subjects (mean age=64.9 years, std. dev.=9.1; mean number of school years=12.3 years, std.dev.=4.03; MMSE=28.41, std.dev.=1.25).

A neuropsychological evaluation was conducted on patients previously selected according to the criteria above described, with the aim to obtain an accurate overview of patients' cognitive functioning in order to be compared with the performance on the experimental test.

As to the procedure, participants were included in the study after the neuropsychological evaluation. After a training session, they were asked to complete the Virtual Multiple Errands Test procedure.

3. Results

According to the Mann-Whitney Test, the mean rank for control subjects was significantly higher for *time* in executing the task than for patients (Asym.Sig.=0.06; M=964.6 *vs.* 649; SD=424.18 *vs.* 232.07). This could suggest that control subjects tend to engage in a more extensive planning activity. The same result was also found for the *partial error "Maintained task objective to completion, "* (Asym.Sig.=0.08; M=9.43 *vs.* 8.33; SD=1.34 *vs.* 1.03).

With regard to patients, correlations between neuropsychological tests and the variables of the virtual test (Table 1) in part support the content validity of the adopted procedure as the performances were correlated to the traditional tests aimed at assessing memory, attention and executive functions.

Table 1. Correlations between neuropsychological tests and the variables of the virtual test

	Time		**Searched item in the correct area**		**Sustained attention**		**Maintained sequence**		**No perseveration**	
	r	***p***	***r***	**p**	**r**	**p**	**r**	**p**	**r**	**p**
TMT(BA)			*.96***	*.00*						
Corsi's supra-span					*. 84**	*.04*	*.84**	*.04*	*.84**	*.04*
Street Compl.Test					*- 86**	*.03*	*- 86**	*.03*	*- 86**	*.03*
SemanticFluencies	-*.87**	.02								
Tol	-.82*	.05								

4. Discussion and conclusions

The involvement of executive functions in stroke patient outcome is supported by several studies, showing deficits in information processing speed, abstraction and mental flexibility in patients diagnosed with vascular cognitive impairment [20-21]. Our study proved the presence of impaired strategic behaviour and set shifting abilities in these types of patients, when compared with matched healthy subjects. Indeed, the evidence that control subjects consume higher time in executing the task than patients could suggest that they tend to engage in a more extensive planning activity.

Moreover, considering the correlations analyzed within the present study, it's possible to say that they support the content validity of the adopted procedure as the performances were correlated to the traditional tests aimed at assessing memory, divided attention and executive functions.

As a whole, these results provide support for the feasibility of using the Virtual Multiple Errands Test (VMET) as an assessment tool of executive functions in patients with cognitive impairment acquired after stroke.

However, due to the small sample size these results should be considered preliminary. Further research using the VMET with larger groups and in additional populations is recommended.

In fact, employing larger groups of both healthy adults and patients will provide additional support for the use of the Virtual Multiple Errands Test in assessment and rehabilitation intervention.

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The Moderating Role of Need for Cognition on Excessive Searching Bias: A Case of Finding Romantic Partners Online

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Abstract. Using online-dating websites to expand social networks and form close relationships is popular for people in information technology era. Wu and Chiou (2009) demonstrated that more options triggered excessive searching, leading to poorer decision-making and reduced selectivity. They proposed that the more-means-worse effect refers to more searching leads to worse choices by reducing users' cognitive resources, distracting them with irrelevant information and reducing their ability to screen out inferior options. A 2 by 2 experimental study was conducted to investigate the moderating effect of individual differences in need for cognition (NFC) and number of available options on excessive searching and decision quality. A total of 120 undergraduates with experiences of online romantic relationships participated in the experiment. After participants were administrated their need for cognition, they were assigned to review either a small or a large number of options to search for their most desirable romantic partners via a popular online-dating website in Taiwan. Results indicated that high-NFC participants showed more excessive searching than did low-NFC participants. Moreover, the more-means-worse effect was more salient for high-NFC participants than high-NFC participants. The findings suggest that users with high NFC may be more vulnerable to the negative effect of excessive searching.

Keywords. Need for cognition, search bias

Introduction

To date, one of the predominant reasons for Internet use is online social interactions [1]. Recently, Wu and Chiou [2] demonstrated that more options triggered excessive searching and decreased choice quality for finding online romantic partners based on a cognitive information-processing perspective. Wu and Chiou argued that more options would trigger excessive searching, and then reduce decision quality, i.e., the more-means-worse effect.

Need for cognition (NFC) is a promising cognitive personality characteristic [3]. An individual's need for cognition has been identified as one of the precedent variables contributing to cognitive involvement and, hence, the motivation to process information [4]. Regarding the context of searching a romantic partner on online dating websites, individuals with high-NFC, compared to those with low-NFC, would more likely to engage in an exhaustive search of all available options. Such differences in desires of engaging information processing are attributed to the fact that high-NFC individuals may suffer from creating a more onerous choice-making process for themselves. An experimental study was conducted to examine whether individual differences in NFC would moderate the effects of available options on excessive searching and decision quality in the context of finding partners for online romantic relationships.

1. Method

One hundred and twenty undergraduates (58 males; 15 to 23 years of age, M = 17.49, SD = 2.69) participated in this experiment. A random ordering of experimental packets assigned participant to a 2 (number of available options: small or large number of options) × 2 (need for cognition: low or high)

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between-subjects design. Assignment of participants to levels of the second factor, i.e., need for cognition (high or low), was based on their responses to the Need for Cognition Inventory short form [3] assessed two weeks previously.

In the formal experiment, participants were given a packet with instructions. Actual purpose was disguised by introducing this experiment as a study on "Finding Your Best Partner for a Romantic Relationship." Participants read the explanation of the search engine's ranked list of recommended partners. They were randomly assigned to view either small or large numbers of available profiles (i.e., the top 40 rankings from the recommended list or the top 80). Each participant was asked to review the available profiles till he/she found the most desirable partner for a romantic relationship.

To determine whether providing more options triggered more searching, the first dependent measure was the search ratio measured by dividing the number of available options by the number of unique subjects' profiles examined. The preference difference index measuring the differences between the scores of each participant's most desired characteristics and the characteristics of the chosen option served as the second dependent measure. Because a dichotomous scoring (0 = match; 1 = mismatch) for each of the 16 characteristics was employed, possible scores for the preference difference index ranged from 0 to 16. Finally, the selectivity developed by Wu and Chiou [2] referring to whether more attention was devoted to better alternatives and less attention to worse alternatives was adopted. The time spent reviewing an option (in minutes, recorded to two decimal places) was regressed on the "match score" for that option was computed as the selectivity for each participant. More positive unstandardized regression coefficients indicated that a participant spent more time evaluating the options with high goodness-of-match scores, implying better selectivity.

2. Results

Regarding the searching ratio, participants in the large number condition ($M = 0.81$, $SD = 0.10$) examined more subject profiles than did those in the small number condition ($M = 0.73$, $SD = 0.11$), $F(F(1, 116) = 34.86$, $p < .001$, $\eta^2 = .23$. This finding was congruent with previous studies [2,5].

As to the preference difference of the chosen subject, the effect of number of available options was contingent upon need for cognition of participants, $F(1, 116) = 21.07$, $p < .001$, $\eta^2 = .15$. Further analyses indicated that the more-means-worse effect was robust for high-NFC participants ($M_{\text{large}} = 8.57$; $M_{\text{small}} = 4.57$), $F(1, 58) = 89.38$, $p < .001$, $\eta^2 = .61$. However, this effect was small for low-NFC participants ($M_{\text{large}} = 4.60$; $M_{\text{small}} = 3.23$), $F(1, 58) = 12.45$, $p < .001$, $\eta^2 = .18$. The selectivity data indicated that the more-means-worse effect was prominent for high-NFC participants ($M_{\text{large}} = 0.62$; $M_{\text{small}} = 0.97$), $F(1, 58) = 67.92$, $p < .001$, $\eta^2 = .54$, whereas this effect was small for low-NFC participants ($M_{\text{large}} = 0.92$; $M_{\text{small}} = 1.06$), $F(1, 58) = 9.96$, $p < .01$, $\eta^2 = .15$.

3. Conclusion

Search tools of online-dating websites may provide large sets for users to find a desirable partner. However, the present findings support earlier research by Wu and Chiou [2] and indicate that more options would trigger excessive searching, thus weakening the effort-saving benefit of search tools. Moreover, need for cognition was demonstrated as a moderator of the more-means-worse effect indicating the detrimental effect of excessive searching on decision quality would be more prominent for high-NFC individuals. Those people should aware of their tendencies towards excessive searching when searching tools provide considerable options.

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Efficacy of Virtual Reality in Triggering the Craving to Smoke: its Relation to Level of Presence and Nicotine Dependence

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Abstract. Virtual Reality environments that reproduce typical contexts associated with tobacco use may be useful for aiding smoking cessation. The main objective of this study was to assess the capacity of eight environments to produce the craving to smoke and determine the relation of craving to nicotine dependence and level of presence. The results show that all the environments were able to generate the desire to smoke; a direct relation was found between sense of presence and craving.

Keywords. Virtual Reality, nicotine dependence, craving, presence

Introduction

Broadly speaking, multi-component psychological interventions have proven to be effective for aiding smoking cessation [1,2]. Nevertheless, relapse rates after treatment remains high: between 40 to 70 percent of patients who complete treatment start smoking again. Therefore, these programs need to incorporate more effective strategies to prevent relapse. Cue-induced craving is regarded as the main cause of relapse after smoking cessation [3]. Cue Exposure Treatment (CET) consists of controlled and repeated exposure to stimuli associated with substance use in order to extinguish craving responses [4]. Although CET has proven its value in the treatment of opiates and alcohol addiction [5,6], few studies have focused on its use in tobacco cessation.

Virtual reality (VR) technology has been applied as an exposure tool in several psychopathological disorders [7]. VR exposure offers several advantages over conventional methods, such as *in vivo* and imagery exposure. Since it allows participants to experience vivid real-life recreations, VR permits strict control over variables while maintaining a high ecological validity. Several studies have already used VR to assess the craving to smoke. Using mainly paraphernalia and virtual bars, these studies have shown that VR may be a good alternative to traditional exposure methods for generating craving [8,9]. Nevertheless, as most of them use decontextualized cues, generalizing the extinction of craving to everyday life situations becomes difficult. It appears that more diverse environments are needed in order to adapt this technology to smoking cessation interventions and to enhance the probability of extinction in real life.

The aim of this study was to assess the capacity of eight immersive VR environments to produce the craving to smoke and to determine the relation of level of presence and nicotine dependence to self-reported craving.

1. Method

1.1. Participants

Twenty-five former smokers (mean age 29.7 years, SD = 13.4) participated in the study. A majority of the subjects were male (69%). Inclusion criteria for participation were age 18 or older, having smoked ten or more cigarettes per day over the previous two years. Participants involved in any smoking cessation treatment or those suffering other substance dependence other than nicotine were excluded.

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1.2. Assessment

- Subjective craving: Measured with a visual analogical scale from 0 to 100.
- Sense of presence: Measured with the Spanish translation of the Presence Questionnaire[10].
- Nicotine dependence: Number of cigarettes per day.

1.3. Procedure

Participants were exposed, in random order, to seven complex virtual scenes with smoking-related cues that reproduce typical situations where people smoke: being in a pub, having lunch and having breakfast at home, drinking coffee in a cafe, after lunch at a restaurant, waiting in the street and watching TV at night, and to a virtual environment without smoking cues, the museum.

The VR environments were developed based on the literature on smoking cravings and on the information obtained from an *ad hoc* questionnaire administered to 154 smokers [mean age (*range*) = 30.3 (18-67); mean number of cigarettes per day (*SD*) =13.9 (6.39)] which compiled data about the situations and stimuli in these situations which produced the greatest desire to smoke. Figures 1 to 4 show images of some of the virtual environments developed.

Environments were presented with a Head Mounted Display (5DT HMD 800 Series) with tracking sensors (Intersense Inertia Cube[3]). Participants could interact with avatars and objects in real-time with a mouse device during the exposure in order to make the experience as realistic as possible.

Subjective craving was assessed before the experiment and during the exposure to each environment. Sense of presence experienced by participants in the virtual environments was assessed at the end of the experiment.

1.4. Statistical analysis

Repeated measures analysis was conducted in order to test whether there were significant differences between the smoking craving level experienced by participants in the virtual environments and those reported before VR exposure.

Several correlations were also studied in order to assess the strength of the relation between the craving to smoke, the sense of presence experienced by participants in the virtual environments and between the craving to smoke and nicotine dependence. The confidence level was 95%, and the SPSS-15statistical package was used.

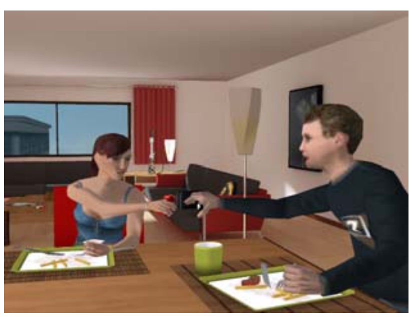

Figure 1. After lunch at home

Figure 2. Watching TV at night

Figure 3. In a pub **Figure 4.** After lunch at a restaurant

2. Results

Mean craving levels were significantly higher in all the environments than on the pre-exposure assessment (mean = 19.5; SD = 14.3, Table 1). Significant differences between craving level experienced in front of the black computer screen (pre-exposure measure) and the craving experienced in each virtual situation showed very large effect sizes, stressing the strength of these differences. All the environments, including the museum, were able to generate the desire to smoke.

Table 1. Craving levels during exposure to virtual environments and differences between pre-exposure craving and craving experienced in each virtual environment

	Mean	SD	F	*p*	η^2
Lunch at home	46.5	28.6	34.5	p<.001	.59
Watching TV at night	45.2	29.8	35.9	p<.001	.60
In a pub	44	28.4	28.7	p<.001	.54
Lunch in a restaurant	43.5	25.8	35.2	p<.001	.59
Coffee at café	41.4	26.4	43.3	p<.001	.64
Waiting in the street	40.9	26.2	38.2	p<.001	.61
Museum	39.6	26.3	27.5	p<.001	.53
Having breakfast	37.2	27.2	18.5	p<.001	.43

Nevertheless, having lunch at home, watching TV at night, being in a pub and having lunch in a restaurant seemed to produce more craving than the other situations. With regard to nicotine dependence and sense of presence, only the correlation between presence and craving levels was significant (Table 2). Nicotine dependence, understood as the number of cigarettes smoked per day, was not related to craving.

Table 2. Correlations between craving and presence, and between craving and nicotine dependence

	Presence	Nicotine dependence (number of cigarettes per day)
Smoking craving	.480* (p = .013)	.095 (p=.664)

* Correlation is significant at the level .05 (bilateral)

3. Conclusions

Our results suggest that complex VR environments simulating real situations are able to elicit cravings. Previous studies of smokers' responses to smoking-related and neutral cues have found that smoking-related cues, such as viewing or holding a cigarette, imagining a scenario involving smoking or being in smokers' real situations, elicit greater reactivity [11]. Likewise, several studies have reported the success of virtual environments for inducing the craving to smoke [12-14]. Nevertheless, these studies only used virtual paraphernalia or avatars smoking in bars or parties as cues, whereas the present study provides evidence about the ability of virtual environments to simulate a wide range of real-life situations to elicit craving in smokers.

VR technology can improve CET for substance use disorders and more, specifically for smoking cessation programs. Moreover, the large number of virtual situations increases the probability of extinguishing craving in real-life.

The results of the present study also highlight the importance of several variables that may be related to the effectiveness of exposure. The strong relation between the sense of presence experienced in the virtual environments and the level of the craving to smoke stresses the need to take characteristics of the patients and the virtual devices into account. Unexpectedly, nicotine dependence did not seem to influence craving in this study. This result may be due to the low levels of dependence shown by participants [mean = 14.8 (SD = 4.7) cigarettes per day].

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Training Presence: the Importance of Virtual Reality Experience on the "Sense of Being There"

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Abstract. Nature and origin of presence are still unclear. Although it can be characterized, under a neurophysiological perspective, as a process resulting from a synchrony between cognitive and perceptive systems, the multitude of associated processes reduces the chances of brain mapping presence. In this way, our study was designed in order to understand the possible role of VR experience on presence in a virtual environment. For our study, 16 participants (M=28.39 years; SD=13.44) of both genders without computer experience were selected. The study design consisted of two assessments (initial and final), where the participants were evaluated with BFI, PQ, ITQ, QC, MCSDS-SF, STAI, visual attention and behavioral measures after playing an first person shooter (FPS) game. In order to manipulate the level of VR experience the participants were trained on, a different FPS was used during the 12 weekly sessions of 30 minutes. Results revealed significant differences between the first and final assessment for presence ($F(1,15)=11.583$; $MSE=775.538$; $p<.01$) and immersion scores ($F(1,15)=6.234$; $MSE=204.962$; $p<.05$), indicating higher levels of presence and immersion in the final assessment. No statistical significant results were obtained for cybersickness or the behavioral measures. In summary, our results showed that training and the subsequent higher computer experience levels can increase immersion and presence.

Keywords. Presence, Immersion, Cybersickness, Anxiety, Personality, Behavioral measures, First-Person Shooters

Introduction

Virtual Reality (VR) is an apparatus that has been used for all sorts of applications in a wide array of fields, like psychotherapy [1-2], architecture [3], military [4], medicine [5], training [6-7] and construction [8]. VR can be defined as an environment where the participant experiences a sense of presence [9-10]. This central element of any VR application can be defined as the "sense of being there" [11].

According to [12], there are two different typologies of factors that influence the sense of presence: exogenous and endogenous factors. Exogenous factors relates to the VR equipment and its specific immersive characteristics. The endogenous factor relates to the way the subject perceives and interprets the VR scenario according to his/her own personal characteristics [13].

Another important variable to VR efficacy is immersion. According to [9], immersion has been described as a psychological state in which the subject perceives that he or she is involved and included in the VR world. Immersion is influenced by the following factors: (a) isolation from the physical world, (b) perception of being involved in the virtual environment, (c) realism of the interaction and environment control and (d) perception of movement within the environment [14]. In a virtual environment, and considering immersion, interaction also seems to play a relevant role since it allows the user to intervene directly in the events [15], which does not happen in other media (i.e. TV, Radio).

However, other factors like cybersickness (negative aftereffects of VR exposure) can hamper the VR experience [16]. Therefore, cybersickness can be defined as a natural physiological response to unusual stimuli, which might result from an asynchrony between visual, vestibular and proprioceptive information [17]. Another study [18] established a parallel between motion sickness and cybersickness, since the latter can be considered as the virtual reality version of the first. Some evidences also suggest that cybersickness decreases significantly with videogame experience [19]. Other studies [20] show that the experience in one specific task can lead to lower levels of cybersickness.

Despite the number of studies published about this subject it is not yet clear how to modulate the sense of being within a VR world, in particular when efforts are made to relate it with individual

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characteristics [21]. In this way, this paper reports on a study devised to investigate the possibility of increasing presence levels through training. So far, it is known that it is possible to train competences with VR [6-7], namely behavioural and technical, but there is no evidence as to whether VR associated variables such as presence, immersion and cybersickness can be educated as suggested by previous work [19], where presence was found to be higher in participants with more videogame experience.

1. Method

1.1. Participants

Study sample consisted of 16 participants ($M=28.39$ years; $SD=13.44$) of both genders without computer experience.

1.2. Measures

- Big-Five Inventory – BFI [22]
- Presence Questionnaire – PQ [9]
- Immersive Tendencies Questionnaire - ITQ [23]
- Questionnaire of Cybersickeness [24]
- Marlowe-Crowne Social Desirability Scale (Short-Form) – MSCDS-SF [25]
- State and Trait Anxiety Inventory - form Y2 – STAI [26]
- Stroop task
- Behavioral measures (number of rounds, shots fired, shots taken, given damage and taken damage)

1.3. Procedure

The study design consisted of two assessments (before and after training), where participants were evaluated with the above listed measures (see section 2.2.), after playing (facing computer controlled opponents - NPCs) a first person shooter game – FPS (Counter-strike) on a Intel P-IV 3.6 GHz with a Nvidia 6800GT graphic board. In order to manipulate the level of VR experience, the participants were trained on a different FPS (Call of Duty – Modern Warfare) during 12 weekly sessions of 30 minutes (Figure 1).

Figure 1. Counter-strike (left) and Call of Duty (right)

2. Results

The results were analyzed through repeated measures ANOVA for the two assessments. A 5% significance level was considered for all statistical procedures.

Data revealed significant differences between the first and final assessment for presence ($F(1,15)=11.583$; $MSE=775.538$; $p<.01$) and immersion scores ($F(1,15)=6.234$; $MSE=204.962$; $p<.05$), indicating higher levels of presence and immersion in the final assessment. No statistical significant results were obtained for cybersickness (Table 1).

Table 1. Repeated Measures ANOVA for presence, immersion and cybersickness, before and after training.

	Before training		After training		
	M	SD	M	SD	*F*
Presence	69.923	3.638	80.846	3.676	11.583**
Immersion	62.615	3.194	68.231	3.455	6.234*
Cybersickness	1339.60	133.80	1199.90	148.06	1.004

* $p < 0.05$; ** $p < 0.01$

Through the behavioral measures no statistical significant differences between assessments were observed, although descriptive statistics have shown an overall increase in performance. For example, the number of rounds decreased from 32 to 31, as well as, the mean shots and damage taken (Figure 1).

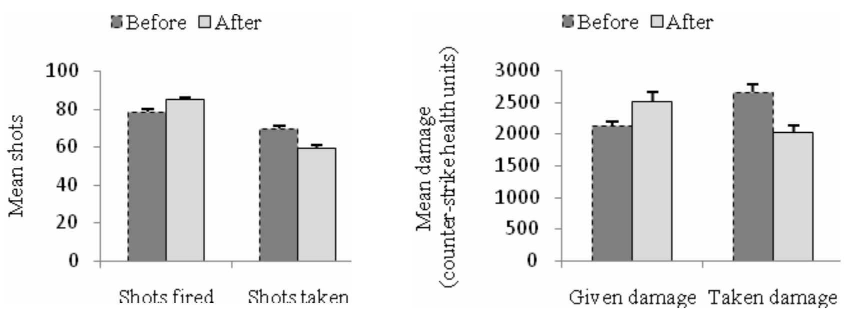

Figure 2. Repeated Measures ANOVA for behavioural measures differences before and after training.

Furthermore, no statistical significant interaction effects of personality type and trait anxiety on presence assessments were registered. Social desirability and visual attention levels were considered as normal.

3. Conclusion

In general, our results showed that training and the subsequent higher experience in videogames can increase immersion and presence. These findings can suggest that beyond exogenous and endogenous factors, presence can also be related to the level of experience with the virtual environment, even with the absence of a clearer improvement in task performance. In particular [12] has suggested the effect of endogenous variables on presence. However, this data failed to demonstrate the influence of personality and trait anxiety on VR outcome variables. This fact may be related to the sub-clinical levels demonstrated by undergraduate students.

As far as cybersickness is concerned, the lack of significant differences can be related to the fact that the negative effects are mostly dependent of neurological factors [17-18], not confirming the results obtained in a previous study using perceived videogame experience [19].

Previous studies have shown that VR environments can be used for several clinical applications [1-2]. Our results suggest that higher videogame experience and training can help to promote engagement with VR exposure, which may constitute an important gain for VR based clinical applications. Even with only 6 hours of videogame practice, results have suggested significant increases in immersion and presence levels. Threshold level for VR related variables is still an issue that should be researched in-depth. The fact is that there is no data concerning the optimal levels of VR outcome measures for maximized VR efficacy. Further research is also needed to establish the amount of hours needed to achieve the abovementioned optimal levels, and to confirm the possibility of significantly decreasing cybersickness with videogame playing hours. These results should be considered, as it makes no sense to use VR therapy if the subject has low levels of engagement (presence and immersion) or high levels of cybersickness.

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Analysis of Distributed-Collaborative Activity during Augmented Reality Exposure Therapy for Cockroach Phobia

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Abstract. Recent research presents Augmented Reality Exposure Therapy (ARET) for treatment of phobia of cockroaches as a potentially effective technique. However, to the authors' knowledge no studies have been published concerning the Human-Computer-Interaction issues of such a system. The aim of this paper is to report some preliminary data on how patients, therapists and an Augmented Reality system collaborate and interact during the therapeutic process. The results show that the therapeutic process is distributed between individuals (patient and therapist) and artifacts (e.g. AR cockroaches, a computer screen, a Head Mounted Display (HMD), a keyboard, a swatter and therapists' notes on paper). The results are discussed in terms of possible improvement of the ARET system.

Keywords. Augmented Reality Exposure Therapy, HCI, Distributed Cognition

Introduction

In vivo exposure therapy is considered to be standard therapy for specific phobias [1]; however, other effective therapies, such as Augmented Reality Exposure Therapy (ARET) can also be used. With the developement of innovative technologies, ARET presents interesting alternatives to *in vivo* exposure therapy with numerous positive characteristics (see [2] for details). Although some preliminary studies have been performed on the ARET system in order to show its clinical effectiveness (e.g. [2]), to the authors' knowledge, no studies of Human Computer Interaction (HCI) issues have been published. There are several reasons that justify research on HCI in the ARET field. First, little is known about HCI in this field. In fact, only a small number of studies that address HCI issues in specific phobia treatments with new technologies have been performed in the Virtual Reality Exposure Therapy (VRET) systems (e.g. [3]). Second, a multidisciplinary analysis framework is needed in order to fully understand the therapeutic context. According to Rogers & Ellis [4], by adopting an individual user performing an isolated task as the primary unit of analysis, many researchers have failed to recognize the importance of the interwoven and social character of the work activity. Certainly, by focusing only on the therapist or patient side of interactions with the system, some crucial characteristics of the work activity may be ignored. Third, the interpretation of the therapeutic work activity in terms of collaboration should be addressed since the relationship between the patient and the therapist, which is defined in terms of the therapeutic alliance concept, is expressed as "the quality and strength of the collaborative relationship between client and therapist" [5].

