Annual Review of CyberTherapy and Telemedicine

Interactive Media in Training and Therapeutic Interventions

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General Information

Annual Review of CyberTherapy and Telemedicine (ARCTT – ISSN: 1554-8716) is published annually (once per year) by the Interactive Media Institute (IMI), a 501c3 non profit organization, dedicated to incorporating interdisciplinary researchers from around the world to create, test, and develop clinical protocols for the medical and psychological community. IMI realizes that the mind and body work in concert to affect quality of life in individuals and works to develop technology that can be effectively used to improve the standards and reduce the cost of healthcare delivery.

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About the journal
ARCTT is a peer-reviewed all-purpose journal covering a wide variety of topics of interest to the mental health, neuroscience, and rehabilitation communities. The mission of ARCTT is to provide systematic, periodic examinations of scholarly advances in the field of CyberTherapy and Telemedicine through original investigations in the telemedicine and cybertherapy areas, novel experimental clinical studies, and critical authoritative reviews.

It is directed to healthcare providers and researchers who are interested in the applications of advanced media for improving the delivery and efficacy of mental healthcare and rehabilitative services.

Manuscript Proposal and Submission

Because Annual Review papers examine either novel therapeutic methods and trials or a specific clinical application in depth, they are written by experienced researchers upon invitation from our Editorial Board. The editors nevertheless welcome suggestions from our readers. Questions or comments about editorial content or policies should be directed to the editors only.

Manuscript Preparation
Manuscripts should be submitted in electronic format on CD-Rom or floppy disks as well as on 8½ x 11-in. paper (three copies), double-spaced format. Authors should prepare manuscripts according to the *Publication Manual of the American Psychological Association* (5th Ed.).

Original, camera-ready artwork for figures is required. Original color figures can be printed in color at the editors' discretion and provided the author agrees to pay in full the associated production costs; an estimate of these costs is available from the ARCTT production office on request.

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Editorials

Welcome to the second volume of *Annual Review of CyberTherapy and Telemedicine*. This publication encompasses a state-of-the-art collection of clinical trials for advanced technologies in mental health, rehabilitation, and disabilities. The quality and significance of the excellent work being presented within this volume reaffirms the fact that virtual reality and other advanced technologies can play a significant role in improving healthcare. It is our hope that by producing this publication, we may further strengthen and advance the efforts to enrich healthcare, improve the quality of life of our patients, and benefit from the remarkable technological revolution that is occurring.

For the past ten years virtual environments have been successfully used for the assessment and treatment of a variety of important mental health problems. It is therefore appropriate to ask, “What comes next?” Although four main areas are heavily represented in virtual therapy (anxiety disorders and phobias, eating disorders, neuropsychological assessment and testing, and distraction techniques during painful or unpleasant procedures), several new and exciting pilot studies and case reports suggest that many other applications can be fruitfully addressed through the continued application of rigorous clinical protocols and practice. As data continues to accumulate, an analysis of clinical outcomes and efficacy should become of paramount importance to assure the acceptance of virtual reality and other cybertherapy techniques by the larger community. It is important to carefully evaluate successful standard clinical protocols that may be easily adapted for use in virtual environments. Along with this evaluation, it is important to develop clearly articulated advantages and disadvantages of the various cybertherapy techniques. Continued tracking of available inexpensive and easy-to-use technology is another important consideration for the continued and future growth of cybertherapy. Explorations of virtual environments that allow for the interaction of the patient and therapist are one example of a potentially interesting and worthwhile approach.

I hope you find this volume to be both an exciting and useful addition to your bookshelf.

Brenda K. Wiederhold, Ph.D., MBA, BCIA
Co-Editor-in-Chief

Editorials

Cybertherapy can be considered the integration of telehealth technologies with the Internet and shared virtual reality. Although cybertherapy is a branch of telehealth, it is differentiated in several important ways: telehealth to date has been largely non-Internet based and has been characterized by point-to-point (e.g., T1) and dial-up (e.g., telephone, ISDN) information exchange.

Cybertherapy, on the other hand, is more accessible due to the integrated use of shared media. Using the Internet and virtual reality tools the therapists may present, from a remote site, a wide variety of stimuli and to measure and monitor a wide variety of responses made by the user.

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. Up till now the benefits of cybertherapy - due to the variety of its applications and their uneven development - have not always been self-evident.

However, the aim of this publication is to show that the emergence of cybertherapy trials is supporting the cost-effectiveness of applications in certain fields, such as neuroscience, rehabilitation, and clinical psychology. Its key advantage is the possibility of sharing different media and different health care tools in a simple to use and easily accessible interface.

Particular attention will be given to the clinical use of virtual reality technology. An important part of this overview are the clinical results coming from the European Union VEPSY Updated – Telemedicine and Portable Virtual Environments for Clinical Psychology - research project (IST-2000-25323 - http://www.cybertherapy.info). Their study will show in detail that different cybertherapy applications have improved the quality of health care, and will later 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 these tools need to pay significant attention to clinical issues, technology, ergonomics, human factors, and organizational changes in the structure of the relevant health service.

To spread the diffusion of cybertherapy, further research is needed. Further evaluation of clinical outcomes, organizational effects, benefits to health-care providers and users, and quality assurance is required. It is also very important that professionals in this field share information about their experience and examine the results of evaluations so that suitable development work can be spead up.

In conclusion, the goal of this publication is to provide a forum for demonstrating the processes by which cybertherapy applications can contribute to the delivery of state-of-the-art health services. We hope that the contents of this publication will stimulate more clinicians and technical professionals to find new solutions in order to expand their intervention interests and make better use of the innovative cybertherapy tools.

Giuseppe Riva, Ph.D., M.S., M.A.
Co-Editor-in-Chief

Critical Reviews

Virtual Reality in Mental Health

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Abstract: *The possible impact of VR on mental health has the potential to be even more than what is currently offered by new communication technologies such as the Internet. In fact, VR is simultaneously a technology, a communication interface, and an experience: a communication interface based on interactive 3D visualization, able to collect and integrate different inputs and data sets in a single life-like experience. Using VRT, it is possible to offer exposure therapy, the most effective form of behavioral therapy for many conditions, and to integrate it with other traditional psychotherapy methods in order to improve their effectiveness. However, the "best" evidence in evaluating the efficacy of a therapy or treatment approach are the results of randomized, controlled clinical trials. To this end the paper discusses the results of the VEPSY UPDATED - http://www.cybertherapy.info - controlled clinical trials. In these trials involving a total of 388 patients - the largest-ever controlled study in VR therapy - different virtual environments were developed and tested to be used in the clinical assessment and treatment of social phobia, panic disorders, male sexual disorders, obesity, and eating disorders.*

INTRODUCTION

The possible impact of Virtual Reality (VR) on mental health could be even more than the impact of new communication technologies like Internet. In fact, VR is at the same time a technology, a communication interface, and an experience.[1] It is a communication interface based on interactive 3D visualization, able to collect and integrate different inputs and data sets in single life-like experiences.

Previous work has shown that even relatively unsophisticated virtual reality tools can prove valuable in psycho-neurological assessment and rehabilitation.[2,3] To date, however, the use of VR-technologies has been limited to single locations – typically hospital or rehabilitation centers. In theory, new multi-user VR technologies, combined with rapid increases in Internet bandwidth and performance as well as steep reductions in the cost of hardware and soft-

ware, making it possible to bring distributed VR environments directly to clients' homes, thereby offering improved access for users who are inadequately served by current approaches. In order to achieve this goal, it will first be necessary to overcome a number of clinical, ergonomic, technological, and organizational challenges. The main contribution of the European Community funded "Telemedicine and Portable Virtual Environment for Clinical Psychology" – VEPSY UPDATED research project to innovation in this area is to design, test, and validate solutions to these challenges.[4]

The main objective of the project is to prove the technical and clinical viability of using virtual reality therapy (VRT) in clinical psychology. In particular, the project designed and developed four clinical modules and their associated clinical protocols to be used for the assessment and treatment of the following disorders:

- panic disorder and agoraphobia
- male impotence and premature ejaculation
- obesity, bulimia, and binge-eating disorders
- social phobia

In fact, VR offers a blend of attractive attributes for psychologists. The most basic of these is its ability to create a 3D simulation of reality that can be explored by patients. VR can be considered a special, sheltered setting where patients can start to explore and act without feeling threatened. In this sense, the virtual experience is an "empowering environment" that therapy provides for patients.[2] As noted by Botella and colleagues,[5] nothing the patients fear can "really" happen to them in VR. With such assurance, they can freely explore, experiment, feel, live, and experience feelings and/or thoughts. VR thus becomes a very useful intermediate step between the therapist's office and the real world.

This paper describes the clinical and technical rationale behind the clinical applications developed by the project. Specifically, the paper focuses its analysis on the possible role of VR in clinical psychology and how it can be used for improving therapeutic change.

VEPSY UPDATED: THE TECHNICAL APPROACH

To produce the VR applications used in its clinical trials, the VEPSY Updated project used PC-based VR platforms. The following paragraphs both describe the rationale behind this choice and detail the technical characteristics of the VR platform chosen by the project.

The Emergence of PC-based Virtual Reality

Even if the history of VR is based on expensive graphic workstations, the significant advances in PC hardware that have been made over the last three years are allowing for the creation of low-cost VR systems. While the cost of a basic desktop VR system has not changed much, the functionality has improved dramatically in terms of graphics, processing power, and VR hardware such as head-mounted displays (HMDs). The availability of powerful PC engines based on Intel's Pentium IV, AMD's Athlon, and Motorola's Power PC G4, and the emergence of reasonably priced 3D accelerator cards allow high-end PCs to process and display 3D simulations in real time.

A standard Celeron/Duron 2 Ghz system with as little as 128 Mb of RAM can offer sufficient processing power for a bare-bone VR simulation, a 3.5 Ghz Pentium III/Athlon with 256 Mb of RAM can provide a convincing virtual environment, while a dual 3.5 Ghz Pentium IV XEON configuration with OpenGL acceleration, 512 Mb of RAM and 128/256 Mb of VRAM running on Windows XP Professional can match the horsepower of a graphics workstation.[3]

Immersion technology is also becoming more affordable. For example, it is possible to have a basic HMD with gyroscopic head-tracking built-in for less than $1200. For instance, Olympus (Japan) distributes its basic video headset for about $600 without head tracking. Two years ago HMDs of the same quality were about 10 times more expensive. A HMD with VGA quality and 3D video produced by a Korean manufacturer is now about $1,500. However, this price will probably decrease during the next five years.

Presently, input devices for desktop VR are largely mouse and joystick based. Although these devices are not suitable for all applications, they can keep costs down and avoid the ergonomic issues of some of the up-to-date I/O

devices such as 3D mice and gloves. Also, software has greatly improved over the last three years. It now allows users to create or import 3D objects, to apply behavioral attributes such as weight and gravity to the objects, and to program the objects to respond to the user via visual and/or audio events.

VEPSY UPDATED: The Hardware

All the VR-based clinical modules were developed to be used on the following PC platforms:

- *Pentium IV/Athlon XP desktop VR system:*
  - 2500 mhz or better
  - 256 mega RAM or better
  - Minimum specification for the graphic engine: ATI Radeon 9600 128MB VRam or Nvidia GeForce 5600 128Mb VRam
- *Pentium IV/Athlon based portable VR system:*
  - 1500 mhz or better
  - 128 mega RAM or better,
  - Minimum specification for the graphic engine: ATI Radeon 9600 32Mb VRam or Nvidia GeForce 5600 Go 32Mb VRam

The hardware also includes:

- *A head-mounted display (HMD) subsystem*. The HMDs used are:
  1. Glasstron PLM-A35/PLM-S700 from Sony Inc. (http://www.sel.sony.com/SEL/). The Glasstron uses LCD technology (two 0.7" active matrix color LCD's) displaying 180,000 pixels (PLM-A35: 800H x 225V) or 520,000 pixels (PLM-S700: 832H x 624V) to each eye. Sony has designed its Glasstron so that no optical adjustment is needed aside from tightening two ratchet knobs to adjust for the size of the wearer's head. There's enough "eye relief" (distance from the eye to the nearest lens) that it's possible to wear glasses under the HMD. The motion tracking is provided by Intersense through its InterTrax 30 serial gyroscopic tracker (Azimuth: ±180 degrees; Elevation: ±80 degrees, Refresh rate: 256Hz, Latency time: 38ms ± 2).
  2. VFX-3D from Interactive Imaging Systems Inc (http://www.iisvr.com). The VFX-3D uses LCD technology (two 0.7" active matrix color LCD's) displaying 360,000 pixels (800H x 400V) to each eye. The HMD doesn't require any optical adjustment. It can be easily worn using the patented flip-up visor. Also included is an accelerometer-based serial tracker (Pitch & Roll Sensitivity +/- 70 degrees +/- ~0.1 degrees; Yaw Sensitivity 360 degrees +/- 0.1 degrees)
- *A two-button joystick-type input device* to provide an easy method of motion: by pressing the upper button the operator moves forward, and by pressing the lower button the operator moves backwards. The direction of the movement is given by the rotation of operator's head.

To ensure the broadest user base, all the VR modules have been developed as shared telemedicine tools available through Internet (see paragraph below) by using a plug-in for the most common browsers (Explorer and Navigator) and as portable tools based on Speed-Step notebook PCs (Pentium IV/Duron, 16MB VRam and 256 Mb Ram). This choice ensures wide availability, an open architecture and the possibility of benefiting from the improvements planned for these machines by INTEL and AMD, consisting mainly of faster processors and enhanced multimedia support. Both solutions allow the support of end-users in their living environment.

VEPSY UPDATED: The Software

Each module was created using the software Virtools Dev. 2.0 (http://www.virtools.com). Based on a building-block, object-oriented paradigm, Virtools makes interactive environments and characters by importing geometry and animation from several animation packages, including Discreet 3D Studio MAX (http://www.discreet.com), Alias Wavefront Maya (http://www.aliaswavefront.com), Softimage (http://www.softimage.com), and Nichimen Nendo and Mirai (http://www.nichimen.com), and combining them with an array of more than 200 basic behaviors. By dragging and dropping the behavior

blocks together, the user can combine them to create complex interactive behaviors.

The Virtools toolset consists of Virtools Creation, the production package that constructs interactive content using behavior blocks; Virtools Player, the freely distributable viewer that allows anyone to see the 3D content; Virtools Web Player, a plug-in version of the regular player for Netscape Navigator and Microsoft Internet Explorer; and Virtools Dev for developers who create custom behaviors or combine Virtools with outside technology. Virtools Dev includes a full-blown software development kit (Virtools SDK) for the C++ developer that comes with code samples and an ActiveX player which can be used to play Virtools content in applications developed with tools such as Frontpage, Visual Basic, or Visual C++.

Content created with Virtools can be targeted at the stand-alone Virtools Player, at web pages through the Virtools Web Player, at Macromedia Director, or at any product that supports ActiveX. Alternatively, the Virtools SDK allows the user to turn content into stand-alone executable files. Virtools' rendering engine supports DirectX, OpenGL, Glide, and software rendering, although hardware acceleration is recommended.

VEPSY UPDATED: The Clinical Rationale

Up till now, the most common application of VR in clinical psychology is the treatment of phobias. The VEPSY Updated project also addressed phobias. Particularly, the Spanish group headed by Cristina Botella focused on the treatment of panic disorder and agoraphobia. The French clinical group headed by Patrick Legeron addressed the treatment of social phobia.

The overall rationale shared by the two groups is very simple: in VR the patient is intentionally confronted with the feared stimuli while allowing the anxiety to attenuate. Because avoiding a dreaded situation reinforces all phobias, each exposure to it actually lessens the anxiety through the processes of habituation and extinction.

The use of VR exposure (VRE) offers a number of advantages over *in vivo* or imaginal exposure: it can be administered in traditional therapeutic settings, and it is more controllable and cost-effective than *in vivo* exposure. Another advantage of VR is the possibility of carrying out exposure to bodily sensations (interoceptive) and situational exposure simultaneously. Traditionally, exposure for panic disorder involves exposure to agoraphobic situations and interoceptive exposure that are performed in different sessions. VR allows the exposure of the patient to an agoraphobic situation (i.e. a train), and can simultaneously elicit bodily sensations through visual or sound effects (blurry vision, pounding heart, etc). In different controlled studies VRE was as effective as *in vivo* therapy in the treatment of acrophobia,[6,7] arachnophobia,[8] and fear of flying.[9-12]

The second clinical focus of the VEPSY Updated project was the treatment of male sexual disturbances. In particular, Optale and his team[13,14] used immersive virtual reality to improve the efficacy of a psychodynamic approach in treating male erectile disorders.

In the proposed VE four different expandable pathways open up through a forest, bringing the patients back into their childhood, adolescence, and teens when they started to experience feelings of attraction. Different situations are presented with obstacles that the patient had to overcome in order to continue. VR environments in this case are used as a form of controlled “dreams,” allowing the patient to express in a nonverbal way, transference reactions and free associations related to the ontogenetic development of male sexual identity. General principles of psychological dynamisms, such as the difficulty with separations and ambivalent attachments, are used to inform interpretive efforts.

The obtained results – 30 out of 36 patients with psychological erectile dysfunction and 28 out of 37 patients with premature ejaculation maintained a partial or complete positive response at the 6-month follow-up – show that VR seems to hasten the healing process and reduce dropouts. Moreover, Optale used *PET* scans to analyze regional brain metabolism changes from baseline to follow-up in patients treated with VR.[15] The analysis of the scans showed different metabolic changes in specific areas of the brain connected with the erection mechanism,

suggesting that this method accelerated the healing process by reopening old brain pathways or consolidating them. The results also suggest that new mnemonic associations and rarely-used inter-synaptic connections characterized by a particular magnitude of activation, may be established, favoring satisfaction of natural drives.[14]

The third part of the project focuses on obesity and eating disorders. Particularly, Riva and his clinical group led by Bacchetta and Molinari[16,17] are using Experiential Cognitive Therapy (ECT) in an integrated approach ranging from cognitive-behavioral therapy to virtual reality sessions in the treatment of eating disorders and obesity. In this approach VR is mainly used to modify body image perceptions.

What is the rationale behind this approach? Different studies show that body image dissatisfaction can be considered a form of *cognitive bias.*[18,19] The essence of this cognitive perspective is that the central psychopathological concerns of an individual influence the manner in which information is processed. Usually, this biased information processing occurs automatically. Also, it is generally presumed that the process occurs almost outside the person's awareness unless the person consciously reflects upon his or her thought processes (as in cognitive therapy).

According to Williamson and colleagues,[18] body size overestimation can be considered a complex judgment bias, strictly linked to attention and memory biases for body-related information: "If information related to body is selectively processed and recalled more easily, it is apparent how the self-schema becomes so highly associated with body-related information... If the memories related to body are also associated with negative emotion, activation of negative emotion should sensitize the person to body-related stimuli causing even greater body size overestimation."

It is very difficult to counter a cognitive bias. In fact, as biased information processing occurs automatically, the subjects are unaware of it. So, for them, the biased information is real. They cannot distinguish between perceptions and biased cognitions. Moreover, any attempt at convincing them of their error is usually useless and sometimes produces a strong emotional defense. In fact, the denial of the disorder and resistance to treatment are two of the most vexing clinical problems in these pathologies.[20,21]

Given these difficulties, there are only two different approaches to the treatment of body image disturbances:[19]

- *Cognitive-Behavioral Strategies*: This approach is based on assessment, education, exposure and modification of body image. The therapy both identifies and challenges appearance assumptions, and modifies self-defeating body image behaviors.[22-24]
- *Feminist Approach*: Feminist therapists usually use experiential techniques such as guided imagery, movement exercises, and art and dance therapy.[25,26] Other experiential techniques include free-associative writing regarding a problematic body part, stage performance, or psychodrama.[26,27]

Unfortunately both approaches, even if effective in the long term, require dedicated patient involvement and many months of treatment.

The use of VR offers two key advantages. First, it is possible to integrate all the methods (cognitive, behavioral, and experiential) commonly used in the treatment of body experience disturbances within a single virtual experience. Second, VR can be used to induce in the patient a controlled sensory rearrangement that unconsciously modifies his/her bodily awareness (body schema). When we use a virtual reality system, we feel our self-image projected onto the image of the visual cues (i.e. a certain figure or an abstract point, such as cursors) appearing in the video monitor as a part or an extension of our own hands.[28] As noted by Iriki and colleagues,[29] “Essential elements of such an image of our own body should be comprised of neural representations about the dimension, posture, and movement of the corresponding body parts in relation to the environmental space. Thus, its production requires integration of somatosensory (intrinsic) and visual (extrinsic) information of our own body in space.” When this happens the information itself becomes accessible at a conscious level[30] and is easier to modify.

In a case study, a 22-year old female university student diagnosed with Anorexia Nervosa was submitted to the ECT treatment.[31] At the end of the in-patient treatment, the subject increased her bodily awareness, which was joined with a reduction in her level of body dissatisfaction. Moreover, the patient presented a high degree of motivation to change. Expanding these results, they carried out different clinical trials on female patients:[32-35] 25 patients suffering from binge-eating disorders were in the first study, 20 in the second, and 18 obese in the third. At the end of the inpatient treatments, the patients of both samples had significantly modified their bodily awareness. This modification was associated with a reduction in problematic eating and social behaviors.

CONCLUSIONS

How is it possible to change a patient? Even if this question has many possible answers according to the specific psychotherapeutic approach, change generally comes through an intense focus on a particular instance or experience.[36] Within this general model we have the insight-based approach of psychoanalysis, the schema-reorganization goals of cognitive therapy, the functional analysis of behavioral activation, the interpersonal relationship focus of the interpersonal therapy, and the enhancement of experience awareness in experiential therapies.

What are the differences between them? According to Safran and Greenberg,[37] behind the specific therapeutic approach we can find two different models of change: bottom-up and top-down. Bottom-up processing begins with a specific emotional experience and leads eventually to a change at the behavioral and conceptual level, whereas top-down change usually involves exploring and challenging tacit rules and beliefs that guide the processing of emotional experience and the behavioral planning. These two models of change are focused on two different cognitive systems, one for information transmission (top-down) and one for conscious experience (bottom-up), both of which may process sensory input.[38] The existence of two different cognitive systems is clearly shown by the dissociation between verbal knowledge and task performance: people learn to control dynamic systems without being able to specify the relations within the system, and they can sometimes describe the rules by which the system operates without being able to put them into practice.

Even if many therapeutic approaches are based on just one of the two change models, a therapist usually requires both.[36] Some patients seem to operate primarily by top-down information processing, which may then prime the way for corrective emotional experiences. For others, the appropriate access point is the intensification of their emotional experience and their awareness of both it and related behaviors. Finally, different patients who initially engage the therapeutic work only through top-down processing may be able later in therapy to make use of bottom-up emotional processing. In this situation, a critical advantage VR provides.

VR can be considered a sophisticated communication interface.[39] Even if the three applications developed by the VEPSY Updated project have very different rationales, all use VR as a communication interface, able to collect and integrate different inputs and data sets in a single life-like experience. Used it accordingly, it is possible to target a specific cognitive or emotional system without any significant change in the therapeutic approach. For instance, behavioral therapists may use a VE for activating the fear structure in a phobic patient through confrontation with the feared stimuli; a cognitive therapist may use VR situations to assess situational memories or disrupt habitual patterns of selective attention; experiential therapists may use VR to isolate the patient from the external world and help him/her in practicing the right actions; psychodynamic therapists may use VEs as complex symbolic systems for evoking and releasing affect.

In fact, one of the main results of the VEPSY Updated project was the use of VR as an *advanced imaginal system*: an experiential form of imagery located between imagination and reality[40-42] that can be used to help the patient differentiate between perception and cognition. As noted by Glantz and colleagues:[43] “one reason it is so difficult to get people to update their assumptions is that change often requires a prior step - recognizing the distinction between an assumption and a perception. Until revealed to be fallacious, assumptions constitute the world;

they seem like perceptions, and as long as they do, they are resistant to change." Using the sense of presence induced by VR, the therapist can actually demonstrate to the patient that what looks like a perception doesn't really exist. Once this has been understood, individual maladaptive assumptions can then be challenged more easily.

The project was developed and validated in different controlled clinical trials including the different virtual environments used in the clinical assessment and treatment of social phobia, panic disorders, male sexual disorders, obesity, and eating disorders. The controlled trials involved a total of 388 patients, the largest-ever controlled study in VR therapy.[44]

From a scientific point of view, the project's most important achievement was the successful integration of virtual reality therapy with traditional psychotherapy approaches, such as cognitive-behavioral therapy and psychodynamic therapy. This resulted in integrated clinical protocols that were tested in rigorously controlled clinical trials. Results have been published in many books and scientific journals such as *Clinical Psychology and Psychotherapy*, *Behavior Therapy and Experiential Psychiatry*, *Eating and Weight Disorders*, *CyberPsychology and Behavior*, and MIT's *Presence*. The quality of both the scientific and clinical work was ensured by the supervision of well-recognized experts who carried out peer evaluations of the work done by VEPSY partners.

However, significant efforts are still required to move VR into routine clinical use. Clearly building new and additional virtual environments - possibly networked and integrated in portable devices such as PDAs or cellular phones - is important so that therapists will continue to investigate applying these tools in their day-to-day clinical practice.[45] In fact, in most circumstances, the clinical skills of the therapist remain the key factor in the successful use of VR systems.

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The Future of Cybertherapy: Ambient Intelligence and Immersive Virtual Telepresence

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Abstract: *The convergence of biosensors, 4G mobile communication and multi channel multimedia technologies manifests itself as the next frontier of Information and Communication Technology. This convergence is stimulating a change in the way health care is carried out. In particular, the emerging result is shared e-therapy or telehealth, a globally distributed process, in which communication and collaboration of geographically dispersed users (patients and/or therapists) play a key role.*

Within this process two trends are expected to shape the future of cybertherapy: Ambient Intelligence (AmI) and Immersive Virtual Telepresence (IVT). AmI is an emerging interface paradigm in which the computer intelligence is embedded in a digital environment that is aware of the presence of the users and is sensitive, adaptive, and responsive to their needs, habits, gestures and emotions.

IVT is a new hybrid platform including shared virtual reality environments, wireless multimedia facilities - real-time video and audio – and advanced input devices – tracking sensors, biosensors, brain-computer interfaces. For its features IVT can be considered an innovative communication interface based on interactive 3D visualization, able to collect and integrate different inputs and data sets in a single real-like experience.

Here is outlined the possible role of IVT and AmI in health care by focusing on both their technological and relational nature. In particular, these tools differ from traditional therapy for their ability to provide the patient with a sense of presence or immersion. Moreover, it discusses the clinical rationale and the expexted advantages associated with the use of these approaches in e-health.

INTRODUCTION

"Managed care" indicates a health care system that uses organizational and management controls to offer patients appropriate care in cost-effective treatment settings. Today, the managed care environment is beginning to focus its attention on new technologies especially in the areas of organization and clinical data management.

To date, some cybertherapy applications have improved the quality of managed care, and later they will lead to substantial cost savings [1,2]. For instance, physicians can review radiological films and pathology slides in remote sites, or assist patients through e-mail.

However, most of the actual applications are used for discrete clinical activities, such as scripting, lab-testing, patient monitoring, and condition-specific diagnostics and treatment [3]. As recently noted by Fifer & Thomas [4] "the new question about E-medicine practice may be not "When will it happen?" but when will the fragmented E-health systems be connected?" (p.52).

The most recent research findings underline the possibility that cybertherapy, by blending with distributed communication media, could become a significant enabler of consumer health initiatives. In fact, in comparison with traditional communication technologies, this new form of cybertherapy offers greater interactivity and better tailoring of information to individual needs. In other words, distributed cybertherapy can be considered a process and not a technology, including different complementary areas: health care information provision, administrative and clinical data collection, therapy and assessment provision.

According to the recent "ISTAG SCENARIOS FOR AMBIENT INTELLIGENCE 2010" [5] the

evolutionary cybertherapy scenarios will be rooted within three dominant trends:

- Pervasive diffusion of intelligence in the space around us, through the development of network technologies and intelligent sensors [6]
- increasingly relevant role of mobility, through the development of mobile communications, moving from the Universal Mobile Telecommunications System (UMTS) "Beyond 3rd Generation" (B3G) [7];
- Increase of the range, accessibility and comprehensiveness of communications, through the development of multi-*channel multimedia technologies* [8].

The convergence of biosensors, 4G mobile communication and multi channel multimedia technologies manifests itself as the next frontier of ICT (Information and Communication Technology). This convergence stimulates a change in the way health care is carried out. In particular, the result is *shared cybertherapy*, a globally distributed process, in which communication and collaboration of geographically dispersed users (patients and/or therapists) play a key role [9,10]. An important role will be played by intelligent environments for health care in which complex multimedia contents integrate and enrich the real space [11].

Within this process two trends are expected to shape the future of Cybertherapy: Ambient Intelligence (AmI) and Immersive Virtual Telepresence (IVT).

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Here is outlined the possible role of IVT and AmI in health care, by focusing on both their technological and relational nature. In particular, these tools differ from traditional therapy for their ability *to provide the patient with a sense of presence or immersion*. Moreover, it discusses the clinical rationale and the expexted advantages associated with the use of these approaches in e-health.

AMBIENT INTELLIGENCE

Ambient Intelligence (AmI), is a new paradigm in information technology, in which people are empowered through a digital environment that is aware of their presence and context, and is sensitive, adaptive, and responsive to their needs, habits, gestures and emotions. [8,12]. As underlined by the AMBIENCE Project, AmI can be defined as the merger of two important visions and trends: "ubiquitous computing" and "social user interfaces":

"*It builds on advanced networking technologies, which allow robust, ad-hoc networks to be formed by a broad range of mobile devices and other objects (ubiquitous- or pervasive computing). By adding adaptive user-system interaction methods, based on new insights in the way people like to interact with computing devices (social user interfaces), digital environments can be created which improve the quality of life of people by acting on their behalf. These context aware systems combine ubiquitous information, communication, and entertainment with enhanced personalization, natural interaction and intelligence*".
(Online: http://www.itea-office.org/projects/facts_sheets/ambience_fact_sheet.htm).

According to the vision of AmI provided by the Information Society Technologies Advisory Group (ISTAG) to the European Commission, all the environment around us, homes and offices, cars and cities, through AmI will collectively develop a pervasive network of intelligent devices that will cooperatively gather, process and transport information [5]. As noted by the ISTAG group:

"*Such an environment is sensitive to the presence of living creatures (persons, groups of persons and maybe even animals) in it, and sup-*

ports their activities. It 'remembers and anticipates' in its behavior. The humans and physical entities - or their cyber representatives - together with services share this new space, which encompasses the physical and virtual world" (p. 6).