The aim of this paper is to report some pilot data on how the patient, the AR system and the therapist collaborate together during ARET for cockroach phobia, and how the design of ARET effectively supports such mixed (both mediated and direct) collaborative interactions.

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1. Method

The analysis was based on the Distributed Cognition (DCog) framework [6], which aims to extend what is traditionally considered as cognitive beyond the individual to include the interactions between individuals and artifacts in the environment. DCog is based on the computational model that describes activity within a mixed, human and socio-technical, system as a set of representations, representational states and representational media, and processes (see Figure 1).

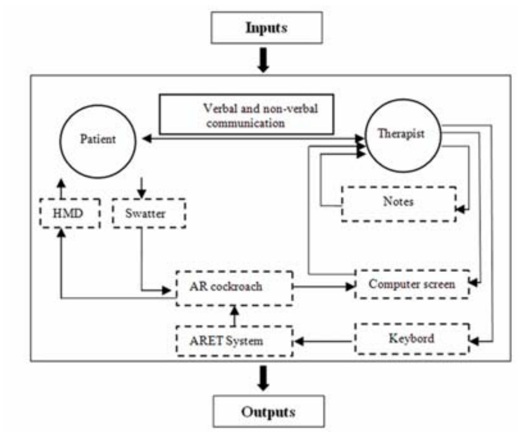

Figure 1. The distributed therapeutic process. The representations show the actors, the artifacts, and the communications among them; the processes are represented by arrows. The dashed boxes show the representational media by which patient-therapist communication is mediated.

The processes propagate representational states across media, where media refers to both internal representations, such as individual memory, and external representations, such as notes or a computer screen. The representational states refer to how the information and knowledge resources are transformed during the activity [4].

1.1. Participants, Procedure and Materials

Two different therapists performed a single therapeutic session with two different patients following a one-session treatment protocol. In order to preserve the privacy of the patient and not influence the data, the two separate sessions were recorded using the digital camera and were analyzed (viewed and coded) afterward.

1.2. Description of the therapeutic session

The one-session treatment protocol has three components: (a) exposure to the phobic stimulus; (b) modeling (by demonstrating the interaction with the phobic stimulus by the therapist followed, if possible, by the patient); and (c) cognitive restructuring. The *in vivo* exposure therapy applying the one-session treatment protocol corresponds to the interaction between the patient and the therapist mediated by a terrarium containing real live cockroaches. In the case of the ARET (see Figure 2), the interaction between the patient and the therapist is mediated using technologies, such as HMD, a computer screen, an AR cockroach and other objects. In both the *in vivo* exposure and AR exposure therapeutic sessions applying one-session treatment protocol, the patients meet the therapist twice (during an interview to collect clinical data) before performing the exposure. The goal of both therapeutic sessions is to allow the patients to confront the phobic stimulus and interact with it with the lowest possible level of discomfort for the patient.

Figure 2. Patient with therapist during the ARET
.

During *in vivo* exposure, even though the therapists can freely interact with the live cockroaches in many ways, they do not have full control of the phobic stimulus. However, this is not the case with ARET; the therapists can completely control the AR cockroaches. More specifically, the therapist controls the phobic stimulus by pressing the buttons on the keyboard that correspond to the following ARET functions: *i* to make a cockroach that is not moving appear; *s* to stop a cockroach from moving; *d* to make a cockroach look dead; *m* to make a cockroach move in different directions; *k* to make the sound of smashing a cockroach (killing a cockroach with a swatter); *f* to make the sound of spraying a cockroach with insecticide; *1* to add 1 cockroach; *3* to add 3 cockroaches; *4* to take away 3 cockroaches; *5* to add 20 cockroaches; *6* to take off 20 cockroaches; and + and – to make cockroaches larger and smaller, respectively.

1.3. Analysis

The interactions between individuals (the patient and the therapist) and the artifacts (AR cockroaches, computer screen, HMD, keyboard, swatter, and notes) were chosen as a unit of analysis for the following detailed description. The data used for coding were the following: (a) a verbal representational state (verbal communication between patient and therapist); (b) a nonverbal representational state (nonverbal behavior of patient and therapist); and (c) a propagation of a representational state between the therapist and the AR system (key pressed by the therapist to change the AR cockroach). The events observed were coded according to these categories.

2. Results

2.1. Verbal and nonverbal behavior (the coordination of representations states and representational media during the therapeutic process)

The analysis showed that the notes were used as external representational media for the coordination of the representational states for the therapist in order to do the following: reduce the memory load of the therapist, track the changes over time (to confirm that the anxiety level of the patient is diminishing) and to help the therapist plan the next action.

The coordination of the representational states between the therapist and the patient was performed mainly by referencing to the AR cockroach (external representational media). The ARET process seems to be slightly different from a traditional computer-mediated collaborative work context, such as a design activity [7]. In our opinion, the difference corresponds to the lower level of knowledge sharing between the therapist and the patient in ARET than between two co-workers in a traditional computer-mediated collaborative work context. In addition, the knowledge propagation between the therapist and the patient is only unidirectional (the therapist attempts to change the representational state of the patient and not the contrary). In fact, the acceptance and integration of the concepts presented by the therapist, as well as the exposure time to the phobic stimulus, lead to a decrease in anxiety and a higher level of the knowledge coordination of both patient and therapist.

2.2. Propagation of a representational state between the therapist and the AR system

The results in Table 1 show that a consistent therapeutic pattern corresponds to the protocol of the one-session treatment (exposure of phobic stimulus, modeling and cognitive restructuring) followed by the measurement of anxiety and other characteristics and notetaking.

In general, almost all ARET functions were used; the only functions not used were adding or taking away 20 cockroaches (coded by *+20* and *–20*). In our opinion, this decision by the therapist is related to the lack of realism of the situation (too many cockroaches at the same time).

During the video coding, the researchers observed that the therapists often hesitated before choosing a function to apply. This could be related to a non-structured presentation of the functions on the keyboard.

Table 1. The therapeutic patterns for cockroach phobic stimulus.

Therapeutic session 1 (Therapist 1)	Therapeutic session 2 (Therapist 2)
HMD VE T C M VE A N VE A N	HMD T VE N A N
HMD +1 A N VE	C A N VE
+3 P P1 A N VE	B B B VE A N
P P1 J A N VE	D VE A J N A VE N
C B B B VE A N	S S S M J A N VE
B B B +1 +1 M VE A N	M VE A VE A VE
+3 VE P P1 J VE A N VE	C M P P1 J A N VE A N
S S S O KW(x6) A N VE	F C O KW (x4) N VE A N
F C A N VE	O M BBB KW (x7) VE A VE
M A N VE	R
+3 A N VE	
P P1 A VE	
R	

The spatial position of both the external representational media, such as the computer screen, notes, and the patient required the therapist to be in an awkward, uncomfortable position (continuous trunk twist). The results also show that patients presented a momentary scare (coded by *J*) due to the appearance of the phobic stimulus (2 times in session 1, and 3 times in session 2).

3. Discussion and Conclusions

The DCog allows ARET to be presented from a multidisciplinary perspective, thereby explaining the therapeutic process as a socially distributed, cognitive work activity that is mediated by an AR application. The results showed some important information in terms of therapist-AR system-patient interactions and brought to light some interesting information about possibilities for improvements. First, a more structured and conceptually easy to remember set-up of functions on the keyboard should be taken into consideration for future versions. Second, only uses for a therapeutic process function should be presented. Third, the spatial set-up of the individuals and the artifacts should be improved. Moreover, the presence of a patients' momentary scare lead us to conclude that the AR cockroaches produce true tension and anxiety in patients just as real live cockroaches do. Finally, the nonverbal exchanges between the patient and the therapist were slightly limited by the HMD worn by the patient. This could be an interesting topic to study in terms of a comparison of the patient's perception of the therapeutic alliance in both *in vivo* exposure (where eye contact is not limited) and ARET (with HMD). We assume that the therapeutic alliance has already been established between the patient and the therapist before exposure (during two clinical sessions previous to the exposure), and that the use of the ARET reinforces the bond of the therapeutic alliance because of the ability to control the phobic stimulus (patients have greater confidence and trust in the therapist). Thus, the therapeutic alliance in the ARET system would be equal to or even greater than the *in vivo* exposure.

The DCog framework allows us to present the therapeutic activity as a distributed process. In our opinion, this holistic design approach, which does not give preferential treatment to any of the actors of artifacts, can make a great contribution to the improvement of ARET activity.

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Understanding the Psychological Motives Behind Microblogging

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Abstract. This research aims to understand the psychological motives behind microblogging. We conducted two studies to investigate if social exclusion and existential anxiety would lead to a high tendency to microblog. Our results show that participants did not use microblogging to satisfy their needs for social connection and affiliation, but highly extraverted participants did use it to relieve their existential anxiety.

Keywords. Microblogging, motive, ostracism, social exclusion, existential anxiety

Introduction

Microblogging has recently become a new form of communication that is rapidly changing everyone's life. Through services such as Twitter, millions of people can broadcast short messages to their followers via instant messaging, SMS, or web interfaces. Recent research has been trying to understand this phenomenon. For example, Java, Song, Finin, and Tseng [1] found that the majority of messages posted on Twitter are "pointless babbles" such as "I am eating a salad" or "I am going to dinner with my parents tonight." These mundane messages describe day-to-day routines and are often meaningless to others. However, they appear much more often than messages for other purposes such as replying to others' posts, sharing information (URL), or reporting news. While celebrities who have millions of followers may post these messages to interact with fans, why do average people want to post them? In this study, we aim to understand the psychological motives behind microblogging. We hypothesize that when one faces social exclusion or existential anxiety, one is more likely to microblog. We conducted two controlled lab studies using the popular microblogging website Twitter to verify our hypotheses.

1. Study 1

Previous research has shown that social exclusion has immediate negative impact on psychological well-being [2]. It depletes one's primary needs of belonging, control, self-esteem, and meaningful existence[3]. In response to exclusion, the ostracized individual often acts to increase the chance of inclusion by being more socially attentive and pliable [4, 5, 6, 7]. In this study, we put subjects in a situation where they were ostracized so that they would have a need for social connection and inclusion. We then observed if the subjects would microblog more due to their need for connection and inclusion.

We created the situation of social exclusion by using the Cyberball game [8]: Participants were asked to play a web-based ball tossing game on the computer. They were led to believe that two other players in other rooms were playing with them. Participants could indicate which player they wished to throw the ball to by clicking the player's avatar in the game. The game was set so that participants only received two out of thirty throws. This would make participants feel ostracized. For the non-exclusion condition, the game was set so that the participants received the ball 10 out of 30 throws from others.

1.1 Procedure

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We recruited 74 undergraduates and randomly assigned them to the control and experimental group. During the study, the participants was first introduced to Twitter and given an existing Twitter account. The participant was told that there were 30 followers in the account and his/her posts in Twitter (i.e., tweets) could be seen by these followers if they were online. Then, the participant was instructed to play the Cyberball game for five minutes. After the game, the participant was told to wait for the next task and the experimenter left the room. The participant was left alone in the room for four minutes. We used the four-minute break to give the participant opportunities to tweet. (There were a total of three four-minute breaks in the study for the participant to tweet.) After the four-minute break, the experimenter came back to the room and asked the participant to perform two trivial tasks each followed by a four-minute break (the same as the one described above where the experimenter left the room and the participant stayed alone). The first task was to slot 20 pictures into 20 envelopes and the second task was to sort the envelopes into three trays according to their colors (white, red, and yellow). During each four-minute break, the experiment posted two tweets (e.g., "helping my friend with her work" or "feeling pretty random right now") from different followers' accounts. These tweets were randomly chosen from a collection of typical tweets generated by college students. This was to show the participant that there were other users online and they could see each other's tweets in real time.

During the study, we administered a number of surveys to access the participants' personality and emotional state. The participant filled out the Big Five Personality Test [9] at the beginning of the study before the Cyberball priming task, and the Positive and Negative Affect (PANAS) scale [10], and the Need for Affiliation scale [11] at the end of the study.

1.2 Results

Our analysis showed that while participants in the social exclusion condition (M = 3.48, SD = .49) had higher needs for affiliation than those in the control condition (M = 3.19, SD = .53; $F(1, 72) = 5.82$, p = .02), they did not tweet significantly more (M = 4.19, SD = 2.77 and M = 3.38, SD = 2.53, respectively; $F(1, 72) = 1.73$, p = .19). This suggests that one does not use microblogging to satisfy the needs for social connection and inclusion. It is reasonable to argue that as microblogging usually only involves publishing messages to be read by strangers, it would not serve as a means to satisfy the affiliation need of ostracized participants who would actually be looking for opportunities to reassert social connection with friends or acquaintances.

2. Study 2

In study 2, we tested the effect of existential anxiety on microblogging. We hypothesize that existential anxiety will lead to higher tendency to microblog, because microblogging allows one to tell others about one's current activity or status, and therefore convey a message of existence. We manipulated existential anxiety by making mortality salient [12]: The experimental group was asked to write a short essay about death whereas the control group was asked to write about dental pain.

2.1 Procedure

We recruited 70 undergraduates and randomly assigned them to the control and experimental group. We follow the exact same procedure as described in Study 1 except that the Cyberball game priming task was replaced with existential anxiety priming.

2.2 Results

In examining the interactions between condition (2 levels: death primed vs. not primed) and the individual difference variables, we found a significant Condition X Extraversion (mean centered) interaction on the number of tweets generated by the participants, $F(1, 66) = 4.87$, p = .03. Simple slopes analyses examined this effect at 2 standard deviations above and below the mean extraversion score and revealed that highly and lowly extraverted participants did not differ in the number of tweets when death was not primed;

however, highly extraverted participants tweeted significantly more than their lowly extraverted counterparts when mortality were made salient (see Figure 1).

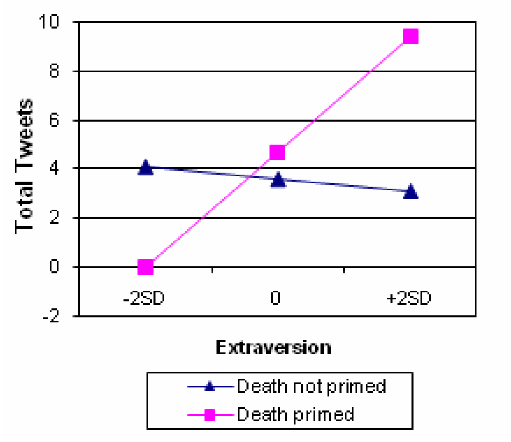

Figure 1. Total number of tweets generated by participants, as a function of extraversion (2 *SD* above and below the mean) and condition (death primed vs. not primed).

3. Conclusion

Microblogging has recently become a fast-growing phenomenon that has affected millions of people. While studies have been conducted to understand why and how people participate in micrblogging, they mostly rely on interviews, surveys, or the analysis of the existing content produced on microblogging websites. Our studies employed a between-subjects design to understand the psychological motivation behind microblogging. Our results show that participants did not use microblogging to satisfy their needs for social connection and affiliation, but highly extraverted participants did use it to relieve their existential anxiety.

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Virtual/Real Transfer of Spatial Learning: Impact of Activity According to the Retention Delay

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Abstract. Within the framework of cognitive rehabilitation using virtual reality (VR), one of the major challenges is to study beforehand the effectiveness of the virtual-real transfer of learning and to define cognitive aids. The aim of this experiment was to verify if, after learning spatial knowledge (*i.e.*, a route) in VR, performances can be transferred to reality, then maintained in real time, and improved with the aid of an active navigation (*i.e.*, using a joystick). Ninety student volunteers from the University of Bordeaux 2 (45 men and 45 women) participated in the experiment. The virtual environment (VE) used for learning was a replica of an area of Bordeaux. The factors tested were retention delay (Immediate *vs.* 48 hours) and type of navigation (Passive virtual *vs*. Active virtual *vs*. Real), using three recall tasks: *wayfinding*, *freehand sketch* and *photograph classification*. Our results showed that the virtual-real transfer was not degraded by a retention delay of 48 hours and that active navigation allowed performances to be optimized.

Keywords. Virtual reality, spatial cognition, knowledge transfer, exploration mode, retention delay, recall tasks.

Introduction

The study of virtual/real transfer allows determinate optimization situations for spatial learning and proposed recommendations for constructing cognitive rehabilitation programs. Several factors can have an influence on the transfer of knowledge [*e.g.*, 1-3]. In this experiment, we tested the influence of retention delay and navigation mode.

Retention delay is seldom studied within the framework of spatial cognition in VE. The results obtained by Witmer *et al.* [4] indicate that spatial knowledge is mostly still present one week after learning. Richards *et al.* [5] showed that configuration knowledge of a VE could be retained for a period of one month. These authors stated that they tested configurational knowledge by asking their subjects to remember the spatial relationships between different places in the VE. These overall findings are interpreted as the result of configurational knowledge, which is more robust than time-based forgetting [4-5].

The user's mode of navigation is largely identified as impacting the virtual-real transfer of spatial knowledge [3, for review]. For example, Wilson *et al*. [6] distinguished two types of navigation: *active vs. passive mode*. Most often, exploration is seen as being active if the individual can move with few constraints in the VE and as being passive when the subject is constrained to visualize a pre-determined recorded route. When a benefit from active navigation is observed [*e.g.,* 3, 7-9], it is often related to a well-known effect called subject-performed tasks (SPTs). SPTs concern tasks performed directly by the subject and are the opposite of experimenter-performed tasks (EPTs). The most widely accepted explanation for this SPT effect is that performing actions provides excellent item-specific information, making the actions easily discriminate [*e.g.*,10].

Therefore, the main aim of this study was to investigate whether an active navigation promotes more than a passive navigation the virtual-real transfer of spatial learning according to the retention delay (immediate vs. 48h).

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1. Method

1.1. Participants and design

The participants were 90 student volunteers from Victor Segalen Bordeaux 2 University (45 men and 45 women, with an average age of 20). All subjects were native French speakers and were right-handed.

The experiment used a 2 (Retention delay) x 3 (Navigation) factorial design with only independent measures.

1.2. Material

Two environments were used in our experiment: virtual and real. The real environment was an area near the Bordeaux hospital and the virtual environment (VE) was a 3D replica of that environment created in 2006 by engineering students from the Bordeaux 2 University using the Virtools© software. Inside these environments, the route measured 1,457 metres and included 14 streets, 18 intersections and 18 direction changes. To manipulate the navigation mode in the VE under the passive condition, participants only visualised the route without any interaction, whereas under the active condition, participants used a joystick in order to interact with the VE.

The apparatus used in the virtual reality room was a Dell© personal computer (3 GHz, 5 GB RAM) with an nVidia© Quadro FX 4400 graphics card, a F1+© projector, a 2 x 1.88 metre screen (to allow immersion of the subject) and a Logitech© force 3D pro joystick for the active navigation mode. The participants were seated two metres away from the display screen.

1.3. Procedure

The experiment procedure for each participant consisted of the following two steps:

1) *A learning phase of the route*: participants randomly visualized either the immediate recall or the recall at 48 hours during the test phase. In each condition, the participants were divided into three groups according to the display mode: (*i*) a *passive virtual environment* (with a recorded route and directions given by the researcher) vs. (*ii*) an *active virtual environment* with a joystick (the route was still pre-established by the researcher, who gave instructions about the direction), vs. (*iii*) the *real environment* (the participant actually physically travelled the route by following instructions). This latter condition was used as the control condition to provide the *baseline* measure for an optimal and natural spatial learning transfer (from real to real; *e.g.,* Richardson, Montello, & Hegarty, 1999; Waller, Knapp, & Hunt, 2001).

2) A *test phase*: three spatial knowledge recall tasks were presented in a counterbalanced order between the participants: *i*) the *wayfinding task in reality* was a reproduction of the route in reality. The participants had to replicate the learned route in real-life. Direction errors were noted. In the case of error, the participants were stopped and asked to take another direction. Participants hesitated in some cases, followed by a directional error, or even made several directional errors in the same intersection. In all cases, each error was counted. *ii*) The *sketch-drawing task* was a freehand reproduction of the visualized route in the form of a sketch. The required sketch was a simple outline sketch (connected segments) and the goal of the task was to indicate the directional changes and to count them. *iii*) The *picture-classification task* comprised a series of pictures taken along the route that needed to be sorted into chronological order. The experimenter counted the number of classification errors.

2. Results

For each spatial knowledge recall task, the score was compared to the best potential score in order to obtain percentages. The results were analyzed using an ANOVA [3 (Navigation: Passive virtual *vs.* Active virtual *vs.* Real) x 2 (Retention delay: Immediate *vs.* 48h)] with independent measures. To examine the differences between the virtual (Passive/Active) and real navigation conditions, Fisher's procedure ($p<.05$) was used for post-hoc comparisons. In addition, when an interaction effect was significant, partial analyses were made for each route condition by using a simple ANOVA that included the presentation factor followed by post-hoc comparisons. All means and standard deviations are reported in Table 1.

Table 1. Percentage of errors (or hesitations) and standard deviations for each condition (Type of recall and Type of navigation) and each task (Wayfinding, Freehand Sketch and Classification).

	IMMEDIATE RECALL			**RECALL at 48 hours**		
Recall tasks	**Passive virtual**	**Active virtual**	**Real**	**Passive virtual**	**Active virtual**	**Real**
Wayfinding	**.17** ***(.06)***	**.12** ***(.04)***	**.04** ***(.04)***	**.13** ***(.12)***	**.11** ***(.09)***	**.04** ***(.04)***
Freehand sketch	**.42** ***(.11)***	**.48** ***(.10)***	**.09** ***(.06)***	**.32** ***(.27)***	**.26** ***(.21)***	**.18** ***(.14)***
Classification	**.50** ***(.10)***	**.46** ***(.10)***	**.07** ***(.07)***	**.38** ***(.23)***	**.29** ***(.29)***	**.30** ***(.27)***

2.1 The wayfinding task in reality

The ANOVA revealed:

- A significant effect for the navigation factor [F(2,84) = 18.73; p < .0001]. The post-hoc comparisons indicated that performances were best (*i.e.*, fewest errors) when the subjects were trained in the real world, second-best when they actively navigated in the VE, and worst when they passively moved in the VE.
- No significant effect for the retention delay factor [F(1,84) = 1.18; p > .200], indicating that the learning does not significantly diminish at 48 hours.
- No significant effect for the “navigation x delay” interaction [F(2,84) = 0.44; p > .600], indicating a similar performance pattern (*i.e.*, learning in a real environment > active learning in a VE > passive learning in a VE), irrespective of the retention delay.

2.2 The sketch-mapping task

The ANOVA revealed:

- A significant effect for the navigation factor [F(2,84) = 18.79; p < .0001]. The post-hoc comparisons indicated that performances were best (*i.e.*, fewest errors) when the subjects were trained in the real world, second-best when they actively navigated in the VE, and worst when they passively moved in the VE.
- A significant effect for the retention delay factor [F(1,84) = 5.01; p < .03], indicating that learning does not significantly diminish at 48 hours.
- A significant effect for the “navigation x delay” interaction [F(2,84) = 6.12; p < .01]. The partial analyses and post-hoc comparisons indicated that in the 48-hour-delayed recall condition, the difference is more significant in the "active/passive" condition [F(2,84) = 35.47; p < .001], than in the "immediate" condition [F(2,84) = 12.82; p < .01].

2.3 Picture classification task

The ANOVA revealed:

- A significant effect for the navigation factor [F(2,84) = 13.40; p < .0001]. The post-hoc comparisons indicated that performances were best (*i.e.*, fewest errors) when the subjects were trained in the real world, second-best when they actively navigated in the VE, and worst when they passively moved in the VE.
- No significant effect for the retention delay factor [F(1,84) = 0.28; p > .600], indicating that learning does not significantly diminish at 48 hours.
- A significant effect for the “navigation x delay” interaction [F(2,84) = 9.00; p < .001]. Partial analyses and post-hoc comparisons indicated that in the 48-hour-delayed recall condition, performances are close within the type of navigation factor [F (2.84) = 16.05, p <.001]. Unlike in the

immediate recall condition [F (2,84) = 62.20, p <.0001], subject performances in "virtual" conditions (*i.e.*, both active and passive) decrease compared to the real condition. In other words, the subjects did not profit by actively learning in the VE.

3. Discussion/Conclusion

Our results, concerning the retention delay, agree with those obtained by the few studies previously conducted on this factor [4-5]. Indeed, we show that the transfer is just as efficient after 48 hours of retention. Performances are even improved by this delay for the sketch task (a measure of allocentric representation). An active navigation promotes performance on all tasks. However, as indicated by the interaction effects, if an active navigation benefit is observed in the wayfinding task, irrespective of the delay retention factor, it is mostly efficient at 48 hours for the two paper-pencil tasks (*sketch-mapping* and *scene-classification*). This highlights the differential impact of an active navigation according to the ecological aspect of the task. These results are important in the field of cognitive rehabilitation for spatial problems in VR. They show that elaborate spatial knowledge can be transferred 48 hours after learning and that active navigation might allow optimal repercussions on daily living activities.

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SNSs Usage among Chinese Internet Users: An Empirical Study

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Abstract. Renren and Kaixin, which are Chinese versions of "Facebook", are the main Social Network Sites (SNSs) in China. Although many researchers have been exploring SNSs usage and have gained rich results, there are limited studies for the understanding of SNSs usage in China. In this present study, with 777 Chinese participants, we test variables influencing Chinese SNSs usage based on the technology acceptance model (TAM). Using structural equation modeling techniques, the empirical results confirm that the perceived ease of use significantly determines the perceived usefulness, which in turn influences SNSs use intensity. Meanwhile, the Internet self-efficacy could affect perceived ease of use and further determine SNSs use intensity indirectly. Overall, our results could be used to describe and predict SNSs usage among Chinese Internet users.

Keywords. Social Network Sites (SNSs), Technology Acceptance Model (TAM), Internet

Introduction

With the development of Web2.0, namely the second generation of Web-based communities and hosted services that facilitate collaboration and sharing between users[1], social network sites (SNS) have become a buzzword in the recent media market. Social network sites are designed to provide Internet users with social network service, which is defined as a web-based service that is based on certain meaningful and valuable relationships including friendship, kinship, interests and activities, etc. Social network service allows individuals to network for a variety of purposes including sharing information, building and exploring relationships, etc [2]. In recent years, social network sites have become popular and more and more Internet users are using them. For example, Facebook has been one of the most popular SNSs in the U.S., and with its extending market all over the world, Facebook has already gained 350 million users since December 2009. This number is increasing by more than 700 thousand people per day. Another example is Cyworld, which is the most popular social network site in Korea, enjoyed more than 18 million accounts since 2006[3], and has been expanding their service to China since 2001 and to the U.S. since 2006[2]. Social network sites are popular because they provide users with services from a perspective different from the traditional task-oriented information systems, which aim to provide users with useful information for better decision making. SNSs belong to the information systems and put more emphases on human-relationship development by allowing users to create their own profiles, post diaries for others to comment, share images, tag friends in pictures, and join virtual communities with people who have the same interests. Even though the booming trend of SNSs development could be significantly perceived, Kwon and Wen claimed that research on the psychological process of using social network services is still limited[2].

The currently existing studies focusing on the psychological process of SNSs usage are widely based on a model called Technology Acceptance Model (TAM), which was developed by Fred Davis and Richard Bagozzi [4]. TAM is based on the Theory of Reasoned Action [5] and one of its extensions, the Theory of Planned Behavior, both of which emphasize the role of behavior intention in determining actual behavior. Following these two models, TAM develops and explores two constructs that might affect people's intention to use SNSs: perceived ease of use and perceived usefulness. Perceived ease of use is the belief that it would be easy to acquire the knowledge for using the information technology or system, while perceived usefulness is the belief that the target information technology or system will help the user in performing his or her task. TAM was originally widely used to explain the acceptance of mainly task-

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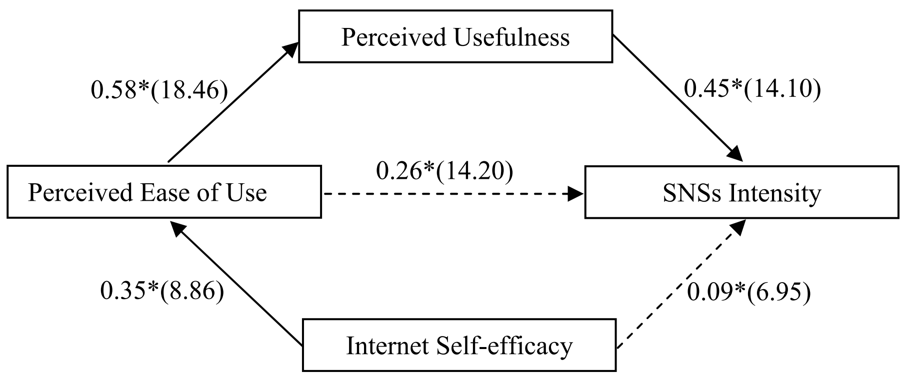
oriented information systems. However, with the coming era of Web2.0, the validity and correctness of TAM have already been further tested under relationship-oriented information systems [2,3,6].

Even though some studies have been done about SNSs usage, and have generated rich findings, there are limited results related to China. However, the market of SNSs in China is also growing dramatically in recent years. Since 2005, Xiaonei has become the main social network site. With the name changed to “Renren”, which aimed at targeting a wider group of consumers, and the incorporation of Kaixin, which was another popular social network site, Renren/Kaixin has become the most popular social network site among Chinese Internet users, especially college students [7]. For reasons,



* $p < .01$

Figure 1. Proposed model description and model results

(Dotted lines indicate indirect results)

such as culture difference, and the way people deal with SNSs, usage might differ between eastern countries, such as China, and western countries, such as America. To further understand the psychological process of SNSs usage in China and gain better knowledge of SNSs’ potential influence on Chinese Internet users, more fundamental research need be done in China, such as testing whether TAM is still applicable under Chinese context. Accordingly, our purpose in this present study is to test an extended model based on TAM (Figure 1), which incorporates a new construct called Internet self-efficacy. Internet self-efficacy is the individual’s self-perception and self-competency in interacting with the Internet, and the measurement of this variable is based on Bandura’s conceptualization of self-efficacy and other studies of social and cognitive psychology [8]. The change of Internet self-efficacy is thought to be the individuals’ learning about the Internet and interacting with it [8]. People with high Internet self-efficacy might deal with and learn from Internet more frequently and easily, which probably make them think that the Internet is easy to use. Therefore, the hypotheses in our proposed model are listed below based on the above discussion. Additionally, in some former studies that tested relationship between variables in TAM, results might suffer methodological bias if multiple regressions was the key tool in testing the relationship between variables, where statistic errors may exist when lots of variables are taken into account at the same time. Therefore, in our proposed model, to avoid these biases, we use structural equation modeling instead of multiple regressions as an improved methodology.

H1: Perceived ease of use has a positive effect on perceived usefulness.

H2: Perceived usefulness has a positive effect on SNSs intensity.

H3: Perceived ease of use has an indirect effect on SNSs intensity through perceived usefulness.

H4: Internet self-efficacy has a positive effect on perceived ease of use.

H5: Internet self-efficacy has an indirect effect on SNSs intensity through perceived ease of use and perceived usefulness.

1. Method and measurement

The population sample was selected from college students in Beijing who were using social network sites including Renren and Kaixin. Eventually we obtained a population of 777 usable responses which could be used for final analysis out of 864 (with a ratio of 89.9%). Specifically, the demographic information of this sample is listed as follows: it consisted of 46.1% male and 53.7% female participants (with two missing data) ranging from 17 to 35 (average age is 22.64, *SD* = 2.03) in age. Most of the participants were heavy users of social network sites: 78.4% and 14.4% of the respondents have used SNSs from one to three years and more than three years respectively. Moreover, 61.4% of the respondents spend 15 to 60 minutes on Renren/Kaixin every day, and 12.6% of the respondents spend more than one hour on them.

Since TAM has a well-validated measurement inventory, we directly used the original measurements for perceived ease of use and perceived usefulness that were developed from Davis's prior studies, with modifications to fit the specific context of this present study. To avoid the intention-behavior gap, we followed Kwon and Wen and used SNSs intensity instead of SNSs intention in our model. In order to test the variable of SNSs intensity, we followed Ellison, Steinfield, and Lampe's method and included in our study, both self-report assessment of SNSs behavior, which was designed to measure the extent to which the participants were actively engaged in SNSs activities, and a series of Likert-scale attitudinal questions designed to tap the extent to which the participants were emotionally connected to SNSs and the extent to which SNSs were integrated into their daily activities [9]. When measuring Internet self-efficacy, we followed Torkzadeh, Chang and Demirhan [8] and used a scale developed by Torkzadeh and Van Dyke [10]. Two items of the original instruments were deemed redundant and were dropped, with 13 items remained.

2. Results

In Table 1, we present the descriptive statistics for all measures, including means, standard deviations, correlations and inter-item reliabilities (ISE, PEU, PU and intensity are short for Internet self-efficacy, perceived ease of use, perceived usefulness, and SNSs intensity, respectively). According to Table 1, the relationship between Internet self-efficacy and perceived ease of use, perceived ease of use and perceived usefulness, as well as perceived usefulness and SNSs intensity are all significant, which provide preliminary support to H1, H2, and H4.

We used Mplus 4.0 to conduct a confirmatory factor analysis to test the measurement model. χ^2/df, TLI, CFI, RMSEA, and SRMR were chosen to be the indicators of model-data fit. As a result, the χ^2/df was 3.12, TLI was 0.91, CFI was 0.93, RMSEA was 0.56, and SRMR was 0.08, which indicated a good fit. Then, Cronbach's alpha coefficient, which is shown in the parentheses along diagonal in Table 1(all of them are equal to or above .85), was used to estimate the reliability and convergent validity of the constructs. Moreover, we used factor loadings to evaluate convergent validity. According to Hair, Anderson, Tatham and Black's suggestions [11], factor loadings greater than 0.50 were considered to be significant. Since all the items in the present study satisfy this recommendation, we could conclude the scales we used had convergent validity. Above all, all four constructs in our study had reliability and validity which could be used for structural model testing.

We further tested the structural model and also gained good fit: χ^2/df was 3.13, TLI was 0.91, CFI was 0.93, RMSEA was 0.56, and SRMR was 0.08. Moreover, all the proposed direct pathways (shown in Figure 1) were significant, further supporting H1, H2, and H4. The indirect paths between perceived ease of use and SNSs intensity, as well as between Internet self-efficacy and SNSs intensity were also significant, which supported H3 and H5.

Table 1. Means, Standard deviation, Correlations, and Alpha Reliabilities for all measures

Measures	**Means**	***SD***	**1**	**2**	**3**	**4**	**5**	**6**
1. Age	22.64	2.03	--					
2. Gender	.46	.50	.00	--				
3. ISE	3.97	.63	.03	.03	(.87)			
4. PEU	3.91	.73	.09*	-.04	.33**	(.85)		
5. PU	3.65	.77	.01	-.07	.25**	.55**	(.87)	
6. Intensity	3.11	.75	-.08*	-.06	.09**	.26**	.45**	(.85)

Note. N=777. Alpha coefficient reliabilities appear in parentheses along diagonal. * $p < .05$, ** $p < .01$.

3. Discussion and Conclusion

As described above, perceived ease of use might determine perceived usefulness, which in turn influences SNSs intensity. Internet self-efficacy affects perceived ease of use directly, and influences SNSs intensity indirectly. Although this present study is not complicated, it lays sound foundation of the understanding of psychological process of SNSs usage among Chinese Internet users by using large samples and valid statistic method. Through our study, it can be concluded that TAM is also applicable when doing research on SNSs usage in China. Therefore, based on our study, further studies can be done on cause and effect of SNSs usage.

However, our study also suffers several limitations. In the first place, all of the participants in our study were college students, so we should be cautious when generalize our conclusions to all Internet users in China. Secondly, only Renren/Kaixin was studied while all the other social network sites were neglected. Even though Renren/Kaixin is the main social network site among in China, sounder conclusions can be drawn only if other SNSs are included. Lastly, other external variables that might play important roles in influencing SNSs use intensity should be included to better understand the psychological process of SNSs usage, and lots of research in this field is needed. However, despite all the concerns above, we believe our model has certain implications and could be applied to understand social network sites usage.

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The Illusion of Presence Influences VR Distraction: Effects on Cold-pressor Pain

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Abstract. This study investigated whether VR presence influences how effectively VR distraction reduces pain intensity during a cold-pressor experience. Thirty-seven healthy students underwent a cold pressor task while interacting with a VR distraction world. After the VR cold-pressor experience, each subject provided VAS ratings of the most intense pain experienced during the hand immersion and rated their illusion of having been inside the virtual world. Results showed that the amount of VR presence reported correlated significantly and negatively with ratings of pain intensity. The importance of using an appropriately designed VR to achieve effective VR analgesia is highlighted.

Keywords. Virtual reality, Presence, Distraction

Introduction

The use of virtual reality (VR) as an innovative distraction technique for pain management has been gaining attention. VR distraction typically involves visually stimulating scenery and audio and tactile feedback delivered through computer, HMD, eyeglasses, and even, water-friendly systems. VR distraction has been studied in different clinical settings to reduce acute pain (i.e., burns care, dental pain, cancer chemotherapy) [1, 2]. Basic investigations have also explored some mechanisms behind the effects of VR distraction in laboratory-induced pain studies with healthy populations [1]. Some examples of studied variables in basic studies are the quality of the VR system [3], the effectiveness of interactive versus passive distraction [4] or the use of VR distraction over several repeated exposures [5]. Other controlled studies have recently explored whether the magnitude of VR analgesia is related with VR presence levels [3, 6]. Both studies used an experimental thermal pain model that involved the exposition to a 30-sec heat stimulus with temperature ranged from 44 to 48ºC. However, a possible weakness of both studies was that VR exposure time and pain stimulation duration were brief. A different laboratory-induced pain paradigm that allows administering longer painful stimulation is a cold-pressor. It induces pain by the submergence of the hand in cold water, with water temperatures used in previous studies ranging between 0°C and 7°C. Cold-pressor pain has been suggested to be a method that mimics the effects of chronic pain conditions effectively because of its unpleasantness [7], and it has excellent reliability and validity [8]. The procedure has been used in studies investigating a wide range of pain management techniques such as acupuncture [9], hypnosis [10], neutral distraction [11] and cognitive preparation [12]. The aim of this study was to explore whether the illusion of VR presence influences how effectively VR reduces cold-pressor pain.

1. Method

1.1. Participants

Participants were undergraduate Psychology students, who were awarded course credit for participation. Exclusionary criteria were cardiovascular disease, hypertension, metabolic dysfunctions, pregnancy, Raynaud disease, epilepsy, mental disorders, chronic pain conditions, diseases producing neuropathic pain

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and use of pain/anti-inflammatory medications within 4 hours prior to the study. Also, participants were instructed via email to refrain from using alcohol or other drugs within the day prior to the study.

The sample consisted of 37 students (33 women, 4 men) between 20 and 40 years old (mean age 23.76, *SD* = 4.34). Each participant completed a Statement of Informed Consent for the forty minutes-long session that contained the appropriate information for participation in a pain investigation [13]. The study was approved by the Ethics Committee of the University of Barcelona.

1.2 VR intervention and equipment

The VR intervention consisted of a stereoscopic environment named "Surreal World" that involves attention-diversion techniques. It was presented via two BARCO ID R600 projectors onto a 2.43 x 1.82 m. Maxwell polarized screen. The "Surreal World" is a virtual environment with auditory and visual inputs based on art images designed to surprise the participant with unreal objects that challenge the laws of physics. A number of interactions with the objects in the virtual environment are possible. Thus, participants could modify its movement, colour and sound. Pressing the space bar, the participant could go on to another scene composed by different objects. These features and the interactive nature of the experience enable the environment to attract and keep participants' attention, leaving less attentional resources available to focus on pain. Figure 1 shows four black-and-white pictures of what subjects saw in the "Surreal World".

Figure 1. Black-and-white pictures of what subjects saw in the "Surreal World"

1.3 Design and procedures

Present study was part of a larger research that required a within-subjects experimental design. Subjects participated in two consecutive cold-pressor trials, one using VR and one with-out. During the VR condition, the participants interacted with the VR environment using the mouse with their dominant hand, while immersing their non-dominant hand in the cold-pressor. During the control condition, the participants immersed their non-dominant hand in the cold-pressor while a static black screen was presented to them. The order of the experimental conditions was randomized and counterbalanced.

Instructions and procedures for cold-pressor tasks were conducted as usual. Subjects were asked to keep their hand immersed for as long as possible, but were instructed that they could withdraw at any time. The immersion was limited to a 5-minute duration, but subjects were not informed of that time limit. Once the participant decided to remove the hand from the water, the participant was asked to complete a VAS rating of the most intense pain experienced during the hand immersion. Also, a VR presence measure adapted from Slater et al [14] was administered. Other measures for other research purposes not reported here were provided.

2. Results

In comparison with the control condition, VR distraction decreased levels of pain intensity by an average of 51%, across male and female students. The ratings of VR presence were medium (mean = 3.57, *SD* = 1.66, range 0-6). 67.6% of participants reported a rating of moderate or higher sense of VR presence. The relationship between VR presence and the intensity of pain felt during the VR cold-pressor trial was investigated using Pearson product-moment correlation coefficients. The amount of VR presence reported correlated significantly and negatively with ratings of most pain intensity, r (37) = -.37, $p < .05$.

3. Discussion

This study is the first to find a significant negative correlation between subjective presence ratings and amount of pain reduction during a VR cold-pressor trial. Thus, the participants that had a stronger illusion of being in the stereoscopic virtual world reported lower levels of pain experienced during the hand immersion in the cold-water. These results are consistent with previous studies [3, 6] that had showed that VR presence influenced VR analgesia when a brief thermal pain stimulus was administered. The results of the present study and previous results are consistent with the notion that pain and VR compete for attention. Although further research about the specific mechanisms of VR analgesia is needed, current findings suggest that the greater the sense of VR presence, the more the participant's attention will be drawn into the virtual world, leaving less attention available to focus on pain. This preliminary research promotes the need for future related studies. Although the VR presence measure used in the current study has been proved useful, additional research on measurement of VR presence, based on questionnaires or other instruments (observation or physiological recordings) is recommended. Furthermore, although the cold-pressor test is thought to be a good analogue of naturally occurring continuous pain, future research should replicate the present work under more natural conditions with chronic pain patients. These and other studies addressing the conditions that maximize VR presence seem crucial to design VR systems that increase analgesic effectiveness for patients.

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The Effects of Augmented Reality on Learning

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Abstract. In this study, a new approach to the implementation of Augmented Reality (AR) in the educational environment was taken by creating a Chemistry Augmented Reality Learning System (CARLS), using the existing teaching curriculum, together with physical activity. This system combined learning with three types of physical activity: aerobic fitness, muscle strength and flexibility fitness. This study reveals that the students using all three types of physical activity together with CARLS result in significantly higher academic performance compared to the traditional Keyboard-Mouse CAI (KMCAI). This improvement is most evident for the non-memorized knowledge component of Science. Moreover, the students in the AR group with 'muscle strength' physical activity had significantly more positive learning attitude change toward Science than those in the KMCAI group. A great additional benefit of our approach is that, students also obtained more physical fitness while learning.

Keywords. Augmented reality, physical activity, learning

Introduction

Adolescent health concerns have been the subject of much recent study as the typical amount of time spent on physical exercise has decreased, while the time spent on computers has increased. A recent national survey in Taiwan revealed that adolescent students spent too much time on computers and this resulted in negative impacts on their daily life routines and health conditions [1]. However, it is not clear that increased computer-related activity always have negative health consequences, for example, a recent study reported that some computer game players are fitter than the general population in the U.S. like one of the popular online games, MMO EQ2 [2].

Given that computer use will become a life-style choice by adolescents later in life, it would seem beneficial to explore new ways to utilize computers to assist learning and recreation, while avoiding the risk of negative health effects. Moreover, given the need to increase physical activity for health reasons it is interesting to determine if there is a link with learning. This study describes new findings that indicate a strong link between increased physical activity and learning.

1. A Series of AR Learning Systems

Augmented Reality (AR) technology is recently being applied in an increasingly large range of applications for improved educational efficiency [3, 4] as well as mental and physical health [5, 6, 7, 8]. To investigate the link between physical activity and learning, a series of the implementation of AR in the educational environment, together with physical activity, was taken.

One of our previous studies investigated a new series of AR learning systems, which provided current-day curriculum in English to primary school combined with two types of physical activities, stretching and jumping, for 137 second grade students [9]. The findings from this earlier study revealed that students using the AR learning system combined with physical activity had better academic achievement and learning attitude toward the English language than those in a control group, which only used the traditional textbook teaching method.

An Augmented Reality Aided Instruction System (ARAIS) was developed to assist 115 fifth grade students learning Science in primary school while doing only one type of physical activity, which was

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jumping. Results showed that students in the group using ARAIS had more positive learning attitude change toward primary school Science than those in the traditional textbook teaching group [10].

Another AR learning system for high school Science that involved 973 seventh grade students from 37 classes in five high schools implemented an Ecosystems Augmented Reality Learning System (EARLS) to help students learn Ecosystems with two types of physical activity, jumping and boxing. Students in the group using EARLS also showed more positive learning attitudes toward high school Science than those in the group using the traditional textbook teaching method and those in a group that used the Keyboard-Mouse Computer Assisted Instruction (KMCAI), in spite of no significant differences in academic achievement. Hsiao and Sung reported that qualitatively most teachers involved commented and concluded that EARLS did not diminish academic achievement in Science and further that students tended to have a more positive learning attitude toward Science and had more physical activity in school [11].

Based on the above experiences of AR learning systems development, and preliminary evaluations of thousands of users, including both teachers and students, we have extended the AR concept to include in this study Chemistry high school Science for seventh and eighth graders and added three types of physical activities, ‘aerobic fitness’ (Jumping), ‘muscle strength’ (Boxing) and ‘flexibility fitness’ (Stretch). We term this system Chemistry Augmented Reality Learning System (CARLS).

2. Methods

In the updated study, the implementation of AR in the educational environment was taken by creating a Chemistry Augmented Reality Learning System (CARLS), using the existing teaching curriculum, together with physical activity. This system combined learning with three types of physical activity: aerobic fitness, muscle strength and flexibility fitness (see Figure 1 and Figure 2). Students (n=673) from five high schools were divided into four groups. The first three groups used the CARLS learning system while a control group used a traditional way to operate the computer: a keyboard and a mouse. Students from all four groups followed the conventional instruction using textbooks and CAI materials to implement the first part of the teaching activity, but adopted four different approaches to carry out the second part, ‘practice’.

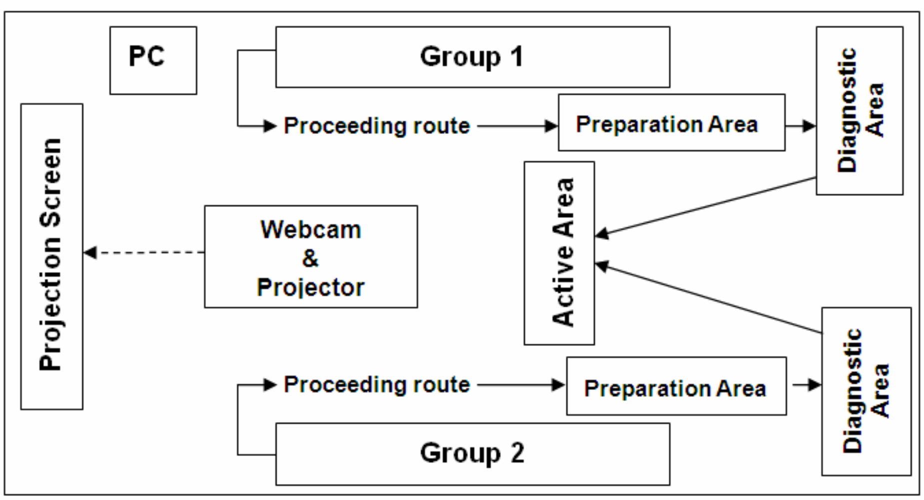

Figure 1. Block diagram of CARLS configuration.

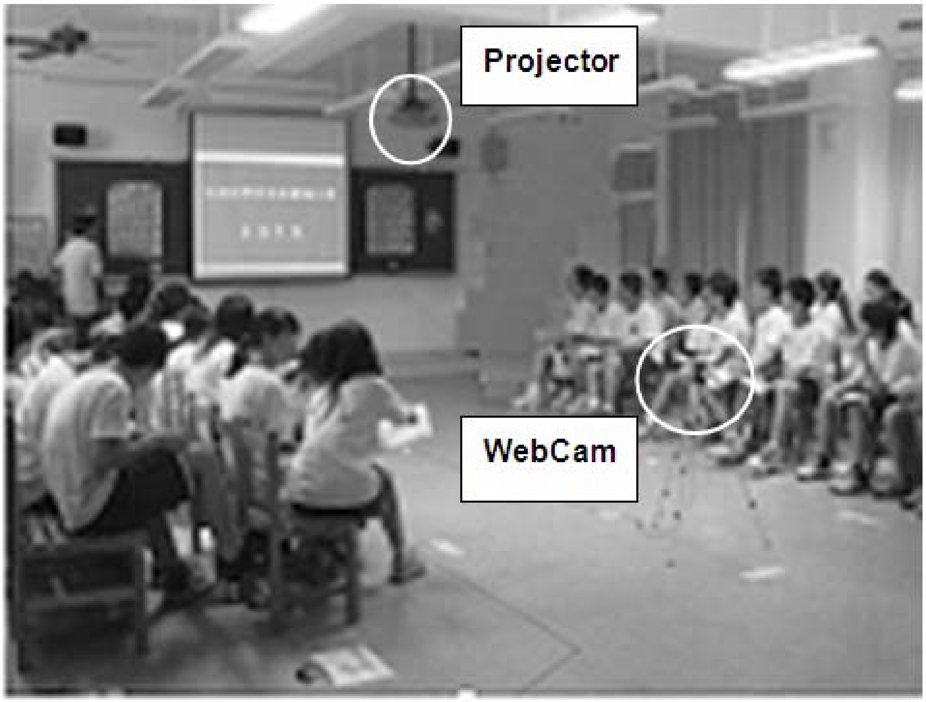

Figure 2. Real practice picture of CARLS.

We explored changes in academic achievement as well as attitudes towards learning Science resulting from the implementation of CARLS. In order to explore the academic achievement in high school Science, pre-test and post-test paper-and-pencil examinations were designed into this study. There were eight items of the memorized type and seven items of the non-memorized type each examination. Among these 15 items, eight items were the same in both of the pre-test and post-test examination and the other seven items were different, but of the same level of difficulty. The examination items were identified by four subject teachers from four high schools and one director of Teaching Affairs. In addition, the scale for measuring Science learning attitude was revised from the previous studies of Germann [12] and also of Osborne et al [13]. After the Factor Analysis in this study, there were 13 items left in the revised scale. All items were measured using a five-point Likert-type scale (ranging from 1 = strongly disagree to 5 = strongly agree). Regarding the content validity, the questionnaire was refined by a pilot study which focused on question wording, clarity and validity. In the pilot study, the four subject teachers and director, mentioned above, provided comments on the questionnaire as a basis for revisions. The reliability (alpha) coefficient for the scale was 0.925.

3. Results

As a result, this study successfully created the AR learning system, CARLS, using the existing teaching curriculum, together with three types of physical activity: aerobic fitness, muscle strength and flexibility fitness.

Analysis of covariance, with pre-test score as covariates, revealed that the students using all three types of physical activity together with CARLS resulted in significantly ($F(3, 615) = 4.92$, $p<0.01$) higher academic performance compared to the traditional Keyboard-Mouse CAI (KMCAI). In the ANCOVA test analysis, a series of the Pairwise Comparisons based on estimated marginal means showed that there were significant differences (all $p<0.01$) in the non-memorized type academic achievement between the students in Group AR-Jump (mean = 3.70; *SE* = 0.11) and Group KMCAI (mean = 3.25; *SE* = 0.10), Group AR-Stretch (mean = 3.73; *SE* = 0.11) and Group KMCAI, and Group AR-Box (mean = 3.65; *SE* = 0.11) and Group KMCAI. The results clearly showed that all students in the three AR groups had better academic achievement in Science than those in Group KMCAI. The improvement was most evident for the non-memorized knowledge component of Science.