On one side this approach enables knowledge, content organization and processing. On the other side, it also enables the direct natural and intuitive interaction of the user with applications and services spanning collections of environments - including the cyberspace level. In this sense the AmI paradigm can be seen as the direct extension of today's concept of ubiquitous computing: the integration of microprocessors into everyday objects. However, AmI will also be more than this: a pervasive and unobtrusive intelligence in the surrounding environment supporting the activities and interactions of the users.[8]

In the near future, even simple objects like a pen or a box, will be able to sense the presence of a user and calculate his/her current situation. Throughout the environment, bio-sensing will be used to enhance person-to-person and person-to-device communications. Biometrics technology will be used to enhance security by combining static (facial recognition) and dynamic information (voice and lip movement, uncontrolled user gestures), as well as user's habits, which the network will be able to acquire and maintain.

The interaction process will be enabled by the Ami Space: *networked* (using a changing collection of heterogeneous network) *embedded systems* hosting *services* which are dynamically configured distributed components (see Figure 2). The *AmI Space* can be seen as the integration of functions at the local level across the various environments and enables the direct natural and intuitive dialogue of the user with applications and services spanning collections of environments - as well as at the cyberspace level - allowing knowledge and content organization and processing [13].

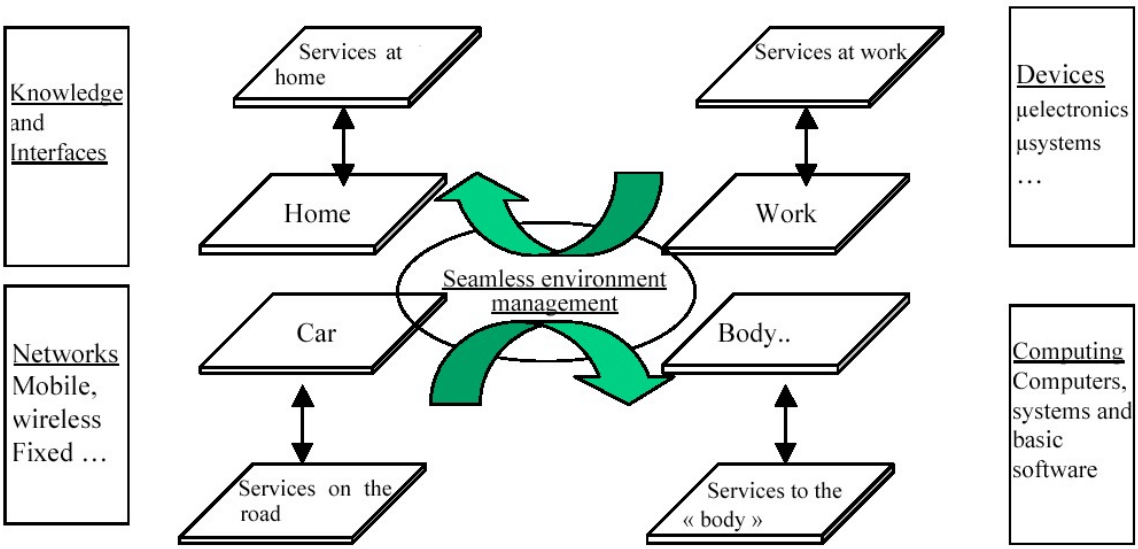
In particular the Ami Space should offer capabilities to:

Model the environment and sensors available to perceive it, to take care of the world model. This deals with the list of authorized users, available devices, active devices, state of the system, and so on.

Model the user behavior to keep track of all the relevant information concerning a user. Also, it automatically builds the user preferences from its past interactions and eventually, abstracts the user profile to more general community profiles.

Interact with the user by taking into account the user preferences. Natural interaction with the user replaces the keyboard and

Figure 1. The AmI Space (adapted from ISTAG, 2002).



windows interface with a more natural interface like speech, touch or gestures.

Control security aspects to ensure the privacy and security of the transferred personal data and deal with authorization, key and rights management.

Ensure the quality of services as perceived by the user.

The most ambitious expression of the AmI is *Intelligent Mixed Reality* (IMR). Using IMR it is possible to seamlessly integrate computer interfaces into the real environment, so that the user can interact with other individuals and with the environment itself in the most natural and intuitive way. Within IMR, a key role will be played by *Immersive Virtual Telepresence*, the enhancement of information of a mobile user about a real scene through the embedding of any objects (3D, images, videos, text, computer graphics, sound, etc) within his/her sensorial information [14]. In this scenario, the embedded information is based on factors like location and direction of view, user situation/context aware (day of the time, holidays of business related, etc), user preferences (i.e. preference in terms of content and interests), terminal capabilities and network capabilities.

IMMERSIVE VIRTUAL TELEPRESENCE

A typical first generation IVT system is virtual reality (VR) [15]. In VR, using visual and auditory output devices, the user can experience the environment as if it were a part of the world. Further, because input devices sense the operator's reactions and motions, the operator can modify the synthetic environment, creating the illusion of interacting with and thus being immersed within the environment. The critical advantage offered by VR to cybertherapy is a new human-computer interaction paradigm in which users are no longer simply external observers of images on a computer screen but are active participants within a computer-generated three-dimensional virtual world [16,17,18]: in the virtual environment (VE) the patient has the possibility of learning to manage a problematic situation related to his/her disturbance in a functionally relevant, ecologically valid experience [19,20].

IVT, however, is not only a hardware system [21]. According to different authors the essence of IVT is the inclusive relationship between the participant and the synthetic environment, where direct experience of the immersive environment constitutes communication [22,23]. In this sense, IVT can be considered as the leading edge of a general evolution of present communication interfaces like television, computer and telephone. Main characteristic of this evolution is the full immersion of the human sensorimotor channels into a vivid and global communication experience: IVT provides a new methodology for interacting with information [24].

This is possible because the key characteristic of IVT, differentiating it from other media or communication systems, is the sense of *presence* [12], usually defined as the "sense of being there" [25], or the "feeling of being in a world that exists outside the self" [26]. In particular, a growing group of researchers considers presence as a neuropsychological phenomenon, evolved from the interplay of our biological and cultural inheritance, whose goal is the control of agency [12,23,27,28,29,30,31,32,33,34].

The link between communication, action and presence is theorized to contribute to the efficacy of VR as rehabilitation tool: the successful use of VR exposure therapy for phobias [35,36,37,38], postraumatic stress disorders [39,40,41], and the pain reduction obtained in burn patients during a VR session [42,43,44,45] underline the possible role that an high level of presence, elicited by the VR experience, may have in the rehabilitation process.

For this reason, next generation IVT systems will have an improved focus on the communication capabilities. A possible future IVT application is *Mobile Mixed Reality (MMR)* [14], the enhancement of information of a mobile user about a real scene through the embedding of one or more information objects within his/her sensorial field. These objects may be part of a wider virtual space – the AmI Space - whose contents can be accessed in different ways and using different media (cellular phones, tablet PCs, PDAs, Internet, etc.).

The possibilities offered by MMR are huge. By integrating within a common interface a wireless network connection, wearable computer and head mounted display, MMR virtually enhances users' experience by providing information for any object surrounding them. They can

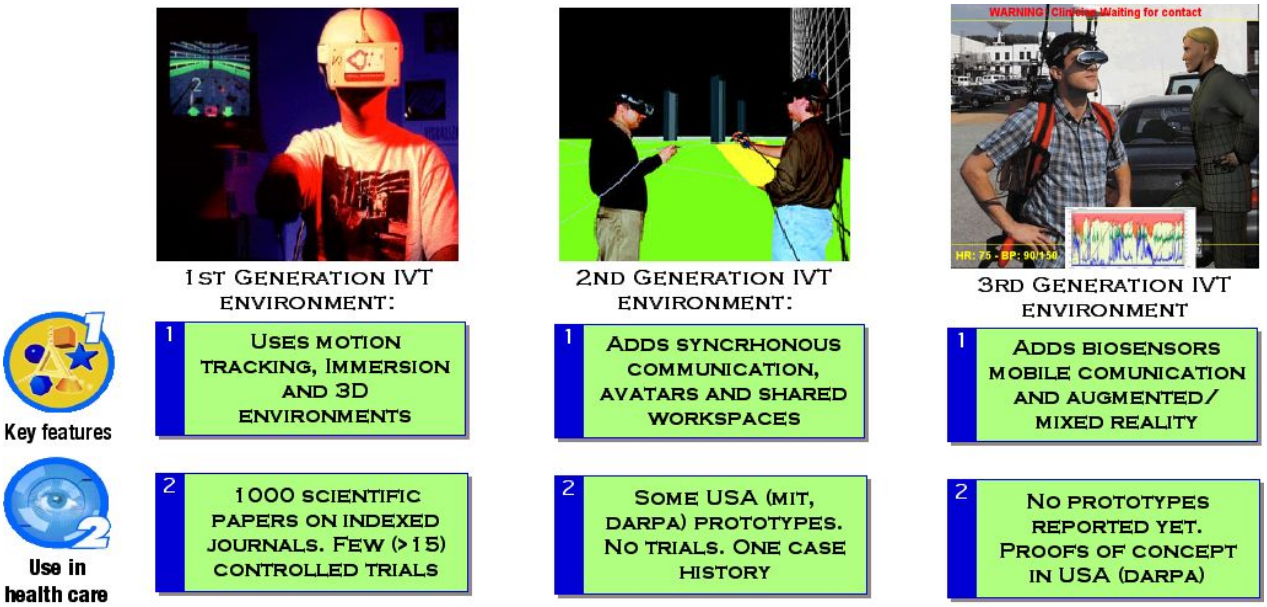


Figure 2. The evolution of IVT.

manipulate and examine real objects and simultaneously receive additional information about them or the task at hand.

Moreover, using Augmented or Mixed Reality technologies, the information is presented three-dimensionally and is integrated into the real world. Recently, Christopoulos [46] identified the following applications of MMR:

- *Smart signs added to the real world*: Smart signs overlaid on user real world may provide information assistance and advertisement based on user preferences.
- *Information assistant (or "virtual guide"):* The virtual guide knows where the user is, his/her heading, as well as the properties of the surrounding environment; interaction can be through voice or gestures, and the virtual guide can be an animated guide and provides assistance in different scenarios based on location and context information.
- *Augmented Reality or Virtual Reality combined with conversational multimedia* (*or "virtual immersive cooperative environments*"): Conversational multimedia can be also added to a VR or an augmented reality scenario, where a user can see the avatar of another user coming into the scene and a 3D video conference is carried on. If we use VR, given the position and orientation information of the first user in the world, the second user can put the first one (or his/her avatar) in a 3D synthetic world.

In general, the IVT perspective is reached through:

- the induction of a sense of "presence" or "telepresence" through multimodal human/ machine communication in the dimensions of sound, vision, touch-and-feel (haptics).
- the widening of the input channel through the use of biosensors (brain-computer interface, psycho-physiological measurements, etc.) and advanced tracking systems (wide body tracking, gaze analysis, etc.).

Typically, the sense of presence is achieved through multisensorial stimula such that actual reality is either hidden or substituted via a synthetic scenario, i.e. made virtual through audio and 3-D video analysis and modelling procedures. In high end IVT systems, multimedia data-streams, such as live stereo-video and audio, are transmitted and integrated into the virtual space of another participant at a remote system, allowing geographically separated groups to meet in a common virtual space, while maintaining eye-contact, gaze awareness and body language. Presence with other people who may be at distant sites is achieved through avatar representations with data about body

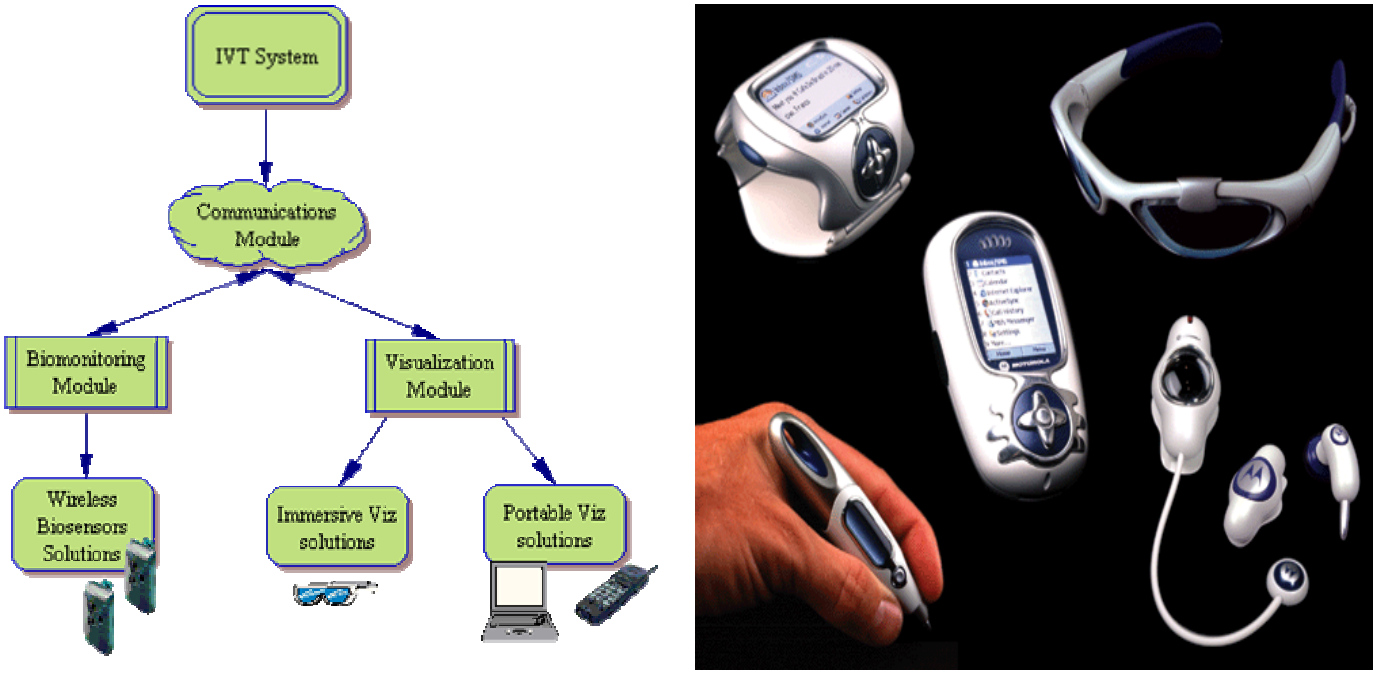


Figure 3. The IVT system functional architecture and a prototype under development by Motorola.

movement streamed over a high-speed network. Following these premises, a general system functional architecture for a high-end IVT systems should includes three main modules:

The *Visualization Module* will use virtual environments and augmented reality to provide totally new clinical services and interfaces to patients. The research will focus on the characteristics and components of wearable personal virtual reality systems with augmented reality display systems, tracking systems, wireless communications and wearable computing. An essential requirement of IVT personal interface is that it should work wireless, otherwise the patient is tied with cables and the freedom of movement is lost. Wireless communication is needed between components of the system and also between personal augmented reality system and networks services, such as world models and other users or avatars.

The *Biomonitoring Module* will give therapists access to a wide range of physiological data to support highly individual and focused clinical interventions. Biosensors are a neural interface technology that detect nerve and muscle activity. Currently, biosensors exist that measure physiological activity, muscle electrical activity, brain electrical activity, and eye movement. Extracting accurate physiological data from biosensors is often a complex task. In particular, extracting data from different typologies of biosensors will require architecture of great flexibility and the possibility to connected them to different external monitoring devices.

The *Core Module* within the system manages the information flows both internally within the software and externally within the clinical environment to allow remote access and interrogation. This model requires unique XML messaging services that make the IVT database accessible to external authenticated users. Moreover, IVT standards are needed in both client and server configurations making a whole range of medical data available for export and import over clinical connections.

CONCLUSIONS

Since e-health is principally involved with the handling and transmission of medical information, Ambient Intelligence and IVT have the potential to enhance the e-health experience

through the expansion of human input and output channels. The two principle ways in which these tools can be applied are:

- *as an interface, which enables a more intuitive manner of interacting with information*, and
- *as an extended communicative environment that enhances the feeling of presence during the interaction*.

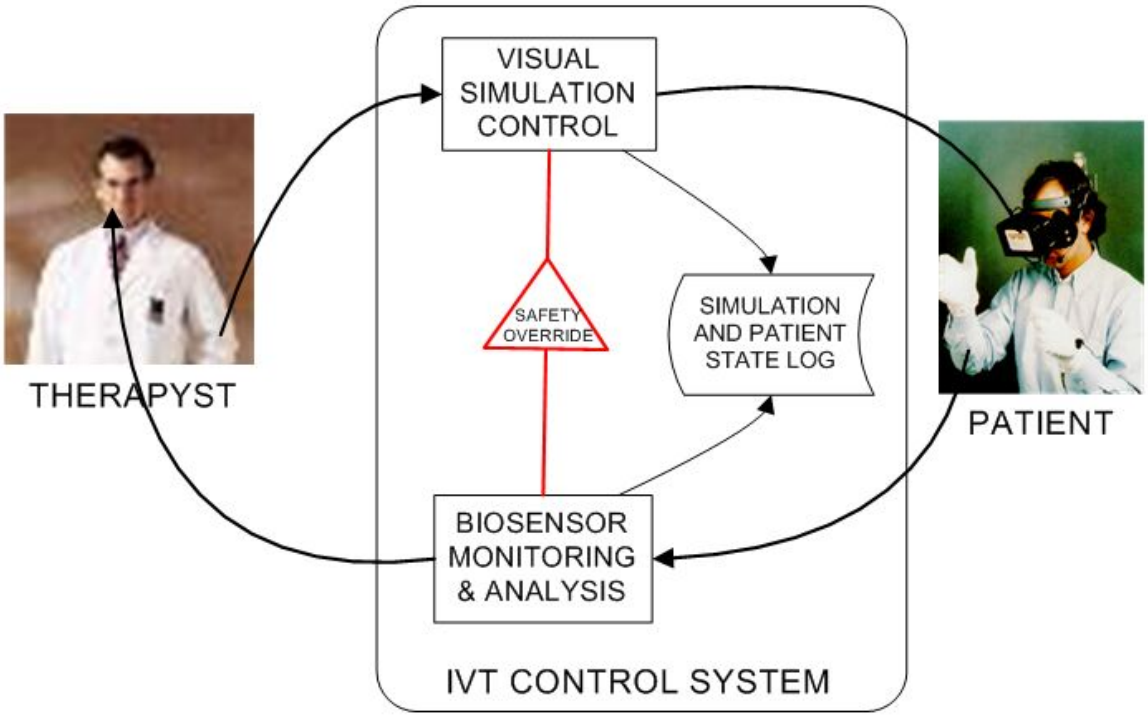
For these reasons, IVT and Ambient Intelligence offer a blend of attractive attributes for therapists. In particular, these tools differ from traditional therapy for their ability *to provide the patient with a sense of presence or immersion*.

More in detail, AmI and IVT provide a new human-computer interaction paradigm in which users are no longer simply external observers of images on a computer screen but are active participants within a real or augmented world [47]. Moreover, these tools offer a high level of control of the experience without the constraints usually found in computer systems. They are highly flexible and programmable. They enable the therapist to present a wide variety of controlled stimuli, such as a fearful situation, and to measure and monitor a wide variety of responses made by the user. This flexibility can be used to provide systematic restorative training that optimize the degree of transfer of training or generalization of learning to the person's real world environment [48].

Finally, these tools open the input channel to the full range of human expressions: in rehabilitation it is possible to monitor movements or actions from any body part or many body parts at the same time. On the other side, with disabled patients feedbacks and prompts can be translated into alternate and/or multiple senses [20].

AmI and IVT also offer a strong support to patient mobility. It will enhance patient's compliance by introducing home-based therapeutic exercises and treatment. IVT, provides the patient access to an augmented interface that will take advantage of state-of-the-art biosensors mobile or pervasive computer technology. The immersive nature of IVT and its ubiquity may also provide numerous psychological benefits, such as mood elevation,

Figure 4. IVT in the patient-therapist relationship.



improved motivation, increased hope for recovery, and an internal locus of control.

In order to transform this vision in reality, below we tried to outline a real health care scenario including all the innovations described before:

Luigi, a 35-year obese subject was directed by his general practitioner to start a self management education program. Before beginning the programme Luigi is asked to provide for information that enables the clinician to target the educational contents for his age, lifestyle, risk factors and medical history. When Luigi goes to the hospital to book for the class and for the visit the unique ID code of his Personal Area Network is recorded into the Information System and tracked in the Local Area Network of the hospital. Moreover, a micro-payment system will automatically transfer the amount into the e-purse of the hospital when he gets out of it.

When a week later Luigi comes back to the hospital; his Personal Area Network is immediately recognized. In a couple of seconds a young nurse appears on the UMTS phone and describes the diagnostic tests and the location of all the different professionals. In the mean time, each professional can track the position of both Luigi and any other patient on his office monitor. In case of delays or problems the visit schedule is modified to reduce the waiting time. In this way, all testing is done in one morning in one place. Through the use of GRID technologies, the collected data are stored and compared with millions of images and files of relevant medical information held on distributed computer. All the analyses are normal.

In the afternoon, Luigi can choose lifestyle consultations customized to meet his health needs. The hospital endocrinologist, clinical psychologist, exercise physiologist and registered dietitian give to Luigi specific indications that are recorded on the PDAs of the professionals. Should Luigi come back later to the office of the specialist, his Personal Area Network is tracked by the Local Area Network and through the GRID system all the info about any previous visit and any assessment result will be immediately available on the specialist's monitor.

After the visits, the primary examining physician explains Luigi test results and provides a personal health action plan. Through the UMTS phone, a detailed written report and individualized directions are provided to Luigi at weekly intervals. In this way Luigi can follow the plan independently from his physical location.

In his home, a couple of days after, Luigi wears its IVT system and starts his learning programme. In a few seconds the headset switches on and appears a wide shared 3D environment: a room looking much like a hotel foyer with comfortable furniture pleasantly arranged. As Luigi enters the room and finds himself a place to work, he hears a voice asking "Hello Luigi, here is the program of the courses: are you ready?" The electronic tutoring system goes briefly through its understanding of Luigi's availability and preferences for the day's work. Luigi is an active and advanced student so the electronic tutoring system says it might be useful if Luigi spends some time today trying to pin down the problem using enhanced interactive simulation and projection facilities. It then asks whether Luigi would give a brief presentation to the group. Finally, Luigi agrees on her work programme for the day. During the connection individuals and sub-groups locate in appropriate spaces in the ambient to pursue appropriate learning experiences at a pace that suits them. The electronic tutoring system negotiates its degree of participation in these experiences with the aid of the mentor. Time spent in the 3D environment ends by negotiating a homework assignment with each individual.

Transforming this vision in reality is not an easy task: the most a technology is complex and costly, the less the user is prone to accept it. Significant efforts are still required to move AmI and IVT into commercial success and therefore routine clinical use. Possible future scenarios will involve multi-disciplinary teams of engineers, computer programmers, and therapists working in concert to treat specific clinical problems. It is hoped that by bringing together this community of experts, further stimulation of interest from granting agencies will be accelerated. Information on advances in IVT and AmI technology must be made available to the health care community in a format that is easy-to-understand and invites participation. Future potential applications of

these tools are really only limited by the imaginations of talented individuals.

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Evaluation Studies

General Practitioners' Attitudes Toward Telemedicine: The Italian Case

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Abstract: *The beginning of experimentation in telemedicine in Italy dates back to 1976, when The Marconi Foundation and the University of Bologna developed the first Italian electrocardiograph remote sensing prototype. Since then, a number of interesting pilot projects have been undertaken in the fields of telecardiology, teleradiology, telepathology, home oxygen therapy monitoring, emergency services, teleoncology, and more recently, psychotherapy. In spite of this rapid growth and a proliferation of formal initiatives, widespread diffusion of telemedicine services has not occurred.*

To understand why, this paper explores Italian physicians' attitudes towards the use of telemedicine, with particular reference to medical teleassistance. An analysis of responses about the perceived advantages and disadvantages of telemedicine revealed that some doctors still consider telemedicine an approach of minor interest, well-suited for technology enthusiasts. Further, many physicians are not convinced that telemedicine can effectively improve clinical practice. These beliefs are deep-rooted in doctors with higher seniority, probably because they are more reluctant to accept the change of well-established clinical procedures (and also less familiar with emerging technologies than their younger colleagues).

To reduce such negative evaluations, a better circulation of information about the state-of-the-art of research and development in telemedicine is needed, because this is the prerequisite to a more pervasive culture of telehealth care in Italy.

INTRODUCTION

Telemedicine means "medicine at distance" where "medicine" includes not only medical activities - involving ill patients - but also public health activities - involving healthy people. In other words, telemedicine is a process and not a technology, which involves many different health care activities carried out at distance.[1] Even if most of the telemedicine trials are now running in the United States, different studies are being carried out in European countries. In particular, due to the geographical particularities of Italy, this country is considered a unique place to implement telemedicine services on a wide scale, and the situation is progressing rather rapidly.

During the 1950's and 60's many individual experiments with medical services were carried out on the basis of telecommunication. Enthusiasts with medical backgrounds often saw the possibilities as the teletechnology gradually developed. We may safely assert that those experiments were mainly directed towards the technology, even if medical and organizing matters were on the agenda. The equipment used was poorly adapted to its purpose. The predicted cost was so high that the data obtained could not be generalized to lead to safe conclusions.

Gradually the development of telemedicine moved towards solving concrete medical problems. In particular, the beginning of real world experimentation with telemedicine in Italy dates back to 1976, when the Marconi Foundation and the University of Bologna developed the first Italian electrocardiograph remote sensing prototype. In 1990, the Ministry of Universities, Research and Technology (MURST) funded a National Telemedicine Research Programme with €50 million (about $50 million) to foster the implementation of telehealth services and to

estimate their practical costs and benefits for the public sector, caregivers, and consumers.[2] Since then, a number of interesting pilot projects have been undertaken in the fields of telecardiology,[3,4] teleradiology,[5] telepathology,[6,7] home oxygen therapy monitoring,[8] emergency services,[9,10] teleoncology,[11] and more recently, psychotherapy,[1,12] to cite a few. In spite of this rapid growth and a proliferation of formal initiatives, the widespread diffusion of telemedicine services has not occurred.[13] Yet the implementation of medical remote assistance would meet concrete needs. For example, the rapid aging of the Italian population implies an increasing need for domiciliary assistance, especially for patients suffering from chronic illnesses.[14] Considering previous experiences and the need for the development of telemedicine in Italy, what are the barriers resisting its diffusion? High costs and technical limitations have been significantly reduced and are no longer a primary barrier. Furthermore, there has been a significant increase in Internet usage by Italian doctors: in June 2002, 65% had an Internet connection, compared with an EU average of 64%. However, the number of Italian physicians who are using the Internet for clinical applications remains low (16% compared with an EU average of 27%).[15] According to several authors,[16,17] to understand the reason of poor diffusion of telemedicine, more attention should be paid to human factors. Currently, little is understood regarding the psychosocial and cultural implications of telemedicine technology. Indeed, research in this field often addresses the technological aspects while neglecting the needs, expectations, and attitudes of medical professionals, although it is known that acceptance of technology plays a key role in program's ultimate success.[18] The aim of the present study was to investigate the attitude of an Italian sample of physicians towards telemedicine, with particular reference to medical teleassistance. The survey took place in the Province of Milan, which represents the biggest metropolitan area in Italy. In this territory, development of telemedicine services is in an early stage.[15] The questionnaire addressed the following research questions:

- What is the current telemedicine technology knowledge/usage level?
- What is the general attitude towards telemedicine applications?
- How much money would a medical professional invest in a telemedicine application?
- Which factors predict the intention to use telemedicine?

METHODOLOGY

Questionnaire

After a preliminary literature review, a focus group that included ICT experts, physicians, and psychologists met to identify critical areas to be covered by the questionnaire. Then a draft was designed, developed, and tested on a small pilot sample to identify misinterpretations and reactions to the survey instrument. The final questionnaire had the following structure:

a. Statements to explain the research project and filling instructions
b. A demographic section including items about background knowledge of ICT systems
c. Attitudes towards the use of telemedicine
d. Perceived efficacy of telemedicine in enhancing quality of care
e. Telemedicine technology section

The definition of telemedicine used in the questionnaire was “the use of electronic information and communication technologies to provide and support health.”[19] In order to measure attitudes throughout the questionnaire, respondents were asked to indicate their level of agreement or disagreement with a given statement on a five point Likert scale. To measure physicians’ technology acceptance, the definition "intention to use" was adopted following the approach suggested by Hu and colleagues in a similar study.[16] In addition, open-ended questions, specific questions, and questions requiring a yes/no answer were utilized. Most specific questions allowed the respondents to add their own additional response. The average time taken to complete the questionnaire was five minutes.

Participants

The questionnaire was sent to all the physicians in the Province of Milan. This area includes 188 municipalities within the Lombardy Region, with a population of almost four million people. Physician and patient demographic data are comparable to national averages: on a national level the number of physicians per 1,000 inhabitants is 2.0; in the Lombardy Region it is 1.9.[20] A total

of 2,987 questionnaire packets (1,140 to Milan residents and 1,847 to hinterland residents) were delivered between December and January 2003 to the targeted physicians, who were given four weeks to complete the questionnaire. A letter soliciting internal promotion of the study accompanied the survey. Physicians returned the completed questionnaires either by mail or by fax.

RESULTS

Demographic Data and Background Knowledge of ICT Systems

A total of 361 doctors out of a potential 2,950 responded to the survey (12%). Thirty-seven questionnaire packages (1.2%) were lost because of incorrect address. Respondents averaged 49.4 in age (SD = 7.1) and the majority (59%) had more than 20 years of clinical experience. Females made up 28.3% of the respondents. 66% of respondents were general practitioners (GP), 25% were both GP and specialists, and 8.6% had only a specialist practice. Most surveyed physicians worked for the public health system (76.7%). A few of them had both private and public practices (13.6%) and 8.3% had only private practices. In regards to background knowledge of ICT systems, 67% of respondents declared intermediate informatics skills (basic knowledge of the operating system, knowledge of at least two office applications), and 6.9% reported no informatics skills (Table 1). About 58% of respondents spent less than one hour a day surfing the Internet, 17% spent 1 to 2 hours a day, 4% were used to surfing the web more than 2 hours a day, and 20.8% never used the Internet.

Knowledge and the use of Telemedicine

Results showed that 82.5% of respondents had already heard about telehealth care. No significant correlation was found between telemedicine knowledge and demographic data such as age or gender.

Table 2 shows the principal media through which doctors got information about telemedicine (more than one option could be selected).

Source	%
Intermediate	67.3
Low	16.3
High	9.1
None	6.9
Missing	0.3
Total	100

Table 1. Background knowledge of ITC systems.

Source	%
Journals	46.0
Colleagues	41.0
Meetings	25.8
Television	19.1
Internet	10.2

Table 2. Information sources about telemedicine (more than one answer possible).

Specialized journals (46%) and colleagues (41%) were the principal sources of information, followed by scientific meetings (25.8%), television (19.1%), and the Internet (10.2%).