In terms of learning attitude change toward Science, analysis of covariance, with pre-attitude score as covariates, showed that the students in the AR group with 'muscle strength' (mean = 3.28; *SE* = 0.06) physical activity had significantly ($F(3, 423) = 2.58$, $p<0.05$)more positive learning attitude change toward Science than those in the KMCAI group (mean = 3.25; *SE* = 0.05).

4. Conclusions

This study provides a new approach to increasing students' extra physical activity without diminishing students' academic performance. In addition, better academic achievement in non-memorized knowledge of Science and a more positive attitude toward Science were also promoted by using CARLS. Further a great additional benefit of our approach is that, students also obtained more physical fitness while learning. If the school timetable has been constrained, an AR learning system with physical activity function, like CARLS, might be part of a possible solution.

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Indoor Orientation and Mobility for Learners Who are Blind

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Abstract. This study consisted of designing a mobile technology to identify the position and orientation of people who are blind in closed environments, such as a school, building or home, identifying the necessary infrastructure based on criteria of usability, reliability and accessibility, in order for PocketPC device interface developers to be able to define the technology to be used at an early stage. The technology consisted of using PocketPC devices with a data collecting application and another for the representation of space. We evaluated its usability, accessibility, reliability, efficiency, and availability. The results of the usability evaluation assured us that the interface designed and developed is usable for users who are blind, which is reaffirmed through the accessibility evaluation. The reliability, efficiency and availability evaluations of the system show that a user who is blind can use the system confidently, because it provides correct information for more independent navigation.

Keywords. Orientation & Mobility, People Who are Blind, Blind Navigation, Indoor Context

Introduction

The real world is in constant movement and change, which causes a big problem for the visually disabled, who are not able to make sense of their surroundings with a simple blink of the eye, and who find hardships in their daily activities and autonomy. Recently, studies have been carried out that aim to solve this problem [4-5], [10] by embedding users in virtual worlds in order to prepare them for more effective action in the real world. As such, software has been designed that allows people who are blind to work with problem-solving methodologies, but based on problems presented by a facilitator [8-9]. The question that emerges is: how to support blind people's autonomous decision making in the real world?

For most visually disabled users the biggest obstacle to increasing their quality of life is the lot of problems they have of moving about freely. This complication denies such users equal access to certain areas, buildings, means of transportation and even jobs **Error! Reference source not found.**. In addition, in moving around they are restricted to the same spaces, because to change their route or branch off from the road could be dangerous or confuse them **Error! Reference source not found.**, impeding them from finding their way back. As a result, users who are blind are limited to following routine movements and for exploring new places **Error! Reference source not found.**. Other obstacles for a person who is blind include the determination of their location in an environment, knowing which way their head is facing, or the direction of the movement of their body, and the lack of information about important objects in the environment, such as the distance at which they are located both in terms of closeness and at a distance [1].

In this work we present technology for identifying the position and orientation of a user through the use of a Pocket PC device that is usable, low-cost, accessible, and which enjoys a certain degree of penetration in the market. Such technology can be used in order to assist users who are blind to achieve autonomy in their navigation through indoor spaces such as corporate buildings, schools, and residential buildings.

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1. PYOM System

The system is based on the use of WiFi technology together with a previous representation of the environment, which admits fewer access points for determining the necessary information. To these ends, the system consists of three applications: PYOMDatos, which captures the intensity of the signal from the required points; PYOMAnalyses, which analyzes the data collected and maintains the data organized and structured for its future use; and PYOM, the user application that captures the intensity of the signal from the environment and compares the results with those that are stored, being able to provide the user with information on his/her position and orientation, on command.

The software was designed and developed with a user-centered methodology, in such a way as to achieve fast, reliable and usable results. The PYOM software, which is the application that the users who are blind utilized, was built. To create this software it was essential to learn of the end users' opinions and their apprehensions when navigating through unfamiliar environments. In order to gather this information, a Focus Group was implemented at the beginning of the study, including 4 people who are blind between 19 and 34 years of age. The Focus Group was conducted by 2 interface experts and 1 special education teacher specializing in visual disorders. The data and information obtained was used to redesign and improve different stages of the interface design process. Also, as a result of the software usability evaluation, we were able to polish and improve the interfaces in order to tailor them to the user, which was reflected in the results of the end user evaluation.

The application's opening interface of the PYOM software uses the buttons on the PocketPC device as well as the touch screen. Of the 4 buttons on a PocketPC only two are used, located at the extremes so that it is easy to find them. The left button is used to send help to the user; in pressing this button the user comes to know the way of interacting with the application. In starting up PYOM software, instructions are given to the user about the buttons that are used in the device. The right button is used to quit and shut down the application (Figure 1).

The screen is divided into two vertical parts. In each vertical part of the touch screen (left and right), the user can interact by using the fingers to execute the corresponding command. In the left rectangle the user can ask for information about his/her position in space, while in the right section the user can request information about orientation. For the device to recognize the user's instructions, it is necessary for the user to trace the finger upwards from below, not necessarily in a straight line but as straight as possible (Figure 1).

Figure 1. Initial PYOM Interface (A) Form of use in order to request Position. (B) Form of use in order to request Orientation.

2. Usability Evaluation of the PYOM Software

The sample was made up of 5 users, from the city of Santiago, Chile, with ages between 14 and 34 years old, 2 women and 3 men, 1 totally blind user and 4 users with low vision, according to ophthalmologic diagnoses. An engineer who is an expert in interfaces, as well as a special-education teacher specializing in visual disabilities guided the evaluations.

We used three instruments:

1. A PYOM Evaluation Questionnaire especially designed for this software consisting of 3 open questions focusing on the problems directly related to the use of the software.
2. An Evaluation Questionnaire with Open Questions was also used, which contains 10 questions regarding the use of the software and its applicability.
3. Finally, for the end-user evaluation the Software Usability for Blind Children Questionnaire, designed by Sanchez **Error! Reference source not found.**, was used.

The instruments used sought to determine if the software designed and developed for users who are blind is usable and if it resolves any problems regarding the information they need for navigation. This evaluation and the proposed system do not consider the development of navigational skills in users who are blind to be an objective. On the contrary, the system is the base of another system that would seek to develop such skills **Error! Reference source not found.**.

3. Results

The results obtained from the PYOM software evaluation questionnaire were clear and denoted a lack of information from the system. Regarding the problems with position, users pointed out that they needed more details on the room they were in, or more specific information on their location within the room. On orientation they pointed out that they had better ways of orienting themselves, by means of key places or the clock technique that they already knew through the use of the aGPS software **Error! Reference source not found.**. Finally, in response to the question on whether or not the software is useful, all the users agreed that it was useful and that it allowed a person to be able to navigate an unknown place and get to a destination.

From the Evaluation Questionnaire with Open Questions, valuable information was obtained. From the first usability evaluation users criticized the lack of details and information provided by the PYOM application.

For the analysis of the End-User Usability Questionnaire, the sentences were grouped into three categories: Satisfaction, Control & Use, and Sounds. For each of these categories an average score that the users from the sample gave was obtained, achieving a detailed evaluation of different aspects of the software.

In the first usability test the results were low regarding what was expected. Of the maximum total of 10 points that each category could receive, all were rated in the middle. The Satisfaction and Control & Use categories obtained the lowest score, with 5.3 points, while the Sounds category was rated slightly higher with 6.2 points.

If we separate the sample by gender, the females gave a higher evaluation of the software than the men, but the difference is not statistically significant. Females also showed a bigger difference regarding Control & Use of the application ($F=1.333$, $p>0.05$; female=6 points, male=5 points), followed by satisfaction with the software ($F=0435$, $p>0.05$; female=5.8 points, male=5 points), and the smallest difference was shown in the evaluation of the sounds ($F=0.006$, $p>0.05$; female=6.3 points, male=6.1 points).

The scores were higher than the first test, and there was considerable improvement expected for the changes made to the software based on the results of the first evaluation. The category that obtained the highest evaluation was still sounds, with 8.3 points, followed by Satisfaction with 7.9 points and finally Control & Use with 7.4 points.

If we observe the results by gender, men evaluated the Satisfaction category ($F=1.335$, $p>0.05$; male=8.7 points, female= 6.5 points) and the Control & Use category ($F=0.044$, $p>0.05$; male=7.5 points, female= 7.2 points) of the PYOM software more highly. The sounds in the application were more highly evaluated by the women ($F=0.268$, $p>0.05$; male=8.1 points, female=8.5 points)

The final test received a higher evaluation than the first, but without any statistically significant differences, reaching 2.6 points more in Satisfaction ($t=-1.015$, $p>0.05$; pretest= 5.3 points, posttest=7.9 points), 2.1 points difference in Control & Use ($t=-1.973$, $p>0.05$; pretest=5.3 points, posttest=7.4 points), and 2.1 points difference in Sounds ($t=-2.113$, $p<0.05$; pretest=6.2 points, posttest=8.3 points)

4. Conclusions

In this paper we presented the design, development and evaluation of a technological system that allows a user who is blind to know of his/her position and orientation in an indoor environment. From the usability evaluation we were able to obtain relevant information that users who are blind need to be able to locate and orient themselves spatially in a certain place. Also, the way in which the information is provided is a critical point that is identified in this study. The users worked correctly with the clock system for identification, achieving clarity as far as where they had to go in the environment, thus being able to arrive to their destination independently.

Although there were no significant differences in the usability evaluations for both tests, including by gender differences, the PYOM software was evaluated highly, achieving high results in the end-user evaluation guideline and the open questions guideline. The final usability evaluation achieved the highest results of all three aspects evaluated, which were user satisfaction, control & use and sound quality, which implies an improvement in the system's interface both in the way it presents data and in the data itself.

The entire process of the design and development was carried out with a user-centered methodology, for which reason the results were usable and accessible for the end-users. The main application, PYOM, has a touch screen and audio interface that allows for simple use by users who are blind, which is reflected in the results of the usability evaluations.

The proposed system is a simple and viable solution to be able to provide a legally blind user with his/her position and orientation in specific indoor spaces, making it so that this user can move about autonomously and even wander through unknown spaces. The PocketPC, or in its absence a device such as a Smartphone, represents a technology that is widely available to users, and which can be obtained in the traditional market at reasonable costs. The same is true for a WiFi network, which are currently available in many buildings and homes. This infrastructure can be used in order to provide necessary information to blind users.

The novelty of the proposal lies in its betting on the fact that the system developed and evaluated is not only capable of providing the user's position in a certain place, but the orientation in space as well. All existing applications to date provide solutions for the user to be able to know the position in a determined area (R&D office, meeting room, kitchen, etc.), but are not capable of providing information on the user's orientation (in the R&D office facing the door).

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The Use of Virtual Reality for a Human Classical Conditioning Procedure

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Abstract. The present study investigated the use of a VR stereoscopic figure as conditioned stimulus (CS). A differential conditioning procedure was applied on 67 participants, where a VR stereoscopic figure (CS+) was paired with electric shock and other VR stereoscopic figure (CS−) was presented without shock. Evaluative and expectancy measures were taken. Results showed that, after acquisition, the CS+ by itself became a more negative stimulus, as evidenced by the evaluative ratings. Besides, the presentation of the CS+ evoked an active expectancy of the unconditioned stimulus (US). The use of VR stereoscopic figures as CSs seems feasible to design innovative experimental paradigms.

Keywords. Virtual reality, Classical conditioning

Introduction

Classical conditioning studies are very useful for experimental research on fears and phobias and exposure-based techniques. The application of VR technology to exposure treatments has proved to be effective [1] but major questions regarding fear conditioning in virtual reality environments remain relatively unexplored. Although VR has been successfully applied to demonstrate a general context conditioning to a virtual room where colored panels functioned as explicit conditioned stimuli [2], the use of VR stimuli as CSs has been scarcely studied. Therefore, the present study is novel in that it aims to elicit fear conditioning using VR stereoscopic figures as CSs.

1. Method

1.1. Participants

The sample consisted of 67 students (61 women, 6 men) between 19 and 31 years old (mean age 22.75, *SD* = 2.61). All participants provided written informed consent prior to enrolment in the study. The study was approved by the Ethics Committee of the University of Barcelona.

1.2. Stimuli and Apparatus

The virtual reality environment was adapted from a research about VR to cope with pain conducted at the authors' research team and consisted of a stereoscopic figure presented via two BARCO ID R600 projectors onto a 2.43 x 1.82 m. screen. The CS+ consisted of an 8-sec presentation of an irregular sharp-edged polygon, mainly in hot colors (i.e., yellow and red) (see Figure 1, top left panel), which was presented together with an unpleasant sound (600 Hz; 80 dB). The CS− consisted of an 8-sec presentation of a spherical shape, mainly composed of cold colors -blue and white- with a certain resemblance to natural scenery (see Figure 1, top right panel), and combined with a quiet sound produced by a generative music engine. Two stationary figures (C1 and C2) were used as control stimuli. Two black-and-white pictures of both are shown in Figure 1 (bottom panels). Electric shocks were used as unconditional stimulation (US). For its administration, an isolated square-wave stimulator (Lafayette 82415-IS) was used. It delivered

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constant voltage electric shocks (1 sec. in duration) through two disposable adhesive round electrodes attached to the inner surface of the participant's nondominant arm.

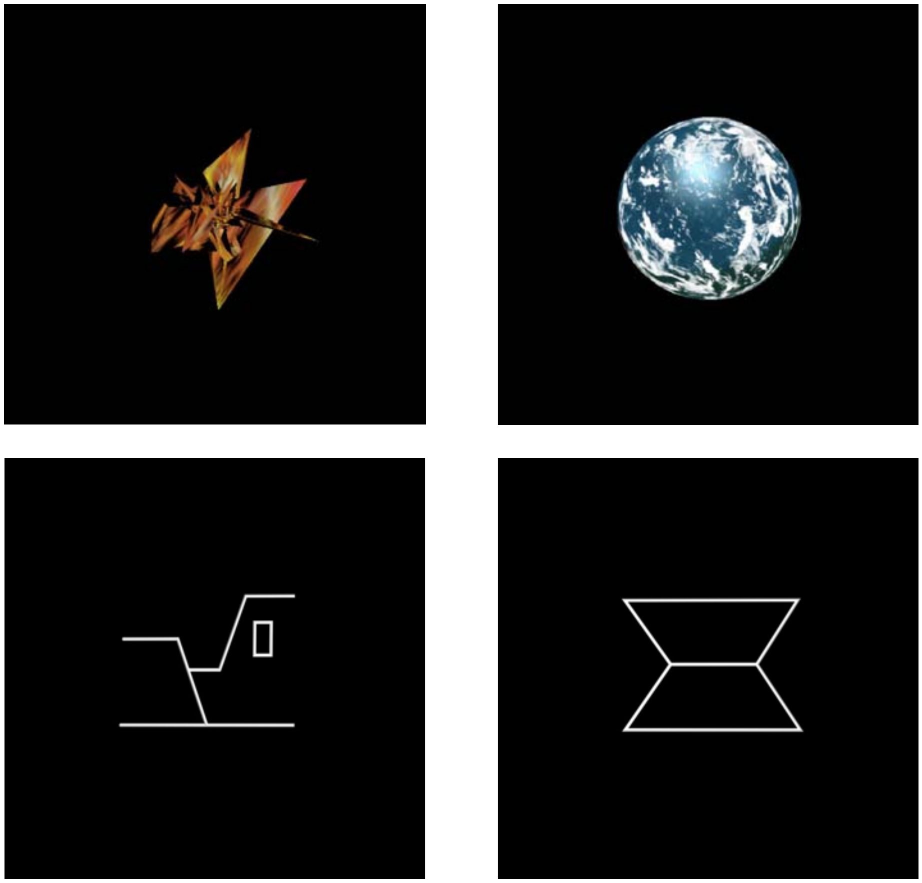

Figure 1. Black-and-white pictures of the stimuli used in the differential conditioning procedure: the CS+ (top left panel), the CS− (top right panel), the control C1 and C2 (bottom panels)

1.3. Procedure

Prior to conditioning trials, participants were asked to make ratings of the CS+, the CS− and two control stimuli (C1 and C2) on two 21-point scales: arousal (-100 = very calm; +100 = very aroused) and valence (-100 = very pleasant; +100 = very unpleasant).

Next, the experimenter placed the electrodes on the participant's forearm and informed that he or she would be receiving a series of shocks in increasing intensity in order to determine the voltage level of the shocks that would be delivered during the task afterwards. The shock voltage selection was performed as follows: starting with 20 V, the experimenter gradually increased the voltage of each subsequent shock in 20-V steps, until the participant reported that the shock was unpleasant enough, but not painful. The minimum and maximum voltages selected by any participant were 40 V and 100 V. After shock voltage selection, the aversive differential delay conditioning procedure was applied. Both CSs were individually presented, centred in the screen, with a fixed duration of 8 s. The offset of CS+ was always simultaneous to the presentation of electric shock (US), which had the intensity that was selected in a prior phase. The CS− was presented alone, directly followed by the intertrial interval (30s.) In sum, each CS was presented ten times in quasirandom order, with the constraint that the same stimulus could not appear consecutively more than twice. After the acquisition phase, the participant was asked to rate the set of the four stimuli (CS+, CS−, C1 and C2) for a second time on the arousal and valence dimensions. It was stressed that their rating could have remained the same or could have changed as compared to their previous ratings, and that we were only interested in how they rated these stimuli at this very moment. Next, they were asked to provide the anxiety ratings and the US-expectancy ratings for these stimuli on separate 11-point rating scales. For the anxiety ratings it was asked to mark the extent to which they had felt anxious during the presentation of the CS+ and the CS−. This rating scale was anchored by 'not anxious at all' (0) and 'very anxious' (100). For the US-expectancy ratings it was asked they indicate to what extent they had expected an electric shock following the presentation of the CS+ and following the presentation of the CS− during the acquisition phase. The rating scale was anchored by 'never' (0) and 'always' (100).

2. Results

Mean arousal scores for CS+, CS−, and the two control stimuli at the beginning and at the end of the experiment are presented in Figure 2 (top panel). After acquisition, the CS+ (M = 48.65) was rated as more arousing than at the beginning of the experiment (M = 3.88), t (66) = -10.54, p <.001. At the end of the experiment, arousing scores for the CS+ were also significantly higher than CS− (M = -61.79), t (66) = -17.37, p < .001. Since pain-relevant stimuli were used as CSs, differences on arousal ratings between CS+ and CS− were found at the beginning of the experiment. However, these differences were much larger after acquisition. Thus, differences between CS+ and CS− at the end of the experiment remain significant after adjusting the pre-acquisition differences, F (1, 65) = 137.47, p <.001, η^2 = .68. For control stimuli (C1 and C2) no pre-post shifts on arousal ratings were found, all t (66) < 1.4, *n.s.*

The pattern of results was the same for the valence scores. Mean valence scores for CS+, CS−, and the two control stimuli before and after conditioning are presented in Figure 2 (bottom panel). After acquisition, the CS+ was rated as more unpleasant (M = 37.61) than at the beginning of the experiment (M = -4.18), t (66) = -10.94, p <.001. At the end of the experiment, the CS+ was also rated as significantly more unpleasant than the CS− (M = -58.36), t (66) = -17.49, p <.001. Since pain-relevant stimuli were used as CSs, differences on valence between CS+ and CS− were also found at the beginning of the experiment. However, these differences were much larger after acquisition. Thus, differences on valence between CS+ and CS− at the end of the experiment remain significant after adjusting the pre-acquisition differences, F (1, 65) = 151.10, p <.001, η^2 = .70. For control stimuli (C1 and C2) no pre-post shifts on valence ratings were found, all t (66) < 1.1, *n.s.*

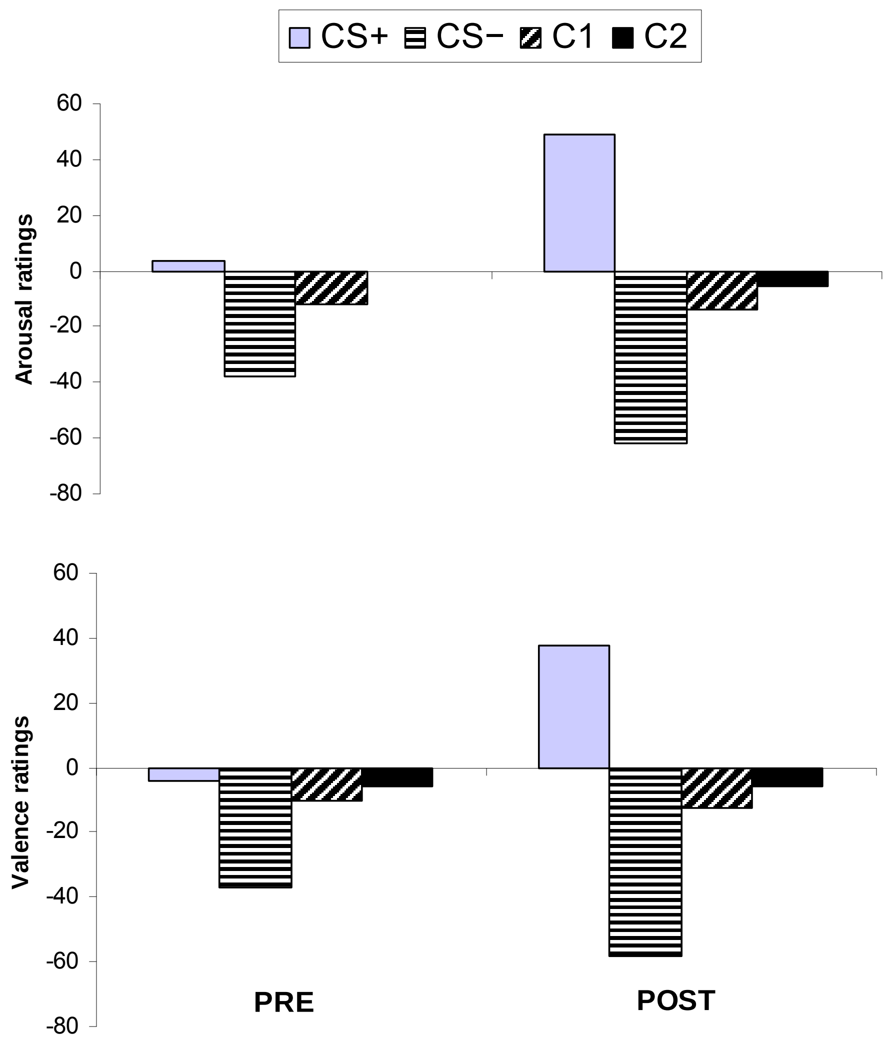

Figure 2. Mean arousal scores (top panel) and valence scores (bottom panel) for CS+, CS−, C1, C2 before conditioning (Pre) and after conditioning (Post)

With respect to the anxiety ratings, data showed that after acquisition the CS+ (M = 60.30) elicited significantly more anxiety than the CS− (M = 9.70), t (66) = 16.35, $p < .001$. Moreover, the mean US-expectancy rating after acquisition was 95.37 for the CS+ and 8.21 for the CS−, t (66) = 36.11, $p < .001$.

3. Discussion

This study is the first report of the use of VR stimuli as CSs in a differential conditioning procedure. The main result was that the experience of repeated contingent presentations of a VR stimulus (CS+) and an aversive electrical stimulus (US) altered the meaning of the CS+ in two different ways. First, the CS+ by itself became a more negative stimulus, as evidenced by the arousal, valence and anxiety ratings. On the other hand, the CS+ became a valid predictor for the US, as evidenced by the expectancy ratings. Although future studies should replicate these findings with physiological measures, these preliminary findings justify further efforts to advance on the use of VR in fear-conditioning experiments. It opens the possibility of using a very controlled experimental paradigm based on VR for the future study of fear learning effects like extinction, counter-conditioning or discrimination.

Acknowledgements

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Teaching Tactical Combat Casualty Care Using the TC3 Sim Game-based Simulation: A Study to Measure Training Effectiveness

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Abstract. The effectiveness of games as instructional tools has been debated over the past several decades. This is due to the lack of empirical data to support such claims. The US ARMY developed a game-based simulation to support Tactical Combat Casualty Care (TCCC) Training. The TC3 Game based Simulation is a first person game that allows a Soldier to play the role of a combat medic during an infantry squad mission in an urban environment. This research documents results from a training effectiveness evaluation conducted at the Department of Combat Medic Training (Ft Sam Houston) in an effort to explore the capability of the game based simulation as a potential tool to support the TCCC program of instruction. Reaction to training, as well as, acquisition of knowledge and transfer of skills were explored using Kirkpatrick's Model of Training Effectiveness Evaluation. Results from the evaluation are discussed.

Keywords. Game-based Simulation, training effectiveness evaluation, Kirkpatrick's Model, medical skills training, trauma care training.

Introduction

Tactical Combat Casualty Care (TCCC) is the pre-hospital care rendered to a casualty at the point of injury in the battlefield [1]. TCCC principles have proven highly effective and are a major reason why combat deaths in Operation Iraqi Freedom and Operation Enduring Freedom are lower compared to other conflicts in the history of the United States [2]. Providing the right tools and training to Combat Medics assist in achieving the ultimate goal of reducing the mortality rate in combat environments. Current tools and methods used for initial skills and sustainment training of combat medics throughout the Army can be improved. New technologies are needed to provide medics with greater opportunities to develop and test their decision making and technical medical skills in multiple and relevant training scenarios [3]. The U.S. Army Research Development and Engineering Command, Simulation and Training Technology Center (RDECOM-STTC) developed the 68W Tactical Combat Casualty Care Simulation (TC3 Sim) for the US Army Medical Department (AMEDD) Center & School at Fort Sam Houston. The Army is considering the use of the TC3 Sim game as a tool to improve the training of individual soldiers as well as improve the readiness of combat medics. The potential of using games to encourage learning has been the focus of numerous literature research published. In fact, for several decades, the benefits of games have been debated ([4-5]). Some of the claims include that games can increase the motivation and interest of trainees, improvement of learning and improvement of attitudes towards a particular subject matter. Several authors ([6-12]) have presented extensive reviews of the literature trying to provide a better understanding of those claims in terms of available empirical data. Recently Hays [13-14] and Wiebenga [15] updated those findings with more recent data. Both agreed that little attempt is being made to conduct empirical research regarding the effectiveness of games in training resulting in a critical gap between theory and practice that needs to be addressed. This research evaluated the effectiveness of the TC3 Sim as an instructional game developed to teach the concepts of tactical combat casualty care. Experiments were conducted to evaluate the training effectiveness of this tool in supporting the 68W10 Healthcare Specialist Course program of instruction (POI). Evaluation of the game was performed utilizing Kirkpatrick Model for evaluating training effectiveness.

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1. Methodology

In order to assess the effectiveness of the TC3 game-based simulation in supporting the learning of tactical combat casualty care principles, three levels of Kirkpatrick's Model were evaluated: User Reaction (Level 1), Skills Acquisition (Level 2), and Skills Transfer (Level 3). The study was conducted at AMEDD, Ft. Sam Houston, Texas. The experimental group consisted of 180 Soldiers participating in the TCCC program of instruction at the US Army Medical Department Center and School, Department of Combat Medic Training. Three defined media sets were available for instruction of TCCC principles during the experiment: Multimedia, Interactive and Experiential. The current program of instruction utilizes PowerPoint multimedia training to teach principles of TCCC. The control group (Multimedia) was exposed to PowerPoint-based training on three areas of TCCC: Hemorrhage Control, Airway Management, and Breathing. The interactive consisted of TCCC computer-based courseware on the same three areas with a variety of interactive presentation methods with immediate feedback and remediation. The experiential consisted of TCCC computer-based courseware with the TC3 Sim game-based simulation. The TC3 Sim is a first person game where the trainee plays the role of a 68W Combat Medic assigned to a squad conducting surveillance in a Middle Eastern urban environment. The main goal of the game is for the Soldier to stay safe, prioritize treatment and treat casualties. Participation in the study was voluntary and was conducted over a period of three months. Participants were assigned randomly to one of the three training conditions: TCCC PowerPoint Training (Multimedia), TCCC Computer-Based Courseware (Interactive), and TCCC Interactive Courseware and TC3Sim game-based simulation (Experiential). Reaction data was obtained via questionnaires, knowledge acquisition was measured using pre-post tests and transfer of skills was assessed with a paper and pencil scenario exercise.

2. Results

The research described focused on assessing three different conditions to train combat medics in three areas of TCCC principles. One of those conditions involved the use of a game-based simulation as a tool to augment more traditional content training. An experiment was designed to enable discernable statistical differences in effectiveness between treatments at $\alpha = 0.05$ and $\beta = 0.20$. Statistically significant findings were the following:

2.1 Trainee post-training reaction

Medic trainees rated training as "Very Good" regardless of the training condition received. They also agreed that the training objectives were met during training and that the technology should be incorporated into the program of instruction. They all agreed that the technology was easy to use regardless of training media. There was no significant difference in Overall Reaction between training treatments, $F\ (3.00) = 2.25$, $p = 0.1082$.

2.2 Knowledge Acquisition

A mixed ANOVA ($\alpha = 0.05$) with Training Treatment as the between-subject variable and Session (Pre-test vs. Post-test) as the within-subject variable was performed to test acquisition of knowledge. Acquisition of Knowledge occurred for all participants, $F\ (3.00) = 461.284$, $p = .000$. A one way ANCOVA (using pre test as a covariate) tested the hypothesis regarding differences in gain scores between treatments. Statistically significant differences were found between treatments, $F\ (3.00) = 33.18$, $p = .000$. Scheffé Post-hoc tests indicate that significant statistical differences were found in pre-post test gain scores between participants in the multimedia training treatment and participants in the interactive and experiential training treatments ($p = .000$ respectively). No significant difference in post test scores was found between participants in the interactive and experiential treatments. This was expected since the content training for the experiential training was provided by the TCCC interactive courseware.

2.3 Skill Transfer

Statistically significant differences in Transfer Scores were observed amongst treatments, F (3.00) = 6.622, p = .000. Scheffé Post-hoc results indicate that participants that received interactive and experiential training scored higher in the transfer task test (paper and pencil scenario exercise) than participants receiving multimedia training (p = .013 and p = .001 respectively). No significant difference was found for participants that received experiential and those receiving interactive training.

3. Discussion and Conclusions

There has been an increasing trend advocating gaming technologies to support training in recent years. This research focused on a particular instructional game developed to support training of combat medics in the principles of tactical combat casualty care. The reaction to training using a game to augment traditional training was explored, as well as, knowledge acquisition and skill transfer. Results from the study suggest that games that have been developed to support specific learning objectives could augment current content training delivery mechanisms. Games appeal to the younger generation that has been exposed to their use since early age. Motivation is a big factor observed within the training audience. One area that was not addressed in this study is to evaluate how it would be more effective to incorporate the game component in a particular program of instruction. Future research should also explore whether or not trainees would use the game as a tool to improve critical thinking skills after training hours during down time. Finally, it would be of benefit to conduct longitudinal studies to explore the impact of game-based training on performance and retention of learning objectives and skills.

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Visual Properties of an Object Affect Time to Target in VR Reaching Tasks

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Abstract. Virtual Reality is being used increasingly for upper limb rehabilitation. The type of virtual objects used for reaching tasks varies widely, but there has been little work exploring the effect of different characteristics of objects on target acquisition time. This study investigates how target acquisition times vary for virtual objects with different visual cues. Results suggest that the visual properties of an object may have a notable effect on target acquisition times. Simple (low polygon) objects with richer depth cues are acquired more easily than a standard sphere.

Keywords. Virtual reality, virtual rehabilitation, visual cues, depth perception

Introduction

Virtual Reality (VR) is being used with increasing success for a wide variety of rehabilitation goals, facilitating increased engagement with therapy [1] and reduced perception of pain [2]. Upper limb rehabilitation often involves reaching and grasping tasks, which lend themselves well to Virtual Reality [3-4].

From a clinical practitioner's perspective, the ability to motivate patients to reach with their arm and hand, and intercept to a predetermined point in space has notable rehabilitation value. In order to achieve this, a number of studies have used spheres as target objects in reaching tasks in the evaluation of the potential for VR in a rehabilitation context [5-9]. Spheres have a natural appeal as a 3D model as they are simple to create, and offer a convenient narrative context for task based exercises, for immersion in VR, as they are readily perceived as balls or orbs for grasping, catching or intercepting in a game-like analogy. An alternative approach that some VR applications often find appealing is to render 3D images as realistically as possible to enable knowledge of the object itself, in the real world, to convey a sense of perspective and distance [10] and to enhance the immersion or sense of presence [11-12]. These approaches have yet to be sufficiently assessed for their impact on the users' perception of target location and distance to interception.

Visual compression of distances in virtual reality [5,13] is a well documented issue and this can influence the user's ability to accurately locate and reach an object in virtual space. Whilst some evidence suggests that practice and training can afford some accommodation to this distance compression [14], nevertheless it is a potential source of frustration and difficulty, which may add to the physical and cognitive load when using VR for physical rehabilitation. The additional time required to locate an object in virtual space may also place an undesirable burden on the shoulder musculature in order to maintain the upper limb in an elevated position whilst attempting to determine the precise location of the virtual target.

To facilitate the creation of ecologically valid and task-relevant virtual rehabilitation environments, it is important to understand whether and how the visual properties of an object affect the ability to locate it in virtual space, and how this can be used to facilitate upper limb rehabilitation.

Previous approaches to aid perception of proximity to target have involved reflections, interreflection, shadows, brightness and shading [15-17] but these can be computationally intensive and can compromise real time rendering as well as having technical and financial considerations for wider implementation. A better solution might be one with lower computational load but which can still facilitate location and

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acquisition of targets. Therefore this paper reports the results of a preliminary study to investigate whether the geometry and brightness of a target object can affect acquisition times.

1. Method

Thirteen healthy subjects (10 male, 3 female, age 22-43) participated in the study. The tasks were carried out in a Virtual Reality laboratory with a 'Virtual Orchard' back-projected onto a large (5m x 3m) display screen (**Figure 1**), with the target objects projected stereoscopically in negative parallax (i.e. to appear as if they are in the room).

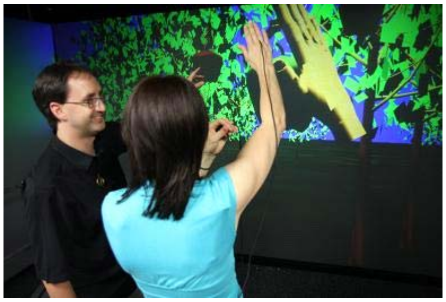

Figure 1. Virtual Orchard simulation (tracker placement not as used in study).

Participants were equipped with Ascension Technology (Flock of Birds) magnetic motion trackers attached to the acromion process of the shoulder and the radial styloid of the dominant hand, and their movements were tracked in the Virtual World with a virtual representation of the same hand. For each condition, 10 virtual objects were presented in pre-determined locations in randomised order. The objects' positions were varied in vertical and horizontal axis, and also in depth-to-screen. Continuous position data of the sensors were recorded throughout each test, and the time to target acquisition was recorded in milliseconds. The time was recorded from the point of target proximity (20cm) until the final intercept with the virtual object, to eliminate variations due to initial visual acquisition of the target, and time to orientate the participant to the target. The target objects were apples, spheres or simple polyhedra (icosahedrons) of the same diameter (Figure 2).

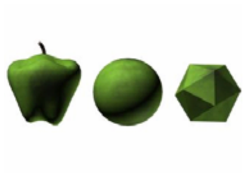

Figure 2: The three object shapes used in the study.

The experiment was a 2 x 3 factorial design (shape x brightness), with the objects either staying constant, or increasing brightness on 'proximity', for each experimental condition.

Descriptive statistics of mean time-to-target for each condition were calculated, and a 2 way ANOVA was used to determine if there was a difference between conditions at an alpha level of $p<0.05$.

2. Results

Two-way ANOVA (shape x brightness) for time-to-target showed a significant effect of object shape ($F_{2,24} = 4.31$ $p< 0.05$). Post Hoc analysis demonstrated that the mean times to target for the terminal stages of reaching were lowest for the icosahedron conditions (1.6 s) compared to the acquisition of the spheres (2.2 s) and the apples (2.1 s). Both these differences were significant at $p<0.05$. There was no significant difference between the apple and the sphere (3). Changing the brightness had no significant effect on time-to-target, nor was there any significant interaction between the brightness and object shape.

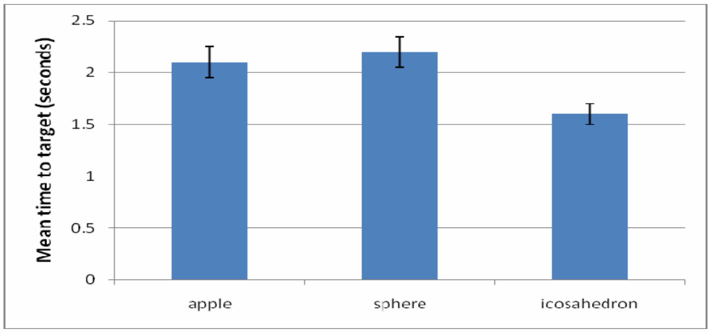

Figure 3. The effect of target shape on mean time (s) to intercept target.

3. Discussion

Preliminary results suggest that a simple low polygon model object, whilst having the benefit of a low computational load, may nevertheless still provide effective depth cues, improving the ability to acquire the target without the frustration of loitering and searching strategies.

Conversely the commonly used spheres were associated with the longest time-to-target and this may have implications for the design of VR rehabilitation environments, particularly where target perception, reaching times or cognitive load is an important factor.

Realistic model rendering, whilst aesthetically pleasing, gave no noticeable advantage to target acquisition and performed less well than the simple polyhedral models. Realistic models could be used judiciously in virtual environments to aid immersion, presence and a sense of narrative as these have therapeutic roles [18-19], but it is suggested that the use of this type of virtual object should be carefully evaluated in a reaching task orientated environment.

Whilst overall the brightness changing polyhedral gave the lowest mean time to target it was not significantly different from that shown by the simple polyhedra on its own. Interestingly, although brightness or luminance have been discussed in the literature as a perceptual distance cue, with objects that are brighter being interpreted as nearer [20], in this study the use of increasing brightness with target proximity did not demonstrate as clear an impact on time to target as that seen between the various object model geometries.

Many participants expressed a preference for a given target type, or a dislike of another. Analysis of the data for individual participants suggested that these preferences were reflected in the time-to-target. Some of the expressed preferences were supported by individual data whose pattern was contrary to the general trend. Thus for effective therapeutic intervention a single overriding solution or strategy might not be valid in all cases. Instead, consideration could be made for calibrating targets and environments to the individual end user and their expressed preferences.

This pilot study demonstrated a large variance both within and between subjects, and therefore these preliminary group results should be interpreted with caution. Nevertheless they suggest that the visual properties of an object may have a significant impact on target acquisition for individuals, and this should be considered when designing timed reaching tasks for rehabilitation or assessment. It is plausible that optimum rehabilitation protocols for reach tasks should be individually tailored. A larger study is now in progress to investigate these findings further.

4. Conclusion

If VR is to be used to improve motor function without necessarily increasing loiter time, muscular burden or cognitive load then there should be an awareness of the differing object properties, their effect on individual's perception and subsequent reaching and grasping tasks.

In contrast to previous studies, these findings suggest that it may not be necessary to utilize a sophisticated computationally-intensive solution, with a low-poly object offering similar benefits at lower computational cost. The results also suggest that VR environments for rehabilitation should consider individual preference.

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Psychophysiological Indicators of Acute Stress Disorder

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Abstract. Aim: The aim of the current study was to compare basal psychophysiology and startle reflexes in acute stress disorder (ASD) patients and controls. Stress reactions to traumatic event include acute and chronic reactions like ASD and posttraumatic stress disorder (PTSD). They are characterized by prominent psychophysiological symptoms that can give insight into the pathogenesis of PTSD. Methods: We measured heart -rate (HR), respiratory sinus arrhythmia (RSA), electrodermal activity (EDA) and electromyography (EMG) of musculus orbicularis occuli during an acclimation period and during the presentation of startle stimuli in 29 ASD patients with different traumatic experiences and in 33 healthy controls. Results: ASD subjects had similar habituation to the startle probe as healthy controls. EDA for individuals with ASD after traffic accident was higher then for healthy controls. There were no differences for heart-rate in two compared groups. Conclusion: EDA appears to offer the most reliable psychophysiological indices in the ASD following traffic accident.

Keywords: ASD, PTSD, psychophysiology, heart-rate, electrodermal activity, startle reflex

Introduction

Acute stress disorder (ASD) as an acute reaction to a traumatic event and posttraumatic stress disorder (PTSD) as a prolonged reaction are characterized by re-experiencing, avoidance and hyperarousal symptoms [1]. ASD and PTSD differ in request for the time of the occurrence of symptoms and their duration, as well as in dissociative symptoms that are prerequisite for ASD. Peritraumatic dissociation within ASD was recognized as an important predictive factor for subsequent PTSD [2-3] and not as an adaptive coping mechanism as it was regarded earlier [4]. Results of some of the psychopsysiological studies have indicated a difference in suppression of autonomic response (sympathetic and parasympathetic) in individuals who develop high peritraumatic symptoms in the aftermath of trauma [5].

Psychophysiological symptoms are prominent for both disorders. There is strong evidence for biological dysfunction [6-7], as well as for physiological activation during stressful events in a pathogenesis of PTSD. Activation of the autonomic nervous system in the response to trauma [8-12] with physical correlates can be corroborated using the laboratory methods. Laboratory assessment is typically noninvasive and recorded from different systems in the body, cardiovascular system, electrodermal and electromyographic with typical measures for each of those, under different conditions [9]. Most of the studies have addressed baseline conditions, response to startling sounds and trauma cues.

Exaggerated startle response is one of the early symptoms of both ASD and PTSD and has been proven to be sensitive predictors of the PTSD outcome [10]. In a quantitative review of psychophysiological studies of PTSD it was found that PTSD is associated with persistent hyperarousal, exaggerated responses to startling sounds and elevated responses to external and internal trauma reminders [11-12].

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1. Aim

To examine the psychophysiological indicators of acute stress disorder.

2. Methods and participants

The data presented here is part of a larger-scale prospective investigation of the psychophysiological parameters of ASD and PTSD that is conducted at our Department. All participants were informed of the research study and signed an informed consent form approved by the Committee for Ethical Conduct of Research, University Hospital Dubrava. ASD subjects were evaluated within the first month after the traumatic event.

The Acute Stress Disorder Structured Interview [13] was used to asses ASD symptoms. The Peritraumatic Dissociative Experiences Questionnaire [14] was used to evaluate the dissociative experiences in the ASD group. The Mini International Neuropsychiatric Interview, Croatian version, [15] was applied to both groups of participants and was used to assess other psychiatric disorders in ADS group and to exclude psychiatric disorders in control group.

Laboratory assessments included the baseline recording and physiological response to sudden and loud tones. The study included 62 participants in total: 35 male and 27 female patients. The ASD group comprised of 29 subjects: 16 males and 13 females; healthy controls comprised of 33 subjects: 19 males and 14 females. The traumatic events experienced by the ASD subjects in the current study included traffic accidents (16 participants) and violent attack (13 participants). The average age of the ASD patients was 38.4 years, and the age of the controls was 41.5 years.

3. Psychophysiological Assessment

Assessment and procedures were part of a study done in cooperation with the team in Atlanta, GA, USA, and were published (see: T. Jovanovic, S.D. Norrholm, A. Jambrošić Sakoman, S. Esterajher, D. Kozarić-Kovačić, Altered Basal Psychophysiology and Startle Response in Croatian Combat Veterans with PTSD, International Journal of Psychophysiology 71 (2009), 264-268.) See the description of the Biopac (Biopac Systems, Inc., Aero Camino, CA) system assessment and startle procedure.

4. Exclusion criteria

Persons with substance abuse, suicidal behavior, epilepsy, craniocerebral injuries, neurological disorders, history of a prior psychotic episode, schizophrenia, bipolar disorder, dementia, mental retardation, sight and/or hearing impairment and any major acute or chronic medical illness were excluded.

5. Statistical Analyses

The dependant variables were the following physiological measures: Startle, Tonic Skin Conductance (SC), SC change, Tonic Heart-rate (HR), Respiratory sinus arrhythmia (RSA) and HR reactivity. Startle magnitude was measured from the EMG of the orbicularis occuli muscle; we used the peak amplitude recorded between 20 to 200 ms after the startle probe offset. Tonic SC was averaged over six seconds during the five acclimation phase trials and for six seconds after the offset of the startle probes. SC change was defined as the average increase (from a 1 s pre-startle baseline) from three to six s after the startle probe offset. Tonic HR and RSA measures were averaged over ten seconds during the acclimation trials and after each startle probe trial. HR reactivity was calculated by averaging the IBI change (from the 1 s pre-startle baseline) during the first three seconds after the startle probe offset.

In order to examine the effects of the startle probe on the above physiological variables we used a 2 X 7 mixed analysis of variance (ANOVA) with GROUP (ASD vs. CONTROL) as the between-groups factor, and TRIAL (7 STARTLE TRIALS) as the within subject factor. Interaction effects were followed-up by one-way ANOVAs. In order to deal with sphericity violation, we used the Huynh-Feldt term of the repeated-measures ANOVA. Alpha was set at 0.05. Effect sizes of the individual effects are reported using partial Eta square (η^2). All analyses were conducted using STATISTICA 7.1 (16).

5.1 Results

5.1.1 Startle magnitude

We analyzed the peak startle amplitude using a 2 X 7 mixed ANOVA with GROUP (ASD vs. CONTROL) as the between-groups factor and TRIAL (7 STARTLE TRIALS) as the within subject factor. We found a significant main effect of TRIAL ($F=3.16$, $p<0.01$, $\eta^2=0.052$); however, there was no GROUP difference in startle magnitude and no interaction of GROUP and TRIAL.

5.1.2 Electrodermal activity

Skin conductance response (SCR) during the startle trials were analyzed using a 2 X 7 mixed ANOVA with GROUP (ASD vs. CONTROL) as the between-groups factor and TRIAL (7 STARTLE TRIALS) as the within subject factor. We found a significant main effect of TRIAL ($F=14.97$, $p<0.01$, $\eta^2=0.208$, and a significant main effect of GROUP ($F=5.233$, $p<0.01$, $\eta^2=0.155$); and no interaction of GROUP and TRIAL. We found statistically significant difference between groups, for the ASD-traffic accident group at the level of $p<0.01$.

5.1.3 Electrocardiogram activity

Tonic HR during the startle trials was analyzed using a 2 X 7 mixed ANOVA with GROUP (ASD vs. CONTROL) as the between-groups factor and TRIAL (7 STARTLE TRIALS) as the within subject factor. We found no effect of GROUP, TRIAL and no interaction of GROUP by TRIAL.

Analysis of RSA during the startle trials was analyzed using the 2 X 7 mixed ANOVA with GROUP (ASD vs. CONTROL) as the between-groups factor and TRIAL (7 STARTLE TRIALS) as the within subject factor. We found a significant main effect of TRIAL ($F=2.18$ $p<0.05$, $\eta^2=0.036$), and no interaction of GROUP by TRIAL. The polynomial contrasts were significant for linear term ($F=7.34$; $p<0.01$, $\eta^2=0.112$).

The data from the first psychophysiological recording, within the first month following the traumatic event, were analyzed. We found that ASD patients in general habituated to the startle probe to the same degree as healthy controls. Skin conductance levels during the startle phase increased for patients with ASD following traffic accident group compared to healthy subjects. This result is consistent with increased activity of autonomous nervous system.

These results are not final because of the follow-up design of the study.

Conclusion

In summary, the present study found an increase in skin conductance response in ASD patients following traffic accident. Exaggerated startle response in this sample, as it was reported in earlier studies, was not observed.

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SECTION IV

CLINICAL OBSERVATIONS

Cybertherapy is a field that is growing rapidly due to today's technology and information boom.

Virtual Reality and advanced technologies have been used successfully to in a variety of healthcare issues, including treatment of anxiety disorders and phobias, treatment of eating and body dysmorphic disorders, neuropsychological assessment and rehabilitation and distraction during painful or unpleasant medical procedures.

The novel applications of these technologies yield many advantages over traditional treatment modalities, and the disadvantages that accompanied the first trials of virtual reality are quickly being addressed and eliminated.

Virtual reality peripherals such as data gloves, physiological monitoring and Internet worlds are swiftly demonstrating their usefulness in cybertherapy applications.

Wiederhold & Wiederhold, 2004

Presence is Just an Illusion: Using fMRI to Locate the Brain Area Responsible to the Meaning Given to Places.

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Abstract: Researchers have suggested different models to describe the feeling of presence. Most of them imply that presence is some kind of alternate state. Research conducted in our research team lead us to consider presence simply like a very powerful perceptual illusion, with the addition of challenging the meaning given to the place where the user actually is (i.e., being "there"). The aim of this study is to investigate the neural correlates of the illusion of presence in VR. Five right-handed adults were scanned in the fMRI and were immersed in two conditions: high and low presence, where the exact same stimulus was presented to participants during each condition but the context (narrative) provided differed significantly. Results show a clear, specific and statistically significant involvement of the parahippocampal area, the brain responsible for giving contextual meaning of places.

Keywords: Presence, fMRI, parahypocampus.

Introduction

Being immersed in virtual reality (VR) can create the subjective impression of being "there" in the virtual environment (VE) [1,2]. The illusion of presence requires processing multimodal input (visual, auditory, tactile, kinaesthetic or olfactory) from the VE to form coherent perceptions so the VE can be recognized as "real", and integration of these multimodal stimuli into some egocentric reference frame is needed so the user feels that he or she is within the environment. A previous study [3] showed that it is possible to increase presence simply by manipulating the narrative context of an immersion in VR (i.e., without changing any objective properties of the VE). It opened the possibility of studying neural correlates of presence without creating artefacts induced by the modifications of the stimuli (i.e., comparing immersions with/without sound, or in mono/stereoscopy would predictably stimulate different brain areas).

After a brief overview of studies suggesting that presence is simply a perceptual illusion, we will report on a study investigating neural correlates associated with the illusion of presence in VR.

1. Method

Five adults (all right-handed, three females, two males, mean age of 33) provided their informed consent and were submitted to a standardized psychiatric assessment to ensure qualification for study participation. Selection was based upon severalexclusion criteria (e.g., not suffering from a mental disorder, based on the Structured Clinical Interview for DSM-IV-Non-Patient Edition [4]). During the experimental task, participants first visited a staff room adjacent to the fMRI scanner room and were informed that during their brain scan they would at times see a live video-feed from this room (high presence condition) or a 3D copy of the room (low presence condition). Participants were scanned in the fMRI using a 1.5 Tesla scanner. A preliminary rapid sagittal T1-weighted scan was used as a localizer to verify participant head position and image quality. For the experimental scan, a three-dimensional gradient echo acquisition was used to collect 160 contiguous along with a 1 mm T1 weighted structural images in the sagittal plane for corregistration with the Echoplanar images. Structural images were acquired using the modified International Consortium for Brain Mapping T1 Protocol. The VE was displayed using a stereoscopic fMRI-friendly HMD (Silent Vision SV-7021) and sets of noise cancellation headphones to reduce the loud ambient noise caused by the scan. The localization of brain areas was based on the Wake Forest University PickAtlas (v. 2.3).

For the high and low presence conditions, the exact same virtual stimuli were presented to participants during each condition. However, the context (narrative) provided to the participants differed significantly In the high presence condition, participants were informed, via instruction provided in the HMD, that the images were coming directly from the adjacent staff room, “relayed in real time from the real staff room”. In the low presence condition, they were informed, via instruction provided in the HMD, that the images were copies of the adjacent staff room. The paradigm we used was a repeated measures condition where each participant saw the “real staff room”, thenand then the “copy of the staff room”, followed again by the “real” and the “copy” of the staff room. During each immersion, participants observed as the camera flew over the VE and were asked to look at the details.