Only 20.5% respondents who were informed about telemedicine qualified as adopters by indicating previous or current use of telemedicine technology. The majority of adopters were male (80.3%) and 55.7% of them had had more than 20 years of clinical experience. 77% of adopters declared intermediate informatics skills and 55.7% of them spent less than one hour a day surfing the Internet. About 67% of adopters worked for the public health system, 21.3% had both private and public practices, and 9.8% had only private practices. When asked about their frequency of use, most of them (67.2%) indicated that they used telemedicine occasionally; only 27.9% of them reported a weekly use of telemedicine. Table 3 shows which tools were used by adopters. The most cited tools were

Tools	%
Telemetry applications	66.7
E-mail	21.7
Internet applications	18.3
Videoconference	6.7
other	4.2
No answer	1.9
Chat	0

Table 3. Tools used by adopters (more than one answer possible).

telemetry applications (66.7%), followed by e-mail (21.7%), Internet applications (18.3%), videoconferencing (6.7%), and other uses (4.2%).

Perceived Efficacy of Telemedicine in Enhancing Quality of Care

The first question of this section asked doctors how much they agreed with the statement, "Telemedicine has the potential to enhance quality of care." The answers were given on a five-point Likert scale. Results showed that on average doctors moderately agree with that statement (M=2.94, SD=0.87).

Respondents were also asked to explain their answers. Open-ended responses were coded by three independent judges. To evaluate agreement among judges, a correlation test was performed using Cohen's *K*. Resulting values were high, ranging from 0.91 to 0.96 for the final 16 categories. Table 5 shows the full list of responses. The most cited (12.2%) positive statement was, "Telemedicine allows immediacy for intervention and diagnosis," while the most cited (9.4%) negative statement was, "Telemedicine lacks face-to-face contact between doctor and patient."

Few items focused on physicians' attitude towards telemedicine use in medical practice (see Table 6). Results showed that doctors are not confident that telemedicine is likely to reduce the number of examinations during surgery hours (M = 2.5, SD = 0.9). They moderately agreed that telemedicine has the potential to improve effectiveness of therapeutic intervention (M = 2.8, SD = 0.9). Respondents were not very optimistic about the possibility of implementing a telemedicine system through easy-to-use devices (M = 2.6, SD = 0.9). However, most doctors agreed that making good use of telemedicine is a deontological duty (M = 3.5, SD = 1.0).

Response	1	2	3	4	5	missing	M	SD
% of total	3.9%	23%	53.2%	12.5%	6.1%	1.4%	2.9	0.9

Table 4. Potential of telemedicine to enhance quality of care (1=strongly disagree to 5=strongly agree).

Response Category	%	Cumulative %
TM allows immediacy for intervention and diagnosis	12.2	12.2
TM lacks face-to-face contact between doctor and patient	9.4	21.6
TM improves continuity of assistance (chronic patients/monitoring)	8.6	30.2
TM allows saving of time, procedures, costs, travel	8.3	38.5
TM improves continuity of communication between doctor and patient	6.1	44.6
Not classified	4.4	49.0
TM allows more exchange of clinical information at a distance	3.9	52.9
TM is generally better than traditional approach	3.3	56.2
TM provides advantages for elderly patients	2.8	59.0
TM should not be considered a replacement of traditional method of assistance	2.5	61.5
Issues related to TM technology and procedures	2.2	63.7
TM improves home-based assistance	1.9	65.7
TM improves compliance	1.7	67.3
TM encourages exaggerated conduct of patients (i.e. alarmism, hypochondria...)	1.1	68.4
TM is generally worse than traditional approach	1.1	69.5
TM usefulness is limited to a low number of cases	1.1	70.6
Missing	29.4	100.0
Total	100	100.0

Table 5. Perceived advantages/disadvantages of telemedicine.

item/response	1	2	3	4	5	M	SD
TM is likely to reduce the number of examinations during surgery hours	12%	42.1%	33.5%	8.6%	3.0%	2.5	0.9
TM can improve effectiveness of therapeutic intervention	7.5%	25.2%	48.5%	12.7%	4.7%	2.8	0.9
TM can be activated through easy-to-use devices	10.5%	34.1%	42.4%	9.4%	2.5%	2.6	0.9
Making good use of TM is a deontological duty	2.8%	8.0%	38.2%	31.6%	17.7%	3.5	1.0

Table 6. Physicians' attitudes towards telemedicine use in medical practice (1=strongly disagree to 5=strongly agree).

One set of questions focused on possible advantages telemedicine could provide to patients. Table 7 shows that on average, doctors moderately agree that telemedicine can overcome the inconvenience of going to medical surgery (M=2.8, SD=1) and that telemonitoring allows prompter intervention (M = 3.3, SD = 0.9). Moreover, doctors were moderately convinced that telemedicine provides psychological support (M=3.0, SD=1.1) and that it can foster patient compliance (M = 2.9, SD = 1).

Another critical issue addressed by the investigation was to estimate the percentage of patients that would be willing (and able) to be involved in a telemedicine program. Results are shown in Table 8. According to the large majority of doctors (about 80%), less then 25% of their patients would be willing to try this approach. Moreover, about 80% of respondents estimated that less then 25% of their patients would be able to use telemedicine devices.

To understand which kind of devices physicians believe to be more appropriate to implement a medical teleassistance service, respondents were asked to give their preference rate on a five-point scale (1 = not appropriate; 5 = very appropriate) to different communication tools (see Table 9). Telephones were given the highest rating (M = 3.3, SD = 1), followed by: e-mail (M = 2.4, SD = 1); videoconferencing (M = 2.1, SD = 1.1); online instruments for clinical evaluation (M = 2.1, SD = 1.0); chat rooms (M = 1.9, SD = 1.0); and sms (M = 1.8, SD = 0.9).

The last section of the questionnaire focused specifically on respondents' intention to use telemedicine technology. This part included two items. The first question asked doctors whether they would provide a telemedicine service if they would not have to pay for the enabling technologies (and for their maintenance). The second item required participants to estimate how much they would eventually invest in a

Item/Response	1	2	3	4	5	M	SD
TM can overcome the inconvenience of going to medical surgery	8.6%	26.6%	41.8%	16.3%	5.5%	2.8	1.0
TM monitoring allows prompt intervention	3.3%	10.5%	46.5%	29.6%	9.4%	3.3	0.9
TM provides psychological support	9.1%	22.4%	35.5%	22.7%	9.4%	3.0	1.1
TM improves compliance	8.0%	26.0%	42.7%	16.6%	5.3%	2.9	1.0

Table 7. Perceived advantages of telemedicine for patients (1=strongly disagree to 5=strongly agree).

Item/Response	0-25%	25-50%	50-75%	75-100%
How many patients would be advantaged by telemedicine?	82.6%	10.8%	2.5%	1.6%
How many patients would try telemedicine?	83.1%	9.1%	2.5%	1.6%
How many patients would be able to use telemedicine device?	79.7%	11.4%	4.2%	0.9%

Table 8. Estimation of patients' participation.

Device	M	SD
Telephone	3.3	1.0
E-mail	2.4	1.0
Videoconference	2.1	1.0
Online instruments for clinical evaluation (i.e. questionnaires)	2.1	1.0
Chat	1.9	1.0
Sms	1.8	0.9

Table 9. Ratings of medical teleassistance tools.

telemedicine system. About 63% of respondents answered "yes" to the first question. As concerns the second question, about 54% of respondents indicated that they would not personally invest in a telemedicine system; 25% would invest from €500 to €1,000; 18% would invest from €1,000 to €2,000; and only 3% would invest from €2,000 up to €4,000.

A Model of Physician Acceptance of Telemedicine Technology

A key objective of this study was to form a model to determine which factors influence one's intention to use telemedicine (TM). The underlying hypothesis is that the intention to use telemedicine for a given individual can be predicted on the basis of selected variables. Since the dependent variable is dichotomous (yes = 1, no = 0), the logistic regression model was used to estimate factors. Predictors considered by the analysis were gender, seniority, and the following items:

- TM improves effectiveness of therapeutic intervention
- TM can be implemented through easy-to-use devices
- It is in accords with professional ethics to make good use of TM
- TM can overcome the inconvenience of going to medical surgery
- Telemonitoring allows prompt intervention
- TM provides psychological support
- TM improves compliance
- TM is likely to reduce the number of examinations during surgery hours

To identify which of these factors are included in the final regression equation, forward stepwise selection (Waldesian) for logistic regression was used. The results of this analysis (tables 11-12) indicate that a model including seniority and responses to items: "TM improves effectiveness of therapeutic intervention;" "making good use of TM is a deontological duty;" "TM can overcome the inconvenience of going to medical surgery;" "TM improves compliance," was statistically significant in predicting intention to use telemedicine, c^2 (5, N = 337) = 95.32, p = .001. As shown by the classification table (see Table 13), the model predicts 79.8% of the responses correctly (90.6% of "yes" and 58.8% of "no"); the

Variable	B	S.E.	Wald	P	Exp(B)
Seniority	-.361	.165	4.794	.029	1.435
TM improves effectiveness of therapeutic intervention	.559	.203	7.613	.006	0.572
It is right to make a good use of TM for professional ethic	.397	.176	5.080	.024	0.672
TM can overcome the inconvenience of going to medical surgery	.346	.177	3.817	.051	0.707
TM improves compliance	.449	.196	5.257	.022	0.638
Constant	-2.787	.999	7.788	.005	16.227

Table 10. Predictors of intention to use telemedicine. Note: B is the logistic regression coefficient for the variable; Exp(b) is the odds ratio corresponding to a one unit change in variable; The Wald statistics are distributed chi-square with 1 degree of freedom.

-2 Log likelihood	Cox & Snell R^2	Nagelkerke R^2
335.964	.246	.341

Table 11. Logistic regression: model summary. Note: Cox and Snell R^2 is a measure of the fit of the model, defined as $1-[L(0))/L(B^\wedge)]^{2/N}$, where L(0) is the likelihood of the intercept-only model, L(B^) is the likelihood of the full model, and N is the estimated population size. Nagelkerke R^2 measures the absolute percentage of variation explained by the model.

absolute percentage of variation explained by the model (Nagelkerke, $R.^2$) is 0.34.

DISCUSSION

The survey sample was made up of 361 spontaneously returned questionnaires. The fact that on average respondents were 50 years old, were well-informed about telemedicine, and had 20 or more years of experience suggests that the doctors surveyed were in a sound position to provide feedback to the possible improvements that telemedicine may (or may not) deliver to their practice.

About half of the physicians moderately agree that telemedicine has the potential to enhance quality of care. Immediate response, easier accessibility, lower costs, and time saving were the main benefits noted by respondents. However, several doctors underlined potential shortcomings of telemedicine, emphasizing in particular the importance of having face-to-face contact with patients. These observations suggest that although many physicians recognize the advantages of telemedicine, they also question the potential of this technology to replace traditional methods of diagnosis, intervention, or treatment. This moderately positive attitude is reflected by the results of Section II, which focused on the possible advantages that telemedicine could provide to patients. According to the majority of respondents, telemedicine consultations could enhance quality of care by improving promptness of intervention, overcoming the inconvenience of going into medical surgery, providing psychological support, and fostering compliance. However, perceived advantages for patients and estimates of patient participation were quite discouraging: according to the large majority of doctors, less than 25% of their total patient care would be assisted by telemedicine; moreover, respondents indicated that less then 25% of their patients would want to be involved in a telemedicine program. These rather conservative estimations can be interpreted in different ways. First of all, it is likely that only a few patients of the doctors included in this sample need therapy monitoring or frequent changes in management. Another reason could be the doctors' lack of confidence in their patients' ability to handle telemedicine devices. Indeed, telephones were indicated by doctors as the most appropriate device for telemedicine, while more sophisticated and powerful communication technologies such as the Internet and its various applications (email, chat, videoconference, etc.) were given lower ratings. Besides usability aspects, there are further reasons that may explain this preference. First, the telephone is a standard feature in most Italian homes, and with the more recent advent of mobile phones, the Italian population has even readier access to communication by telephone. Moreover, telephones have been used on a routine basis in professional practices for a number of decades

	Predicted		
Observed	**Intention to use telemedicine**		**Percentage correct**
	YES	NO	
YES	202	21	90.6
NO	47	67	58.8
Overall Percentage			79.8

Table 12. Logistic regression: classification table.

(i.e. for giving and receiving referrals, scheduling patients, and providing emergency care), while the clinical use of the Internet, whether through e-mail, chat rooms, or via audio or video connection, is not yet widespread. With regards to Internet-based technologies, results show that e-mail is considered the best alternative communication tool for patients and providers, although its average score was low (2.4 on a 5-point Likert scale). This may reflect doctors' concerns regarding the technical and day-to-day aspects of actually integrating e-mail into clinical practices. These concerns are usually related to the potential for increased demand on physician time (particularly with the overuse of e-mail by patients), generating timely responses, inappropriate or urgent content in the messages, and confidentiality issues.[21]

Results showed that 63% of respondents would accept telemedicine if all the devices were provided for free. Moreover, 97% of potential adopters indicated that they would be willing to invest less than €2,000 in a telemedicine platform. This data indicates that cost reduction is still a critical issue in promoting the adoption of telemedicine. Regarding factors affecting intention to use telemedicine, the logistic regression model (see Tables 10 and 11) indicates that: (1) physicians with higher seniority are about 1.5 times less willing to use telemedicine than colleagues with lower seniority; (2) doctors who are more confident about the potential of telemedicine to improve effectiveness of therapeutic intervention are more willing to adopt this technology; (3) the more doctors believe that making good use of telemedicine is a deontological duty, the higher their interest is in using this approach; (4) physicians who are more confident about the potential of telemedicine to improve patients' compliance are also more willing to adopt it. It is interesting to note that with the exception of seniority, all predictors have in common the perceived advantages for patients. This confirms that the propensity to use telemedicine is higher for those professionals who are more persuaded by the added value of telemedicine in improving quality of care.[16]

CONCLUSION

The aim of this study was to investigate physicians' attitudes towards the use of telemedicine. As with all pioneering research, there are limitations. Further longitudinal research is required at various levels and on a national scale before national/regional average comparisons can be made. However, outlining the situation allows us to draw some rough guidelines and indications for improving the situation. An analysis of responses about the perceived advantages and disadvantages of telemedicine revealed that some doctors still consider telemedicine an approach of minor interest that is well-suited for technology enthusiasts. Further, many physicians are not convinced that telemedicine can effectively improve clinical practice. These beliefs are deep-rooted in doctors with higher seniority, probably because they are more reluctant to accept change in well-established clinical procedures (and also less familiar with emerging technologies than their younger colleagues). To reduce such negative evaluations, a better circulation of information about the state of the research and development in telemedicine is needed, because this is the prerequisite for a more pervasive culture of telehealth care in Italy. This concerns issues related to technology usage and learning, and there is a compelling need to improve the usability of these devices[22] and the set of core competencies and knowledge that are required to productively operate telemedicine technology. This could be achieved by increasing the provision of specialistic training to the operators. At present, only one post-graduate master's degree in Telemedicine and E-Health is available at Politecnico di Milano.[19] The outcomes of a logistic regression model indicate that in order to overcome physicians' doubts towards telemedicine it is important to maintain the centrality of the patient in the evaluation of telehealth programs. Rather then relying solely on service utilization data, a common practice in managed care, the goal of a patient-centered evaluation is to understand the human impact and meaning of the change in the service patterns.[17] Finally, as recently indicated by the final report of the EU-funded project VEPSY (Virtual Environments and Telemedicine in Clinical Psychology, IST-2000-25323 [23]), it is necessary to develop an appropriate health administration policy that supports the implementation of telemedicine services at both financial and organizational levels. In conclusion, the results of this study confirm that attitude is an important determinant of physician acceptance of telemedicine. They also emphasize the strategic importance of collecting psy-

chosocial information to offer insight regarding the improvement of the use of telehealth systems.

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Evaluating Psychiatric Patients Using High Fidelity Animated Faces

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Abstract: *We describe the development and early clinical testing of a novel psychiatric assessment tool that animates 3D faces of virtual humans in real-time to evoke and measure the emotional responses of psychiatric patients. The purpose of this new tool is to create a screening protocol where repeatable and parametric facial stimuli are presented interactively to patients in order to characterize and later identify their respective mental disorders using their measured responses. The computer system, presented herein, uses photo-realistic animated 3D models of human faces that display basic emotions, which can be most reliably recognized from facial expressions. The patients' ability to recognize these basic expressions (neutral, happiness, surprise, fear, anger, disgust or sadness) is used as an indicator of their mental health and mapped onto scientifically evaluated symptoms of the respective brain disorders. This paper presents our early clinical results demonstrating that the new assessment tool can be effectively used to screen patients for a group of well-defined psychiatric disorders.*

INTRODUCTION

Recognizing an emotion shown in a face involves many different brain structures responsible for both perceptual processing and the recognition of facial components.[1] Various stages of emotional processing represented different evolutionary advantages and thus developed at different times.[2,3] This distributed architecture gives rise to the possibility of studying various disorders of the brain by the simple means of facial image animation.

Clinical psychologists have long used facial photographs to study their patients. As an example, the Szondi Test[4] - which is used to detect psychiatric disorders - is a projective technique based on a person's reaction to a series of 48 photographs of psychotic patients. The photographs were chosen in accordance with the principle of genic relationship; that is, the person assumedly selects a photograph which portrays a psychiatric disorder also inherent in the subject's own familial genealogy. Similarly, it is well-documented that depression can be detected as a cognitive bias in emotion.[5,6] In fact, when a depressed patient is asked to select a "neutral" face from a database, he or she tends to choose faces that are approximately 15% biased toward being sad.

The diagnosis of Alzheimer's disease currently "depends on clinical acumen more than objective biological markers" writes N. Relkin.[7] Early research suggests that AD patients tend to be particularly impaired in the central executive component of working memory which effects facial processing.[8] In fact, a possible explanation comes from MRI imaging studies that have shown that the average brain shrinkage in patients with AD has been found to be 2.5% per year, compared to 0.4% for age-matched normals.[9] Recently, strong evidence came from a study of 22 AD patients who were significantly impaired on tasks of facial emotion matching.[10] In particular, the ability to recognize sadness, surprise, and disgust was more impaired than recognition of happiness, fear, and anger. The progression of many other diseases related to the aging or the damage of certain areas in the brain can be detected and qualitatively evaluated through processing facial emotions. Subjects with obsessive-compulsive disorder are impaired disproportionately in the recognition of disgust.[11] Some studies have reported impaired recognition of facial emotions in patients with Parkinson's disease (although other studies failed to support that conclusion).[12] Strong evidence supports the disproportionate impairment in recognizing disgust from facial expressions in

persons with Huntington's disease.[13,14] Further examples include Schizophrenia,[15] Autism,[16] and Multiple Sclerosis.

THE PSYCHO DISC DEVICE

Recent advances in computer animated humans,[17] particularly those in high fidelity facial modeling and animation technology, have laid the foundation for novel clinical applications relying on "virtual patients"[18] that can be digitally controlled to express subtle emotions in a time-varying manner.

The Psycho Disc Device (PDD) consists of a circular interface with the neutral position in the center and six to twenty-four 3D examples of the six basic facial emotions on the periphery. The 3D emotion examples are high fidelity, photo-real facial models that were created using a large 3D database of people. The user may navigate in this "emotion space"[19,20] by moving a pointing tool, such as a mouse, game pad, or joy stick.

Doctors may use the device to create specific psychological tests to measure the timing and reaction of their patients to any given sequence of emotional stimuli, thereby allowing them to diagnose their patients' respective psychological disorders. The PDD provides a unified platform for designing new psychiatric diagnostic tests that involve facial emotion recognition tasks. These experiments may focus on multiple aspects of the recognition process, including (i) temporal transition from one expression to another, (ii) the effect of viewing angle, (iii) latency in the recognition of particular emotions, (iv) famous & known vs. unknown people, (v) inconsistent emotions, and (vi) static recognition tests. This will provide a very detailed and refined parametric model as well as a description of patients and their respective disorders.

A major advantage of using the PDD is that it maps individual patient characteristics onto a well-defined mathematical space in which signatures of particular disorders may be recognized using statistical methods. It is this output that finally provides a standardized, parametric, and repeatable data set that can be used by psychologists and researchers to finely map and correlate a large number of mental disorders to the mental state and early symptoms, possibly even before full onset of the disease itself.

EXPERIMENTAL PROTOCOLS

Our investigation focused on creating a medical screening protocol where the repeatable PDD method and parametric facial stimuli are presented interactively to a group of patients in order to characterize and later identify their respective mental disorders using their measured responses.

The purpose of this investigation is to verify theoretical results and gather evidence that disorders, under clinical circumstances, may be differentiated solely based on the degradation in performance of recognition and the direction of mistakes in recognition when compared to a control group.

In the experiments we used high fidelity, photo realistic digital replicas of a male and a female face capable of expressing fine tones of neutral and six basic emotions (happiness, anger, sadness, disgust, fear, surprise). Their circular arrangement conformed to the findings of describing how transitions occur in emotional space.

In our preliminary experiments we evaluated ten schizophrenic and five depressed patients and compared them with a control group of ten normal subjects. All of the non-control subjects are in-patients; the inclusion criteria were as follows:

- All subjects were between the ages of 18 and 35 years
- Schizophrenic patients included in the experiments must have had a positive BPRS
- All depressed patients had to have at least 15 points in Beck depression scale
- All controls had to fill in the SCL-90 and had to have a negative psychiatric anamnesis

Before starting each experiment we first had all subjects sign a release statement (permission) and provide collected personal and medical data (name, age, gender, address, phone number, qualification, clinical diagnosis (DSM-IV), medicines taken, etc.) for later analysis. Each

N(PICTURE ID)						
Neutral	Happiness	Surprise	Anger	Disgust	Fear	Sadness
Expressionless	Joy	Amazement	Wrath	Distaste	Dread	Sorrow
Glassy	Pleasure	Astonishment	Furious	Loathing	Awe	Unhappiness
Toneless	Smile	Revelation	Spite	Abomination	Apprehension	Gloom
Pudding-face	Laugh		Irate	Abhorrence	Dismay	Tribulation

Table 1. Expression table used in Experiment #1.

subject was asked to carry out two different tests (see below) and their performance was measured on a point scale to assess their respective performance.

- In Experiment #1 we used frontal views of the two 3D animated heads and asked the subjects to identify emotions as they appeared briefly on the screen. We recorded two separate sequences (seven pictures each), one with textured models and the second one without textures (gray heads). We have used a table with the names of the basic emotions and their synonyms. Patients were given the following instructions: *"We will be showing pictures of faces, expressing different emotions on the computer screen. Your task is to choose and mark the appropriate emotion from this table in front of you. Each table corresponds to one picture and you may mark only one expression at a time. Each column of the table consists of synonyms of one basic emotion."* (See Table 1 for details.)

- In Experiment #2 we created slowly varying emotional displays that gradually changed from the neutral position towards their respective 100% activation values in a five second period. Subjects were asked to start and stop the ani-

Test 2.							
Number of the animation	Happiness	Surprise	Anger	Disgust	Fear	Sadness	Frame number
Frontal Views							
1							
2							
3							
4							
5							
6							
3/4 profile Views							
7							
8							
9							
10							
11							
12							

Table 2. Expression table used in Experiment #2.

mation sequence by pressing and releasing a button when they recognized any emotion on the digital face. Before starting the experiment, the following specific instructions were given to each subject: *"You are going to see an expressionless face on the monitor. When you push this button the face will start changing its expression smoothly. At some point it will begin to show an emotion. When you recognize what emotion it is you should release the button and find it in the table for me to mark it."* This experiment was carried out with textured 3D head models in two batches viewing them both from frontal and ¾ profile directions, respectively. (See Table 2.)

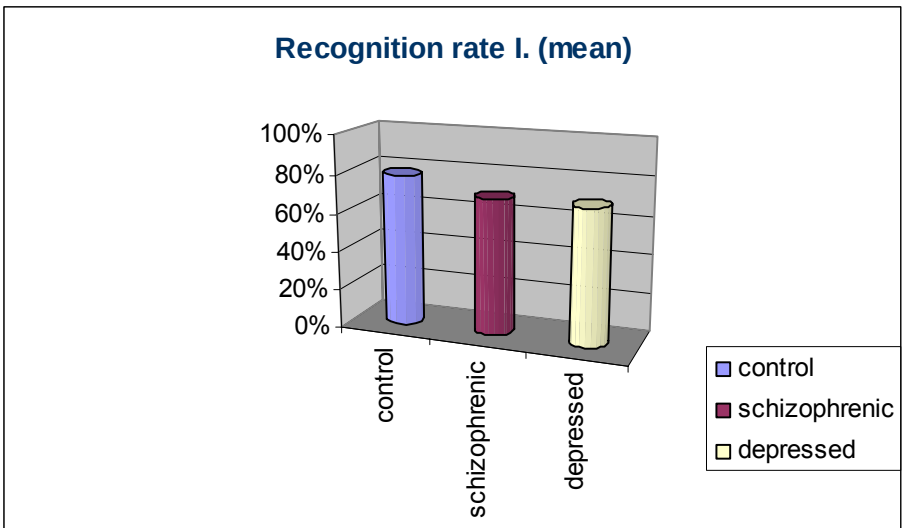
Finally, when both tests were complete, each subject had to fill out a short questionnaire to record their opinions and general feedback on the tests themselves. This questionnaire included questions such as "*Was the test boring or exciting, long or short, etc."*

RESULTS

Tables 3 through 5 show the results of the two experiments described in the preceding section. Based on statistical analysis of the data collected our most important finding is that even in this relatively small sample of the patient population and the control group we have found measurable difference in the recognition rate. Specifically, control persons had an average score of 78.5%, while depressed (p=0.021, deviation=8.22) and schizophrenic persons (p=0.062, deviation=16.92) had an average of 70%. Significance (p) values are relative to control group. (Table 3.)

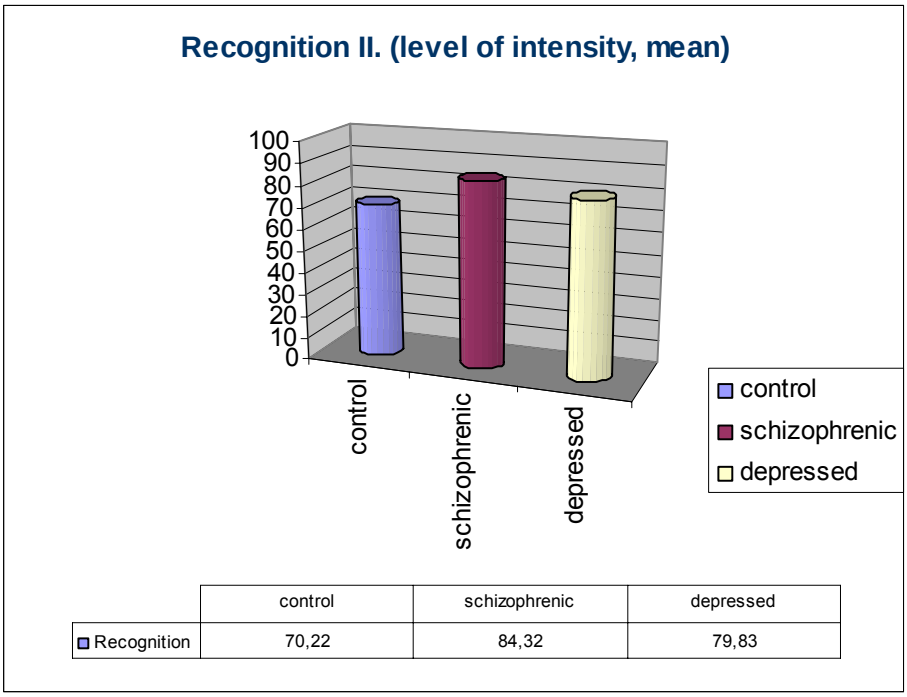
We also found a significant level of difference in the second experiment, more precisely in the average intensity levels of emotions when subjects recognized them. In particular, control persons in this experiment (#2) had an average score of 74%, while depressed patients (p=0.080, deviation=11.27) scored 80% and schizophrenics (p=0.015, deviation=11.92) scored 84% on average. The significance values (p) are relative to control group. These results are shown in Table 4.

Although the main aim of the research described herein was to find and clinically prove that differences exist between the control and inpatient group when recognizing digitally created basic emotions, we also had a secondary goal: to find out what other aspects influence



	control	schizophrenic	depressed
Reconition	78,57%	70,36%	70,00%

Table 3. Statistical results obtained from the static emotion identification experiment (Exp. #1).



	control	schizophrenic	depressed
Recognition	70,22	84,32	79,83

Table 4. Statistical results obtained from the dynamic/time-varying emotion intensity recognition experiment (Exp. #2).

the very process of emotion recognition itself. These results are summarized in Table 5. As a general conclusion we found that:

- Expressions on the gray models (i.e. only shape information without facial texture) are more difficult to recognize than others.
- Recognition rates of particular expressions were almost the same whether they were presented from a frontal or ¾ profile view.
- The shorter an emotion is displayed (Test I.), the more difficult it becomes to recognize it.

CONCLUSION

In this paper we described our preliminary clinical experiments using a novel method, called Psycho Disc Device or PDD, of diagnosing psychiatric disorders. The PDD uses animated, high fidelity faces to provide an objective and parametric assessment of patient performance. Using a small group of schizophrenic and depressed patients as well as a control group of healthy individuals, we managed to show statistically measurable differences between the respective populations and thus gather evidence that the PDD may be used as an efficient method to screen patients for a variety of psychiatric diseases. Our specific findings can be summarized as follows:

- Evaluation of the data collected provided evidence that schizophrenic and depressed patients consistently showed differentiable degradation in performance when compared to the control group on all tests carried out.

- We examined two aspects of performance (recognition rate and the level of intensity by recognition). We found significant difference ($p = 0.021$) between depressed subjects and the control group in the first aspect, and a significant difference ($p = 0.015$) between schizophrenics and the control group in the second aspect.

Finally, we noted that significant performance difference was recorded when using gray or non-textured models vs. textured ones.