At the fMRI clinic, participants met the research assistant who provided a visit of the experimental set-up in the staff room and explained that, “we want to know which areas of the brain are involved in the experience of VR by using a high tech device that will take images of your brain in action. For the very first time, we were able to create a system that allows projecting, in real time, images taken from the adjacent staff room and project it directly, live, in the fMRI scanner. Therefore, you will be able to see this room, as you are just doing now, but through the eyes of VR. Our cameras will record images in real time as they move in the room and send them to our computers and our VR software; they will recreate the VR and send it directly into the scanner. The cameras will move along a predetermined path so you will not have anything to do but let yourself be immersed in the virtual environment and look around. We also built a copy of this staff room. After having the unique chance of being immersed in the real staff room, we will also show you a copy of the staff room. The experience will be repeated twice, so you will again see the real room and the copy of the room.” Once placed in the fMRI scanner, the HMD was adjusted for clear vision and a first scan was performed to ensure participants had no brain abnormalities. For the experimental scan, the instructions were projected in the HMD once more, “in this unique experience, you will visit the real staff room, then a copy. This will be repeated twice. Let go, observe these virtual environments and we will talk about it after the scan.” Then a message appeared in the HMD indicating, “live staff room. Let go of yourself and take the time to observe the virtual environment” and the 60-second immersion in the VR environment began. In the next condition, a message appeared in the HMD indicating, “copy of staff room. Let go of yourself and take the time to observe the virtual environment” before the 60-second immersion. The two immersions were repeated before participants stepped out of the scanner and were debriefed.

2. Results

Significant differences were found in only one structure, located in the medial temporal lobes. Both the right and left parahippocampus (uncorrected, $p < 0.001$) were significantly activated by the experimental manipulation. Significant cluster of voxels in the right parahippocampal gyrus (MNI 28 -4 -36) cluster size KE= 5 cluster was activated, as well as a significant cluster in the left parahippocampal gyrus (MNI -28 -16 -24) cluster size KE = 5 cluster.

3. Conclusion

The design of this preliminary study was based in previous findings [3] where manipulating the context or narrative associated with the immersion statistically influenced presence. Any other manipulation involving the properties of the stimuli would have blurred the results by recruiting other areas of the brain.

Despite the small sample size, clear and significant results were obtained in one specific region, the parahippocampal cortex. This area of the brain mediates the representation and processing of contextual associations [5]. The parahippocampus provides contextual meaning of scenes and places. Our results follow this recent finding and suggest that contextual processing may be involved in feelings where events are happening in a VE, or where the person is during the immersion in virtual reality. We propose that an immersion in VR create a strong perceptual illusion that triggers three events: (a) basic reflex reactions, (b) integration of sensory information, and (c) self-reflexive conscious-cognitive dissonance. We propose that conscious-cognitive dissonance involves the parahippocampal gyrus and constitutes what is usually referred to as Presence.

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Contributions of Functional Magnetic Resonance in the Field of Psychological Treatments with Virtual Reality

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Abstract. Many studies have been developed using brain imaging methods to investigate psychological disorders. On the other hand, there are many studies that make use of virtual reality (VR) to simulate a real condition during psychological treatments. In this research, we plan to analyze brain activity during the exposure to a virtual environment related to phobias. Our first goal is to study the possibility of activating brain areas related to phobias, specifically phobias to small animals (spiders and cockroaches), using virtual reality as stimulus, while the patient is inside a functional magnetic resonance imaging (fMRI) machine. The second goal of the research is to analyze if there are differences in the activated areas after patients have followed a psychological treatment for this specific phobia. That is why two different sessions with fMRI will be performed, before and after an intensive treatment for the phobia. In the fMRI room, participants will wear special glasses to visualize the VR environments in which they have to navigate (using also a joystick adapted to fMRI). They will have to perform some tasks while being exposed to the phobic stimuli. The VR environment used in the fMRI sessions has three different conditions: first, a clean room without spiders or cockroaches; second, the same room, but dirty and disordered (giving the sensation of having small animals, although actually there are none); third, the same dirty room but having spiders and cockroaches. It is our hypothesis that the patients will get anxious in the situation in which it is possible that the animal appears and the patterns of brain activation will be different in this condition.

Keywords. Virtual Reality, phobia, fMRI

Introduction

Many studies have taken advantage of the goodness of fMRI to analyze brain activation in different experimental conditions. Between the reasons for its use, it can be pointed out that fMRI is not invasive and has not secondary effects. Magnetic resonance uses frequencies in the non-ionizing range (10-100 MHz), which are totally benign to the patient, so the experiments can even be repeated several times in order to compare the results between different moments.

The fMRI technique is based on the monitoring of changes in the blood oxygenation and blood flow in the brain. It has a spatial resolution between 1 to 3 mm, and a temporal resolution in the order of 1s for the complete volume of the brain [1]. However, there are also drawbacks with the resonance magnetic methods. First of all, exploration times are long. Secondly, the fMRI machine is big and expensive. Thirdly, one of the most important limitations of this technique is that the machine uses magnetic fields, so it works like a big magnet and no metallic objects can be introduced in the exploration room. That is the reason for using adapted devices for virtual reality environments that have to be visualized in an fMRI room, more specifically the glasses to visualize the environment and the joystick to navigate through it. Finally, it is

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uncomfortable for the user, who has to be in a supine position while hearing the noises generated by the machine.

There are many areas where fMRI's studies can take place, such as the study of mental disorders, medical diagnosis (brain tumors) or investigations about brain performance. There are also works where brain activation generated by a specific psychological disorder is analyzed. That is the case of phobias [2] and, more precisely, spider and cockroach phobia [3]. These phobias consist of an irrational fear before any possible contact with the animal. This fear is associated to a continuous state of anxiety when there is a possibility of finding it [4], a repulsion response before any representation of it [5] and a defensive reaction in case of contact [6]. Some of the previous studies [3-4-6] have analyzed spider phobia using fMRI to study the activation of related brain areas, such as the amygdala. For example, Paquette et al. [3] performed an fMRI examination before and after a psychological treatment to analyze the differences between both moments. The results they got were that the brain areas related with phobias were no longer activated after the treatment. These studies use images of real animals or videos to stimulate activation of brain areas related to the phobia during the fMRI examination.

On the other hand, much research has been done combining VR with fMRI, for example, for motor rehabilitation [7] or for pain distraction [8]. However, the research field of phobias combined with VR and fMRI is unexplored yet.

VR has been employed for many years in the field of mental disorders and clinical psychology to help the therapist during the treatment. Moreover, it was used by Carlin et al. [9] to develop a treatment of spider phobia using VR. In this work, VR was used for the treatment itself. Subjects were monitored during the treatment by means of questionnaires and physiological measures, such as skin conductivity or heart rate. Brain imaging techniques, that can provide a more reliable analysis of the processes that occur in the brain during the exposure to phobia stimuli, were not used in this study.

In the present work, based on Foa and Kozak's approach [10], our main interest is to analyze the brain areas related to anxiety and fear in the brain, which have to be activated during a psychological treatment in order to achieve successful results. It is fundamental to understand how these areas are activated in the presence of the phobic stimuli to improve actual psychological treatments.

Our first goal is to demonstrate that we can obtain activation levels similar to previous fMRI studies about spider phobia which used videos or photographs, but using virtual spiders and cockroaches included inside environments where it is possible to navigate and make some tasks.

Our second goal is to analyze if there are differences in the activated areas after patients have followed a cognitive-behavioral therapy for this specific phobia.

fMRI has been used to monitor brain activation during the exposure to different virtual environments, some of them related to the phobia. Two different fMRI examinations where performed, before and after following a psychological treatment for spider and cockroach phobia. It is our hypothesis that the degree of activation of the brain areas related to the phobia will be reduced after the treatment.

1. Method

The study is currently being performed in the Hospital General of Castellon, using a 1.5 Tesla magnetic resonance unit. There are 30 participants: 20 phobic subjects and 10 control subjects. Patients have been diagnosed by experienced psychologists. All of them are right-hand females with ages between 19-30 years. A homogeneous group of females has been selected because previous studies have shown that they are more emotive before the stimulus is shown, so the activation in their brain is expected to be higher [2].

An initial fMRI examination is made at the beginning of the process for all the subjects. After that initial fMRI examination, the phobic subjects receive an intensive psychological treatment for their phobia. The 20 phobic subjects are divided in two groups of 10 subjects. Each group will receive a different treatment, to allow posterior comparisons between them. The control group receives no treatment. A month after the first fMRI session, all the subjects go to a second fMRI examination. The different stages during each fMRI examination are described below.

Before entering in the fMRI room, subjects do a training process to learn to navigate in a virtual environment. Furthermore, they answer some questionnaires related to the phobia and to hemispheric dominance.

Then, subjects enter in the fMRI room and the fMRI examination is performed. They have to wear special glasses (VisuaStim Digital, Resonance Technology Inc.) to visualize the environment and a helmet to fix their head and avoid any movement. Subjects also use a MRI compatible joystick (Resonance Technology Inc.) to navigate through the environment. Both the glasses and the joystick are adapted to the magnetic fields inside the magnetic resonance unit.

Our study uses as stimuli virtual environments where subjects can navigate freely during short periods of time (about 20 seconds to avoid the possible habituation effect). The virtual environments have been developed with GameStudio. Different experimental conditions are applied in a repetitive and counterbalanced way in all the experimental groups:

- A clean room without spiders or cockroaches.
- The same room, but dirty and disordered (giving the sensation that small animals can appear).
- The same dirty room but with spiders and cockroaches.

The subjects are trained to search for some red keys that will appear and disappear during the task. That assures us the subject is always on movement in the virtual environment, so when the small animals appear, they do not just look to another side of the room and stop moving.

The different experimental conditions have been designed to minimize differences between them, so that the brain areas in which activation differences are observed between conditions are related to the presence of phobic stimuli and not to other factors. That is why subjects are specially trained to move the joystick all the time and tasks, such as key searching, are common to all the conditions.

Figure 1. Captions of the environments.

2. Results

We have started the experimental sessions with the control group. The sessions with patients will begin soon and we expect to have results available in the following months.

At this moment, we can just hypothesize what we will obtain, supported by previous results in related experiments. Firstly, we expect brain activation obtained with the virtual reality environments to be similar to the studies that used images of real spiders as stimuli, or even higher. Furthermore, we expect the areas related with the specific phobias will reduce their activation after the psychological treatment, getting an activation map more similar to control subjects'. Finally, we also hypothesize that the activation in the control subjects will remain the same in the second fMRI session, demonstrating that nothing has changed between both moments.

We will specially analyze the activation of amygdala, which is a commonly detected area in studies related with phobias.

3. Conclusions

Virtual Reality allows us to emulate the reality trustworthy, obtaining similar results to that obtained with real methods. In this work, we expect that it will generate the same brain activation patterns of fear/anxiety in phobic subjects that are observed in the presence of the real feared stimulus. Apart from that, we expect that areas detected as activated by phobic stimuli will stop their activity after psychological treatments for the phobia, obtaining an activation map similar to the control subjects.

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Sounding Better: Fast Audio Cues Increase Walk Speed in Treadmill-Mediated Virtual Rehabilitation Environments

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Abstract. Music or sound effects are often used to enhance Virtual Environments, but it is not known how this audio may influence gait speed. This study investigated the influence of audio cue tempo on treadmill walking with and without visual flow. The walking speeds of 11 individuals were recorded during exposure to a range of audio cue rates. There was a significant effect of audio tempo without visual flow, with a 16% increase in walk speed with faster audio cue tempos. Audio with visual flow resulted in a smaller but still significant increase in walking speed (8%). The results suggest that the inclusion of faster rate audio cues may be of benefit in improving walk speed in virtual rehabilitation.

Keywords. Virtual reality, audio cues, gait speed, treadmill walking

Introduction

Music and sound effects are often added to Virtual Environments (VEs) in an attempt to enhance engagement or enjoyment. However, Virtual Reality (VR) is being used increasingly for motor rehabilitation, and it is not yet known whether audio input may not only enhance engagement but also influence the speed or quality of movement of individuals moving in VEs. Treadmill-mediated VR has the potential to be used for locomotor rehabilitation [e.g.1-4], but indiscriminate use of audio without understanding its effect on the desired outcomes could confound treatment goals. If audio is to be included in VR rehabilitation environments, it is important to understand whether, and how, it affects gait, and thus how audio cues can be utilized to facilitate the achievement of therapeutic goals.

There is evidence that music can influence cadence (step tempo) and effort in exercise [5, 6] and also that increased audio beat frequency can increase walk speed [7-9] and decrease gait variability [10,11]. However, music can also influence mood (affect) during exercise [6], and this altered affect can modulate gait kinematics [12]. Furthermore, the type of music also has a differential effect on gait kinematics [5, 6, 13]. Nevertheless, although it has been observed that walking with music is a rich multidisciplinary topic [8], it is also clear from a wide range of studies that there is an underlying effect of audio tempo on gait, whether delivered as music or as a simple metronome-type beat. Indeed a number of researchers suggest that the body has an intrinsic ability to synchronise to an external rhythmic cue [13-15], and this may have the potential to enhance walking rehabilitation.

However, to date there is little research into the effect of audio cues in Virtual Reality. Moreover, it has previously been noted that self-speed estimation is altered when walking in VR [4, 16, 17], and it is not known whether this visuo-motor modulation may interact with the effect of audio cues on walking speed. Thus it cannot be assumed that the results of previous 'real-world' studies can be generalized for application in Virtual rehabilitation. This paper reports a preliminary study investigating the influence of gait-referenced audio cue tempo on treadmill walking in Virtual Environments.

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1. Method

Eleven healthy adults (4 male, 7 female, aged 23-54) participated in the study. All participants were familiarized with the self-paced motorized treadmill placed in front of a large (5mx3m) display screen. A virtual walkway lined with pillars was back-projected on the screen (Figure 1). During the test conditions the image of the walkway was either static on the screen (no visual flow) or linked to the treadmill via a virtual camera (VR condition - visual flow present). The VR condition was matched to the treadmill speed, such that each 1m walked on the treadmill advanced the participant 1m in the Virtual Environment.

Figure 1. Walking in treadmill-mediated VR.

Previous work had demonstrated that baseline cadence (step frequency) differs between treadmill and over-ground walking [18], therefore a 3-min baseline walk test was conducted on the treadmill, during which average speed (m/s) and cadence (steps/s) were recorded. Participants then walked for 3 minutes in each of the test conditions (Table 1) in pre-randomised and counterbalanced order.

Table 1: The combination of audio cue rate and visual flow used in the experimental conditions

Audio Cue rate as % of baseline cadence	none (baseline)	75%	100%	125%	none	75%	100%	125%
Visual flow linked to treadmill motion	absent (no VR)				present (VR)			

2. Results

Table 2: Mean speed (m/s) and cadence (steps/s) for audio condition in the presence and absence of visual flow

Audio Cue rate as % of baseline cadence	**Visual flow absent (no VR)**		**Visual flow present (VR)**	
	Speed (m/s)	**Cadence (steps/s)**	**Speed (m/s)**	**Cadence (steps/s)**
no audio	1.12	1.76	1.16	1.77
75%	1.24	1.78	1.07	1.70
100%	1.20	1.77	1.13	1.75
125%	1.30	1.87	1.26	1.86

A two-way ANOVA (audio x visual) for gait velocity showed a significant main effect of audio cue tempo ($F_{3,30} = 4.69$ $p < 0.05$). Participants walked fastest in the 125% audio-only condition, with a 16% increase in gait speed compared to baseline ($p<0.01$), and an 8% increase compared to matched audio cue tempo. There was no significant difference between the other conditions (**Figure 2**).

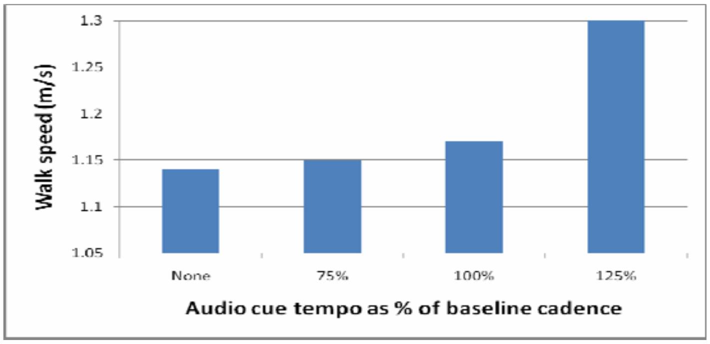

Figure 2. Modulating effect of audio cues on walk speed.

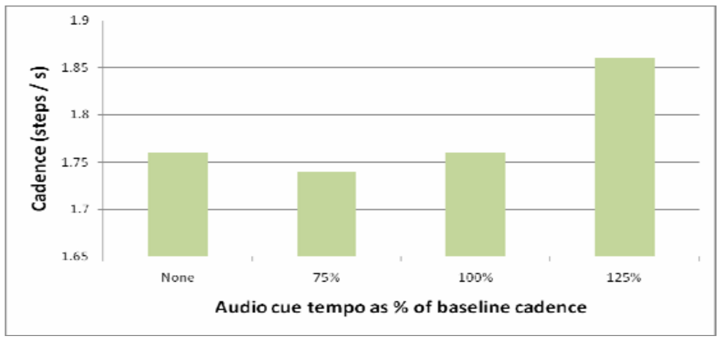

Figure 3. Modulating effect of audio cue tempo on cadence.

There was however a significant interaction between the audio cues and visual flow ($F_{3,30}$ = 3.45 p <0.05). In both the fast and slow cue conditions, participants walked significantly slower in VR than with audio alone. However, the participants walked faster (8%) in the 125% VR condition, compared to baseline.

For cadence there was a significant effect for audio cues ($F_{3,30}$ = 2.89 p = 0.05), with a 6% increase in cadence in the 125% audio condition compared to baseline and matched audio conditions. There was no significant difference between the other conditions (Figure 3). There was no significant effect of visual flow on gait cadence.

3. Discussion

This study demonstrated a clear effect of audio cue frequency on treadmill walk speed, with audio cues above baseline step frequency being associated with a significant increase in walk speed. This is consistent with the findings of previous studies [7-9]. Although there is a natural tendency for humans to synchronize movements to external audio rhythms [9, 13], the increased walk speed is achieved by a combination of increased cadence and increased stride length. This supports the observations of Durgin *et al*. [19], who note that step length/cadence is maintained at a relatively constant ratio across varying walk speeds.

This study extends previous work, by evaluating the effect of audio cues when the treadmill was linked interactively to a virtual environment. In the presence of visual flow there was still a significant effect of audio cue frequency on walk speed, although there was difference in the effect in the fast and slow audio conditions. It has previously been observed that perception of self-motion is altered in treadmill-mediated VR [e.g. 16, 17], leading to visuo-motor recalibration [20], and this may influence the magnitude of the effect of the audio cues. However, one would expect this to be consistent across all audio conditions, but it was observed that the VR only changed the effect of audio cues in the conditions where the cues were in conflict with the preferred cadence. This suggests that a different mechanism of action needs to be considered.

Auditory and visual stimuli both require attention, which can be considered to be a finite shared resource [21]. In the presence of audio cues alone, there is sufficient attention to respond to the cues, but by adding the visual cues the attention is divided between two cues [9]. Audio cues which are in conflict with the preferred cadence may disrupt the automatic synchronicity of walking, necessitating more conscious attention. The suppression of the effect of audio on walk speed by the addition of visual flow may therefore be attributable to a reduction of attention to the audio cues in the presence of a competing attentional load. It is notable that there is a marked difference in the effect of the slow audio cues between the two conditions. In the audio-only condition, the slow audio was associated with an increase in walk speed. Previous studies have noted the ability to 'double' a tempo [8], and this would be consistent with the speed increase seen with this cue frequency. However, in the VR condition the slow audio frequency was associated with a decrease in walk speed, which may be attributable to a decreased ability to double tempo with additional attentional demands.

4. Conclusion

This study demonstrated that the frequency of audio cues in treadmill-mediated VR can significantly influence walk speed. This supports and extends previous studies, which have indicated that rhythmic audio cues may have a facilitating effect on the descending motor pathways, giving rise to an increased walk speed with increased tempo. The results suggest that the inclusion of faster rate audio cues may be of benefit in improving walk speed in virtual rehabilitation, and further studies are underway to evaluate this effect in clinical populations.

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Multi-Modal Memory Restructuring for Patients Suffering from Combat-Related PTSD: a Pilot Study

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Abstract. The paper discusses the design and evaluation of a multimedia software application, which can be used in the treatment of combat-related posttraumatic stress disorder (PTSD). The application allows patients and therapist to visualize the patients' past experience using maps, personal photos, stories and self-created 3D virtual worlds. The tool aims to allow patients to restructure and relearn about their past experience involving the problematic stressors. Findings of a first experiment with non-patients (N=18) suggests that the tool can facilitate more detailed storytelling. Participants stated that using the application was appealing and enjoyable. Insights were also acquired with a case study of a veteran suffering from combat-related PTSD. This case study showed how a patient uses and interacts with the system in a therapeutic setting.

Keywords. PTSD, trauma-focused psychotherapy, memory, multimedia, restructuring, reappraisal

Introduction

Combat-related posttraumatic stress disorder (PTSD) is one of the health problems soldiers may face upon their return from deployment. As an increasing number of soldiers return from war situations, such as Iraq and Afghanistan, the demand for PTSD treatment is also likely to increase. A review of PTSD treatments by Schottenbauer et. al [1] reports high drop-out rates for Cognitive Behavioral Therapy (CBT) and Eye Movement Desensitization and Reprocessing (EMDR). In an attempt to increase appeal relative to traditional face-to-face talk therapy, interest has gone out to developing other methods for improving activation of the traumatic memory during exposure therapy, thereby providing a treatment approach that may be more attractive to some service members. The proposed system presented in this paper explores the possibility of using computer-assisted technology to support trauma-focused psychotherapy, to be used both in a group therapy setting as well as a single patient-therapist setting. Supporting the treatment with computer-assisted technology is, however, not new; recently Virtual Reality Exposure Therapy (VRET) has been extended to the treatment of PTSD. Patients are exposed in virtual reality worlds resembling war situations, such as those in Iraq [2]. Using the here proposed Multi-Modal Memory Restructuring (3MR) System; patients can now build these virtual worlds themselves and link them to a specific day on a timeline, together with media, such as personal pictures and geographical maps. This way the system aims to give the patient more flexibility to restructure, reappraise and narrative about their deployment and to manage various deployment related memory elements themselves with the purpose to facilitate time sequencing of memory content.

1. 3MR system

Traditional treatment of veterans with deployment related PTSD is often set within a group context as soldiers are familiar to operate in a group [3]. In these sessions, patients talk about their experiences, in an exposure based format, facilitated by the drawing of maps and other visual aids. Usually a flap–over as well as maps and photographs are used to facilitate memory content. Often memory is compromised and due to

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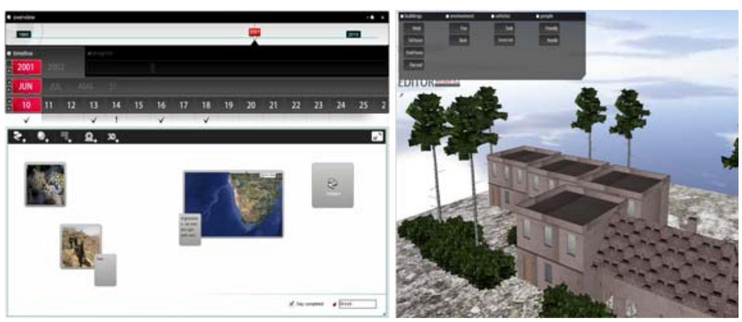
memory distortions or amnesia for details these elements can be quite helpful. The 3MR approach takes this a few steps further. The 3MR focus does not lay on direct exposure, but on the way patients facilitate and manage their memory to restructure and relearn about their past experience involving the problematic stressors. Patients are invited along a set timeline to sequentially add media and self-created virtual 3D worlds, patients are able to express and rethink about their experiences during their time of deployment. The 3MR system provides contextual information in various modalities to these experiences. It is designed to run on a laptop with a projector displaying the computer screen on the wall for the group members to see. This in itself creates a safe zone, in which direct eye contact among members can be legitimately avoided; some patients do not like to be stared at during their exposure, and others do not want to look at someone in a potentially distressing state. Additionally, a camera is attached to the laptop allowing snapshots from photos or objects patients brought with them. The system support consists of several elements:

1. Information of patient is created, as a digital space or folder.
2. The session starts with a projection of a timeline set on the present day. From here the patient can move to a specific day of their deployment. To emphasize that this event has taken place in the past, the years and days from the present day to the selected day are counted back while showing photos of historical events of that time period.
3. Once the patient arrives at the specific day, they are asked to organize the event of that day by using their own photographic material, videos, or music, and by annotating satellite based geographical maps (Figure 1a). In addition, the patient can also use an easy-to-use 3D editor to recreate a specific scene (Figure 1b). Using these facilities the patient can restructure the events and place them, together with narrative elements, on a chronological timeline.
4. This can be worked through, commented on back and forth.
5. The session ends again by visually moving back from the event in the past to the present day. The way a patient initially perceives a past deployment may change if the patient continuously also adds positive pictures and documents to his or her timeline.

Although a past deployment is often related to traumatic events, the good memories, also related to the same deployment, are often forgotten. Photographs are usually taken during non stressful moments. This material can therefore be very useful, even though they are not directly linked to a stressor. In addition to these features, a psycho-educational element is incorporated to display the past and coming treatment sessions on the timeline. This gives the patient an overview of the entire treatment procedure.



a **b**

Figure 1. Left the timeline with content management (a), right the 3D world editor (b)

2. Analysis and design

The design of the system followed a situated cognitive engineering approach as described by Neerincx and Lindenberg [4]. It is an iterative approach where the requirements baseline is continuously refined as new insights are acquired through prototype evaluations and reviews with therapists. An inventory of envisioned technology, relevant human factors, and operational (therapeutic) demands was established during the domain analysis. This was done in close cooperation with a military psychiatrist experienced in treating PTSD patients. With this information scenarios and claims were specified, which resulted in three short films[2] focusing on (1) personalization of the system (timeline, own text annotations, and 3D virtual world),

[2] http://mmi.tudelft.nl/vret/index.php/PTSD

(2) the use of the 3D editor (pausing and resuming editing work, and interaction with the therapist and other group members), and (3) the return to a previous session (amending and extending previous work). These films were used in a review with ten therapists. At the start of the in-depth interviews, the films were shown to a therapist, followed by a discussion of the underlying claims on the usability and support of the therapeutic process. The three most noticeable changes made after the review were:

1. More modality was added to facilitate memory.
2. Options were introduced to personalize the system.
3. The patient was now able to tag or summarize a particular day with keywords.