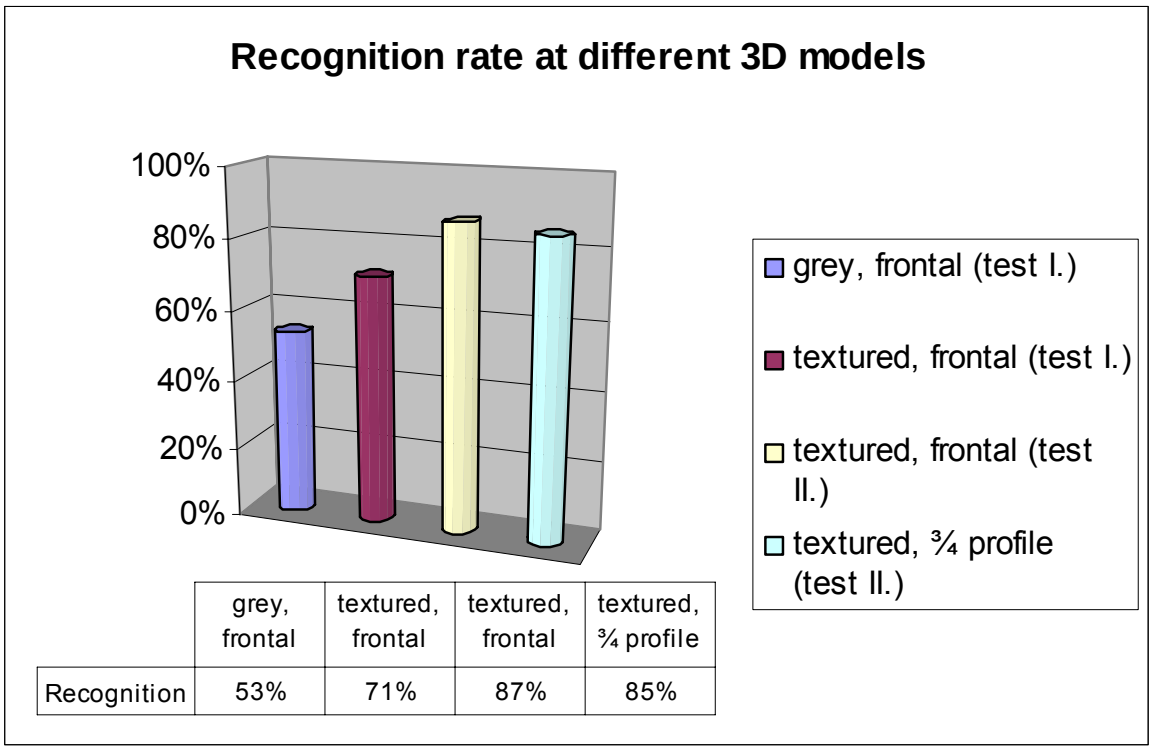


Table 5. Comparison of recognition rates as a function of 3D facial model quality.

Based on the above, we conclude that PDD is a promising new way to screen populations for psychiatric disorders. In the future we will continue our research by testing the protocol on a larger number of people and by verifying the results presented here. We are also planning to update the protocol and design new experiments that may better show the difference between healthy and affected people. Finally, a set of new experiments focusing on other psychiatric disorders is also in development.

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A Virtual Supermarket to Assess Cognitive Planning

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Abstract: *Patients with diffuse or focal cerebral lesions encounter cognitive planning alteration that interferes with social and professional activities. Standard cognitive tests of detection have some difficulties in predicting what occurs in patients' everyday life and seem inadequate in terms of sensitivity or specificity. Virtual reality offers the capacity to assess patients in situations close to their daily activities, thanks to the safe and controlled progress of the patients in a virtual environment (VE). Moreover, the introduction of gaming factors may improve the motivation of patients.*

We present our approach in cognitive planning assessment for patients with Parkinson's disease. We designed a fully textured virtual supermarket (VS) in which the patient can freely move behind a cart and execute precise tasks. During a session, we record all the efficient and inefficient actions of the patient, her/his errors, and her/his regular positions in the VS. We also developed an analysis procedure of all the recorded data. The performances collected among six patients were compared to those of five healthy volunteers in order to validate this approach and to evaluate its sensitivity.

Executive function disorders are difficult to categorize. Many studies emphasize the requirement accurate cognitive assessment and rehabilitation cognitive methods relevant to the patient's real world. We expect that virtual reality techniques should allow significant progress in the prediction of action planning in everyday life. The ecological characteristics of our environment allow further use for behavioral training.

INTRODUCTION

The cognitive disorders of neurological pathologies constitute a major public health problem, consequently, the detection and the rehabilitation of these deficits must be adequate and occur as early as possible.[1] A major criticism of work carried out to date is that the traditional cognitive tasks are very dissimilar to the everyday situations. These issues are especially important for neurological pathologies in which the cognitive alteration induces an important social and professional impairment, as with Parkinson's disease (PD).[2,3] This degenerative pathological entity is characterized by an extrapyramidal syndrome combining akinesia, rigidity, tremor, and axial signs. However, PD patients frequently develop cognitive dysfunction even the early stages of the disease.[4] This impairment predominantly involves executive functions that are largely sustained by the prefrontal cortex and related to deficits in control of attention, planning, capacity to elaborate a strategy, set shifting, and working memory.[5] Furthermore, among the cognitive functions, planning is omnipresent in everyday life and is the most important component of cognitive PD alteration.[6] This cognitive process is an executive component which ensures the fitting and space-time scheduling of the various stages necessary to a particular plan of action. Different but complementary models were proposed.[7-10] One of the significant concepts introduced here is that of schemas of action.[7] The schema corresponds to an elaborate cognitive representation during various sensori-motor and intellectual experiments of the subject; it is composed of units of articulated circumstantial elements. If the articulation of these units works stereotypically, they remain flexible and able to adapt to the external constraints. The traditional executive tasks do not make it possible to explore such concepts, and they are frequently inefficient in terms of sensitivity or of specificity.[7, 8] These tests in particular leave little initiative to the subject. Some ecological paradigms were built to rectify this

situation,[7] but as they are held in real time and in a real environment, this considerably limits their use, especially for patients who are not physically autonomous. The modeling of planning, as presented above and the need for tests with the ecological character contributed to the emergence of new cognitive tests. The scripts of these new tests try to relate the assessment with equivalent daily life behavior. In fact, the test of scripts[8-10] consists of a sequential and hierarchical organization of actions referring to a particular situation (for example, going shopping). These paradigms, while placing the subject as far as possible in current situations, aim at better understanding the deficits which are specifically expressed in daily activities, and at a better comprehension of the complex interactions of cognitive disturbances that has occurred within these activities. However, without any physical activity, the subjects have to verbally describe what they are supposed to do.

The recent advent of virtual reality technology allows the presentation of scenarios or scripts that are ecologically valid (i.e. very close to daily situations).[9,10] The technology of the virtual environments has the capacity to create sets of 3D dynamic stimuli, inside which all the behavioral answers can be recorded and measured. In addition, the introduction of the gaming factors into the cognitive evaluation improves the motivation of subjects.[11,12] It has also been shown that active patient participation is a key factor in successful rehabilitation.[13] Finally, such an environment makes it possible to optimize the training, the generalization, and the transfer of acquisitions toward the real world.[14,15]

PROJECT GOALS

Since we intend to provide indications on the cognitive capacities in everyday life, it seems of higher interest to conceive of diagnostic situations that maintain the characteristics of the real situations while preserving the criteria of standardization necessary to any evaluation. We propose to evaluate planning using a 3D environment built on the model of scripts described above.

The Tasks and the Environment

We developed an original paradigm similar to the "shopping list test"[16] in a supermarket, which foresees a series of actions; concretely, the patient should buy a certain number of products. The search for a particular object (for example, a cleaning product) allowed the clinicians to analyze the strategic choices made by the subject and thus the capacities of planning.

We wanted to analyze the visuospatial and temporal aspects of planning. The correct responses and the errors were recorded.

Target Population

This methodology was applied first in a pilot study involving both healthy elderly subjects and patients suffering from PD.

The PD patients were referred by a neurologist and selected from out-patients at the Neurology Department of the University Hospital of Caen, France. They were included in the study according to the following inclusion criteria:

- Age ≤ 80 years
- Ability to read and write French, with more than five years of education
- Idiopathic PD, according to the criteria of Gelb[17]
- Only L-DOPA and dopamine agonists allowed as anti-parkinsonian therapy
- Good response to therapy
- Lack of dementia as evaluated by the DSM-IV[18]
- Hachinski modified vascular score of less than two
- No known history of brain or thyroid gland disease, alcoholism, use of psychotropic major agents, or depression as measured by a Montgomery and Asberg Depression Rating Scale score below six[19]

The severity of clinical symptoms (mild to moderate: stage 1 to 2.5) were assessed on dopaminergic medication using the Hoehn and Yahr scale.[20]

The control subjects were included in the study according to the following inclusion criteria: Age ≤ 80 years; ability to read and write French, with more than five years of education; lack of depression and dementia as evaluated by the DSM-IV;[25] Hachinski modified vascular score of less than two; no known history of brain or thyroid gland disease, alcoholism, or use of psy-

chotropic major agents, as evaluated using a clinical examination and a medical questionnaire.

Assessment Tools

The evaluation of global intellectual efficiency was carried out with Mattis' scale,[21] which explores through its sub-scores the following cognitive processes: attention, initiation, capacities of conceptualization, and memory.

The classical exploration of executive processes was done with a validated executive battery that included the Wisconsin Card Sorting Test,[22] the Brown-Peterson Modified Paradigm,[23] the Stroop test,[24] and Verbal Fluency.[25]

MATERIALS AND METHODS

Equipment and Software

The system configuration is a Compaq Minitour, Intel Processor 2.4 GHz, 512 MB of RAM, video card GE Force4 MX420 64Mo, and a plug-in to visualize the virtual worlds. Such equipment can be made available in every hospital environment.

The virtual world images are displayed on a large screen monitor. The patient navigates in the world either with the keyboard or with a Wingman Logitech game pad. The patient interacts with the world using the mouse or the game pad.

We used two main software tools to create the 3D virtual exposure environment. We designed the objects, the visual effects, and the virtual worlds with Discreet 3D Studio Max 4. The 3D design was then integrated in a behavior-based interactive 3D development tool, Virtools Dev, which allows the implementation of behaviors through scripts.

The environments are running on PC and can be viewed with the freely downloadable Virtools Web Player (www.virtools.com).

The Virtual Environment

The Virtual Supermarket (VS) was designed to train action planning in PD. It simulates a fully textured medium-size supermarket with multiple display stands for drinks, canned food, salted food, sweet food, cleaning equipment, clothes, stationery and flowers. It also contains refrigerators for milk and dairy products, freezers, four specific stalls for fruits, vegetables, meat, fish, and bread. It also has four check-out stands, a reception point, and a cart (Figures 1 and 2). Some obstacles, such as packs of bottles or cartons, were designed to hinder the advance of the patient in the different paths. They can be removed if the patients feels it is too difficult to move around them. We introduced some characters in the supermarket such as a fish counter clerk, a butcher, check-out operators, and some customers.

The patient enters the supermarket behind the cart and moves freely inside. Her/his first task is to buy a clearly defined list of products, go to the check-out stands, and pay. Other tasks could be defined later.

We let the patient experience the environments from a first person perspective without the intermediary of an avatar. The patient is represented by a 3D frame (a reference point) bound to a camera and the cart. They move together because of a hierarchy link. The collision tests between the patient and the objects in the environments are managed by the cart, which is also bound to be on floor.

The patient navigates in the virtual supermarket using the cursor movement keys or a Wingman Logitech game pad. These devices allow translation and rotation movements.

The patient is free to pick up products by pressing the left mouse button. If they appear in the list defined by the therapist, they are moved to the cart. At the check-out stand, the patients can put the products on the conveyor belt or put them back in the cart by pressing the left mouse button on the belt. Finally, by clicking on the purse, the patient can pay and go to the supermarket's exit.

Session Protocol

During two preliminary training sessions, the patient learns to move in the virtual supermarket, to recognize the various places, and to pick up objects which are different from those on the therapist's list.

Figure 1. Supermarket front view.

Then the patient enters the supermarket for a cognitive planning evaluation. Her/his task is to buy a clearly defined list of products, go to the check-out stands, and pay. The instructions related to the task are, at first, written on the screen, and the defined products are shown in the right part of the screen. As the patient progresses through the supermarket, the products

Figure 2. Supermarket back view.

appear in the cart and disappear from the screen. The instructions related to the check-out area are verbally given before the beginning of the session.

Recording and Measurement

For the purpose of further analysis, the system records and measures various parameters while patient experiences the virtual environment. All the patient actions are recorded. If the patient chooses goods that are not on the list, her/his action is recorded as a mistake. The patient can leave the supermarket without buying anything (and thus without paying). The patient can also stay in the supermarket. All these situations are recorded.

We also measured and recorded the duration of the session and the path of each patient.

RESULTS

Our preliminary study compared six PD patients (2 females, 4 males) to five control subjects (4 females, 1 male). All the subjects met the inclusion criteria previously defined in this paper. The mean age of each group was 74.0 years (SD = 5.4) for PD patients and 66.6 years (SD = 7.7) for control subjects. Mattis' mean score was 136.4 (SD = 6.6) for PD patients and 139.8 (SD = 4.1) for controls, which is consistent with a preserved global intellectual function of our patients. All the recorded data (means and standard deviations) are shown in Table 1. Interestingly, all the patients' performances are lower than the controls data.

In this small group, only the covered distance and the duration of the test are significantly different. The trajectory, shown in the Figures 3 and 4, demonstrates that numerous stops and turning around the same shelves seem to be characteristics of the PD patients.

DISCUSSION

Specific alteration of executive function is a well-known trait of PD.[4,26] However, planning deficit, although often reported in PD (using the tests of Towers, for example), was not as perfectly clarified as the mechanism (i.e. alteration of planning latency or accuracy of shifting processes). The Tower of London, developed by Shallice to assess planning capacities, is a paradigm in which the subject must move colored balls to match a specific arrangement in the minimum number of moves possible. Using this task, Morris showed that PD patients do not make more moves than those required to resolve problems as compared to controls, but show slowness in the initial thinking time (time between the presentation of the problem and

	PD Patients N= 6 (2 F, 4 M)	Controls N= 5 (4 F, 1 M)
Age	74.0 ± 5.4	66.6 ± 7.7
Mattis Scale	136.4 ± 6.6	139.8 ± 4.1
Distance (m)	343.1 ± 113.9 *	224.8 ± 36.4
Duration (min)	20.4 ± 8.2 *	10.4 ± 1.3
Stops Number	56.6 ± 32.9	25.4 ± 3.5
Mean Stop Duration (sec)	13.4 ± 2.3	12.3 ± 2.3
Time to Pay (sec)	14.6 ± 12.8	5.7 ± 8.1
Good Actions	11.6 ± 1.5	12.0 ± 0.0
Intrusions	3.6 ± 3.3	2.0 ± 0.7

* : $p < 0.05$, significant difference between the two groups, using the non parametric Mann-Whitney test.

Table 1. Means and standard deviations of the recorded data.

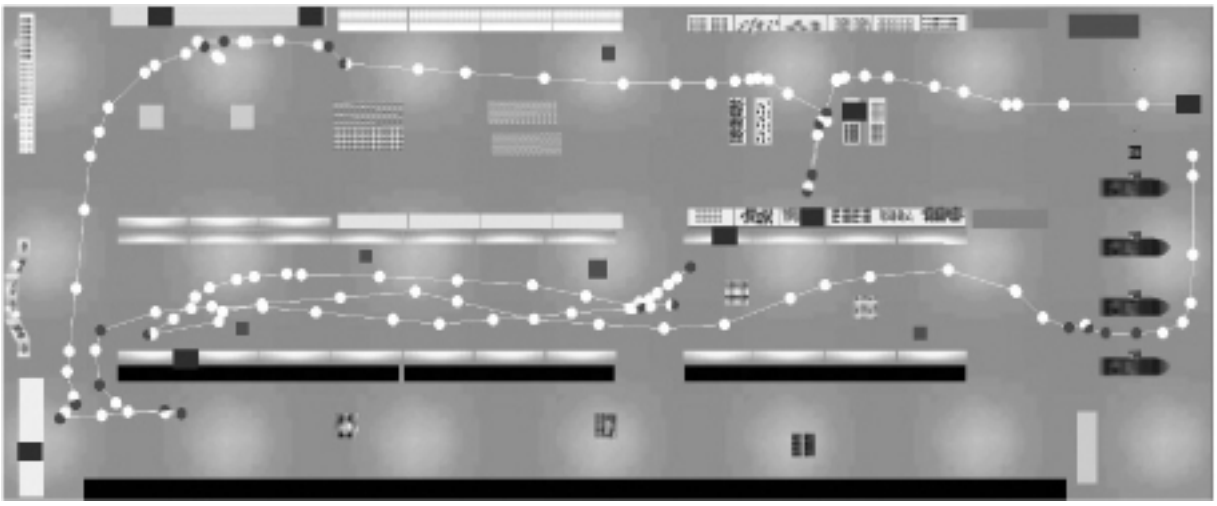

Figure 3. Path of a control subject.

the first movement). The authors interpreted these results as a difficulty to elaborate an action plan, a deficit which essentially concerns the anticipation of the optimal solution. Taylor et al. suggested that the principal cognitive deficits in patients with PD occurs in tasks involving "self-directed behavioral planning." However, in a later study involving patients with mild PD, no deficits were found using a three-disk planning problem solving similar in design to the Tower of London test. The fact that patients with mild PD were not impaired in terms of solution accuracy contrasts with the severe impairment observed in these patients on other "frontal lobe" tests. This may suggest that planning deficits remain undetected if the task employed is insufficiently challenging for these patients.[34] These results underline the usefulness and the difficulties of an adequate evaluation of planning abilities.

Our data suggest a partially altered planning function and provides further understanding concerning the mechanism of this deficit. The absence of significant difference with regard to control subjects for the number of correct actions suggests that global access to the semantic knowledge of the script is normal in PD. However, in our study, the introduction of specific measures such as, distance, duration, number of stops (see Table 1), as well as the trajectory record, allow us to precisely identify

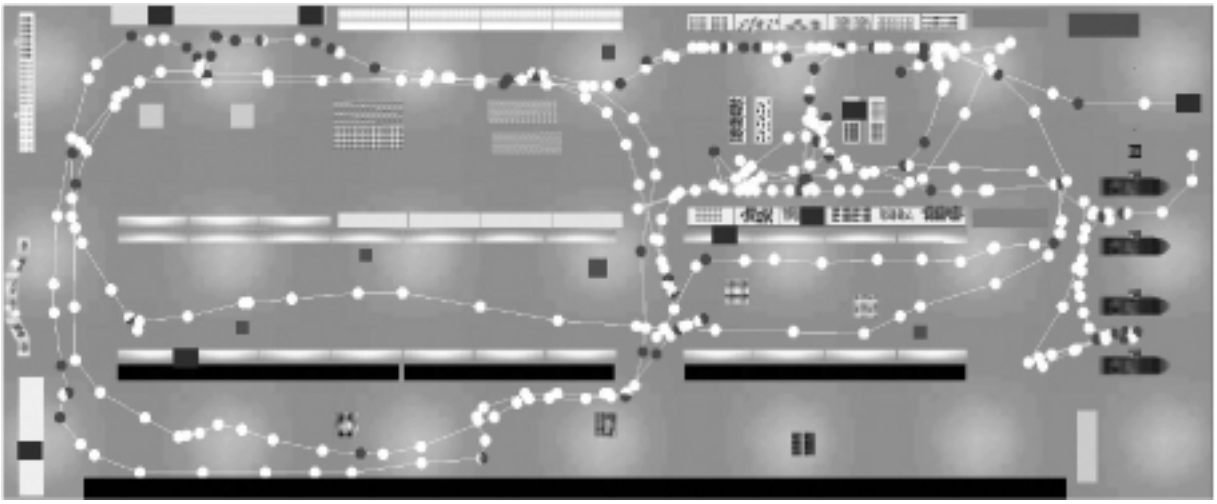

Figure 4. Path of a PD Patient.

the planning alteration in PD. Godbout et. al. tried to precisely identify these mechanisms using a script generation test. It was found that the patients with PD generate less sub-orderly actions, "minor actions," than super-orderly actions, "major actions." The patients would have difficulties recalling contextual elements and consequently their representations of routine activities would not be as rich and detailed as those of controls. Such difficulties could reflect a SAS (Supervisory Attentional System) deficit[8] which modulates cognitive operations. The increased distance and duration, as well as the inefficient trajectory (see Figure 4) observed in our PD group, are consistent with a slowness of information treatment and with the insufficient use of contextual elements.[40] These results underline spatial and temporal aspects of planning deficits in PD. The trajectory utilized by the patients could also suggest a dysfunction in the switching mechanism necessary to treat in parallel several items of information. Our future analyses using correlations with classical executive tests could help interpret our results.

From a more general point of view, this kind of VE seems to be a useful tool for planning evaluation and rehabilitation. Several teams have already underlined the advantages of this technique, particularly its ability to evaluate the executive functions and attention properties.[36] One of the specific interests of our VE, compared with previous studies, is the strict similarity to the real word. In fact, we took into account the real dimensions of a supermarket, we reproduced the various shelves, and unlike other studies, the subjects can move freely throughout the supermarket. Finally, our principal target population, those with PD, are characterized by a dysfunction in motor symptoms. VR describes the alterations of planning by utilizing a non-clinical point of view, by testing "pure" mental sequences without the interference of motor disability.

CONCLUSION

In accordance with our experience in action planning, and our dissatisfaction with the current tools of evaluation, we decided to design a 3D-supermarket to assess action planning for patients suffering from PD. As with many applications in behavioral neuroscience, we designed a controlled environment that is as life-like as possible. We defined the requirements, the patient tasks, and the assessment tools. Our data suggests a gradual decrease of planning processes in PD as well as an inefficient use of contextual elements; however, these results must be confirmed on a larger group. Furthermore, the criteria of success will be constituted by the following additional points: the facilitated use by the subjects, the adaptability of the software, sensibility superior to that of the usual cognitive tools, and improvement of cognitive deficits after training.

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Robotic Toolkit for Pediatric Rehabilitation, Assessment and Monitoring

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Abstract: *Children with disabilities receive various types of rehabilitation therapies, including physical, occupational, and speech/language therapy. The CosmoBot™ system is a robotic toolkit designed to motivate and monitor children with developmental disabilities, aiding them in therapy, education, and general developmental progress. This patented technology includes CosmoBot™, an interactive robot toy, and Mission Control, an adaptive control interface. CosmoBot™ is a child-friendly robot that moves and talks while controlled by a user. Mission Control is a multimodal interface that allows a user to control CosmoBot™ using gestures and voice. The CosmoBot™ system targets therapeutic and educational goals while allowing children to engage in a play activity. A feasibility study was conducted to evaluate the effectiveness of the CosmoBot™ system for combined occupational and speech/language therapy. Based on qualitative data consisting of feedback from the therapists and parents of the children participating in the study and observations made by the engineering design team, the CosmoBot™ system was found to be a useful motivational tool, targeting a number of therapeutic and educational goals.*

INTRODUCTION

Children with developmental disabilities often must perform a variety of therapeutic exercises during and between therapy sessions to strengthen muscles, increase range of motion or vocabulary, and address basic developmental goals. While necessary for achieving developmental goals, such exercises can be tedious, fatiguing, and sometimes even painful. In addition, there are currently few objective methods for obtaining outcome measurements of a child's therapeutic progress while performing the prescribed exercises. Therefore, a need exists for a tool that provides both motivation and embedded assessment capabilities for therapeutic and educational applications.

Studies have shown that when children are engaged in a purposeful activity, such as play, they are intrinsically motivated and actively engaged, sometimes yielding better results than those achieved using rote exercise. One such study, conducted by Sakemiller and Nelson, found that embedding exercise within a play occupation enhanced the prone extension of two children with hypotonic cerebral palsy.[4] AnthroTronix, a human factors and rehabilitation engineering company, has designed a technology tool to target developmental goals within a play environment.

DESIGN AND DEVELOPMENT

All rehabilitation technologies developed by AnthroTronix are designed via a user-centered model. This user-centered design process draws on input received from the end users during focus groups, formal and informal interviews, and system evaluations at each step in the design process (Figure 1). This method of design results in user-defined specifications, as opposed to engineer-defined specifications. The end users define needs to be met by the technology. Requirements, capable of meeting the specified needs, are then generated by the design team. The users continually provide feedback to the design team throughout the development of the concept, the detailed specifications, and the resulting prototype. The prototype is then evaluated by users in a therapeutic or educational setting, leading to product development as well as additional needs for subsequent design iterations.

A list of needs was identified by the end users, in this case children with disabilities and their therapists, teachers, and parents. The needs identified were that the technology must 1) provide motivation, 2) provide empowerment, 3) be applicable across therapy domains, 4) accommodate a variety users, 5) provide long-term motivation, 6) be easy to use, 7) provide objective measures of progress, and 8) be applicable

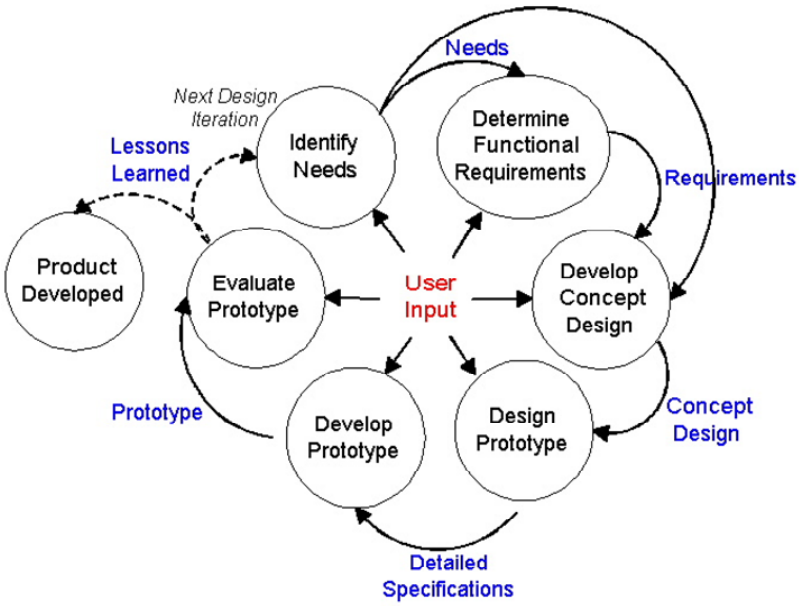

Figure 1. User-Centered Design Model.

for both on-site and remote therapy. From these needs, requirements were defined (Figure 2).

As previously identified, a primary need defined by both therapists and researchers is motivation. The requirement identified for the technology to meet this need was the provision of a play environment, implicating that the technology must involve some type of game or toy. The second need, that the therapeutic activities provide empowerment, is met by enabling children to control their environment. This provides children with a sense of independence and accomplishment and prevents the activity from being passive. In addition, this sense of control combats "learned helplessness," the condition in which children become passive and learn to depend on others to interact with their environment. The third need was that the technology must be applicable across therapy and educational domains, including physical, occupational, speech-language, and behavioral therapies, as well as special education. The associated requirement, defined by the therapy and design team, was that the technology must

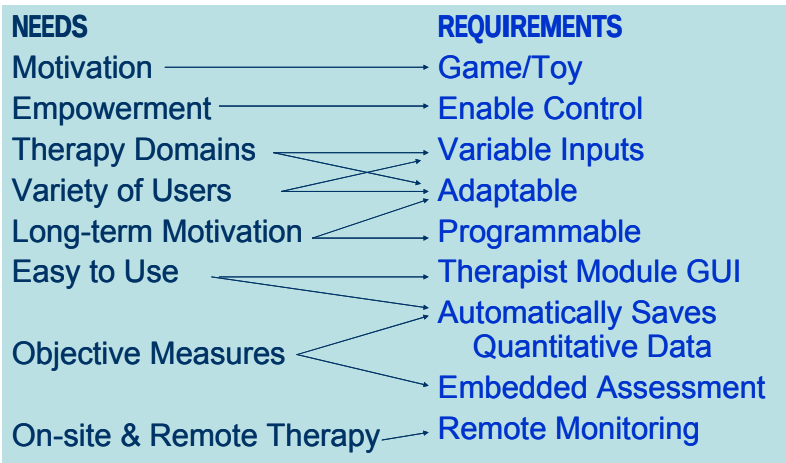

Figure 2. Derivation of Requirements from User-Defined Needs.

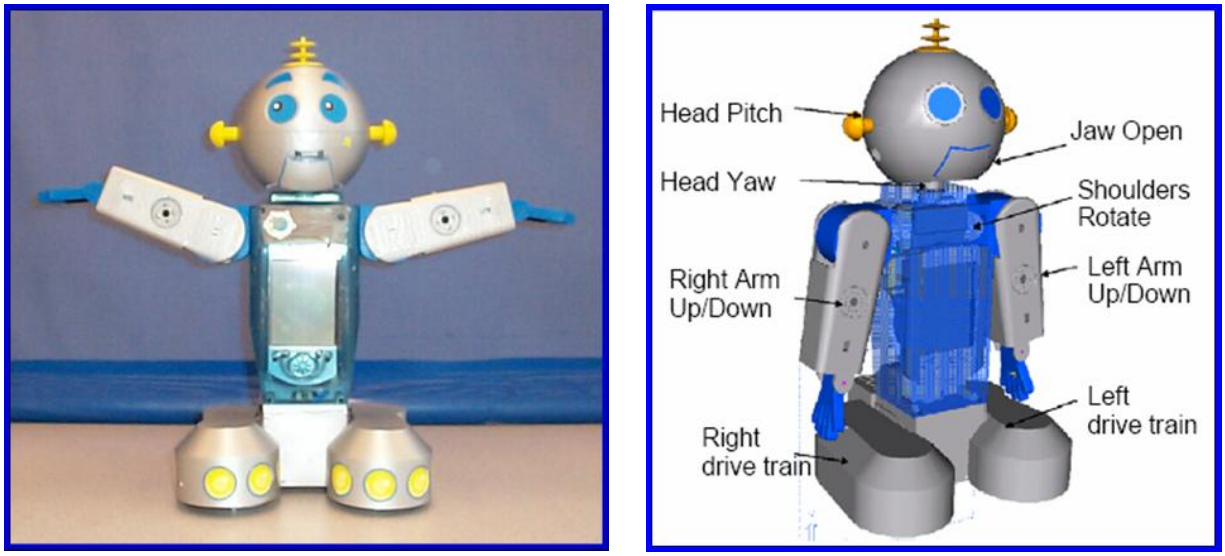

Figure 3. CosmoBot's™ wheels can move forward, backward, left and right, its arms move up and down and together and apart, and its head can move up and down ("yes"), left and right ("no"), and any combination of the two.

have variable inputs and be adaptable. As defined by the fourth need, the technology must be designed to meet the needs of a variety of users with varying types and degrees of disabilities. In this case the requirement was defined as the adaptability of the technology, as well as programmability. This last need of programmability is also associated with the fifth need, which is long-term motivation. It is important that the technology not lose effectiveness. By making the technology programmable, it can effectively meet the specific needs of individual users, and continue to meet their changing needs over time. An important requirement for all technologies, as identified by the sixth need, is ease of use. In order for successful technology transfer to take place, the child must consider the technology easy to use, as should the child's therapists, teachers, and family members. The design team therefore identified the requirement of a graphical user interface to allow users to easily adjust settings and view data. Therapists also identified the need for objective measures of assessment and monitoring of therapeutic progress. This supports the requirement for embedded assessment software, which will automatically save quantitative data. Finally, in order to meet the need for both on-site and remote therapy, a final requirement was identified: the technology had to include remote monitoring capabilities.

The defined needs and requirements led to our initial concept design, CosmoBot™, a child-friendly robot that moves and talks while controlled by a user (Figure 3). CosmoBot™ was developed as part of a robotic toolkit system to motivate and monitor children in physical, occupational, and speech/language therapy. The toolkit includes CosmoBot™ and Mission Control, an adaptive control interface.

The robot, shown in Figure 3, contains six servos which control head, arm, and mouth movements, as well as two DC motors that drive a set of wheels under its feet. The robot also contains an analog to a digital (A/D) board and a handheld computer for receiving commands. The handheld computer allows the robot to be programmed in a variety of ways to meet various therapeutic and educational goals. By giving children control over the robot's movements and speech, they are empowered with a sense of environmental control. The robot was designed to be child-friendly, as well as hygienic, for use in schools and clinics. It allows for a variety of control inputs, including speech and gestures.

Figure 4. Mission Control is an adaptive interface that allows children to control CosmoBot™ using movements and speech.

Mission Control is a multimodal interface which provides wireless control of CosmoBot™ over TCP/IP. Like the robot, this adaptable control interface contains a handheld computer, which can be programmed to map control of the robot's movements to a variety of inputs, including gestures and voice (Figure 4). Gestures may include reaching for a button, operating a joystick, or activating wearable sensors through body movement. Voice control is enabled through voice recognition software, allowing control of CosmoBot™ by speaking into the microphone.

The wearable, gestural sensors plug into Mission Control and allow the child's movements to be mapped onto those of the robot. Figure 4 demonstrates one such sensor: here the child is wearing an armband which contains an accelerometer. A threshold is set in the Mission Control software and mapped to the robot's arm movements, so that when the child raises his arm, the robot mimics this movement. The system can be configured to correspond to a variety of therapy exercises by altering the position of the sensors on the body and the threshold of activation set in the software, thereby targeting various muscle movements and therapeutic goals across domains. The sensors themselves are designed to be comfortable, adjustable, and hygienic for use in an educational or clinical setting.

The novelty of this innovation is in the versatility of the technology, as well as its ability to target developmental goals across therapeutic domains. While many tools exist for meeting specific therapy and educational goals, there are few that can be applied across physical, occupational (OT), and speech/language (SLP) therapies, and assist in the achievement of general developmental goals. Additionally, the range of interface options makes this system useful for a variety of age and disability groups.

METHODS OF EVALUATION

The CosmoBot™ system was evaluated by the end users, in this case children with disabilities, as well as their parents, therapists, and teachers. The objectives of this evaluation were to identify and address problems with the technology, and to evaluate its usability in a therapy setting. In order to do this, we conducted a research study in a combined SLP and OT setting, and conducted several focus groups involving a variety of professionals working with children with disabilities. The feasibility study was funded by a National Science Foundation Phase I SBIR. It took place at Claremont Academy in Arlington, Virginia, where three children (and their therapists) participating in combined occupational and speech/language therapy used the system during individualized therapy sessions over a ten-week period. Prior to introducing the technology, three baseline therapy sessions were conducted without the use of

Figure 5. A Gestural sensor is used to control CosmoBot's™ arm movements.

the technology, informing the design team as to the practices and therapeutic interventions employed during a typical therapy session. Subjects were recruited based on the following criteria: 1) attendance at weekly occupational and speech therapy sessions, 2) having a developmental age of 2 or more, and 3) parental consent. Based on these criteria, the following subjects were recruited by the therapists: Subject 1 was a 5-year-old Latin American male diagnosed with Down Syndrome, Subject 2 was an 8-year-old African American male with global developmental delays, and Subject 3 was a 6-year-old Caucasian/African American male diagnosed with autism. Data was collected in the form of therapist and parent interviews, videos of therapy sessions, and notes and observations taken by the participating therapists and the design team. Qualitative methods informed us throughout the study of problems and successes in CosmoBot™'s usability, as well as general and specific responses to CosmoBot™ by participants. Each session was videotaped. Therapists and an observer used a questionnaire to record data. A second observer not affiliated with the study took data on every third session. Questionnaires covered therapeutic approaches used, adjustments needed, speech/language and occupational therapy goals addressed, participant responses to the technology, and compatibility of the technology with treatment.

RESULTS

Based on the feedback from the therapists and parents of the children in the study, as well as observations made by the engineering design team, the CosmoBot™ system was determined to be a useful motivational tool, targeting a number of therapeutic and educational goals. The system was found to be particularly useful for facilitating directed play involving auditory processing, following directions, spatial positioning, matching and associations, and verbalization of associations. CosmoBot™ was also successful in targeting social greetings, eye contact, two-word utterances, language concepts, auditory processing, word association skills, and coordination and understanding of body positions in space. Individual subject results, as indicated by the therapists and video observations, were as follows:

Figure 6. An occupational therapist and speech-language pathologist use CosmoBot™ to facilitate an integrated therapy session with two of the study participants while a member of the engineering design team observes.

Subject 1 liked the technology and was highly enthusiastic. The technology assisted in enabling him to produce spontaneous and imitative single words. The therapists also noted that from the start, he smiled a lot when in the presence of "Bot." When the therapists were distracted for a minute, he was definitely in charge of "Bot." Subject 2 was highly enthusiastic and especially enjoyed speaking through the microphone. As the sessions progressed, he began to speak more spontaneously, using the microphone as a tool; he seemed empowered by this experience. Additionally, Subject 2 was sensitive to whether or not the technology was working. It was clear that when CosmoBot™ was fully functional, he was more motivated to engage in the session's activities and he displayed more energy. During these sessions there was a smooth transition between activities, an increased number of activities, and consistent attentiveness. Subject 3 was also highly enthusiastic; he spontaneously gave verbal commands to "Bot" and also imitated several commands. He enjoyed manipulating the controls, and easily controlled "Bot." It was clear from the video analysis that even when no one else could get this subject focused on a therapeutic activity, CosmoBot™ commanded his attention.

Additional feedback was obtained during several focus groups involving a variety of professionals working in the fields of physical therapy, occupational therapy, speech/language

therapy, and special education. Two such focus groups were conducted at the California State University at Northridge Center on Disabilities conference in March of 2002 and 2003. An additional focus group was conducted in November of 2002 at Kennedy Krieger School in Maryland, which is a non-public special education facility employing several speech language pathologists. These focus groups provided the basis for prototype evaluation and incorporation of changes for the subsequent design iteration. At each of the three focus groups the participants were asked to identify critical problems or needs of children that might benefit from using CosmoBot™; some examples identified included aiding with pretend play, manipulative play, physical activities within the classroom (e.g. circle time, song leading), direction words, action words, creative play, action learning processes, and concept development. Additional applications identified included modeling use of a switch, data logging to monitor an activity such as hitting a switch or calculating the mean length of utterance (MLU), acting as a receiver of communication to facilitate interaction, aiding in language for movement/ spatial concepts, sequencing, using CosmoBot™ as a calming effect for sensory integration, and taking turns. The results of the focus groups were particularly helpful in identifying development plans for interventions to meet therapeutic goals and composition ideas for future interactive content.

DISCUSSION

This study demonstrated the technical feasibility of a robotic toolkit for pediatric rehabilitation in combined occupational and speech/language therapy. Specific therapeutic interventions were identified for each of the functional goals and objectives. From a clinical perspective, CosmoBot™ showed potential in making an impact on the speech and language development of several children while contributing to their motivation for learning. All of the children were highly motivated by the technology and made some progress toward their goals. Feedback from the end users (children with disabilities, families of children with disabilities, and therapists), as well as observations from the engineering and design team, provided the basis for prototype evaluation and incorporation of changes in the subsequent design iteration. Currently, AnthroTronix is manufacturing a second generation prototype for use during clinical testing at two outpatient therapy sites and one school. It is hoped that clinical testing will provide qualitative data supporting this research effort, investigating the effectiveness of the CosmoBot™ system in targeting therapy and educational goals. The clinical testing will use controlled experiment design and data collection methods to obtain objective and concrete data to validate this research. Feedback obtained during clinical testing will also enable us to move toward a commercial product for use by therapists, teachers, and other professionals working with children with disabilities.

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Real Time Implementation of an On-Road Video Driver Drowsiness Detector: Two-Camera Profile Inputs for Improved Accuracy

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Abstract: *Drowsiness in drivers and pilots is a major cause of injuries and accidents. A real-time on-road alertness monitor is described whose output is derived from two laterally mounted video cameras outside the driver's field-of-view. Output from the system is a 12-channel scalar set that measures the frequency and duration characteristics of the driver's head position in relation to a standard driving position correlated behaviorally with alertness. The two-camera enhancement results in greater accuracy and stability allowing for validation studies with other parameters of alertness that are useful (such as electroencephalography) but not readily adaptable to the on-road environment. The processing methods described can be implemented in an embedded-processor configuration suitable for in-vehicle deployment.*

INTRODUCTION

Driver and pilot fatigue, as well as pilot impairment resulting from drowsiness or environmental factors of incapacitation, are major sources of accidents and injuries. An approach to continuous, practical, noninvasive, real-time, on-board video behavioral monitoring has been described by Steffin and Wahl.[1] That method provides the mechanism for extracting behavioral corollaries of drowsiness from salient changes in feature complexes involving stable facial regions (fiducials) including eyebrow-palpebral fissure complex (EPFC), the mouth region, and the facial boundaries. As a result of the video-to-scalar operation of that approach, 12 scalar data channels are generated for each of the video analysis subregions (SRs) in each of three major regions of interest (ROIs), head, EPFC, and mouth. The method previously described was limited by processing video data from a single centrally mounted windshield camera. A shape detection algorithm that filtered video data according to shape expectations of the respective SRs resulted in 12 scalar channels whose values were representative of the precision of alignment of the subject facial features to the standard facial position correlated with alertness.

However, this configuration partially impaired the driver's view, and was less than optimally sensitive and specific. Improvements in the technique include simultaneous input from two laterally mounted cameras that capture profile facial views rather than a frontal view. The result is increased resolution of facial features that are relevant to drowsiness.

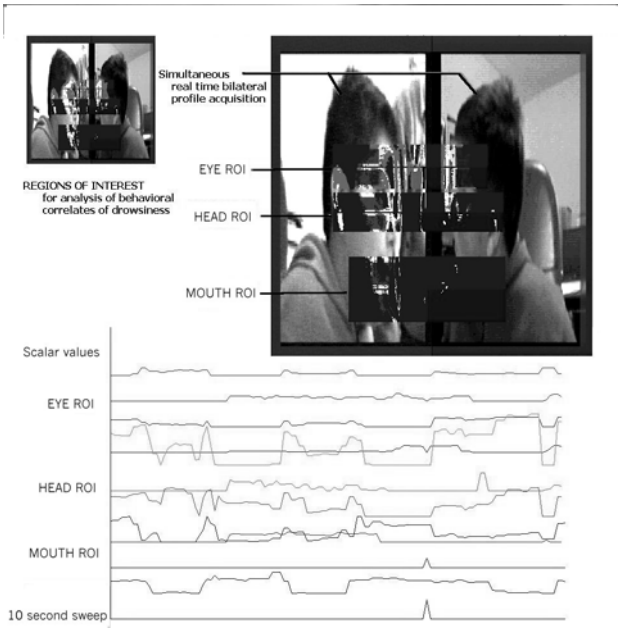

Figure 1. Schema for data collection with two cameras. Outputs from laterally placed cameras are transferred to a frame buffer for video-to-scalar image processing. Levels of processing include intensity discrimination of facial fiducials (left panel) and shape discrimination (right panel).

Figure 1 shows the schema of this approach. Real time video from the two cameras is transferred to a frame buffer for analysis. Two levels of processing, intensity discrimination (upper left panel), and shape discrimination (center panel) allow derivation of 12 channels of data corresponding to the alignment of the facial fiducials (eye, head, and mouth) with the standard, straight-ahead position. Further, the profile schema generates comparison of the fiducial shapes in real time against shape references derived from the actual face in standard position, which may be grabbed as the driver first approaches cruising speed. This procedure enhances accuracy, as compared to the somewhat arbitrary shape discrimination functions employed in the previous method, and will simplify calibration of the system to the individual driver.

RESULTS

Figure 2 demonstrates the increased resolution of facial fiducials resulting from the improvements in facial video acquisition described. For clarity, identical video input is fed to both channels, and analysis is performed on the left channel. The active scalar outputs shown represent the mouth and chin regions for the left channels. In A, there is a clear downward deflection, with good signal-to-noise level in both active channels, representing changes in configuration of the labial region (upper trace) and mental region (lower trace) at the time of mouth opening. The movements were on command, rather than as a result of a natural yawn, so the deflections are abrupt and stable, and give a good estimate of the frequency response and noise characteristics of the system. Similar deflections resulting from mouth closure, also on command, are shown in B. In C, a series of openings and closings are shown over a 10-second sweep.

Figure 3 shows a similar level of resolution and favorable signal-to-noise characteristics for eye blinks, also, in this instance, on command. The upper channel records eyebrow movement and the lower channel records the time characteristics of the palpebral fissure. In A, eye opening is followed by eye closure, while in B eye opening is the final state, as indicated in both the video and the scalar data. A series of eye blinks (on command) is indicated in C.

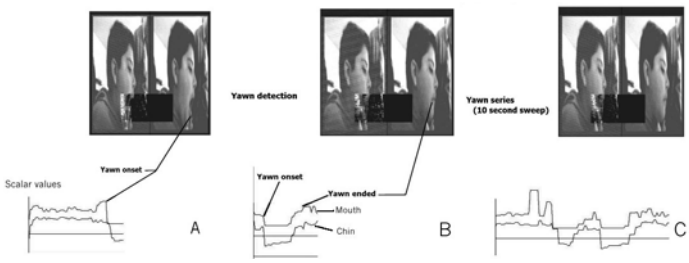

Figure 2. Yawn detection as implemented with the data collection method of Figure 1. A. Detection of mouth opening on command, as shown in video. Upper active trace: scalar for labial region; lower active trace: scalar for chin movement. B. Detection of mouth closing as in A. C. Series of openings and closings, 10-second sweep.

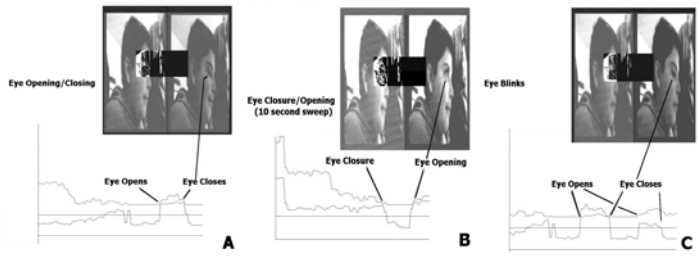

Figure 3. Detection of eye opening and closing on command, with same schema as Figure 2. A. Initial eye opening, then closing, as shown in final video. B. Eye closing followed by opening, as shown in video. C. Series of eye blinks on command, 10 second sweep.

DISCUSSION

The approach previously described (Steffin and Wahl[1]) represents methodology for extracting behavioral correlates of drowsiness from facial features with practicable hardware that can be reduced to a self-contained embedded-processor system. However, ergonomic factors of frontal camera placement cause driver inconvenience and tend to reduce the accuracy of the technique. The reliability of the measurements with this new configuration have increased, and the intrusion into the driver's field-of-view has been reduced by the dual camera monitoring techniques in the described implementation. As a result, the reliability of the technique appears to be significantly increased.

Future directions include enhanced compensation for ambient light variation. Initial considerations indicate that near infrared monitoring, as opposed to visible light, will provide further improvements in the stability of the system in daylight and will be required for this measurement system at night. Research is in progress regarding data collection with limited infrared.

It is anticipated that the same attributes of efficiency in processing and coupling of system output to relevant driver behavior will be realized in the described configuration, so that a reliable system of drowsiness detection, independent of ambient visible light, will be achievable. Behavioral studies are underway to determine correlation of the scalars with more generalized measures of performance (such as reaction time and accuracy of obstacle avoidance) and with electroencephalographic monitoring of alertness as a prelude to on-road testing.

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A Clinical Protocol for the Development of Virtual Reality Behavioral Training in Disaster Exposure and Relief

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Abstract: *This paper deals with the development and evaluation of two different virtual reality cognitive-behavioral treatment settings and compares their effectiveness in disaster preparedness and acute stress response (ASR). Given the extent of the mental health problems following or anticipating large-scale natural or human-made disasters, a brief, effective, and cost-effective treatment intervention is urgently needed. A common and limiting characteristic of the above interventions is the fact that they are post-disaster interventions. That is to say, beliefs, attitudes, and behaviors of interest were assessed and treated after the occurrence of the various disasters. Consequently, conclusions concerning the impact of disasters on these types of variables and even predisposing factors have been largely based on post-hoc data. In the present study, we are investigating predisposing factors that relate to "seismophobia" using a virtual reality setting and biopsychobehavioral correlates. No experimental research has examined the hypothesized factors related to readiness and level of control in youth in real-time disaster exposure in order to provide effective pre-disaster stress inoculation training. This study continued work done in correlational studies and uses two different virtual reality settings to examine the role that these settings play in helping increase normal youth and survivors' problem and emotion-focused coping. Children (n=* 209) *were randomly assigned to a condition based on a school classroom from three earthquake sites in Greece. The "plain emergency condition" consisted of a realistic virtual earthquake scenario program, occurring inside a school classroom populated with behaviorally realistic, unfamiliar faces on digital avatars. The "familiar faces" condition consisted of the usual condition combined with avatars using familiar co-student faces. Factors assessed included both problem and emotion-focused factors: knowledge of mitigation and emergency response activities, school and home hazard adjustments, hazard-related fears, emotion-focused coping ability, and perceptions of co-students' hazard-related fears. Overall, the results supported the conclusion that pre-disaster virtual reality programs increased resilience in youth. In particular, large intervention-produced effect sizes were seen as both normal children and survivors reported hazard adjustments. Significant interactions provided additional support for the role of a familiar faces focus in the problem-focused areas of both (1) normal children hazard adjustments and (2) survivors increased preparedness, self-efficacy, and stress inoculation. These initial findings provide a continuing foundation for further research in this emerging area. The discussion section considers the role for such programs in the future and the possible role of a treatment focusing on familiar faces in facilitating rapid recovery from traumatic stress.*

INTRODUCTION

Numerous studies of risk have attempted to isolate factors related to readiness for a future hazard. Perceived personal consequences are thought to relate to the level of control one has over available coping resources given the potential for a particular stressful event. In addition to risk perception,[1] two other precursor variables are proposed. Critical Awareness (the extent to which people think and talk about a specific hazard) is an important precursor[2] and reflects the relative importance of natural hazards to a person. Only when they are perceived as salient or critical will such hazards motivate protective behavior. Given their destructive potential, earthquakes can represent a source of long-term anxiety which can reduce the likelihood that people will prepare.[3,4] This is illustrated in Figure 1. If risk perception, critical awareness of hazards, and hazard anxiety are present at appropriate levels, a person will progress to the next phase, forming intentions to adopt. Progression between motivation and intention formation is, however, influenced by another set of variables (Figure 1).

Lazarus and Folkman described a model for coping with stress that delineates the differences

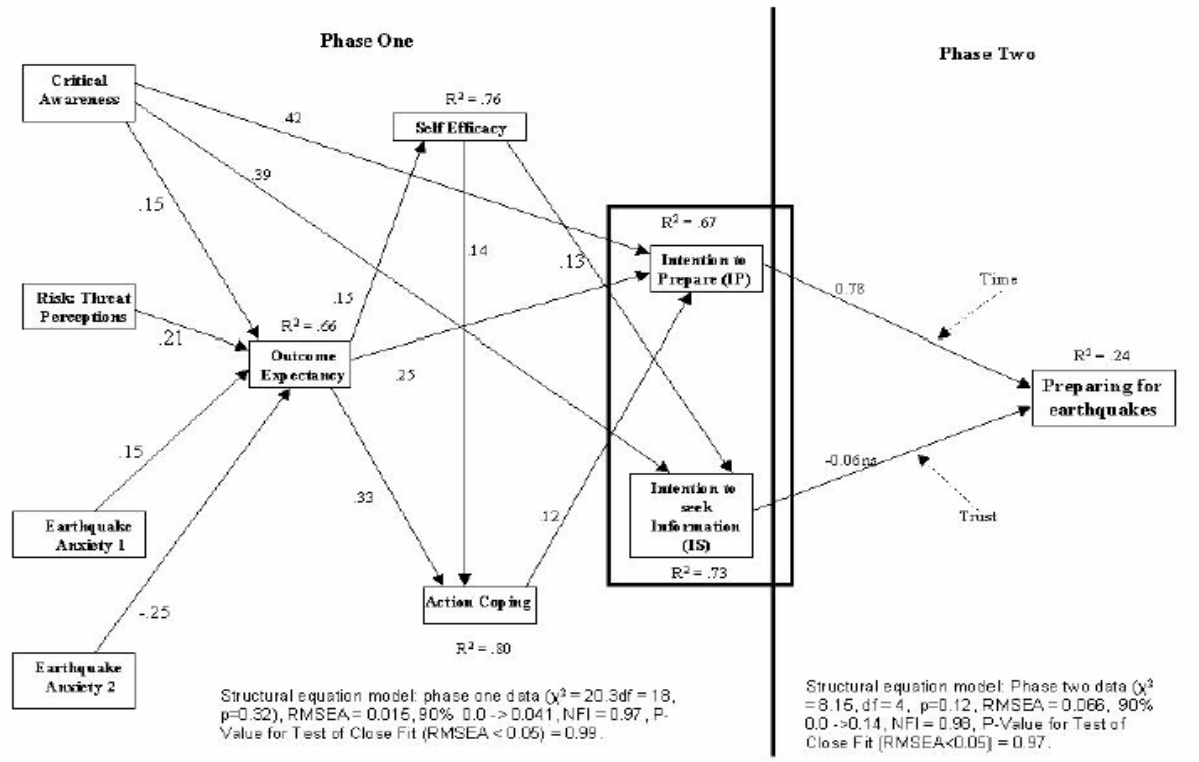

Figure 1: Combined Phase One and Phase Two Structural Models

between problem and emotion-focused coping resources. Problem-focused resources are aimed at "doing something to relieve the problem" and, in some ways, "are similar to strategies used for problem solving often directed at defining the problem, generating alternative solutions, weighting the alternatives, choosing among them, and acting."[5] Of course, these strategies can be aimed both outwardly (i.e. at the environment) as well as inwardly (i.e. at the self).[6] In terms of responding to risk information, problem-focused resources would include factual knowledge related to readiness and response behaviors (i.e. knowing what to do in the event of a hazard) as well as more performance- or behaviorally-based forms of readiness. In the present context, this would include actually doing something, such as engaging in risk reduction activities. These activities, also referred to as hazard adjustments, include efforts aimed at both hazard mitigation (passive protection) and emergency preparedness (active response).[7]

Emotion-focused coping revolves around the idea of emotion regulation.[5] This form of coping can include direct emotional regulation as well as strategies aimed at increasing emotional regulation. In the former category, this would include reduced fear levels in relation to various stimuli (e.g. hazards).[6] In the latter category, one way to increase the potential for emotional regulation is through adaptive cognitive appraisal. For example, in the current context, this would include one's appraisal of or confidence in the ability to cope emotionally with a current or future stressor, including a hazardous event.[8] An additional factor here that has been shown to be salient for children is the perception of parental levels of distress moderating their own fear levels.[9]

As pointed out by Lazarus and Folkman, each form of coping is usually involved in a given situation, though it may not be possible to identify it explicitly. However, the two forms of coping have been demonstrated to some extent in risk-related research with adult samples. For example, a lack of awareness and knowledge, combined with unrealistic risk perceptions, have been shown to have a negative impact on preparedness and responses to warnings.[10-12] Recently, Sjoberg has pointed out that such factors (e.g. unrealistic risk perceptions) may be exacerbated by hazard-related fears.[13]

In terms of child samples, previous research with 400 children and young adolescents in school settings found relationships between problem-focused and emotion-focused factors.[8] For example, this study found, like Sjoberg's, that children demonstrating unrealistic risk perceptions (i.e. those perceiving low-frequency events at a high rate) also had much greater frequencies of hazard-related fears (by a factor of more than two), and lower levels of confidence in their ability to cope emotionally with a future hazard as compared to children with more realistic risk perceptions. In addition, the fearful group of youth also demonstrated consistently lower levels of knowledge about emergency response compared to less fearful children. These findings underscore the potential value of addressing both problem and emotion-focused factors in research and applied settings.

Given such findings, it comes as no surprise that children who demonstrated more realistic risk perceptions, more knowledge, and less fear had been exposed to hazards, whereas their counterparts, who had decreased knowledge, unrealistic risk perceptions, and increased fear had not been so exposed.[14] In addition, children involved in disasters reported increased perceptions of being hurt physically in the event of a range of hazards compared to children not involved. However, these same children, when compared with those children not involved in disasters, also reported a lower frequency of hazard-related fears (12% versus 28%, respectively, reported often feeling scared) as well as lower levels of perceived fears in their parents (9% versus 22%, respectively). Furthermore, the more children were involved in disasters (i.e. two or more disasters), the more they derived benefits.[15]

Critical awareness, risk perception, and anxiety predict outcome expectancy. The role of anxiety was more complex than anticipated. Possibly the most interesting relation is the finding that 'intentions' comprise two variables: ‘Intention to Prepare’ and ‘Intention to Seek Information.’[16] Critical awareness demonstrated direct and indirect relationships with both ‘Intention to Prepare’ and ‘Intention to Seek Information,’ reiterating the relative importance of critical awareness as a motivating factor. The general findings are that children's reactions to hazards are based on a combination of factors that include (1) direct exposure to the hazard combined with the perception of increased physical risk, (2) pre-existing characteristics (e.g. demographic factors including medical factors, age, gender, ethnicity; pre-existing emotional problems), (3) availability of adaptive coping ability and resources, (4) access to social and family support, and (5) the occurrence of major life stressors (e.g. parental divorce, family death) following the hazard.[7-9]

One stressor for children appears to be perceptions of co-students distress. That is, research following a hazard has found that those children perceiving greater levels of co-students’ distress were also seen to cope less effectively in the aftermath of a hazard.[8] The implication here is that the perception of decreased co-students upset in relation to hazards has benefits for youth. This study is attempting to model all of the above factors into a virtual reality scenario and propose a generic hazard preparedness and relief clinical protocol tailored to individual children profiles.

DESIGN

Overview of the Design

The current research was designed to provide information concerning various aspects of emotion and problem-focused coping in a sample of Greek school children. The following areas were assessed: emotional factors (level of hazard-related upset in children and perceived emotional coping ability) as well as the child's knowledge of hazard mitigation and emergency response behaviours. In addition, an assessment of a variety of hazard adjustments was made based on both child and parent report.

The design was quasi-experimental[17] with a control group. That is, it was a pre-test/post-test control group design. It was quasi-experimental in that it involved administration of the independent variable (i.e. the two different versions of the virtual reality scenario) to intact groups. Two groups and a control were involved. The first was designated "Emergency Condition" (EC) and consisted of a virtual earthquake scenario inside a school classroom in the middle of a class, populated with full body behaviorally realistic avatars. The second condition involved EC supplemented with avatars digitized with

explicit photo-realistic faces resembling the ones of the usual co-students of the school children. The groups were mixed with children that had experienced a medium earthquake before and children that had not. In this study, four classrooms from three different regions of the country were assigned to the EC Condition (*n*= 104), and four classrooms to the Familiar Faces (FF) Condition (*n*= 105). Participants were from intermediate schools. Of the 209 total participants, 95 were female, 86 were male. The ages of the children ranged from 11 to 13 years (mean age = 11.8; *SD*= 0.45; modal age = 12).

The virtual environment was constructed using a combination of tools including the WorldToolkit R6 from Sense8, the DI-Guy scenario from Boston Dynamics and the proFACE face modelling software from Famous3D. The hardware included an SGI dual processor platform, an InterTrax2 (serial) head-tracker and the i-visor DH-4400VPD (stereo) head-mounted display. The overall performance of the system was in real-time (35fps). We also measured the biopsychobehavioral corollaries in real time with a Vienna Test System to associate the children's psychosocial and physiological responses.

Measures

Measures included self-report indices, the virtual scenario, and a home-based instrument filled out by parents after the treatment.

Self-Report General Self-efficacy Measures

Participants completed a questionnaire that included both problem and emotion-focused factors across a range of hazards and mass emergencies: floods, storms with high winds (e.g. cyclones), fires, earthquakes, volcanic eruptions, tsunamis, and chemical spills/gas leaks. Items intended to reflect problem-focused coping were assessed in three ways (child's knowledge about mitigation and response; child-reported hazard adjustments; parent-reported hazard adjustments). The items themselves were gathered from both emergency management/civil defence recommendations as well as previous research on hazard adjustments.[18] Other items were intended to reflect the youth's emotion-focused coping in three areas (hazard-related fear levels, perceptions of other's hazard-related distress, and perceptions of ability to cope emotionally with a future hazard). Each of these items, developed from previous research,[24] has been linked to meaningful findings (e.g. with problem-focused coping; with reductions in problems following a hazard; responsiveness to intervention): both prior to a hazard's occurrence as well as in the aftermath of a hazard. Anxiety before and after the scenario was correlated with biopsychobehavioral reactions during the scenario, using the State-Trait Anxiety Inventory (STAI) and the Vienna Test System.

We now provide an overview of each section of the virtual scenario. The following areas were assessed in addition to the data reported earlier with the questionnaire.

Problem-focused coping: Knowledge mitigation and response behaviours

Children were instructed that more than one item could be endorsed if it represented an appropriate response to that hazard. These items were adopted from those highlighted in Greek hazard education programs as well as emergency management brochures. The alpha reliability of these items using a larger sample (*n*= 548) from previous research was found to be 0.85.

Problem-focused coping: Hazard adjustments

Children were asked to follow the Drop, Cover and Hold drill adjustments inside a virtual setting. The 23 specific adjustments included taking cover, storing hazardous materials safely, adding lips to shelves, having a fire extinguisher, having a smoke detector, storing emergency equipment, picking a contact person, learning how to administer first aid, finding out which hazards are more likely in their area, and having the school inspected for resistance to earthquakes. The alpha reliability here based on a larger sample (*n*= 557) used in previous research was found to be 0.92.

Emotion-focused coping factors

The items were as follows: (1) the child's level of overall fear or upset when encountering virtual hazards (1 = not at all, 2 = sometimes, 3 = often), (2) the child's perceptions of any co-

student's upset when discussing hazards (1 = yes, 2 = not sure, 3 = no). These items were taken from a 10-item scale used in previous research that also assessed fears for eight specific hazards. The alpha reliability of that 10-item measure based on a larger sample (n= 405) was found to be 0.76. These two items were chosen for this research because they produced the most meaningful findings as reviewed earlier. A final item here was the child's perception of the ability to cope emotionally in the event of a hazard (1 = not at all able, to 7 = completely able to "to help self feel comfortable/less upset"). This was a stand-alone item that was based on previous research reviewed earlier. A previous three-item version used in research following a hazard (n= 118) reported an alpha of 0.71.