Several prototypes were developed and after a heuristic evaluation and a continuous formative evaluation approach, keeping both experts and therapists in the loop, the proposed 3MR system was created and ready to be used in both an experiment and case study. It is important to note that the proposed system is a new concept and insights are necessary on what features of the system are of importance and how people would use the application. In this early stage the aim was not to acquire data to study the effectiveness of a treatment using the 3MR tool.

3. Experiment and case study

Before the case study with a real patient took place, an initial experiment was conducted to see if the system would support people in telling a story from the past. The participants were asked to tell two different autobiographic stories (e.g. holiday trips) of six minutes each, one with the help of the 3MR system and one without. The order in which the stories were told was counterbalanced. Prior to the storytelling participants already explored the 3MR system. A total of 18 people participated in this experiment, none suffering from a combat-related PTSD. Participants were allowed to bring related photographs with them to make the storytelling a bit easier. After both stories were told, each participant was asked to fill out a seven-point likert scale questionnaire. Using a one sample *t*-test, the following significant results (H_0*: score = 4, p < .001*) were acquired: (1) participants thought they put more details in the story told with the help of 3MR (*M* = 6.00, *SD* = 0.69), (2) comparing the two stories, they found more memories came back by using the application (*M* = 5.94, *SD* = 0.80), (3) participants enjoyed telling a story with 3MR more than telling a story without the application (*M* = 5.28, *SD* = 1.27) and (4) they thought the timeline was an essential component in a way a story was told (*M* = 5.50, *SD* = 1.29). Less positive seems the rating on whether the system encouraged them to use the features offered by the application (*t* (17) = 0.92, *p* = .37) (*M* = 4.39, *SD* = 1.79). Although there was no need to use them, as most of the components were designed specifically for soldiers with a PTSD, another reason could be that the available six minutes were too short to allow them to make use of the available features. Although the results from the questionnaires favor the use of 3MR, an additional analysis was done to see if the tool affected people's storytelling. For this analysis the sound recordings of only 12 participants could be used as 6 participants, mainly typed instead of talked when using the 3MR tool. The analysis focused on: (1) time referencing, (2) location, (3) event description and (4) time period covered. A Wilcoxon Signed-ranks test indicated that more participants mentioned a precise date with 3MR (*Mdn* = 2.50) than without (*Mdn* = 0.00), *Z* = -2.96, *p* = .003. The opposite was true when participants referred to a less precise time frame, *3MR-Mdn* = 1.5, *non-3MR-Mdn* = 4.0, *Z* = -2.77, *p* = .006. Concerning events, participants were more precise with the system (*Mdn* = 4.00) than without (*Mdn* = 3.00), *Z* = -2.56, *p* = .011. Examples of these events are actions, such as buying a cola and watching football on TV. Again the opposite was the case when participants referred to more general events, *3MR-Mdn* = 1.5, *non-3Mdn* = 3.0, *Z* = -2.46, *p* = .014. Going to a business trip and studying for an exam are examples of general events. Also, stories told with 3MR covered a smaller time period in months (*Mdn* = 0.13) than without (*Mdn* = 0.50), *Z* = -2.43, *p* = .015. However, the test indicated no significant difference (*p* > .05) when participants referred to locations.

A small case study of two clinical sessions was organized with a veteran with PTSD who has served in various deployments, such as Dutchbat I (Srebrenica). As the proposed system was a new concept, the aim was to acquire insights into how a patient would use and interact with the system. Before the case study started, the psychiatrist (EV) informed the patient of the study, explained what was going to happen and asked the patient to bring some photographs with him so he could add the data into the system during the first session. The patient was not new to treatment of PTSD; he was already undergoing another form of outpatient PTSD treatment at the time the case study was taken. Typically PTSD patients have difficulty to sequence events and experience distorted processing of time in the context of traumatic memories. A clinical environment was chosen for the observations, with the patient sitting behind a laptop and the therapist sitting next to him. After introducing the patient to the system, the patient created a profile by stating his name and adding the different deployments he was in. Instead of picking a date, the patient put all the collected (digital) photos on the first date of the deployment. Here, he also added various text elements to explain, in detail, what was shown on the pictures. Instead of letting the patient type the text, the therapist decided to do it. This way the patient could read what he just said and add details if needed. One of the most used features during the first session was the 'Google Maps' option. The patient occasionally added a snapshot of a map to the timeline. Using the maps, the patient was encouraged to go into details. He started talking about the things he saw and how things have changed compared to the time he was there. He also tried to find specific places and buildings he remembered from back then. The patient usually added elements to the timeline independently. However, he did not always provide much information. In these cases the therapist asked the patient to tell more about the things he experienced by encouraging to use the narrative element within the system. Overall, the patient was very pleased with the approach and suggested that the system might be interesting to be used at home. That way the patient can create an 'archive' of the past events at any time and share these stories with friends and family. The second meeting started with a reflection of what was discussed during the session conducted in the previous week. The patient mentioned that presenting memories and treatment visually was very appealing and, according to him, useful. He felt that by using the application he was aware of the events that happened a long time ago. Also, the patient liked that he was the one working on his own timeline. He felt that he was more in control of his own treatment and also thought that other veterans with the disorder would find this new approach appealing. For the second session the patient brought a document with him. The document was related to the deployment he was editing in the previous session and he thought it was useful for his timeline. The remainder of the session was focused on the events written in the document. Mainly interaction between the therapist and patient took place, putting the 3MR system aside for a while. Unfortunately the 3D editor option was not chosen during this small case study, but both psychiatrist and patient were hopeful that it would indeed help facilitate processing of complex stressful experiences.

Looking back at both the experiment and case study, participants found the system appealing and enjoyable to work with. It acts as an archive of memories and allows patients to manage this archive by adding various multimedia elements related to their memory. The proposed timeline was found to be a useful feature and the participants thought that more memories came back when using 3MR, in an accurate non-time distorted way. Results from the additional analysis showed significant differences in how a story is told, hinting at a more detailed way of storytelling. The veteran who participated in the case study was pleased with the system and felt encouraged to work with it as he saw the purpose of talking about past events by managing a media archive.

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Effectiveness of Brief VR Treatment for PTSD in War-Fighters: A Case Study

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Abstract. War-fighters exposed to combat are at high risk for developing posttraumatic stress disorder (PTSD), a complex and challenging condition to treat. Cognitive behavioral therapies (CBT) have been empirically validated as effective treatments for PTSD resulting from sexual assault, vehicular accidents, and disasters. Exposure, imaginal or in vivo, to the traumatic event is a central component of successful CBT treatment. Early studies indicate that CBT with brief virtual reality exposure (VRE) is beneficial in treating PTSD. The case study examined the effectiveness of brief VRE in treating combat-related PTSD.

Keywords. Virtual reality, PTSD, exposure therapy, combat

Introduction

War-fighters returning from Iraq (Operation Iraqi Freedom [OIF]) and Afghanistan (Operation Enduring Freedom [OEF]) report high incidences of anxiety, depression, and PTSD [1]. Recent mental health surveys indicate PTSD rates ranging from 12%-19% in OIF/OEF veterans[2]. Treatment of PTSD in these warfighters is often more challenging due to multiple deployments and the high comorbidity of depression, traumatic brain injury, and serious physical injuries.

Strong empirical evidence exists for the use of exposure-based CBT to reduce PTSD symptoms[3]. According to Emotional Processing Theory [4], CBT with exposure involves having patients access their emotionally upsetting memories of the traumatic event. By working through increasingly detailed recollections of the traumatic event with a skilled therapist, patients become more comfortable thinking about the event. As this occurs the disturbing memories become less intrusive, and fewer PTSD symptoms are experienced.

Immersive virtual reality (VR) may augment the effectiveness of CBT. Computer-generated VR imagery guides the patient back to the scene of the traumatic event, and assists him to access his own memories of the event. Remembering emotionally painful memories is difficult for PTSD patients Many patients are unwilling or unable to think about their traumatic event during therapy, which hinders emotional processing and impedes therapeutic progress. Preliminary studies have demonstrated the successful use of VRE with CBT in the treatment of anxiety disorders in the general population, including PTSD [5,6]. These results suggest that VRE may prove useful for treating PTSD in war fighters. The virtual environment's capacity to create sights and sounds similar to the battlefield may be a powerful therapeutic tool that the therapist can utilize to assist the war fighter to restructure maladaptive and distorted interpretations of the traumatic event that prolong his PTSD symptoms. The use of VRE in the treatment of combat-related PTSD is growing with positive preliminary results reported among Vietnam veterans [7] and active duty military personnel [8].

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Independent of several other research teams working on related projects, the current case study describes our initial efforts to treat combat-related PTSD in an OIF/OEF warfighter.

1. Methods

1.1 Participant

The participant was a married OIF soldier in his mid-20s with approximately six years of military service. He spent a total of 18 months in Iraq across two deployments, and was assessed to have chronic PTSD with strong avoidance issues. His level of combat exposure fell within the “heavy” range based on the Combat Exposure Scale[9].

1.2 Clinical Outcome Measures

The primary outcome measure used in this study was the Clinician Administered PTSD Scale (CAPS)[10]. The CAPS is a structured interview modeled to evaluate the DSM-IV criteria for PTSD, i.e., exposure to a traumatic event, re-experiencing, avoidance, and hyperarousal. In addition, the CAPS assesses the frequency and intensity of each symptom. Other outcome measures included self-reports of depressive symptoms (Beck Depression Inventory [BDI])[11], trauma-related guilt (Trauma Related Guilt Inventory [TRGI])[12], quality of life (Quality of Life Inventory [QOLI])[13], and PTSD symptoms (Posttraumatic Stress Diagnostic Scale [PDS])[14]. Assessments were conducted at pre- and post-treatment, and three months after treatment.

1.3 Procedures

The VRE treatment in our protocol is designed to include 10 treatment sessions with an initial psychoeducational session followed by 9 CBT plus VRE sessions (only 6 in the present case study). A well-trained PTSD therapist controls visual, auditory, and kinesthetic VR stimuli as the warfighter rides in a virtual Humvee on patrol in a Middle Eastern town. The Middle East VR environment was developed by our collaborators, Firsthand Technology, for treating PTSD in warfighters. The three-dimensional VR environment interfaces with a stereoscopic head-mounted display (HMD) for immersion, and a head position tracker to allow the war-fighter to “look around” in the virtual environment. The HMD is equipped with high-resolution microdisplays (1280 X1024), custom engineered optics for clear visual acuity, and a wide 60° field of view. Heart rate, skin conductance, temperature, and respiration are also measured during each session. Homework is assigned between sessions to reinforce skills learned during the sessions. These assignments include *in vivo* exposure and viewing a DVD recording of the most recent treatment session that includes the virtual environment.

In this case study, the participant completed 10 treatment sessions, 6 of which used VRE. Due to the participant’s impending training assignment and re-deployment, treatment focused on obtaining a detailed trauma narrative before beginning VRE. This task required three sessions. The last six sessions were dedicated to VRE.

2. Results

Figure 1 presents the scores obtained on the clinical outcome measures at pre- and post-treatment, and three months after treatment. There was a decline from pre-treatment to post-treatment scores on the CAPS, BDI, PDS, and TRGI. Scores on the QOLI increased from pre-treatment to post-treatment. At three months after treatment, scores on these measures were similar to the post-treatment scores, except for the QOLI score, which dropped below the pre-treatment score. Although statistical significance cannot be determined with these data, outcome scores on most of the measures showed a reduction of symptoms that was maintained at the 3-month follow-up. In addition, the participant reported positive changes in how he felt and thought about the traumatic events he experienced.

On the primary outcome measure, the CAPS, scores decreased considerably from a pre-treatment score of 90 to a post-treatment score of 25, to a 3-month post-treatment follow-up CAPS score of 16. The 3-month follow-up score indicated remission of PTSD. It is noteworthy that the avoidance symptoms score decreased steadily from 39 at pre-treatment to 13 at post-treatment to 0 at the 3-month follow-up.

The number of symptoms endorsed on the PDS decreased from 16 at pre-treatment to 4 at post-treatment, and this reduction was maintained at the 3-month follow-up assessment. In addition, the PDS symptom severity rating decreased from "severe" to "mild." The overall trauma-related guilt score decreased from 59 at pre-treatment to 15 at post-treatment, and was maintained at the 3-month follow-up. Depressive symptoms on the BDI decreased from 32 at pre-treatment to 18 at post-treatment, and to 15 at 3 months after treatment. The severity of depressive symptoms declined from "severe" to "mild" at post-treatment. However, the quality of life scores remained in the "very low" range across all assessment periods.

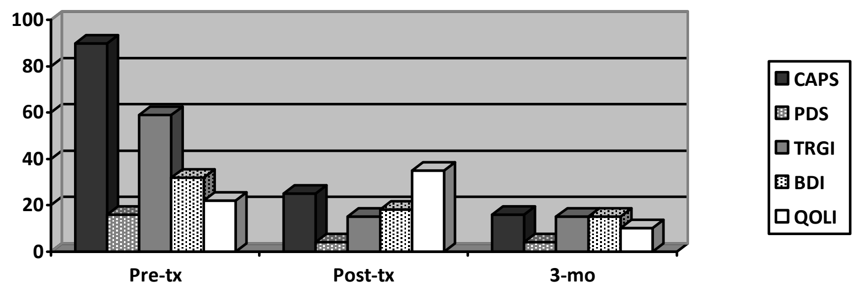

Figure 1. Outcome measure scores at pre, post, and 3 months after treatment

3. Discussion

Reductions on many of the outcome measures suggest that VRE treatment resulted in positive changes, and reductions in PTSD symptoms. The CAPS showed a marked decrease in overall score and large clinically relevant reductions in the number of PTSD symptoms reported. The avoidance symptom cluster decreased continuously from pre- through post-treatment and at the 3-month follow-up. Anecdotally, at the end of treatment the participant reported feeling more at ease about going to places that he had previously avoided such as shopping centers, and greater comfort with expressing his feelings and thoughts about the traumatic events he had experienced.

Interestingly, no changes were observed in his QOLI scores. With the decrease in PTSD symptoms, positive changes in his quality of life may have been expected. It is possible that his approaching re-deployment to Iraq and other life events such as being away from his wife and newborn child may have negatively affected these ratings.

Overall, the results of the current case study are encouraging. The participant tolerated the virtual reality exposure very well, and reported no adverse reactions, e.g., nausea or dizziness, during any of the VRE sessions. He reported that the HMD helped him to feel as if he was "there" in Iraq, and made the scene seem "real" to him. The virtual environment enabled him to remember the event more clearly and to recall details that he had forgotten.

Although some benefits of VRE are identified, limitations of this report must be noted. First, results should be interpreted with caution as case studies are scientifically inclusive by nature. For example, the changes observed may be attributed to the treatment process in general, and not necessarily to the use of VR in the treatment. Second, the results reported are descriptive and based on one participant. Larger randomized clinical trials such as our current research project are needed to determine the efficacy and viability of VRE in treating combat-related PTSD. Without effective treatments, many OIF/OEF warfighters and veterans with PTSD may suffer significant long-term psychological, occupational, social and physical health problems, which will place a considerable healthcare burden on society.

This case study provides preliminary support for the use of VRE in treating combat-related PTSD. Additional research and development is needed to further refine VRE treatment of PTSD in warfighters and civilian populations. It is essential that more randomized controlled studies be conducted to empirically isolate the added benefit, if any, of augmenting CBT with immersive VRE. Treating PTSD in OIF/OEF war-fighters while they are still on active duty is challenging. Work demands, e.g., trainings and unscheduled duties, make regular attendance for treatment difficult. Many war-fighters with PTSD have had several deployments and experience multiple traumatic events that contribute to the disorder. High drop-out rates for those in PTSD treatment [15] suggest PTSD treatments that accelerate symptom reduction and reduce the length of treatment are likely to increase efficiency and improve outcomes [16-17]. The development of these treatments are an important direction for future research.

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A Myoelectric-Controlled Virtual Hand for the Assessment and Treatment of Phantom Limb Pain in Trans-Radial Upper Extremity Amputees: a Research Protocol

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Abstract. At least 90% of individuals of limb amputees experience phantom limb pain (PLP). Recent clinical research suggests that providing patients with the mirror image representation of the amputated limb may alleviate PLP. However, mirror therapy cannot be used with bilateral amputees, as visual feedback is dependent on the movement of the intact limb. To overcome this limitation, we designed a novel myoelectric-controlled virtual reality (VR) system for the treatment of phantom limb pain in trans-radial upper extremity amputees. The proposed system allows the patient to directly control the virtual limb by recognizing stump muscle patterns recorded with EMG sensors. The hypothesis behind this strategy is that the VR image of the amputated limb induces better limb imagery than the reflected image of their intact limb and, therefore, is more effective in reducing PLP. A research protocol to test this hypothesis is described.

Keywords. Phantom limb pain, virtual reality, EMG, myoelectric, recognition, real-time control

1. Phantom limb pain

It has been estimated that at least 90% of individuals of limb amputees experience phantom limb pain [1]. Clinical research suggests that providing patients with the mirror image representation of the amputated limb may alleviate PLP [2]. In a randomized controlled trial in patients who had undergone amputations of lower limbs (n=22), Chan and collaborators [3] found that mirror therapy was effective in reducing PLP. However, the use of mirror therapy is associated with methodological limitations, highlighted by previous research [4]. Mirror therapy cannot be used with bilateral amputees, as visual feedback is dependent on the movement of the intact limb. Further, conventional mirror therapy requires the patient to maintain attention on the reflected image as opposed to the moving anatomical limb. Finally, the mirror box requires the patient to operate from a fixed position.

2. Virtual reality in the treatment of PLP

A possible solution to overcome the drawbacks of conventional mirror therapy is to use augmented reality (AR) or virtual reality (VR) technology to generate a graphical representation of the limb moving in the three-dimensional space. Desmond and collaborators [5] developed and evaluated an "augmented reality mirror box" to allow

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artificial visual feedback to be generated independently of contra-lateral limb movement, thus facilitating presentation of phantom limb movement. The AR system consists of a 3D graphical representation of an arm displayed on a flat screen controlled by a wireless data glove worn on the intact arm, which measures finger flexure and the orientation of the user's hand. The information received from the glove is fed back to the computer so that the image on the screen appears to the participant to move in real time. However, the small number of patients involved in the trial (three) did not allow these researchers to draw conclusions on the clinical efficacy of the treatment.

Murray et. Al [4] designed an immersive VR system to treat phantom limb pain. The VR system provides participants with a 3D virtual representation of the phantom limb by transposing the participant's opposite anatomical limb into the phenomenal space of their phantom limb. Data glove and sensors were used for upper-limb amputees, while sensors were used for lower-limb amputees. The virtual representation of the phantom limb is presented through a head mounted display equipped with head-tracking sensor. The authors evaluated the efficacy of the VR system in a case-series study (n=5). Although this study was small, findings were promising, with the majority of participants reporting reduction of their phantom limb pain throughout testing.

3. Myoelectric-controlled virtual hand for the treatment of PLP

Building on previous research [3-5], the goal of this project is to design, develop and test a novel immersive VR system for the treatment of phantom limb pain in trans-radial upper extremity amputees. Differently from the above-described technological solutions, the proposed system allows the patient to control, in real-time, the virtual limb by means of a pattern-recognition algorithm applied to EMG signals recorded by a g.USBamp (g.tec Guger Technologies, Austria, Europe). The goal of this approach is to recognize, also from residual muscles of transradial amputees, different types of grasping movements and the related strength [6]. The myoelectric-controlled virtual limb is visualized in a head-mounted display equipped with head-tracking sensor.

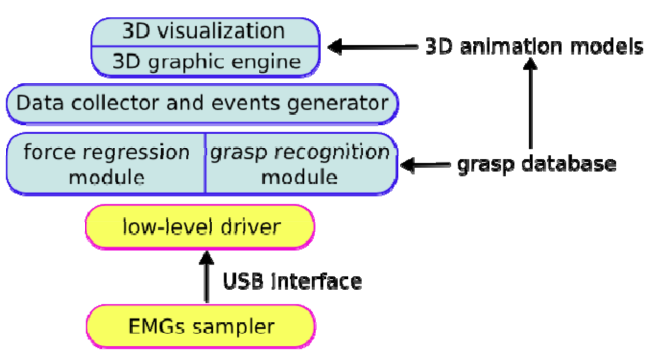

Figure 1. Architecture of the myoelectric-controlled virtual limb

4. Research protocol

The hypothesis behind this strategy is that the VR image of the amputated limb induces better limb imagery than the reflected image of their intact limb and, therefore, is more effective in reducing PLP.

To test this hypothesis, 40 consecutive patients with PLP resulting from traumatic upper-limb amputation are randomly assigned to one of two groups: one that view the myoelectric-controlled virtual limb (VR group), and one that view a mirror image of their intact limb (mirror group). Patients are included on voluntary basis. The Groningen Questionnaire Problems after Amputation (GQPA) is used for defining patients suitable for inclusion in the clinical trial. The exclusion criteria are: upper extremity paralysis after neurological lesions; sensory alterations (caused i.e. by diabetic neuropathy or by lesions to sensory nerves); cognitive deficits (Mini-Mental State Examination < 21).

The treatment protocol for both groups consists of 15-20 minutes daily therapy for a minimum of two weeks. Pre- and post-assessment measures include the Brief Pain Inventory, which is used to assess the intensity of pain (the sensory dimension) as well as the degree to which pain interferes with function (the reactive dimension) and the stump muscle EMG activity.

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Combined Functional Electrical Stimulation (FES) and Robotic System for Wrist Rehabiliation after Stroke

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Abstract. Functional electrical stimulation (FES) and rehabilitation robots are techniques used to assist in post-stroke rehabilitation. However, FES and rehabilitation robots are still separate systems currently; and their combined training effects on persons after experiencing a stroke have not been well studied yet. In this work, a new combined FES-robot system driven by user's voluntary intention was developed for wrist joint training after stroke. The performance of the FES-robot assisted wrist tracking was evaluated on five subjects with chronic stroke. With simultaneous assistance from both the FES and robot parts of the system, the motion accuracy was improved and excessive activation in elbow flexor was reduced during wrist tracking.

Keywords. Functional electrical stimulation, rehabilitation robot, stroke rehabilitation

Introduction

The extent of restoration of limb functions after experience a stroke is highly associated with the intensive practice of the affected limbs by their own neuromuscular efforts[1]. Functional electrical stimulation (FES) can stimulate the muscles through electrical current, which generates limb movement by activating a person's own muscles to restore motor functions and also evoke sensory feedback during muscle contraction to the brain to promote motor relearning[2]. Rehabilitation robotic systems can provide external assistive support to body parts (e.g. limbs), which help persons to experience limb movements at the paretic side to improve related sensory-motor functions during limb movements[3]. Currently, FES and rehabilitation robots are still separate systems. In comparison with FES, robot systems uses the motor to provide external assistive forces; it does not have the same effect as FES, which directly activates a person's own motor power from the paretic muscles to generate assistive force. However, difficulties also could be met when using FES to activate groups of muscles with dynamic limb movements, since electrode size and the number of FES channels would be challenges of whether the paretic muscle groups could achieve movements with desired kinematic qualities, such as speeds and trajectories. In this work we developed a combined FES-robot system, which may assist in wrist rehabilitation training for persons after stroke interactively to their voluntary residual motor intentions.

1. The FES-Robot System

The experimental setup diagram of the FES-robot system is shown in Figure 1. The system could assist wrist tracking for persons after stroke continuously and interactively according to their voluntary electromyography (EMG) from the paretic upper limb. A subject would be asked to conduct the wrist flexion and extension in a horizontal plane from -45^o (extended position) to 60^o (flexed position) to track a target cursor moving with a constant speed. During the tracking, continuous assistance from the robot and the FES parts would be provided, proportional to the real time EMG amplitude of the flexor carpi radialis (FCR) in the flexion phase and extensor carpi radialis (ECR) in the extension phase.

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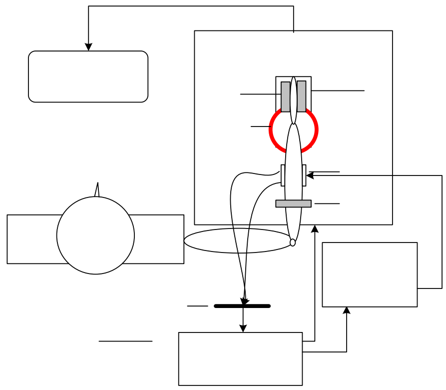

Figure 1. Experimental setup diagram of the FES-robot system for wrist training

The detailed control algorithm for the assistive FES and torque from the FES and robot parts could be described as follows

$$\text{Assistance}_{\text{FES-robot}} = \text{Assistance}_{\text{Robot}} + \text{Assistance}_{\text{FES}} \quad (1)$$

where, $\text{Assistance}_{\text{FES-robot}}$ represented the ultimate support from the FES-robot system, $\text{Assistance}_{\text{Robot}}$ was the supportive torque from the robot part applied to a manipulandum (Figure 1), $\text{Assistance}_{\text{FES}}$ was the electrical stimulation from the FES part applied to the FES electrodes on target muscles. The robot assistance generated was controlled by

$$T_a = \begin{cases} G \cdot T_{IMVF} \cdot M_{Flexion}, & \text{During the flexion tracking phase} \\ G \cdot T_{IMVE} \cdot M_{Extension}, & \text{During the extension tracking phase} \end{cases} \quad (2)$$

where, T_a represented the motor generated assistive torque in the flexion or extension phase during the tracking, G is a constant gain used to adjust the magnitude of the assistive torque (ranging from 0 to 1 and set before experiment); and T_{IMVE} and T_{IMVF} are the maximal values of the torque during isometric extension and flexion respectively, at the wrist angle of 0^o [4, 5]. $M_{Flexion/Extension}$ was defined as

$$M_{Flexion/Extension} \equiv \frac{EMG_{m,Flexion/Extension} - EMG_{mREST}}{EMG_{mIMV} - EMG_{mREST}}, \quad (3)$$

where $EMG_{m,Flexion/Extension}$ was the EMG of the agonist muscle, *m*, in its contraction phase during the tracking (e.g. the EMG of FCR during the wrist flexion phase, or the EMG of ECR during the wrist extension phase); EMG_{mREST} was the averaged EMG level of the muscle, *m*, during its resting state; and EMG_{mIMV} was the maximal EMG value of the muscle, *m*, during its isometric voluntary contractions (IMVC).