Home-Based Child Preparedness Questionnaire

This questionnaire asked, like the Mulilis-Lippa Preparedness Scale,[3] for the capability in coping with the disruption associated with hazard activity. It was included, like the other measures, both before and after the virtual earthquake distress programs to assess intervention effectiveness. It also was included to provide a validity check of child reports. Our previous research assessed the correlation between child and significant other's report to be r= 0.30, p< 0.01. The alpha reliability of the measure based on a larger sample (n= 280) used in that previous research was found to be 0.77.

Procedure

The study was administered before, during, and after intervention within each of the schools by a trained doctoral-level child researcher with the assistance of classroom teachers. Children were able to fill out questionnaires by reading to themselves after the instructions were read aloud to them. Children were then encouraged to enter the virtual scenario individually. Total time necessary to administer the scenario was approximately 5-6 minutes. As part of a post intervention homework exercise, children were asked to take a home-based questionnaire to their parents/guardians, to have it filled out, and to return it.

Emergency Condition (EC)

This condition involved a Virtual Reality Environment (VRE) around an existing Greek classroom of a school interior and part of the exterior. The VRML model of the school was photorealistic and imported directly, as a scale and layout reference. The classroom was populated with 12 students and a teacher, each capable of realistic emotive responses to an earthquake situation, such as showing fear, communicating distress to varying degrees, and moving around the classroom. We provided two basic modes of interaction – a guided "storytelling" mode and an interactive mode, where the participant controls his or her navigation/actions in a simulated earthquake. When an earthquake event is triggered, avatars respond appropriately, items in the VE respond with some degree of physics, and the environment shakes along with the appropriate sound effects. The participant must evacuate the classroom and go to an exterior area. Visible and audible navigation cues arise if they deviate from the optimal path. The software was integrated with an InterTrax12 tracker and the researcher was using an interface (Vienna Test System) that allowed an adult to observe the participant's actions and biopsychobehavioral corollaries as the child navigated through the VRE during the exercise.

Familiar Faces (FF) Condition

This condition involved the EC plus a realistic representation of the co-students' faces, enhanced with emotional reactions in real-time. This condition focused on emotional factors and intentions to seek information explicitly; it was thought that a focus on the social self-image, psychological preparation, and related fears would increase a sense of control and consequently benefit emotional factors.

Plan of Analysis, Assumption Checking, and Intervention Fidelity

Prior to assessing intervention effectiveness, differences between groups on each dependent variable were assessed. Given our focus on outcome analysis, intervention effectiveness was assessed through a 2x2 split plot repeated measures analyses of variance (ANOVA). All necessary assumptions (homogeneity of variance, sphericity, homogeneity of covariance

matrices, or intercorrelations) were met for these analyses with one exception. That is, the homogeneity of variance assumption was mildly violated between groups for pre-test fear scores (Levene's test, $F(1, 138) = 5.38$, $p < 0.03$). Various transformations (logarithmic, square, square root, reciprocal, arcsine) did not improve the homogeneity of variance estimate. However, given similarly shaped distributions, the variances being no more than four times different from each other (different by a factor of 1.3), and nearly equal sample sizes (difference of only six participants per cell in this analysis), the ANOVA procedure is generally robust under these conditions.[18] However, as an additional confirmation, an independent samples *t*-test was carried out on pre/post change scores (and, for the trials effect, a paired *t*-test for pre/post scores). Here, the homogeneity of variance assumption was met ($F(1, 138) < 1$), and the findings reflected the same statistics (when *t* scores were compared with *F* test scores based on *F* statistic, figures were within 0.007 of each other for between group and within 0.0004 for within group) and pattern of significance (within 0.001 of each other). Therefore, ANOVA findings were retained and are reported in the Results section.

Analysis of covariance (ANCOVA) and other forms of statistical control (e.g. hierarchical linear modelling (HLM)) were considered. However, in addition to the assumptions for ANOVA, ANCOVA requires the assumption of homogeneity of regression. In fact, this assumption is quite critical and if not met has been shown to lead to "misleading analyses" in relation to education programs.[19] In inspecting the scatter plots (using pre-treatment scores as covariates), regression lines were not uniformly similar in slope across parameters, thus making the results from ANCOVA potentially suspect. However, as an exploratory device, ANCOVA was carried out and results were uniformly equivalent to those reported from ANOVA in Results (i.e. same pattern of significance). In terms of effect size (ES) comparisons, generally they were quite similar. However, when they differed, the ES estimated from the ANOVA was always more conservative than that from the ANCOVA.

In terms of HLM analyses, given that the unit of generalization here was the individual child,[20] the decision was made *a priori* (i.e. prior to the study commencing) to consider the classrooms within treatment conditions as equivalent. This decision follows the convention, particularly in treatment outcome research that is evaluating the initial effectiveness of an intervention,[21] that uses the individual child as the basic unit of analysis. This is done despite the fact that in such studies each child is typically assigned to a different therapist (equivalent to the teacher/classroom here) within a particular intervention condition. The rationale for such a decision relates to the idea of intervention fidelity (i.e. equivalence in producing the named independent variable despite some individual variation on other factors). Given that, we had confirmation from each teacher (and as a validity check, their overall supervisors for this project, the vice-principal and lead teacher) that the protocols described earlier followed improved confidence in using the more basic repeated measures analysis. Additionally, in terms of a rationale for HLM, we had, as recommended,[22] no *a priori* data collected (e.g. teacher competence, systematic student differences by classroom) that spoke to what might underlie variability among the classrooms if an HLM procedure uncovered differences. Related to this idea, moderating or mediating influences were not considered a primary focus of this study. Finally, recent recommendations regarding HLM have suggested a minimum number of groups necessary for valid HLM analyses to be much greater (30-100) than the number of classrooms involved in this study (eight).

However, to provide a preliminary assessment of the relationships between variables in the study, a zero-order correlation matrix is included. The variables in the correlation analysis not only included dependent (problem and emotion-focused factors, pre, post, and change scores) and independent (intervention condition dummy coded) variables, but other factors were also assessed, including age, sex, previous disaster experience, and classroom.

In the repeated measures analyses, both problem-focused factors (child and survivor-reported hazard adjustments; child hazard knowledge) and emotion-focused factors (fear, perception of co-student upset, emotion-focused coping ability) were analyzed. Both significance levels and effect sizes (eta squared) are reported. For

reader convenience, and using Cohen's conventions, an eta squared estimate between 0.01 and 0.06 is considered to be a small effect; 0.06-0.14, medium; 0.14 and greater, large.

Preliminary Analyses: Pre-treatment Differences

Analyses (*t*-test comparisons) assessed any pre-treatment differences between groups across all dependent variables. No differences were found ($p > 0.10$).

Outcome Analyses

Means and standard deviations are presented in Table 1. Each dependent variable (DV) was analyzed by means of a 2 (group) x 2 (time) ANOVA.

Problem-Focused Coping

Hazard adjustments: Child report

A 2 x 2 ANOVA uncovered a significant trials effect $F(1, 214) = 180.93$, $p < 0.001$ (eta squared = 0.46) and a significant interaction, $F(1, 214) = 13.60$, $p < 0.001$ (eta squared = 0.06).

Hazard adjustments: Survivor report

ANOVA found a significant trials effect, $F(1, 141) = 263.70$, $p < 0.001$ (eta squared = 0.65) and a significant interaction, $F(1, 141) = 3.94$, $p < 0.05$ (eta squared = 0.03).

Emotion-Focused Coping

Hazard related fear

For global fear, ANOVA found a significant trials effect, $F(1, 138) = 4.77$, $p < 0.05$ (eta squared = 0.03), but no significant interaction ($F < 1$; eta squared < 0.01).

Perception of co-student upset

For perception of co-student hazard-related distress, ANOVA found a significant trials effect, $F(1, 146) = 4.49$, $p < 0.05$ (eta squared = 0.03) but no significant interaction, $F(1, 146) = 1.80$, $p > 0.10$ (eta squared = 0.01).

Emotional coping ability

For perception of emotional coping ability in the event of a hazard, the trials and interaction effects were both not significant ($F < 1$; eta squared < 0.01 in both instances).

Relationships Between Variables

Table 2 presents zero-order correlations and significance levels involving all variables measured in the study.

To acquire a biopsychobehavioral corollary analysis, we measured the reaction times (RTs) between normal children and children with previous earthquake experience (survivors) at the different stages of the two scenarios when intense stress was encountered and an emotional, verbal self-report from the students was required. We found out that the mean RT for the survivors was significantly shorter than the mean RT for the normal children. A time-out occurred if there was no response within 2000 ms. Generally, only responses between 150 and 1000 ms were accepted; RTs over 600 ms were rarely encountered. This finding could indicate a bias of previous experience as a preparedness and proactive coping skill that can be trained using a “stress inoculation” protocol. However, no matter how important this finding was, we need a different experiment in order to investigate whether the virtual scenario can isolate the factors that enhance “implicit learning” and measure the quality of the “virtual” experience as a stress inoculation factor in contrast with the actual experience. In other words, we need a real earthquake as a post-test, in order to test this hypothesis.

CONCLUSION

Taken together, based on significant trials effects for five of the six factors under study, the findings here support the role of virtual reality earthquake programs in both problem and emotion-focused domains. In addition, as indicated by significant interaction effects, the findings demonstrated the benefits of an interactive familiar emotional faces focus in producing additional, significant increases in emotion-focused variables: (1) emotion-based hazard adjustments as reported by both children and survivors and (2) fear-related coping skills. These

findings support previous corollary research[3, 10] and provide the first experimental evidence of the benefits of such programs prior to a hazardous event. It also follows similar research supporting the effectiveness of school-based intervention following a natural hazard.[24]

Compared to the EC virtual scenario program, the FF Condition was seen to produce greater benefits in the areas targeted (i.e. problem-focused areas) and the emotion-focused area (i.e. hazard fears, perception of parental fears, emotional coping). What makes this finding particularly encouraging is that previous research following a disaster has found that those children coping less effectively perceived significantly greater levels of co-students distress.[25] The implication here, supported by additional corollary findings discussed below, is that the perception of decreased co-students upset likely has benefits for many children. In addition, the fact that these virtual programs were seen to produce a decreased sense of distress bodes well for these children being able to manage a future event more effectively.

While the FF Condition outperformed the EC Condition in the emotion-focused areas, the EC Condition nonetheless produced benefits as indicated by the large trials effects and related effect sizes, particularly in the area of both child and survivor problem-focused reported hazard adjustments. Those findings support our previous corollary research[24] and provide additional evidence supporting the general idea of increasing any children's exposure to hazards and disasters in educational settings.

In terms of relationships between variables in the study, a few are worth highlighting. First, no robust relationships were seen between problem and emotion-focused factors. However, there were relationships seen involving variables within a given domain (i.e. problem or emotion-focused domains). In particular, problem-focused factors tended to relate to each other. For example, child factual knowledge was seen to relate to both child and survivor-reported hazard adjustments. Fewer systematic relationships were seen within the emotion-focused domain. However, children's perception of co-student upset was seen to predict their own level of fear, as measured with the Vienna Test System. The finding here provides some further support for the idea suggested earlier that children's perceptions of co-students' feelings affect their own fear levels.

Given that youth necessarily rely on adults or co-students for assistance in coping with problems, virtual adults' or co-students' willingness to react to such events may serve to help reassure children as well as provide them with a "coping model."[24] Cognitive behaviour therapy is regarded as a brief form of psychotherapy, but it may not be brief enough in post disaster cognitive behaviour therapy settings, where hundreds of thousands of survivors may need urgent care. The virtual scenario modified with familiar faces presented here appears to be promising as an effective one- or two-session intervention for earthquake preparedness and survivors. It may be particularly useful in large-scale disasters as a cost-effective treatment that can be relatively easily disseminated to the masses.

Nonetheless, future research might include an after an earthquake condition to emphasize internal validity. Additionally, this study focused on short-term effects of virtual reality programs: future efforts might include follow-up assessments over a longer interval to assess whether changes are generalized across time. Finally, additional, *a priori* emphasis on specific nesting factors (e.g. schools, classrooms, families, intervention condition) and related potential mediators and moderators of change (e.g. demographic factors, child and family pre-intervention expectancies, teacher competence at program delivery) would begin to build on the initial foundation provided here.

	EC Condition	FF Condition	ANOVA Summary
Hazard Adjustments: Child			
Pre	5.83 (5.28)	7.00 (5.60)	a, b
Post	11.23 (6.10)	10.07 (6.50)	
Hazard Adjustments: Survivor			
Pre	10.25 (3.96)	9.94 (3.94)	a, b
Post	14.68 (3.96)	13.41 (3.87)	
Emotion-Focused Factors			
Hazard-Related Fears			
Pre	1.62 (0.57)	1.66 (0.48)	a, c
Post	1.55 (0.58)	1.54 (0.53)	
Perceptions of Co-students Distress			
Pre	2.19 (0.49)	2.17 (0.45)	a, c
Post	2.23 (0.56)	2.34 (0.48)	
Perceived Emotional Coping			
Pre	4.24 (1.61)	4.30 (1.49)	d
Post	4.21 (1.72)	4.21 (1.64)	
Note: EC = Emergency Condition; FF = Familiar Faces Conditions; subscripts denote the following based on analysis of variance (ANOVA), a = trials (time) effect significant; b = interaction effect significant (i.e., changes across time by group differed); c = interaction effect nonsignificant; d = trials and interaction both nonsignificant (*n* ranged from 140 to 216 in the analyses).			

Table 1. Problem and Emotion-Focused Factors: Means (and Standard Deviations) and ANOVA Summary.

Table 2. Zero-Order Correlation Matrix.

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}
X_1	1.00																
X_2	−0.06	1.00															
X_3	−0.11	0.05	1.00														
X_4	0.10	0.13	−0.15*	1.00													
X_5	−0.09	0.02	−0.10	−0.14*	1.00												
X_6	0.03	−0.08	−0.25**	−0.12	−0.25**	1.00											
X_7	0.14	−0.00	−0.03	0.03	0.04	−0.19**	1.00										
X_8	0.13	−0.03	0.10	0.14	0.11	−0.13	−0.04	1.00									
X_9	0.01	0.05	−0.05	−0.05	0.07	0.05	0.06	−0.10	1.00								
X_{10}	0.09	0.00	0.02	0.02	0.03	0.03	−0.14	0.11	−0.03	1.00							
X_{11}	0.18*	0.01	0.21**	−0.10	0.08	−0.11	0.12	0.56**	−0.32**	0.12	1.00						
X_{12}	−0.05	−0.03	0.00	0.08	−0.15*	0.15*	−0.18*	−0.18*	0.26**	0.01	−0.24**	1.00					
X_{13}	0.09	0.09	0.12	−0.05	0.20**	−0.06	0.00	0.01	0.00	0.41**	0.15	0.01	1.00				
X_{14}	0.08	−0.06	0.11	−0.00	−0.02	0.31**	−0.05	−0.00	0.03	0.04	−0.16*	0.22**	0.03	1.00			
X_{15}	0.04	−0.04	0.13	−0.17*	−0.05	0.07	−0.05	0.05	0.05	0.11	0.14	−0.11	0.19*	0.30**	1.00		
X_{16}	0.09	−0.05	0.03	0.05	−0.04	0.43**	−0.01	−0.07	−0.03	0.11	−0.10	0.18*	−0.07	0.60**	0.07	1.00	
X_{17}	−0.08	−0.07	0.13*	0.02	0.07	0.29**	0.04	0.00	0.03	−0.01	−0.01	0.06	0.12	0.68**	0.28**	0.46**	1.00
X_{18}	−0.08	−0.04	0.10	−0.02	0.10	0.05	−0.04	0.06	0.09	0.03	0.09	−0.01	0.14	0.27**	0.72**	0.15*	0.52**
X_{19}	−0.04	−0.02	0.06	−0.09	0.03	0.35**	0.01	−0.11	0.05	0.01	−0.07	0.10	0.08	0.38**	−0.04	0.60**	0.61**
X_{20}	−0.16*	−0.01	0.05	0.05	0.11	0.04	0.15*	0.01	0.01	−0.05	0.14	−0.19*	0.08	−0.24**	−0.04	−0.06	0.55**
X_{21}	−0.10	0.05	−0.03	0.06	0.13	−0.18*	0.02	0.04	0.04	−0.16	0.07	0.10	−0.07	−0.11	−0.37**	−0.12	0.13

X_{22}	−0.11	0.01	0.02	−0.15*	0.08	−0.00	0.03	−0.06	0.07	−0.07	0.06	−0.08	0.15*	−0.14*	−0.11.	−0.28**	0.27**
X_{23}	−0.03	0.02	0.11	−0.24**	0.00	0.00	0.13	−0.42**	−0.22**	−0.02	0.51**	−0.11	0.05	−0.09	0.09	0.07	0.05
X_{24}	−0.08	−0.10	−0.01	0.12	−0.17*	0.13	−0.24**	−0.05	−0.55**	−0.02	0.00	0.66**	0.01	0.13	−0.15	0.12	0.03
X_{25}	0.01	0.07	0.09	−0.02	0.15	−0.09	0.07	−0.09	−0.00	−0.49**	−0.04	−0.01	0.60**	0.10	0.10	−0.08	0.20*
X_{26}	−0.04	−0.02	0.02	0.01	0.13*	−0.14*	0.02	−0.06	−0.05	−0.02	−0.05	−0.09	−0.01	−0.10	−0.01	−0.05	0.10
X_{27}	−0.02	−0.11	−0.05	−0.02	0.06	0.00	−0.03	−0.11	0.10	−0.16*	−0.10	0.12	0.00	0.04	−0.05	0.11	0.12
X_{28}	−0.02	−0.01	0.05	−0.10	0.00	0.05	0.08	0.06	0.01	−0.05	0.06	−0.08	−0.10	−0.02	0.07	−0.08	−0.02
X_{29}	−0.09	0.08	0.04	0.13	0.02	−0.10	−0.01	0.01	−0.05	0.15	0.13	−0.05	0.09	−0.16*	−0.09	−0.04	−0.00
X_{30}	0.07	−0.02	−0.01	0.00	0.11	−0.15*	−0.01	−0.04	0.01	0.04	−0.13	−0.18	−0.01	0.00	0.05	−0.06	0.06
X_{31}	−0.05	0.10	−0.10	0.23**	−0.00	−0.25**	0.10	0.10	−0.03	−0.09	−0.09	0.07	−0.03	−0.10	0.10	0.13	−0.24**
X_{32}	0.04	−0.05	0.00	−0.07	0.01	0.09	−0.07	−0.18*	−0.02	0.00	0.16*	−0.02	−0.03	0.04	0.14	−0.12	0.03
X_{33}	0.11	0.05	−0.05	−0.07	−0.02	0.12	0.01	−0.10	0.06	0.03	0.09	0.10	−0.01	−0.06	−0.14	−0.02	−0.15*
X_{34}	−0.04	−0.03	0.11	−0.10	−0.19**	0.25**	−0.07	−0.08	−0.08	0.07	−0.11	0.01	0.07	0.27**	0.09	0.35**	0.20**
X_{18}	1.00																
X_{19}	0.18**	1.00															
X_{20}	0.35**	0.37**	1.00														
X_{21}	0.38**	−0.02	0.31**	1.00													
X_{22}	0.06	0.60**	0.51**	0.09	1.00												
X_{23}	0.00	0.06	0.12	0.02	0.01	1.00											
X_{24}	−0.06	0.03	−0.13	0.09	−0.04	0.06	1.00										
X_{25}	0.10	0.06	0.09	0.06	0.17	0.07	−0.01	1.00									
X_{26}	0.07	0.11	0.24**	0.17*	0.18**	0.05	−0.11	0.02	1.00								
X_{27}	0.05	0.19**	0.12	−0.01	0.11	0.05	0.02	0.18*	0.34**	1.00							
X_{28}	−0.00	0.09	−0.01	0.08	0.19**	0.02	−0.13	−0.08	0.36**	−0.14*	1.00						

X_{29}	0.07	−0.13	0.18**	0.24**	−0.10	0.11	0.03	−0.02	0.39**	−0.15*	−0.16*	1.00				
X_{30}	−0.01	0.03	0.07	−0.06	−0.09	−0.11	−0.10	−0.07	0.39**	−0.15*	−0.16*	−0.17*	1.00			
X_{31}	−0.06	−0.26**	−0.18**	−0.07	−0.18**	−0.24**	0.05	0.09	−0.37**	−0.13	−0.13*	−0.14*	−0.14*	1.00		
X_{32}	0.00	−0.19**	−0.03	−0.17*	−0.10	0.07	0.04	−0.05	−0.39**	−0.14*	−0.14*	−0.15*	−0.15*	−0.13*	1.00	
X_{33}	−0.13	−0.01	−0.13*	−0.00	−0.00	0.06	0.04	−0.06	−0.39**	−0.14*	−0.14*	−0.15*	−0.15*	−0.13*	−0.14*	1.00
X_{34}	0.08	0.28**	−0.05	−0.13	−0.01	−0.03	0.04	0.02	−0.39**	−0.13*	−0.14*	−0.15*	−0.15*	−0.13	−0.14*	−0.14*	1.00

X_1= sex; X_2= age; X_3= social status; X_4= Thessalonica; X_5= Athens; X_6= Kozani; X_7= Ethnic — Other; X_8= pre-fear score; X_9= pre-others upset; X_{10}= pre-coping; X_{11}= post-fear score; X_{12}= post-others upset; X_{13}= post-coping; X_{14}= pre-child report — hazard adjustments; X_{15}= STAI score — hazard adjustments; X_{16}= pre-knowledge; X_{17}= post-child hazard adjustments; X_{18}= post-survivor hazard adjustments; X_{19}= post-knowledge; X_{20}= child adjustments post-pre change score; X_{21}= survivor adjustments post-pre change score; X_{22}= knowledge post-pre change score; X_{23}= fear post-pre change score; X_{24}= co-studentt perception post-pre change score; X_{25}= coping post-pre change score; X_{26}= intervention group (0 = EC, 1 = FF); X_{27}= Room EC 1; X_{28}= Room EC 2; X_{29}= Room EC 3; X_{30}= Room EC 4; X_{31}= Room FF 1; X_{32}= Room FF 2; X_{33}= Room FF 3; X_{34}= Room FF 4 (*n* ranged from 140 to 219); **p*< 0.05, ***p*< 0.01 (two tailed).

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Training Brief Intervention with a Virtual Coach and Virtual Patients

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Abstract: *Alcohol and substance abuse is the number one mental health problem in America as well as a major health problem. Although brief interventions during primary care visits can be effective, clinicians usually do not act on signs of alcohol abuse—often because they do not know how to intervene. Clinicians need training in brief intervention techniques, but this is impractical due to the large number of clinicians, the high costs, and the daunting logistics of the only effective training method currently available—practice with standardized patients. To address this need, we developed STAR™ Workshop, an online training workshop incorporating a virtual coach and virtual standardized patients. The STAR coach motivates and teaches an evidence-based brief intervention protocol. STAR virtual patients provide practice and intrinsic reinforcement. After each practice session, the coach offers additional feedback and any needed remediation. We comparatively evaluated STAR Workshop against a self-paced E-Book covering the same content and a no-training Control, with medical and nursing students as subjects. Students trained with STAR Workshop substantially outperformed subjects in the other conditions, achieving high scores on self-assessments of their own intervention skills and intentions to intervene, as well as on objective assessments of their intervention skills, based on both short-answer probes and recorded interventions with live standardized patients. Thus, STAR Workshop provides a scalable, affordable, and effective approach to training brief intervention skill in alcohol abuse.*

INTRODUCTION

Alcohol and substance abuse is the number one mental health problem in America and a major health problem, impacting individuals, families, friends, co-workers, employers, and communities. Brief interventions administered during routine clinic visits have been shown to be effective in reducing the health risks and social costs of alcohol abuse.[1-4] Primary care settings are ideally suited for intervention, as patients tend to visit them more often than medical specialty settings.[5] Brief interventions are also attractive for their simplicity and low cost. Following a simple 10-15 minute interview protocol, non-specialists can effectively administer brief interventions.[6]

Unfortunately, few providers routinely screen patients or intervene in alcohol abuse. Fleming[26] reports 20% screening rates during hospital admissions, citing insufficient training as the primary reason: “Asking patients about sensitive life-style issues, such as alcohol use, requires strong communication skills. Many physicians have not received training in this area.” The Center for Addiction and Substance Abuse (CASA) finds that physicians miss signs of alcohol abuse 94% of the time and 11% of patients report physicians who were aware of their addictions but did nothing.[7] Calling alcohol and substance abuse America’s #1 disease, Joseph Califano, President of CASA and former Secretary of HEW, said, “Substance abuse is an elephant in the examining room. Doctors may simply be embarrassed to ask the key questions. They don't want to anger their patients. They think patients will lie about this... Medical schools and other education programs for physicians need to provide more training on how to spot and deal with substance abuse." A Commonwealth report on medical education[8] concurs: “Many young physicians do not feel confident counseling patients on such subjects as smoking, weight reduction, safe sex practices, domestic violence, and drug and alcohol use. To prepare students for the challenges facing health care in the 21st century, academic health centers must place more emphasis on skills not traditionally taught in medical schools. Physicians need training to address the behaviors and social circumstances at the root of many health care issues.”

For inter-personal skills such as those involved in brief intervention, role-playing has long been recognized as the training method of choice[9]. Roughly 80% of medical training centers now integrate role-play with "standardized patients" as part of a problem-based medical curriculum.[8,10] More specifically, Fleming[26] suggests that "Role playing can be an invaluable way to teach physicians how to become more comfortable with alcohol screening questions and interviewing techniques allowing them to rehearse their skills before they interact with their patients. Because nothing can substitute for practice and repetitions, role playing can build a physician's confidence in his or her alcohol-screening skills."

On the other hand, cost and logistics make this approach impractical. It takes 10-30 times as many teaching professionals to move from a traditional, lecture-based model to small group instruction of 5-10 students in problem-based curricula. Many smaller community teaching hospitals do not have the resources to implement problem-based curricula and few teachers have expertise in conducting small groups.[8] The use of standardized patients is also expensive. The Uniformed Services University, one of the largest military medical training centers in the country, reports annual operating costs for its Medical Simulation center of $1.3 million with $300,000 for standardized patients and $125,000 in training costs.[11] The American Medical Association estimates the cost of clinical skills testing with standardized patients as high as $1,700 per test.[12] Similarly, test preparation companies are charging approximately $1,000 per day for small group workshops with standardized patients.

Moreover, even live workshops and role-playing appears to have limited efficacy. In our own studies of inter-personal skills for management-staff communication (which are in many ways analogous to brief intervention skills), live training workshops featuring professional instructors and peer role-players produced high learner satisfaction and self-reports of skills improvement, but little or no improvement on objective performance measures.[13] Similarly, in several studies of motivational interviewing for alcohol abuse, live training workshops produced self-reports of skills improvement up to 4 months later, but only modest improvements (too small to affect client response) in objective observations of interviewing performance.[14-16]

We believe that these disappointing results reflect common misconceptions about the nature of sophisticated inter-personal skills and the training experiences required for individuals to master such skills and incorporate them into everyday practice. First, many people underestimate the high skill levels required for efficacy in sensitive inter-personal interactions and the amounts of practice and coaching required to attain skill levels. Compounding this misconception, many people suffer "cognitive illusions" in which they overestimate the efficacy of elementary training experiences and the skills they engender.[17] Third, instructors and standardized patients vary in their own expertise and consistency. After all, they are only human! In sum, we believe that even expert researchers and training providers err in attempting to achieve ambitious training objectives—mastery of sophisticated inter-personal skills—by providing an insufficient amount of insufficiently challenging, training experience of variable quality.

To address the need for effective, efficient, affordable, scalable training in brief intervention skills, we developed the STAR™ Workshop for Brief Intervention in Alcohol Abuse.[18] Following the literature on enhancing human performance,[17,19] STAR Workshop implements a Guided Mastery™ pedagogical strategy, featuring a virtual coach and several virtual standardized patients (VSPs), all built on interactive character technology.[20-22] Figure 1 displays excerpts from a training session in STAR Workshop.

As with live workshops with standardized patients, STAR Workshop provides expert instruction, authentic practice, and detailed feedback. In contrast to live workshops, STAR's Guided Mastery strategy provides as much practice and as much coaching as each individual learner requires, systematic guidance to master the target skills, and individually optimized learning paths. Thus, in addition to being affordable and scalable, we hypothesize that STAR Workshop will be uniquely effective and efficient in its training of brief intervention skills. The present study is designed to evaluate that hypothesis.

MATERIALS AND METHODS

Target Protocol

To provide a training target for our study, we developed a brief intervention protocol called Engage for Change™ (E4C™). The E4C protocol adapts the evidence-based techniques of motivational interviewing.[15] Given the practical needs of a large and diverse population of primary-care clinicians, and the operational requirements of automating the training process, the E4C protocol was constrained to be general, brief, memorable, teachable, and verifiable. At the most general level, the E4C protocol is as follows:

A. Inform the patient of health risks:
   1. Raise the topic of alcohol consumption in a general health context.
   2. Inform the patient of his or her specific health risks associated with alcohol.

B. Acknowledge the patient's point of view:
   3. Invite the patient to express his or her concerns about health consequences of alcohol
   4. Accept the patient's stated concerns.

C. Encourage the patient to make a change.
   5. Invite the patient to make an appropriate change step.
   6. Ask the patient to commit to make the change step.

Motivational interviewing was developed originally as a compassionate alternative to confrontational methods for treating addiction. Its efficacy is supported by many studies, including alcohol abuse studies intervention.[2,14,23,24] Thus, the E4C protocol should be similarly effective for a brief intervention regarding alcohol abuse. However, verification of its clinical efficacy is beyond the scope of this study.

Instructional Content

We created 41 Web pages containing 23 pages of instructional content for use with all learners; 12 pages of coaching content to be used with individual learners at the coach's discretion; and 6 pages for displaying VSP medical histories and role-play scores.

Virtual Coach

We created a virtual coach named "Harmony." She has an animated embodiment with approximately 25 gestures and facial expressions, which she uses to complement her dialogue. She delivers her dialogue in a synthesized voice and typed speech bubbles, personalizing it to call the student by name, quoting segments of the student's role play conversations with VSPs, etc. Harmony presents 80 instructional topics, with approximately 100 associated lines of instructional dialog. She also has about 300 lines of feedback dialogue which she selects and instantiates with student-specific information. She has about 100 lines of coaching dialogue, which she selects based on student performance. She has 124 preconditions, which she uses to select dialogue and actions. Harmony currently accepts only point-and-click input from students wishing to continue or quit.