The assistance from the FES part was defined as

$$\text{Assistance}_{\text{FES}} = \begin{cases} K \cdot W_{max,FCR} \cdot M_{Flexion}, & \text{During the flexion tracking phase} \\ K \cdot W_{max,ECR} \cdot M_{Extension}, & \text{During the extension tracking phase} \end{cases}, \quad (4)$$

where, K is a constant gain factor set before experiment, ranging from 0 to 1, $W_{max,FCR/ECR}$ is the maximum stimulation impulse width applied on the FCR or ECR muscles, which were the threshold values to evoke maximal wrist flexion and extension when the forearm was put horizontally on a table with the wrist joint started at its neutral position. $M_{Flexion/Extension}$ had the same meaning as in Eq 3. The stimulator of the FES-robot system could generate biphasic square impulses with adjustable pulse width, constant stimulation frequency of 40 Hz, and constant stimulation magnitude of 100 V.

2. System Evaluation in Wrist Tracking

The developed FES-robot system was evaluated on its assistive function on wrist tracking tasks by persons after stroking. In the evaluation, two different wrist tracking speeds, i.e., 10^o/s and 20^o/s, were used. For each tracking trial, there were 5 cycles of wrist flexion and extension from -45^o to 60^o. Five subjects with chronic stroke (at least1 year after the onset of a stroke, male, aged from 36 to 56 with mean±SD=48±7) were recruited after obtaining approval from the Human Subjects Ethics Sub-Committee of the Hong Kong Polytechnic University. All of the subjects were hemiplegia due to single cerebral unilateral ischemic event, whose spasticity of wrist flexion/extension at the paretic side was measured by the Modified Ashworth Scale (MAS, equal to 1.8±0.7 at the wrist joint, and 1.6±0.5 at the elbow joint) [6]. Each subject was required to conduct wrist tracking tasks supported by the FES-robot system with five different assistive combinations as shown in Table 1, and two different tracking speeds (i.e., 10^o/s and 20^o/s). In the tracking tasks, EMG signals were collected from the muscles of FCR, ECR, biceps brachii (BIC), and triceps brachii (TRI). The tracking performance was evaluated by EMG activation levels [4, 7, 8], root mean squared error (RMSE) between the target and the actual tracking positions, the maximal range of motion (ROM) during tracking. Each tracking task was repeated twice, and the mean value of an evaluation parameter from a subject was taken as an experimental reading for statistical analysis. During the evaluation, a rest of 2 minutes was taken by a subject to avoid fatigue; and the sequence of the evaluation trials with different combinations of assistance was randomly assigned.

Figure 2 shows the RMSE and the maximal ROM of the subjects during the wrist tracking tasks with different FES and robot assistive combinations and with the two different tracking speeds, i.e., 10^o/s and 20^o/s. The RMSE reflected the wrist tracking accuracy of the tested limb. It was found that with a faster tracking speed (20^o/s), the tracking performance was lowered when no assistance was provided from the FES-robot system (in case of m0f0). With pure support from the FES part, the tracking RMSE had the largest mean values for both tracking speeds. The RMSE had the relatively low values in the assistive patterns of m5f5, m1f1, and m1f0. It suggested that with the support from the robot part, or the combined supports from both the FES and robot parts, the tracking performance was improved. Different tracking speeds affected the maximal ROM greatly (Figure 2). In the tracking trials with 10^o/s the maximal ROM were significantly larger ($P<0.05$) than those with 20^o/s in assistive patterns of m1f1, m0f1, and m0f0. The mean values of the maximal ROM for m5f5, m1f1, and m1f0 were higher than those for m0f1 and m0f0 ($P<0.05$), in which the assistive pattern of m1f1 had the highest mean values for both tracking speeds. The data in RMSE and the maximal ROM implied that with the supports from the FES and robot parts the overall tracking performance could be improved, in comparison with those no system support at all or the pattern with only FES assistance.

Table 1. Combinations of assistances from the FES and robot parts. The FES gain (K) and robot gain (G) are in accordance with the definition in Eq 2, and in Eq 4.

System Assistance	FES Gain K	Robot Gain G
M5f5	50%	50%
M1f1	100%	100%
M0f1	100%	0%
M0f0	0%	0%
M1f0	0%	100%

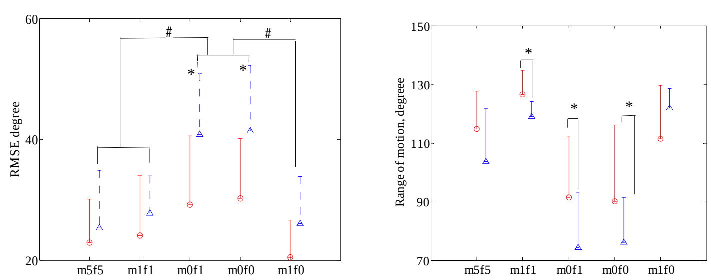

Figure 2. The RMSE and the maximal ROM achieved by the subjects with different FES and robot assistive combinations and with different tracking speeds (circles are for 10^o/s, deltas are for 20^o/s). Differences with statistical significance ($P<0.05$) were denoted by “#” with respect to the FES and robot combinations (ANOVA tests) and “*” to the tracking speed (t-tests).

Figure 3 shows the EMG activation levels of the antagonist muscle pairs related to the wrist and the elbow joints. It was found that most of the FCR EMG activation levels with FES assistance were higher than those without FES ($P<0.05$, 1-Way-ANOVA). It was because that during electrical stimulation on the

FCR, evoked muscular potentials besides the voluntary EMG could be detected in the experiment. However, higher ECR EMG activation levels during assistive patterns with FES (m5f5, m1f1, m0f1) were not observed in this study, especially in the cases with the tracking speed of 20^o/s. It was possibly due to the significant muscle weakness in the wrist extensor, in comparison with the spastic flexors in persons after stroke [8]. In the experiment, most of the subjects had more difficulties in following the tracking target moving with 20^o/s than with 10^o/s. The subjects always paused in tracking when they felt hard to follow the target cursor in trials with 20^o/s. It could be a reason for the lowered EMG activation level in tracking with 20^o/s even with FES assistance. This was also associated with the worse tracking performance measured with the RMSE and the maximal ROM. The EMG activation levels for the BIC muscle were lowered in the assistive patterns with FES (m5f5, m1f1, m0f1) compared to the patterns of m1f0 and m0f0 with the tracking speed of 10^o/s ($P<0.05$, 1-Way-ANOVA), which implied that the elbow flexor was relaxed in the wrist tracking, whereas the pure robot-assisted tracking could not lower down the activity in the elbow flexor.

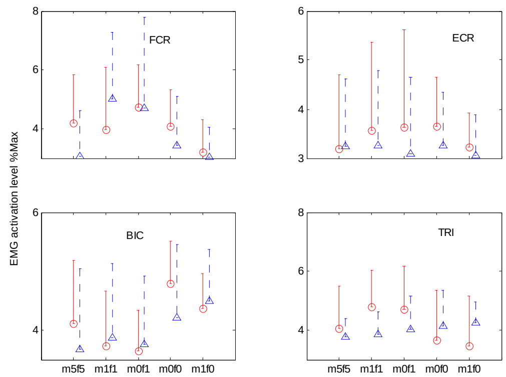

Figure 3. The EMG activation levels of the muscles of FCR, ECR, BIC, and TRI during the tracking tasks with different FES and robot assistive combinations and with different tracking speeds (circles are for 10^o/s, deltas are for 20^o/s).

3. Conclusions

A novel FES-robot system for post-stroke rehabilitation on the wrist joint was developed. With the assistance from the FES and robot simultaneously, the wrist tracking performance was improved in the aspects of the increased ROM, reduced RMSE, and reduced muscle activations in the elbow flexor during the wrist tracking. Clinical trial studies will be conducted to investigate the training effectiveness on persons after stroke in our future study.

Acknowledgements

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Lean on Wii: Physical Rehabilitation With Virtual Reality and Wii Peripherals

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Abstract. In recent years, a growing number of occupational therapists have integrated video game technologies, such as the Nintendo Wii, into rehabilitation programs. 'Wiihabilitation', or the use of the Wii in rehabilitation, has been successful in increasing patients' motivation and encouraging full body movement. The non-rehabilitative focus of Wii applications, however, presents a number of problems: games are too difficult for patients, they mainly target upper-body gross motor functions, and they lack support for task customization, grading, and quantitative measurements. To overcome these problems, we have designed a low-cost, virtual-reality based system. Our system, Virtual Wiihab, records performance and behavioral measurements, allows for activity customization, and uses auditory, visual, and haptic elements to provide extrinsic feedback and motivation to patients.

Keywords. Virtual rehabilitation, tele-rehabilitation, virtual reality, Nintendo Wii

Introduction

The use of low-cost, commercial gaming systems for rehabilitation has received substantial attention in the last few years. Systems such as the Nintendo Wii encourage players to use natural actions to play games (e.g., swinging the arm to roll a bowling ball, or jogging in place to make a virtual character run). The Wii (and similar systems) has been integrated into rehabilitation programs [1] and has gained the support of occupational therapists because it is easy to use and has a wide variety of games available. While the Wii does have benefits, the games are not designed specifically for rehabilitation, leading the Wii to have many limitations: it cannot accurately monitor and track patients' progress, games are often too difficult for patients, and there is a lack of appropriate and motivating feedback for patients. By combining the benefits of Virtual Reality and the Nintendo Wii, we have developed a rehabilitation system, Virtual Wiihab, that can be used in the hospital (by a patient with a therapist) or at home (by a patient, monitored over the Internet by a therapist).

1. Wiihabilitation Today

The Nintendo Wii has been adopted by a number of practitioners to assist in the treatment of various impairments. The Wii has been successful because the environments that it creates are entertaining, thus encouraging patients to continue therapy for longer periods of time [1]. Typically, Wii Sports games such as boxing, bowling, or golf are used during therapy sessions because they encourage gross motor movements [2]. One study using Wii Sports reported increased postural control and visual perception in an adolescent with cerebral palsy [3].

Most recently, the Wii Balance Board was used to improve balance and stabilitiy. Following the use of four Wii Fit games that use the Balance Board, one post-stroke patient showed improvements in various measures of motion and balance (e.g., timed up-and-go, functional reach and the Berg balance scale) [4]. A separate study compared Wiihabilitation treatments to traditional treatments and found that Wii-based interventions result in similar improvements in functional outcomes [5]. This study also reported higher

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levels of patients' satisfaction with the Wii-based rehabilitation compared to a standard rehabilitation regimen.

While the Wii has had much success in rehabilitation, it has a number of problems that prevent it from becoming widely adopted for rehabilitation:

- The motions and interactions required are not focused on rehabilitation outcomes, such as increasing range of motion or muscle strength.
- Game difficulty is calibrated to healthy players, making many games unplayable or too challenging for people with physical disabilities.
- The game scores or progress measurements that are provided are too generic, making them insufficient for tracking patient progress.
- Therapists cannot observe patient progress, watch for cheating, or monitor compliance when patients play games in tele-rehabilitation scenarios.
- There is currently no rehabilitation-specific feedback provided to patients to help guide or motivate their movement or motions.

2. Virtual Wiihab System

The Virtual Wiihab system consists of a standard Windows-based PC in conjunction with off the shelf Wii peripherals. Virtools 4.1 was chosen as the software backbone of the system because it has an add-on package that enables virtual environments to be exported to Wii Console disks or distributed via WiiWare. By combining Virtools with the SNaP framework [6], it is easy to retarget each activity for a CAVE, a head mounted display, single or multiple computer monitors, or a television.

2.1. Overview

The Virtual Wiihab system addresses the Wiihabilitation deficiencies identified in Section 1 in a number of ways:

Rehabilitation focus. Each activity was designed with specific target areas or disabilities in mind. In some activities, patients are encouraged to work on movement precision and postural control, and in other activities patients are encouraged to work on their balance and stability. There are also no loading screens or time-wasting animations. This ensures that patients have the opportunity to maximize the amount of time they spent performing rehabilitation activities.

Customization. Each activity can be customized to meet patients' skill sets or limits of mobility. Across all activities, the sensitivity of the Wii Balance Board (and Wii Remote) can be modified to encourage large movements in patients who do not move very much, or to encourage small, accurate motions in patients who make uncontrolled, spastic movements. Other customizations allow therapists to change the speed of moving objects, the number, size, and location of goal objects, and the frequency and number of stimuli. These customizations allow therapists to change task requirements as patient progress through their rehabilitation program.

Measurement. Virtual Wiihab can record a number of behavioral and performance measurements. The system can record data from the Wii Balance Board and Wii Remotes (e.g., accelerations, button presses, weight distribution, etc.) as well as a number of time-based measurements, such as the time-on-task, the time between user interactions, or the duration of actions (e.g., how long a button is pressed down or how patients' centers of gravity are distributed over time). Recordable performance measurements include the final activity score, the number of 'missed' stimuli, and the number of actions patients perform (e.g., the number of objects thrown).

Feedback. Virtual Wiihab presents patients with a variety of extrinsic feedback cues. Auditory feedback can be played through speakers. Visual feedback can be presented using overlays (e.g., an on-screen Balance Board sprite). Haptic feedback can be presented using the 'rumble' feature on a Wii Remote. Therapists can specify the type of feedback (e.g., visual, auditory, or haptic), the feedback schedule (e.g., concurrent, terminal, or delayed), and the intensity of feedback.

Monitoring. The use of a simple web service allows Virtual Wiihab to be used for tele-rehabilitation purposes. Performance and behavioral measurements can be uploaded and viewed using a web service and authorized web clients. Web clients can enable patients and therapists to view charts, graphs, or animations of task compliance and progress, and should help to identify areas of improvement for the future.

Multi-Player. Each activity can support both single and multiple player interactions. This allows patients to work with other patients, or to interact more directly with their therapists. This functionality has the potential to motivate patients to continue an activity longer than if they were doing it on their own.

2.2. Rehabilitation Specific Activities

The Virtual Wiihab system contains four activities (Snowball Fight!, Mouse House, Startle Fish, and Alien Abduction) that aim to increase trunk control, lower extremity stability, and patient balance. Each activity is suitable for the young and old, as well as a variety of patient abilities. To increase patient compliance and motivation, each activity can be played competitively against a partner (e.g., a family member, a fellow patient, or the therapist).

In Snowball Fight activity, a patient is standing, sitting, or kneeling on a Wii Balance Board and is required to lean from side to side to dodge incoming snowballs that are thrown by an opponent. In order to throw snowballs at an opponent, the patient uses a Wii Remote. The speed, angle, and distance of a snowball depend on the motion of the Wii Remote in the air. If a snowball hits the patient, the Wii Remote in their hand rumbles. Snowball Fight should encourage a patient to work on their dynamic postural control and movement accuracy. Snowball Fight can be played individually or with a partner. In individual mode, the patient plays against a computer-controlled enemy penguin that is throwing snowballs at the patient. If played with a partner, the partner plays the role of the enemy penguin.

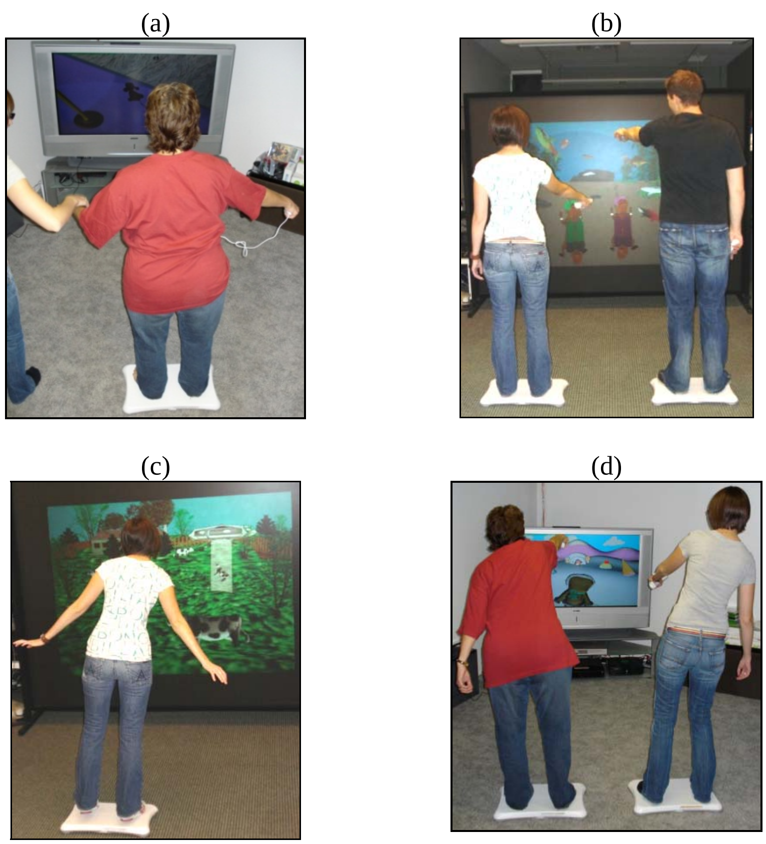

Figure 1: Patients interacting with: a) Mouse House, b) Startle Fish, c) Alien Invasion, d) Snowball Fight

In the Mouse House activity, the patient plays the role of a mouse that searches through a large virtual house to find pieces of cheese. In this activity, the patient uses a Wii Balance Board and a Wii Remote. The patient can sit on, stand on, or kneel on the Balance Board and use it as a navigation interface by shifting their weight to move the virtual mouse. This activity challenges the patient to exercise balance and movement precision. This activity can be played individually or with a partner. In partner mode, both players have their own Wii Balance Boards and view a split-screened virtual environment. In this mode, the players compete against each other to collect the pieces of cheese. This activity could be used to target or evaluate asymmetries in movement accuracy and trunk control.

In Startle Fish, the patient plays a diver and has to remain as still as possible to avoid being eaten by the virtual sharks. As the patients sway on the Wii Balance Board, they attract attention from the aquatic life surrounding them. If the patient moves their center of gravity too much, the Wii Remote in the hand rumbles, and if a pre-determined movement threshold is exceeded, a shark eats the patient's character. The therapist can choose to make this a competitive activity by introducing a second player (who plays a second diver) and ask both players to outlast each other. Alternatively, players can be asked to spear as many aquatic animals with the Wii Remote as possible while still maintaining balance on the Wii Balance Board. The therapist can also change the magnitude and frequency of the visual, auditory, and haptic stimuli that are presented.

In the last activity, Alien Abduction, the patient is the leader of a group of aliens who want to abduct as many animals as possible. The game is set in an abandoned farm field that contains a number of farm animals. A patient must move their center of gravity to different sections of the Balance Board and keep balance in this position (for a predetermined duration) to 'beam' objects up to the spaceship. While an object is 'beaming' up, the Wii Remote in the patient's hand rumbles. If players do not remain steady on the Wii Balance Board, the object being 'beamed up' drops to the ground. This activity encourages patients to work on improving their static postural control, movement accuracy, balance, and lower extremity stability.

3. Conclusion

New methods of rehabilitation play a key role in restoring physical functions in an aging population. Current virtual reality-based rehabilitation and Nintendo 'Wiihabilitation' offer promising alternatives to traditional rehabilitation techniques, but both suffer from problems that prevent widespread adoption. We have presented a new system, Virtual Wiihab, which combines the flexibility of VR rehabilitation techniques with the availability and enjoyment of Wiihabilitation. Our system currently includes four rehabilitation-centric activities that demonstrate solutions to the problems that exist in the Wii and VR-based systems. The effectiveness and usefulness of the system is currently being evaluated in a local rehabilitation hospital.

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Therapeutic Games to Improve Attachment Capabilities and Protect Sexual Health

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Abstract. From the very beginning of life, man's fundamental needs for acceptance, security, trust, warmth and closeness can only be satisfied in relationships [1]. During infancy this is accomplished by body contact and the emotional experience of being taken care of, for instance by the sheltering manner in which an infant is held during breast-feeding. Through this parental loving care the modus of satisfying psychosocial fundamental needs by skin contact is learned by the infant and reinforced on a neuronal level, the way all processes of learning elementary skills generally are. According to present knowledge, chronic lack of security transmitted by frustration of psychosocial fundamental needs increases the probability of developing psychological and physical disorders. Furthermore it hinders overcoming prevailing diseases [2]. In developing therapeutic computer games this phylogenetically established programming for attachment in order to fulfill fundamental psychosocial needs will be the focus of interaction, cognitive triggers and strategic as well as emotional rules to be applied in the games which are designed in a modular way for difficult developmental phases (e.g. adolescence) or various chronic diseases. This is a new approach transferring sexological clinical experience into therapeutic computer games for prevention purposes and protection of sexual health.

Keywords Therapeutic Games, Applied Games, Attachment, Chronic Diseases, Paraphilias, Sexual Health

Introduction

Clinical experience in sexual medicine reveals the increasing difficulties people have in obtaining sexual and/or attachment satisfaction which is often cause for seeking therapeutic help. From a diagnostic point of view, disorders of sexual function, of sexual development but also of sexual preference and sexual behavior are in the center of attention. At the same time - always as a decisive factor of influence concerning reduced life quality - there is a frustration of fundamental basic needs for acceptance, security, trust, warmth and closeness within a partnership. This is also true for chronic diseases or, as in the case of mental retardation, restrictions in social communication capabilities. It is becoming obvious that computerized "applied games" or "serious games" are playing an increasingly important role in curing psycho-emotional destabilization [3,4,5]. On the other hand there are games like a game for female adolescents, where a devaluated stereotype female is generated for young girls and the main aims are making your look attractive, staying slim and financing breast enlargements. With this negative example in mind it seems to make sense to develop "applied games" focusing on other relevant issues, such as trying to enhance cognitive and social competence as well as emotional and attachment capabilities of the players.

1. Approach and Methods

The general idea is to set up a basic concept – a kind of e-sexual health engine - which can be adapted to different fields and be adjusted to reach different target groups (adolescents, the chronically ill, mentally retarded persons and individuals with sexual preference disorders) by employing special modules. The center of interest is a preventive approach with the aim of conveying the latest scientific findings about what enhances sexual and/or attachment satisfaction and which individual skills need to be improved in

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order to get desired results – always specifically adjusted for the intended target group. The project has setup a catalogue of application areas as follows:

- Chronic diseases (e.g. prostate cancer and breast cancer patients) focusing on the resources of partner relationship
- Sexual education of mentally handicapped individuals to prevent sexual behavior problems
- Sexual education of adolescents focusing on fundamental needs of bonding and preparation for respective dangers and disrupters
- Disorders of sexual preference (paraphilias) focusing on the assessment and management of related difficulties

Each of the fields is of enormous epidemiological impact, which is even true for disorders of sexual preference [6]. Basic tools are to be adapted and adjusted for these indications. All effects are measured using standardized proceedings to evaluate social competence including empathy capability and cognitive distortions.

Game success will depend on the degree of empathy for partners and/or within the social network. Negative impact is generated by the degree of cognitive distortions, showing a self-centered perspective etc.

Concerning the paraphilias an exact diagnostic opinion concerning the underlying disorder registering the social competences and the educational status has to precede game application.

Within a combined applied-game approach (methodology from Sexology and Information and Communication Technology) sexology experts define desirable social competences for a set of target groups based on previous analysis. Competences are then mapped on a specification of behavior sequences and interactions within the applied game based on experience with various target groups who are mapped visually and by virtual behavior on a set of game characters and game environments (avatars as well as selected social/geographic environments). A structured criteria catalogue defines actions and reactions and their corresponding value in respect to the desirable goals. Behavior and decisions of the players are later monitored, evaluated against this criteria catalogue and they will trigger specific feedback procedures in order to influence the game progress. A book of duties written by the department of computer science in co-operation with game designers contains a modular structure of software requirements based on the analysis and specifications above. It also defines requirements for tools, applications, data structures, game engine and visualization details. Following the design and implementation phase a test and evaluation phase will be setup in order to identify, enhance and further develop game modules and improve social competence.

2. Results

It has been shown that computer-based interventions can be designed to assist in the therapy of behavior disorders, such as motivating drug users to work on some of their habits [7], and they can be useful for educational goals, for example to teach at risk population about AIDS/HIV [8]. When revealing sensitive private information, participants have been found to be more candid with automated data-collection systems than in case of interacting with a human interviewer [9]. From a sexological point of view, this is particularly the case when dealing with data on intimacy and sexual practice. On the other hand there is accessibility by using virtual images, even for the mentally handicapped, transporting sexually humiliating issues (see Figure 1 and 2 [10] from a picture series showing sexual abuse of a handicapped female to be used for educational purposes offering appropriate response strategies).

Figure 1 and 2. Picture series showing sexual abuse of a handicapped female.

In a clinical sexological setting, individuals with paraphilia-related sexual arousal patterns, patients with chronic illnesses (like Prostate-Ca or Mamma-Ca), patients with mental retardation and even adolescents during their sexual maturation can be reached by learning about the existence of fundamental psychosocial needs. These therapeutic experiences could be enhanced by employing special therapeutic game modules, mainly aiming at prevention by helping to countersteer against a possible false attitude. In a first pilot study a prototype (therapeutic game) will be developed and put into practice with individuals belonging to the above mentioned groups.

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