Virtual Standardized Patients

We created three VSPs—Lee, Nina, and Ed—differing in gender, age, culture, personality, health scenario, resistance, and referral needs. Each VSP has a photographic embodiment (created with actors), with approximately 25 gestures and facial expressions, which he or she uses to complement dialogue. VSPs deliver their dialogue in recorded human voice (created by actors) and typed speech bubbles. They accept typed natural language input from students. Each VSP has 12 conversational contexts, with about 200 lines of dialogue and two-six alternate wordings for each line. They recognize 80 sets of semantically equivalent student inputs, with 8-20,000 alternate wordings accepted for each one. VSPs have 75 preconditions, which they use to select dialogue, gestures, or a new conversation context. They have 18 moods (e.g., confident, unconfident, edgy, defensive, comfortable), which are influenced by their interaction with a student and manifest in the selection of dialogue, gesture, and context.

Training Conditions

Our study had three training conditions: STAR Workshop, E-Book, and Control. STAR Workshop is described above and incorporates all instructional content, the virtual coach, and the

four VSPs. For E-Book, we created a self-paced course, with Web pages incorporating all instructional content created for STAR Workshop, plus all of the STAR Coach's instructional dialogue. Students could access the E-Book like a conventional e-learning application, choosing whether or not to follow the recommended page sequence, how much time to spend on each page, etc. The Control condition had no training.

Subjects

31 subjects included medical students from Stanford University and nursing students from the University of San Francisco and San Jose State University. We assigned subjects to training conditions semi-randomly, balancing education, age, gender, ethnicity, and pre-training assessments of attitudes and skills (discussed below). We did not predict or find any effects of these variables and do not refer to them further. Subjects were paid $100 for their participation.

Procedure

The following procedure was applied for all subjects:

- *Pre-Training Assessment* – Self-reports of attitudes and short-answer skills probes;
  - *Training* – STAR Workshop, E-Book, or Control
- *Post-Training Assessment* – Self-reports of attitudes and short-answer skills probes;
  - *Two Week Post-Training Retention Interval*
- *Post-Delay Intervention with a Live Standardized Patient (LSP)* – Telephone interview;
- *Post-Delay Assessment* – Self-reports of attitudes and short-answer skills probes.

Attitude Assessments

Subjects used 5-point Likert scales to report their attitudes toward these statements: 1. The E4C protocol is effective. 2. The E4C protocol is practical. 3. My training method was effective. 4. I am confident in my brief intervention skills. 5. I plan to intervene with patients who show signs of alcohol abuse. For STAR and E-Book subjects, pre-training assessments included statements 4 and 5; post-training and post-delay assessments contained statements 1-4. For Control subjects, all assessments included only statements 4 and 5.

Efficacy–Skills Probes

Subjects' skills were assessed with short-answer probes, representing the 6 steps in the E4C protocol, on all 3 assessments. Responses were scored 0-3 points: correct step, correct step in context, no errors (e.g., patronize, contradict, advocate change).

> *Sample Basic Probe Item:* Troy, 43, an attorney, is at your clinic to check his recovery from a broken collarbone suffered in a car crash. On his medical history, he reports that he consumes 30 drinks of alcohol per week. He also reports frequent insomnia and gastritis, which you think may be related to his alcohol consumption. Troy says: "The shoulder's much better. We're done for today, right?" What do you say?
> *Correct response step:* Step 1. Raise the topic of alcohol consumption in a health context.
> *Sample correct responses:*
> "I would like to spend a few minutes explaining how drinking may be affecting your health."
> "Troy, I want to discuss the role of alcohol as a contributing factor to insomnia."
> "Let's talk about the how alcohol consumption may be contributing to your gastritis."

Note: Besides basic probes, our study included easier cued probes and more difficult open probes. Since all probes showed comparable effects, we discuss only basic probes here.

Transfer of Retained Skills—Live Intervention

Subjects' skills were assessed in performance of telephone interventions with a live standardized patient (LSP), conducted after the 2-week post-training retention interval. Subjects received the case history below and then were given 10 minutes to conduct the intervention. The recorded intervention was scored 0-18 points, with 0-3 points (correct step, correct step in context, no errors) for each step in the

E4C protocol.

The LSP Case History. Morgan, 51, a recently divorced attorney and mother of 2, is at the clinic for an allergy shot. Her previous record indicates low-normal blood pressure and overall good health. On exam, her blood pressure is significantly higher than on previous exams. She has a slight cough today and reports that she is recovering from a cold. On her medical history, she reports drinking 2-3 glasses of wine daily. She has occasional headaches and moderate stress. According to NIAAA guidelines, a woman may be at risk for alcohol-related problems if she consumes more than 7 alcoholic drinks a week or more than 3 drinks a day. High blood pressure and headaches are both associated with heavy drinking. You are concerned that Morgan's alcohol use may be contributing to these conditions and that she may be headed for future health problems. You suspect that her drinking may be having negative impacts on other areas of her life, as well. An appropriate referral for Morgan might be to a behavioral health case manager to develop a reduction plan.

Scoring and Data Analysis

Two judges blindly and independently scored responses for skills probes and live interventions. An independent 3rd person combined judges' scores and entered them in spreadsheets along with self-report attitudinal data, key demographic data, and learning path data automatically recorded by STAR and e-Book. Summary statistics were computed in these spreadsheets. We omit conventional statistics; these would be redundant and obvious, given the large and consistent differences observed.

RESULTS

Verifiable Individual Progress and Individually Optimized Training with STAR Workshop

100% of subjects in the STAR Workshop condition mastered the E4C protocol. Subjects displayed individual progress in performance improvements with successive VSPs: increasing initial role-play scores (means = 4, 14, 17 out of a perfect score of 18), decreasing number of role-plays required for mastery (means = 6, 3, 2), and a decreasing number of step-coaching events required for mastery (means = 14.3, 5.7, 2.8). In addition, 100% of STAR subjects were guided along unique learning paths, optimizing the sequence, duration, and content of instruction, role-play, feedback, and coaching, based on individual progress and specific individual behaviors during role-play. As a consequence, subjects varied widely in the number of minutes they spent on: instruction (range = 15-23), role-play (range = 24-105), and coaching (range = 28-131).

Comparison of Immediate Impact and Efficacy of STAR, E-Book, and Control

STAR and E-Book produced comparable positive immediate impact on subjects' attitudes. Subjects judged the E4C protocol effective (mean = 5 vs. 5) and practical (mean = 4 vs. 4). They gave positive ratings to their training (mean = 4 vs. 4), their intervention skills (mean = 4.5 vs. 4.25) and their intentions to intervene with patients showing signs of abuse (mean = 5 vs. 4).

However, E-Book subjects performed only slightly better than Control (no training) subjects on skill probes of immediate efficacy. 72% vs. 62% of subjects improved over pre-training skills, achieving 22% vs. 10% of the maximum possible improvement. Subjects averaged 61% vs. 50% correct responses on post-training assessment, with no subjects in either group scoring >90%. Thus, E-Book subjects' positive self-assessments reflected over-confidence.

By contrast, STAR subjects performed substantially better than E-Book and Control subjects, and at a high absolute level on skills probes of immediate efficacy. 100% of STAR subjects improved over pre-training skills, achieving 78% of the maximum possible improvement. STAR subjects averaged 89% correct responses on post-training assessment, with 46% scoring >90%. Thus STAR subjects' performance validated their positive self-assessments.

Comparison of Retained Impact and Efficacy of STAR, E-Book, and Control

Results for retained impact and efficacy following the two-week retention interval were similar

to but more exaggerated than results for immediate impact and efficacy.

Again, STAR and E-Book produced comparable positive retained impact on subjects' attitudes, identical to the immediate data, except E-Book subjects reduced their mean assessment of the effectiveness of the E4C protocol from 5 to 4.

On skill probes of retained efficacy, E-Book subjects fell even closer to Control subjects, whose scores remained constant. 64% vs. 62% of subjects improved over pre-training skills, achieving 11% vs. 10% of the maximum possible improvement. Subjects averaged 56% vs. 50% correct responses on delayed skills probes, with no subjects in either group scoring >90%. Thus, after a two-week retention interval, training with E-Book was no better than no training at all.

Again by contrast, STAR subjects performed substantially better than E-Book and Control subjects, on skills probes of retained efficacy at a high absolute level. 100% of STAR subjects improved over pre-training skills, achieving 78% of the maximum possible improvement. STAR subjects averaged 89% correct responses on delayed skills probes, with 55% scoring >90%. Thus STAR subjects retained their excellent skills over the two-week retention interval.

Comparison of Transfer of Retained Skills to Live Intervention

On transfer to live intervention, E-Book scores were similar to Control scores. Subjects in both groups averaged 50% correct, with no subjects in either group scoring >90%. However, only 18% of E-Book subjects made no extraneous errors, compared to 38% of Control subjects. Again, training with E-Book is no better than no training at all.

STAR subjects performed substantially better than E-Book and Control subjects, on transfer to live intervention at a high absolute level. STAR subjects averaged 94% correct performance, with 55% scoring >90%, and 82% making no extraneous errors. In fact, these scores are at least as good as the scores on the immediate and delayed skills probes. Thus STAR Workshop prepared subjects to perform quite well in live interventions two weeks after training.

DISCUSSION

Results of the present study demonstrate the efficacy of STAR Workshop for training clinicians in the E4C protocol for brief intervention in alcohol abuse. STAR subjects performed extremely well on both immediate and delayed skills probes and on the critical test of intervention with a live standardized patient. In addition, STAR subjects showed 100% uniqueness and broad variability of learning paths, tied to individual progress on learning objectives. Thus, the results confirm our hypothesis that STAR Workshop would provide effective and efficient training in brief intervention skills.

Results of the study also indicate that training with E-Book self-paced learning may induce cognitive illusions in which learners overestimate the efficacy of their training and their own competence. Although E-Book subjects reported high confidence, comparable to STAR subjects, their performance was poor and comparable to Control subjects on all immediate and delayed skills probes, as well as in an intervention with a live standardized patient.

Although this study did not include a live training condition, it is noteworthy that STAR subjects demonstrated very strong intervention skills on all assessments, especially in their interventions with a live standardized patient. With enhancements to STAR Workshop—for example, practice with a greater variety of VSPs—performance will approach a ceiling, leaving the possibility for only small improvements, at best, in live training. Given the high cost and daunting logistics of live training, STAR Workshop may offer an extremely attractive alternative, matching the efficacy of live training at a lower cost. While further study is required to clarify these cost-benefit trade-offs, the prospect of a *Pareto optimal* approach is tantalizing.

It also is worth noting that the E4C protocol is a variable in our study and in STAR Workshop. Although prior research on motivational interviewing suggests that E4C should be clinically effective for brief intervention in alcohol abuse, it is quite possible that new research might sug-

gest improvements to the protocol or an alternate more effective protocol. STAR Workshop can be applied to teach any such new or modified protocol. In fact, STAR Workshop can be an important tool supporting large-scale clinical trials of alternative intervention protocols by providing an efficient and effective means of verifiably training large numbers of clinicians to reliably follow experimental protocols.

In sum, the present findings provide a promising foundation for the development of a comprehensive program for training brief interventions in alcohol abuse and delivering the program to a broad range of primary-care clinicians in a form that is practical, scalable, and affordable. This would enable a larger number of clinicians to perform more effective interventions with a larger number and diversity of patients, at earlier, more treatable disease stages. This, in turn, would enhance immediate and life-long patient health while reducing immediate and life-long costs of health care.

Success with this important application would also lay the groundwork for developing STAR Workshops to train effective intervention protocols for drug abuse, obesity, eating disorders, exercise, safe-sex, diabetes management, asthma management, and other conditions where health outcomes and costs depend on the clinician's skills in facilitating changes in patient behavior.

Figure 1. Illustrative Excerpts from a Training Session in STAR Workshop.

Kay (pseudonym), a Stanford medical student, is learning the E4C protocol in STAR Workbench. Harmony, the STAR Coach, explains, motivates, and illustrates each step in the protocol.	Kay, when inviting your patient to express concerns, try to cultivate an atmosphere of trust and the patient's sense of autonomy. Be sure to ask an open-ended question that invites more than a yes or no answer. A patient who can speak freely may reveal a lot about motivation and readiness to change.  **Step 3. Invite the patient to express concerns…** **by asking open-ended questions that relate drinking behavior to health, work, social, or family consequences.** **Example:** ***"How do you think your use of alcohol may be affecting your health?"***
Lee, a VSP, gives Kay authentic practice, conversing with her in natural language, complemented by appropriate facial expressions, body language, and emotional dynamics. Lee's life-like behavior provides intrinsic reinforcement of Kay's performance. Even smart students like Kay make errors on early practice.	*Kay, a Stanford medical student (pseudonym), performs her 1st post-training role play practice with Lee, a virtual standardized patient (VSP)*  Lee: I really thought I had broken a bone. Kay: Lee, I would like to talk about how alcohol is affecting your health. Lee: OK, fine. Kay: You need to reduce your drinking, Lee. Lee: I don't know that I want to do that. Kay: Well, you should think about it. Lee: I didn't come here for a lecture. So, good-bye.
Harmony scores Kay's role-play performance. She offers detailed, personalized feedback, calling Kay by name and quoting segments of her dialogue with Lee. Harmony provides explicit, systematic reinforcement of strengths and weaknesses in Kay's intervention with Lee. For each step in the E4C protocol, Harmony explains what Lee did, whether or not it was correct, and what its consequences were.	Kay, that didn't go very well, did it? Don't worry. You can try again in a moment. Let's review. You did a good job raising the topic of Lee's drinking when you said, *"Lee, I would like to talk about how alcohol is affecting your health."* By raising the topic in a neutral health context, you made Lee feel comfortable and willing to discuss his drinking. Good work, Kay. Next, you should have informed Lee of his specific health risks associated with drinking. Instead, you suggested that Lee change his behavior, when you said, *"You need to reduce your drinking, Lee."* I know this was good medical advice, Kay. However, advocating change prematurely actually made Lee more resistant. … *[etc.]*  nt Scores 3/3 0/3 0/3 4. Accept the patient's stated concerns. 0/3 Encourage the Patient to Make a Change 5. Invite the patient to move towards change. 0/3 6. Encourage the patient to commit to the change. 0/3

Harmony gives Kay remedial instruction only for those protocol steps on which she made errors in her most recent role-play practice. Harmony suggests, motivates, and illustrates substitute behaviors for Kay to try in her next role-play practice.	Kay, informing your patient of risks associated with alcohol consumption is one of your important functions. Remember to tell your patient how drinki impacts his or her specific health conditi Your message will most likely be heard i stick to the facts and refrain from criticizi your patient's current drinking behavior advising a particular course of action.  **Inform the patient of specific risks… by simply stating the relevant facts.** **Example 1:** "You have elevated blood pressure and gastritis. Alcohol can be a contributing factor to both of these conditions." **Example 2:** "Drinking alcohol is associated with headaches and difficulty sleeping. I noticed that you have both of these problems."
Kay masters the E4C protocol on her 5th role-play with Lee. Note that VSP Lee provides authentic repeat practice. He responds appropriately to changes in Kay's behavior and introduces normal variability in his own dialogue. Thus, Kay cannot simply remember a correct "script" for intervening with Lee. She must listen and engage expertly with Lee on every practice.	*Kay's 5th role play with VSP Lee is perfect*  Lee: Well, I'm relieved there's no fracture. Kay: Let's discuss the impact of alcohol on your hea Lee: OK, fine. Kay: Your alcohol consumption may be negatively affecting your ulcers, blood pressure, and sleep. Lee: Well, that's certainly one of the downsides. Kay: Lee, what effect do you think alcohol has on your health? Lee: I hate having the ulcer! Drunks have ulcers. Believe me, I'm not getting any more drunk diseases! Kay: You're worried that drinking is causing your ulcers. Lee: To be honest, it's tougher to quit than I thought it would be. Kay: I know a counselor that you might be interested in seeing. She's helped other young professionals like you change their drinking patterns. Lee: Interesting. Kay: Will you follow through with this referral? Lee: All right. I'm going to do it. OK. Bye now. And thanks.
Coach Harmony congratulates Kay on her mastery of the E4C protocol with Lee. She systematically reinforces every element of Kay's correct performance. Next, Harmony will introduce VSP Nina and, later, VSP Ed. With each of them, she will guide Kay through the same individualized process of practice-feedback-coaching, leading her to mastery of the E4C protocol.	Excellent Kay! You've mastered the role play with Lee. Let's review. Another good start for you, Kay. You said, *"Let's discuss the impact of alcohol on you health."* By introducing the topic in a hea context, you made Lee feel comfortable a willing to discuss his alcohol consumption Kay, this is your best score so far on step You informed Lee of his specific health risks when you said, *"Your alcohol consumption may be negatively affecting your ulcers, blood pressure, and sleep."* Again, Kay, you did a good job inviting … *[etc.]*  agement Scores 3/3 risks. 3/3 Acknowledge the Patient's Point of View 3. Invite the patient to express concerns. 3/3 4. Accept the patient's stated concerns. 3/3 Encourage the Patient to Make a Change 5. Invite the patient to move towards change. 3/3 6. Encourage the patient to commit to the change. 3/3

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Addiction to Massively Multiplayer Online Role-Playing Games

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Abstract: *As computer and Internet use become a staple of everyday life, the potential for overuse is introduced, which may lead to addiction. Applications such as online chat on Internet Relay Chat (IRC) and text-based role-playing games on Multi-User Domains (MUDS) have been extremely popular for years. Research on Internet addiction has shown these are the types of applications users become addicted to. Recently, these applications have evolved into graphically intense three-dimensional virtual worlds called Massively Multiplayer Online Role-Playing Games (MMORPGs). Addiction to the Internet shares some of the negative aspects of substance addiction and has been shown to lead to consequences such as failing school as well as familial and relationship problems. The factors surrounding these cases must be examined from an HCI perspective as they pertain to both computer usage and the impact it has on users.*

BACKGROUND

Internet addiction is not yet a DSM-IV diagnosis, but its definition has been derived from DSM-IV criteria for addiction and obsession. Young[18] coined the term "Internet Addiction Disorder" and listed diagnostic criteria, which many researchers refer to as a starting point. Yet there is no official DSM-IV diagnosis, and because of this, researchers of Internet addiction form their own criteria for this disorder. Of those criteria, the two most referred to are substance abuse (addiction to chemicals) or behavioral obsessions and/or compulsions. There is an ongoing debate among psychologists as to what distinguishes certain addictions from obsessive behaviors. A substance addiction is defined as something which you enjoy doing, or initially enjoyed, and eventually involves physical dependence. Researchers such as Young[18] replace the word "substance" with "Internet" in their analysis of Internet addiction, concluding that similar symptoms such as tolerance (needing more substance or Internet for satisfaction), withdrawal (a need for the substance or Internet when one does not have it available), craving (doing more of the substance or Internet and investing more time into it), and negative life consequences (job loss, family and social problems) are present in Internet addiction as well. An obsession can be described as ideas or thoughts that dominate a person's mind. Compulsions can be irresistible urges or repetitive behaviors (cleaning or checking something continually). It is a behavior often done in response to an obsession. Research done by Walker[14] would label Internet addiction an obsessive and compulsive behavior, based on its similarities to gambling addiction and compulsive shopping, since all of these disorders lack chemical dependence. Still, very little is known about Internet addiction as a whole.

Early research done by Shotton,[12] who researched Internet addiction in the early 1990's, concluded that addicted computer users were mainly male introverts. These men were highly educated, had an affinity for computers, and had a constant need for intellectual stimulation. However, that data is no longer relevant. A few years later, studies by Griffiths,[4,5] O'Reilly,[9] and Young[15-18] reached drastically different conclusions. Their results revealed that dependent users were primarily middle-aged females on home computers,[16] and that anyone with Internet access could become addicted.[9] This drastic shift has come about simply because there are more Internet-ready computers in homes now than in 1991. This is due to low costs and acceptance in our culture (businesses, mass media, and personal relationships all depend on the Internet). Through e-mail (for business and personal use), chat (mainly personal communication), and the World Wide Web (businesses have embraced it and the near limitless amalgam of topics available on it), the Internet has a niche for anyone who has the time to spend on it. E-mail, chat, and the web are examples of applications used on the Internet whose nature has addictive properties.[17]

Basically, the Internet itself is not addictive, but the services available on the Internet are. Young found that interactive "real time" services such as Internet Relay Chat (live chat with other IRC users in chat rooms, socializing and discussing common topics) and multi-user domains (MUDS – text-based virtual worlds where users meet and explore and where social interaction is required) proved to be most addictive. The use of IRC was examined by Peris,[11] and it was found that frequent users of IRC "find, in online chats, a media for rich, intense, and interesting experiences" while "they consider online relationships as real as face to face relationships". In another study by Moody,[8] it was found that high Internet use (on IRC or e-mail) is associated with high emotional loneliness. Users will eventually spend all their time online and choose not to interact in real life physical social settings. Jacobson[6] researched MUDS users and found that "users participate in rewarding activities that allow them to use their skills and knowledge in the challenges of these virtual worlds," and that "people become absorbed in the activities and relationships that occur in them." When examined as an addictive substance, applications such as IRC and MUDS can be used to "withdraw or escape from negative evaluations and the stress of interpersonal relationships." [2] This results in a loss of control over time spent on the Internet, leading to problems in school, relationships, finances, occupation, and health.[17] Users who tried to cut back the time they spent on the Internet to avoid these addiction-related problems could not. Even those who threw out their modems could not resist the urge of buying new modems to get back on the Internet.[17] Young concluded that users do become addicted and that there is a potential for more addictive applications in the future.

MUDS introduced interactive online role-playing games to the Internet, but as technology advanced, so did this genre of games. With the availability of 3D graphics in games, it became possible to build three-dimensional (3D) visual representations of the once text-only MUDS. Now users are able to see and interact with others in their 3D virtual worlds. These massively multiplayer online role-playing games (MMORPG's) such as "Everquest," "Ultima Online," and "Diablo II" have been categorized as "heroinware" by many of their users, as they contain all of the addictive elements of IRC and MUDS. MMORPGs, which are run in real time, feature social and competitive aspects, making devotion to the game mandatory. If you are not playing online, you are probably falling behind. While traditional videogames end at some point or become repetitive and boring, MMORPGs are endless, because the main feature of MMORPGs is their system of goals and achievements. As you play, your character advances by gaining experience points, "leveling up" from one level to the next, while collecting valuables and weapons, thus becoming wealthier and stronger. This system creates an online "life" for your character and if you die, the penalty is a deduction of experience points. Social interaction in MMORPGs is highly essential, as you must collaborate with other players in the game to succeed in more complex goals. Eventually, a player must join a "guild" or "clan" of other players to advance further in the game. Finding other players in the game "Everquest" is not hard, as there are 433,445 active players worldwide including the 12,000 new players every month, each paying $12-$40 a month for access to the game.[13]

Everquest (or Evercrack, as many players have nicknamed it) is a fantasy game based on concepts similar to the work of Tolkien's Middle Earth and Dungeons and Dragons, and is the most popular of all MMORPGs. Because of its popularity, Everquest has received the most press and the most blame for MMORPG addiction. In a recent News.com article,[1] one recovering Everquest player was quoted as saying, "The game almost ruined my life, it was my life. I ceased being me; I became Madrid, the Great Shaman of the North. Thinking of it now, I almost cringe; it's so sad." The same article describes players who have lost their jobs and even marriages due to overuse of Everquest. Another player explained his addiction, "I'd say the most addictive part for me was definitely the gain of power and status, the way in which as you progressively gain power you become more of an object of awe to other players… each new skill isn't enough." [1] In a Time[13] article, Denise Dituri, a mother of three, who had no interest in fantasy games, became an 18-hour a day player in Everquest. But instead of ruining her family, the game has seemingly brought them closer together. Denise and her husband Gary play Everquest with their three

children, viewing the game as an activity of the mind, and as an alternative to television. Gary confesses that he has learned more about his son than ever before while playing Everquest. Even the topic of dinner conversation in the Dituri household is over what happened while they were in Everquest.

Young[17] provided research that certain users become addicted to specific applications used on the Internet. Griffiths[4] concluded the same, with results showing that addicts are usually addicted to online chat or fantasy role-playing games (MUDS). Griffiths also emphasized that these applications allowed users an anonymity allowing them to create their own social identities, raising the users' self-esteem. It is this anonymity that gives those with low self-confidence and sub-par social skills the desire to create a virtual life for themselves on the Internet. In these cases, the Internet becomes a substitute for real life social interaction, providing the user with an escape from reality.[18] In the early 1990's the Internet addict was stereotyped as a male computer hobbyist, but recent research proves that anyone can become addicted, as it is a combination of personality type and Internet application that causes the overuse that leads to addiction.

MATERIALS AND METHODS

In this study, a comparison will be made between online MMORPG game users and offline video game users, to find elements that differentiate the two types of users and factors that contribute to overuse. It is proposed that factors which cause Internet overuse are similar to those that cause MMORPG overuse.

The evaluations took place online in the form of two surveys which served to compare the two types of users. The surveys are based on a survey developed in 1999 by Pratarelli et al. in their paper "The bits and bytes of computer/Internet addiction: A factor analytic approach." [9] Pratarelli's survey focused on variables indicative of both computer and Internet use and was devised to gather data on the behavioral patterns of heavy Internet users. This survey has been modified to explore the individuals who are primarily MMORPG or video game players (online and offline game players, respectively). To facilitate the comparison study, the same survey was used for the testing of both user groups, with the exception of the terms "MMORPG" and "video games." These two terms were replaced in the context of its respective test; this preserved the questions yet changed the context. The survey questions were collected anonymously through an online survey which was advertised on various gaming forums hosted on the well-known gaming sites eqvault.ign.com, www.everlore.com, and www.fohguild.org. After 10 days, the surveys were taken offline. No rewards were offered to those who volunteered to participate. Questions are generalized so that any sample user from the general population who has played MMORPG's or video games can answer. If a user was primarily a MMORPG player, he or she was asked to complete the MMORPG survey, and similarly for video game users.

Individual survey items gathered data on demographic information, game usage patterns, social behaviors of users, and the user's game purchasing habits. Demographic information collected was gender, educational level, professional level, hours per week spent playing games, and time of day spent playing. All remaining questions were Likert-scaled responses; users were asked to rank their agreement or disagreement to each question on a scale from 1 to 5. Game usage questions focused on how much time users were spending on games, how long a typical session would last, if usage time affected their daily schedules, and measured for indications of spending too much time using games. Social behavior questions collected data on dependence, companionship, self-image, and attitude of the user while gaming. Lastly, users answered questions about their game purchasing habits.

RESULTS

The MMORPG survey demographics had a total of 91 responses. 88% of respondents were male, 44% had a high school degree, and 29% had a bachelor's degree. 37% were students while 53% worked as full-time employees. When asked how many hours a week they spent on MMORPG's, 13% spent between 7-10 hours, 25% spent 11-20 hours, 34% spent 21-40 hours and 11% spent 40+ hours playing a week. 82% played during the hours of 6pm-11pm.

Demographic data for video game users was quite similar to MMORPG users, as expected. 48 responses were reported, and of those, 71% were male. 25% had a high school degree and 54% had a bachelor's degree. 29% were students and 71% were full-time employees. In contrast to the hours spent playing per week, video game users spent significantly less time playing their games per week. 38% played for 1-2 hours a week, 35% spent 3-6 hours and 6% spent 7-10 hours a week. 87% played during the hours of 6pm-11pm, which was similar to the MMORPG players.

Likert-scaled questions on game usage patterns, social behaviors of users, and game purchasing habits were analyzed with an unpaired t-test for significance between the two groups test results. According to the data on game usage patterns, six of the questions on showed a high significance (P=0.0001), two showed some significance and two did not have any significance. MMOPRG players had the tendency to playing for eight continuous hours, lose sleep because of playing, and had been told they spent too much time playing. All questions which suggested heavy overuse were dominated by the MMOPRG users. Social behaviors of users varied for the two groups, as significance was found in 50% of the questions in this category. In general, MMORPG users would rather spend time in the game than with friends, have more fun with in-game friends than people they know, found it easier to converse with people while in-game, did not find social relationships as important, and felt happier when in the game than anywhere else. Offline game users had at times sought out video games to alleviate depression, while MMORPG users didn't. However, neither group used games as a diversion from loneliness or to gain self-confidence. Spending on games between both groups showed no significance, as neither group had any monetary issues associated with gaming.

DISCUSSION

The findings confirm the background research that has been presented and highlights the differences between the two groups. It is clear that MMORPG users have a tendency to spend many more hours devoted to their game and find the social aspects of the in-game world more pleasant and satisfying than what occurs in the real world. However, MMORPG users don't seek self-confidence in-game, would find fun elsewhere if MMORPG's didn't exist, and would not feel irritated if they didn't have the chance to play for one day. This would suggest that as much as MMORPG users enjoy the time they spend in-game, even more so than real life activities with friends, they are not addicted. I would propose that MMOPRG users have a different perspective on social life, which could be labeled as anti-social or introverted by most, and as such choose to spend their social time and energy in-game rather than socializing in the real world. It is the social aspects inherent in MMORPG's that draw in the "hard-core" players who show patterns of addiction. For most users it would seem that MMORPG's are an alternative to other forms of social entertainment. If MMORPG's weren't available or didn't exist, these same users wouldn't seek friends or social situations such as parties, bars or clubs, but perhaps other forms of socializing online in the form of e-mails, chat rooms or instant messenger. Since it is apparent that most users are not addicted, but rather choosing to spend their time on MMORPG's, determining how they spend their time in-game could explain their attraction to the games. For future study, these social aspects and in-game activities could be explored in-depth. In conclusion, it is the social aspects that exist in-game that draw users into MMORPG's. Much like users who are addicted to the Internet, they seek social experiences which are not available elsewhere in their lives. Even with high usage times, MMORPG users cannot be categorized as addicted because they do not exhibit the behaviors of addicts.

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Original Research

Virtual Reality-Enhanced Physical Therapy System

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Abstract: *Joint disease is a significant health issue for a large portion of the general population and an even greater issue for the elderly. Pain associated with joint disease can be treated with pharmacological and non-pharmacological therapies. Currently, there are no pharmacological agents that are able to simultaneously provide relief from the pain and improve quality of life, without the risk of adverse side effects.*

The specific aim of this project is to develop a non-pharmacological treatment option for chronic joint pain. We are working to achieve this by developing a system that combines virtual reality technology with hardware for physical therapy. Physical therapy (PT) has been shown to be an effective treatment for chronic joint pain, resulting in increased range-of-motion (ROM), greater strength, less dependence on pharmacological treatments, and improved quality of life. Virtual reality (VR) has been shown to distract patients from pain during treatment and therapy. By combining VR with a PT system, we expect to achieve more effective treatments with less discomfort in patients suffering from chronic joint pain.

The results of our pilot study confirmed our hypotheses. Of the eight subjects with adhesive capsulitis tested, all of those that were immersed in the virtual reality system were distracted from the pain associated with the therapy. Of all of the test subjects, 87.5% preferred using the VR-enhanced system and would have chosen to continue using the VR-enhanced system (if that were possible) in their continued physical therapy treatments.

INTRODUCTION

Joint Pain is a Significant Health Issue

Joint pain is a leading cause of disability and, as our population ages, it will increasingly affect larger numbers of individuals and our national economy. Aging gradually reduces the physiologic reserve that is available to perform daily activities. When the physical impairments and chronic pain associated with joint pain (such as arthritis or adhesive capsulitis) are combined with age-related changes, the physiologic reserve is further compromised, which increases the risk of functional dependency and greater economic losses. Patients with joint disease commonly first consult a physician because of pain.

Adhesive capsulitis (AC) affects approximately two percent of the general population. Primary adhesive capsulitis is characterized by idiopathic, progressive, and painful loss of shoulder motion. The onset of pain causes many patients to limit the use of the arm. Due to the loss of motion, patients can find it increasingly difficult to perform everyday activities. AC patients also tend to develop pain compensating movements which, over time, result in less shoulder pain but side effects including a stiff shoulder and a significant limitation of function.

The root cause of AC is still not fully understood; however, there are two primary explanations for the underlying pathophysiology of the disease. There is disagreement as to whether the underlying pathologic process is an inflammatory or fibrosing condition. There is significant evidence that the underlying pathologic changes are due to synovial inflammation and subsequent reactive capsular fibrosis. However, the initial trigger of inflammation and fibrosis in most patients is still unknown.

Pharmacological Treatments for Joint Pain

The primary goals of treating patients with joint pain are pain management, minimizing disability, improving quality of life, and preventing progression of the disease. Of these goals, the most important is pain control, because pain has strong associations with disability and quality of life. Furthermore, since there are no causative treatments for joint pain, all therapeutic measures in joint pain treatment are designed to treat symptoms of the diseases (i.e. managing the pain).

The use of drugs for the treatment of pain associated with joint disease has significant drawbacks. Analgesics can cause strong adverse reactions and dependency;[4] NSAIDs introduce significant gastrointestinal and renal toxicity; corticosteroids can cause cataracts, a vascular necrosis of bone, osteoporosis, thin skin, and muscle fiber atrophy; and immunosuppressive drugs may result in respiratory compromise, weakness, cognitive deficit, fatigue, sexual problems, and impaired balance.[7] Clearly, there is no single drug that is both completely effective and safe for treating joint pain. Furthermore, the significant risks from prolonged drug use have required the development of non-pharmacological treatments for joint pain.

Non-Pharmacological Treatments for Joint Pain

Significant effort has been expended in the development of non-pharmacological joint pain treatments. These efforts include heat, cold, electrical stimulation, light therapy, splints and orthoses, diet, weight loss, psychology, and exercise. Of all of the non-pharmacological pain treatments for joint pain, exercise has been one of the most rigorously studied and has shown significant beneficial effects. The proven benefits include increases in strength, range-of-motion (ROM), and aerobic capacity, as well as decreases in disease activity and pain level.[7]

In AC, a supervised physical therapy program has been used effectively in many patients. Physical therapy is preferred because a major objective in treating AC patients is to restore function by decreasing the inflammation and pain, increasing ROM, and reestablishing normal shoulder mechanics. Research has shown that there are significant long-term benefits to physical therapy for AC patients. It has been observed that passive ROM significantly increased flexion, abduction, and internal and external rotation of the shoulder. Physical therapy also resulted in significant decreases in perceived pain between initial and final evaluations. A recent study showed the benefits of using anesthesia during physical therapy treatments for AC. The anesthesia enabled the patients to be distracted from the pain during therapy. It also enabled the anesthesized group to achieve greater benefits in shorter periods of time as compared to the group receiving the same physical therapy without anesthesia.

Virtual Reality Has Been Shown to Reduce Perceived Pain During Therapy

It has been recognized for some time now that virtual reality (VR) has the potential to be used to improve quality of life in the real world. Applications include treatment of phobias, eating disorders, post-traumatic stress, and pain management. VR allows individuals to become active participants in a computer-generated world that changes naturally (i.e. as our past physical experience would suggest) and responds to the individual's motion.

One example of this has been a system developed to distract burn patients from pain during wound care. The system that was developed consisted of a virtual kitchen where patients could open drawers, pick up pots, touch other objects, and see three-dimensional images. Both reports concluded that VR can function as an effective nonpharmacological method for reducing perceived pain during wound care and physical therapy.

Based on evidence in the open literature discussed above, namely that (1) joint pain is a significant health care issue; (2) physical therapy is an effective nonpharmacological treatment for many of the symptoms of joint pain from a number of diseases; and (3) VR can be used to distract patients during painful therapy, Creare is developing a VR system for physical therapy that can be used to treat joint pain.

MATERIALS AND METHODS

System Overview

Figure 1 shows a picture of Creare's Virtual Reality-Enhanced Physical Therapy System. Our system combines an immersive VR system with physical therapy hardware. The system is designed to enable patients with joint pain to undergo rigorous physical therapy treatments while being distracted by VR technology from pain that may be induced by the therapy. Our overall system consists of the following components:

Haptic Interface. The haptic interface is used to perform physical therapy on patients and to provide realistic force feedback for enhanced immersion in the VR system. Previous research has shown that physical therapy is one of the most effective nonpharmacological treatments for joint disease[7] and that haptic interfaces greatly improve the immersion of VR systems. Our design for treating adhesive capsulitis is built around commercially-available devices originally developed for the computer gaming industry.

Visual Display. To provide a greater level of realism in the VR system, we use a head-mounted display (HMD) to present visual content to the user. By using an HMD, we try to fully immerse the user in the VR environment. We make use of off-the-shelf HMD hardware and use graphic rendering software that we have previously developed for a VR training application to render the

Figure 1. Creare's Virtual Reality-Enhanced Physical Therapy System. Creare's VR-enhanced PT system combines immersive VR technologies with physical therapy hardware. The immersive VR technology is used to distract patients from pain experienced during physical therapy treatments. By distracting patients from pain, the Creare system holds the promise of allowing patients to better tolerate existing therapy procedures or to enhance the provided therapy. In the long term it is reasonable to expect that the likely result will be less chronic pain and improved clinical outcomes for patients with joint pain/disease.

graphic content to the user. This software makes use of 3D Linx, a commercial off-the-shelf product for real-time display of visual content in games and training systems.

Head-Tracker. The system is designed to enable the user to wear an electromagnetic tracker mounted to the HMD. The measurement of head motion is used to compensate in real time for motion parallax and other display anomalies common in virtual reality visual displays. In addition, we can make use of the head-tracker measurements to present audio information to the user with proper three-dimensional sound content.

Computation Engine. The computation engine consists of hardware for real-time implementation of the signal processing algorithms. The hardware consists of off-the-shelf computer hardware. The inputs to the computation engine are the measurement of haptic display input, the head-tracking device, and the physics-based models used to determine the behavior of the virtual environment. The output from the computation engine includes the visual, auditory, and haptic displays. We have previously developed real-time software for proper timing and for analog-to-digital and digital-to-analog conversion while making use of off-the-shelf computer hardware that was modified for this application.

Underlying Software. The VR-enhanced physical therapy system is designed around a module architecture that permits each component of the system to be modified without affecting overall operation of the system. This approach facilitates incorporating new hardware, VR content, physics-based models, and physical therapy routines. This design allows our system to be easily modified for new and more challenging applications in chronic pain management that might require specific physical therapy routines or procedures.

VR Graphical Content

The graphical content of the original training system upon which our system is based consisted of city and country roads over which the

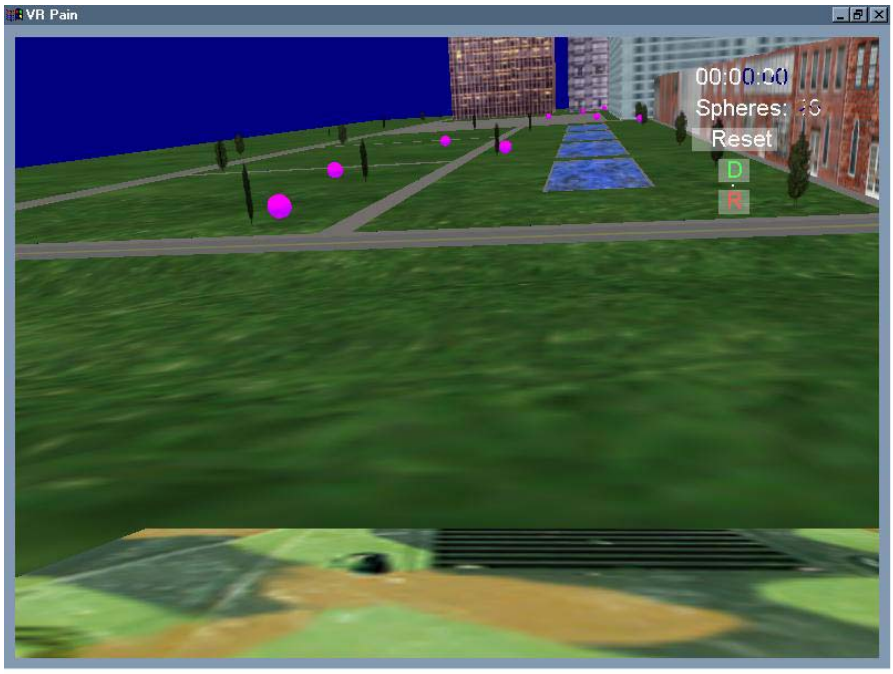


Figure 2. View of Graphical Content for Virtual Reality System. This figure shows the virtual city and landscape that is used for the virtual reality system. The purple balloons are used to define a path for the user to follow with the virtual vehicle, and the steering wheel is used to provide resistance as part of the physical therapy.

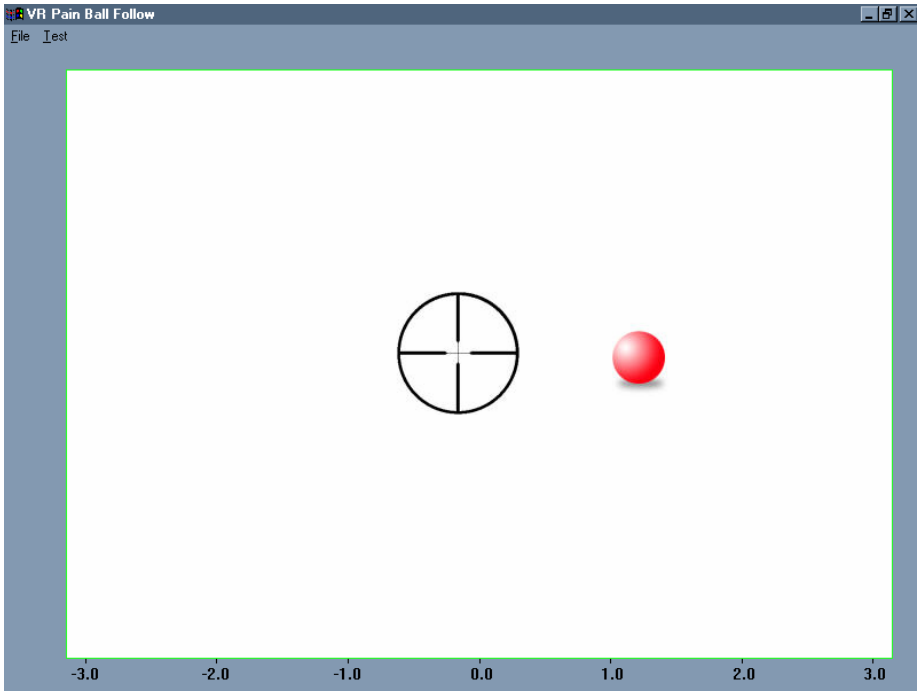


Figure 3. Image of the Non-Enhanced System Screen. This figure shows the non-enhanced task of moving a crosshair using the steering wheel to follow a round ball as it moved on the screen. Torque is applied to the steering wheel while the user moves the wheel.

patient could drive (shown in Figure 2), all the while feeling the interaction of the vehicle with the road and viewing the motion of the vehicle relative to the surrounding environment. The new design adds a well-defined task to the system and makes use of the existing graphical content. We added a "game" to the system such that the driver has a fixed amount of time to drive over markers placed on a number of the roads and part of the countryside. Each marker that is driven over is counted and the patient achieves a score based on the number of markers "collected" (much like the Pac Man video game).

Non-Enhanced System

In order to provide a method for direct comparison between our VR-enhanced physical therapy system and a non-enhanced system, we developed a non-enhanced system using the same hardware as the enhanced system. For this system, the task was to follow a moving round target by rotating the steering wheel to move a crosshair. A picture of the non-enhanced system screen is shown in Figure 3. While the user rotates the steering wheel, the wheel also applies torque so that the user is forced to apply retarding torque, and thereby exercise their shoulder muscles. The target position and torque applied to the steering wheel are "played back" from a data file which contains a time history of target positions and torque values. The data files can be recorded from previous interactions with the hardware, either during a familiarization session or during a VR-enhanced session.

RESULTS

Using the system described above, we performed a pilot human subject test designed to investigate the following hypothesis: An immersive VR system can be used to distract patients suffering from joint disease from pain during physical therapy treatment.

We performed the pilot human subject test at the Massachusetts General Hospital Physical Therapy Clinic with eight test volunteers. Dr. Michael Kane of the Massachusetts Institute of Technology performed the diagnosis of adhesive capsulitis, recruited all of the subjects, and obtained informed consent documents prior to

Subject	Sex	Age	Pain during	System to use	Immersion	Slope (torque/
1	F	76	a little more	VR-enhanced	moderate	-0.024
2	F	53	more	VR-enhanced	high	-0.074
3	M	78	much more	VR-enhanced	moderate	-0.155
4	F	75	less	VR-enhanced	low	-0.286
5	M	69	less	Non-enhanced	low	-0.350
6	F	53	same	VR-enhanced	moderate	-0.096
7	F	56	a little more	VR-enhanced	high	-0.096
8	M	58	a little more	VR-enhanced	high	-0.162

Table 1. Summary of Pilot Human Subject Test Results.

their first visit to the PT clinic. Once at the PT clinic, Katherine Breen, PT, DPT, performed a standard initial PT exam for all of the patients and reviewed the human subject test protocol. Afterwards, the volunteers were brought to the area where the hardware was set up and the testing began, following the approved protocol. All of the test results are summarized in Table 1. The table shows the sex and age of the subject, the subject's responses to the questions that we asked, our qualitative assessment of level of immersion (based on the length of time required to familiarize with the hardware and score on achieving the goals of the task), and the calculated slope of the torque vs. angle curve generated by recording the data during the VR-enhanced session.

The test subjects ranged in age from 53 to 78, with four between the ages of 53 and 58 and four between the ages of 69 and 78. The test subject population consisted of five females and three males; two of the males were in the 69–78 age group.

Pain Perception

Overall, five of the eight participants ranked the relative level of pain experienced during the non-enhanced session as being greater than the pain experienced during the VR-enhanced session. Of the five, three ranked the pain as "a little more pain," one ranked the pain as "more pain," and one ranked the pain as "much more pain." One test subject ranked the pain as being the same between the two systems, and two participants ranked the pain as being less during the non VR-enhanced session.

Affective Results

Seven of the eight participants found the VR-enhanced session to be more pleasurable, preferred to use the VR-enhanced system, and would choose to use the VR-enhanced system for continued therapy if that were possible. The one individual who found the non-enhanced session to be more pleasurable also found the non-enhanced session to generate less pain. This individual also complained of a headache that may have occurred because the HMD was probably not adjusted properly (it was too tight and he did not say anything until the session was over). We believe that this issue with the HMD contributed to this participant's lack of immersion in the VR environment.

DISCUSSION

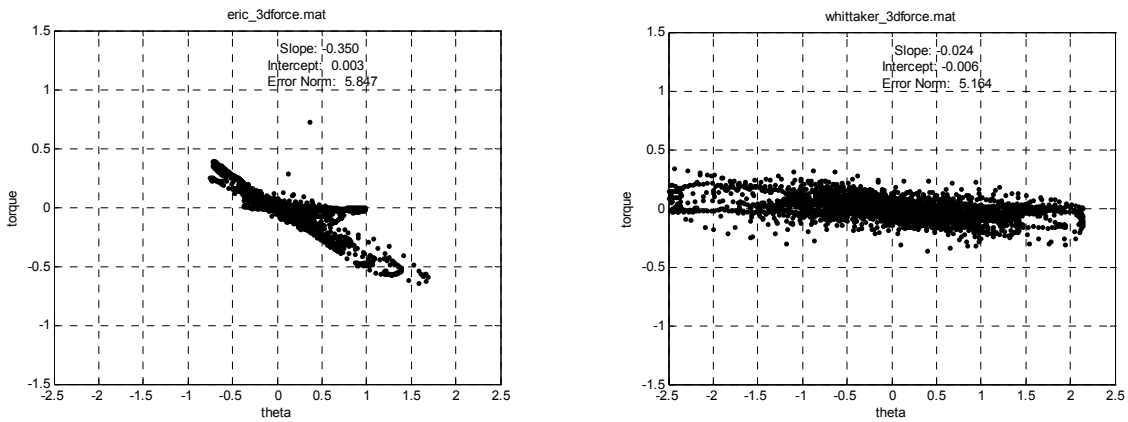
The results of our pilot study clearly demonstrated the feasibility of our VR system. We achieved our research objectives by developing an early prototype VR-enhanced physical therapy system for frozen shoulder, performing a pilot human subject test of the system, and designing a clinical system appropriate for use in long-term studies. Our test results confirm that VR-enhancement has the potential to distract individuals from pain during therapy, that patients enjoy using VR-enhanced hardware, and that patients would like to continue using a VR-enhanced system if that were possible.

The test subject who ranked the pain as the same used the VR-enhanced system second and may have suffered a bit from fatigue due to the buildup of exercise from the intake exam and first non VR-enhanced therapy session. This subject spontaneously said "This works; I am not even thinking about my shoulder," during the VR-enhanced session. This comment indicates that the VR-enhanced system was performing as expected, even though the response to the specific question regarding pain did not clearly support our hypothesis.

Neither of the participants who ranked the relative level of pain in the non VR-enhanced session as "less" were completely immersed in the VR-enhanced system. Both of these participants were in the 69–78 age group and had a difficult time keeping the virtual vehicle near the path defined by the task. In retrospect, we could have recorded the number of balloons on the path that were "collected" by the participant and used this as an indication of immersion. The two subjects who experienced more pain obtained very low scores on the task as defined by "collection" of the balloons; whereas all those who scored well on the VR task reported more pain during the non VR-enhanced session.

Furthermore, the data recorded during the VR-enhanced sessions for these two individuals showed a very high slope of torque vs. steering wheel angle; almost twice as high as the next highest values. This slope is an indication of the "gain" of the force feedback or spring constant. This indicates that these subjects had to work very hard to move the steering wheel against a relatively large resistive force. This came about because both individuals were not able to control the speed of the virtual vehicle and kept it moving at a relatively high speed through the environment. This had the dual effect of making them score poorly on the task as well as increasing the level of work that they needed to perform during the session. Figure 4 shows a graph of the torque vs. angle data for Subjects 1 and 5. These data show the quantitative difference between the interaction that the subjects had with the system during the VR-enhanced session. Effectively, the data in Figure 4a show that the steering wheel resistance is much greater than that shown in Figure 4b, resulting in greater effort being expended by the participant and a greater feeling of pain during the VR-enhanced session.

We also noticed that the individuals in the 69–78 group were on average less familiar with computer technology (especially games) and required more familiarization time with the hardware than the individuals from the 53–58 group. Our evidence suggests that people who were more familiar with the hardware and computers were more likely to become immersed in the VR and were much more likely to be distracted from the pain.



a. b.

Figure 4. Torque vs. Angle Data Recorded During Two VR-Enhanced Sessions. (a) Data from Subject 5 whose effective steering wheel resistance was large compared to other subjects. (b) Data from Subject 1 whose steering wheel resistance was comparable to most of the other subjects.

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The Importance of Significant Information in Presence and Stress Within a Virtual Reality Experience

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Abstract: *We conducted a pilot study on the relationship between significant information, presence, and stress. The experiment was performed with a medical emergency training simulator based on virtual reality, and was conducted with two sets of subjects: critical care specialists and people other academic degrees in scientific fields who lacked experience in medicine. Those lacking experience were trained to properly act with the concrete clinical problem being simulated. During the experiment, the Galvanic Skin Response (GSR) of the subjects was recorded, and presence and stress questionnaires were completed by the subjects. The specialists in critical care with first hand experience report a high degree of presence in both environments tested, but subjects without such experience have a high degree of presence only in the stressful environment. This study found that results from stress and presence measurements show an evident correlation, making apparent a close relationship between both variables. Our results also show the importance of significant information when a high degree of presence or stress is needed in a VR training simulator.*

INTRODUCTION

Intensive care specialists are needed to work in critical situations under high levels of stress. This kind of strain has a great effect on the emotional state of the medical specialist, and so they have to be prepared to work in such adverse conditions. Hence, training simulators in this field must not only provide an environment to teach cognitive skills necessary for patient assessment, they also need to elicit that emotional state in the trainee. In order to achieve those capabilities, training simulators can use virtual reality (VR) technology, which may induce more intense feelings in the trainee.

In this context, presence, as a subjective sense, has been argued to be a very important factor for human performance in general VR systems.[1] Furthermore, studies on this subject have found a relationship between the level of presence and stress.[2,3] If the recreated virtual environment presents a stressful situation, a high degree of presence will yield a high level of stress.[4,5] So, in this kind of environment, stress measurements could be used as indirect presence indicators. But we can go further by hypothesizing that eliciting stress in the subjects exposed to a virtual experience will help to achieve higher degrees of presence. This last hypothesis is discussed in this paper.

In this work we also study how significant information presented in the virtual world concerns the elicited stress and presence. The same stimuli can provoke very different reactions depending on the significance of the presented information. For a medical specialist with real experience in critical care, a virtual patient evokes feelings and memories that can increase both stress and presence. However, subjects without that real experience tend to respond differently, even with the same environment and stimuli.

METHOD AND TOOLS

Training Simulator Description

The experiment discussed in this work was performed with UVIMO, a medical emergency training simulator based on VR and developed for this research. UVIMO provides a virtual environment consisting of a stressful emergency situation with realistic 3D graphics, including a virtual patient lying down on the floor, medical equipment placed around him, and the complete recreation of a typical environment in which the action occurs.

Sense8 WorldToolKit has been used as the simulation engine. A Virtual Research V8 Head-Mounted Display (HMD) was used as the visualization device, and an Ascension Technologies Flock of Birds was used to track head movements.

The virtual patient was presenting an acute myocardial infarction, with a clinical history of ischemic cardiac myopathy and diabetes. He was modeled by means of an expert system, which contained the rules that allowed the patient to respond to the treatment and to progress by himself. The subjects were asked to treat him within UVIMO in two different scenarios: a quiet living room, and a noisy street. Figures 1 and 2 show a snapshot of these two virtual places. The goal of this choice was to provide a non-stressful environment and a stressful one independent of the action to be carried out within them.

Interaction was managed by an assistant who played the role of a nurse, receiving orders from the subject under test. The subject could ask the assistant for any information not directly available in the virtual world, like arterial pressure, temperature, etc. In addition, the assistant could apply any treatment the subject asks for.

Participants

The experiments were done with a total of twelve participants who volunteered for this study, ranging in age between 26 and 47, made up of 5 males and 7 females. There were two

Figure 1. Quiet virtual environment.

Figure 2. Noisy street virtual environment.

sets of subjects: critical care specialists (aged between 31 and 47; 3 males, 3 females), and people with similar academic degrees in other fields of science, and without experience in medicine (aged between 26 and 33; 2 males, 4 females).

The former group, called Group A from now on, reported less experience in using computer than the latter one, called Group B from now on.

Group B was trained in a one hour tutorial that discussed how to treat this specific clinical problem, including the use of available drugs and medical equipment, as well as their effects in the case of inappropriate application.

Measurements

Two main types of measurements were taken: questionnaires to estimate the level of stress and the degree of achieved presence, and physiological measurements of Galvanic Skin Response (GSR). In addition, significant postural movements and attitude changes were noted.

Questionnaires

A presence questionnaire by Slater,[6] translated into Spanish, was used to estimate the degree of presence achieved in the virtual experience. The original questionnaire consisted of five questions, the answers to which were rated from 1 to 7. A sixth question concerning the virtual patient was added. The Presence Index (PI) was taken as the number of questions

rated as 6 or 7, normalized, and expressed as a percentage.

In order to estimate the induced stress, the Stress Arousal Checklist (SACL)[7] was used. The SACL is a state measurement of stress and arousal. In other words, the SACL can measure how stressed or aroused an individual is at any particular time. It does not measure a person's tendency to be stressed or aroused. This test gives a number from 0 to 18 as stress index. A normalized index, expressed in percentage, is used in this paper:

$$PI = \frac{\sum_{i=1}^{6} Q_i}{6} * 100; \quad Q_i \equiv \begin{cases} 1 & \text{if rate(i - th question)} > 5 \\ 0 & \text{otherwise} \end{cases}$$

$$SI = \frac{\text{SACL stress index}}{18} * 100$$

Physiology

Galvanic Skin Response (GSR) of the subjects was recorded by a skin conductance module Coulbourn V71-23, using DC coupling, a sensitivity of 100 mV/μS and two 8mm AgCl/Ag disposable electrodes placed on the middle and index fingertips of the left hand (all the subjects were right-handed). The analog signal was acquired by a National Instruments NI-6036E acquisition card and a software tool developed for this experiment.

Behavioral Annotations

In addition to the above measurements, all significant postural movements, such as pointing or trying to touch virtual objects, were noted. The subjects' attitude to the assistant was also annotated. The idea behind this is that involuntary movements or attitude changes may be signs of high presence.

The Experiment

Before starting each session, the subjects were informed about the methodology of the experiment, and the measurements to be taken. Each session lasted for about 60 minutes, consisted of three different trials, and was carried out with the following scheduling:

1. Estimation of stress previous to the experience
2. Control trial (first trial)
3. Estimation of stress in the control trial
4. Virtual experience in the quiet environment (second trial)
5. Estimation of stress and presence in the second trial
6. Virtual experience in the noisy environment (third trial)
7. Estimation of stress and presence in the third trial

GSR was measured during the three trials, including a period of 90 seconds before the beginning of each trial to obtain the baseline. During this time, the subject was asked to be as relaxed as possible.

Control Trial

For the first trial, a task was chosen which did not require specific knowledge or capabilities related to medicine. Subjects were asked to play the popular game 'Simon,' in which they had to reproduce an increasing random sequence of colours and sounds. This trial lasted four minutes. When the subject failed the sequence, they had to start from the beginning again.

Virtual Experience in the Quiet Environment

In the second trial, subjects were exposed to UVIMO in a quiet living room (see Figure 1). However, it was not a completely silent environment. Beeps from medical equipment could be heard, as well as verbal communication between subject and assistant. This trial had a duration of three minutes, independent of the state of the virtual patient.

Virtual Experience in the Noisy Environment

The third trial took place in a noisy street. Subjects were exposed again to UVIMO in that environment (see Figure 2). This trial had a duration of three minutes, independent of the state of the virtual patient. In this case, the noise acted as a stressful element, and made communication between the subject and the assistant more difficult.

RESULTS

Questionnaires

The SACL, used to provide a stress index (SI), was administered four times to each subject: once before the beginning of the session (SI_0), as a baseline measurement, and once immediately after each trial. The increment of i-th trial stress index (SI_i) relative to SI_0 is defined as:

$$\Delta SI_i = SI_i - SI_0$$

Figure 3 shows ΔSI_i for both groups of subjects. It is easily seen that all trials produce a positive increment of stress. The control trial increases the SI in a small amount, 10% for specialists and 4% for non-specialists. It is important to take into account that subjects from Group A reported significantly less use of computers in their work than subjects from Group B, which could explain this difference.

Similarly, the stressful virtual environment elicits a high increase of SI, approximately 30% in Group A and 20% in Group B. The obvious difference between the two groups is in the second trial, where subjects were exposed to UVIMO within a quiet virtual environment. Subjects without real experience in critical care do not show much more increment of SI than in the control trial. However, subjects with that experience present increments of SI that are similar to those in the third trial.

These results suggest that for Group B, the content of virtual experience has not contributed to increasing SI. However the noise presented in the third trial acted as a stressful element, which may justify the high ΔSI_3. However, for Group A, the content seems to be the main stressor, as the clinical problem was the same in the second and third trials. For Group A, the differing trial is clearly the first one, because ΔSI_1 is much lower than ΔSI_2 and ΔSI_3.

Figure 4 shows the obtained presence index (PI) for both virtual experiences and groups. It is clear that Group A presents similar PI in both experiences, while Group B reports very different PI in both trials. The first trial elicited a very low level of presence in Group B, while the second trial provokes a similar level of presence in both groups.

The correlation between our measurements of stress and presence is evident. High stress levels and high presence indicators are clearly

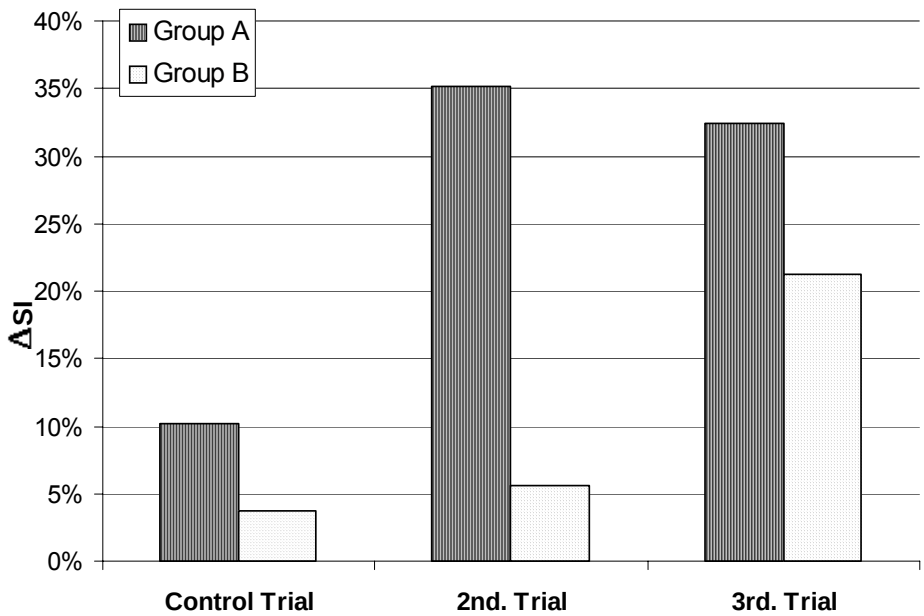

Figure 3. Increment of stress index.

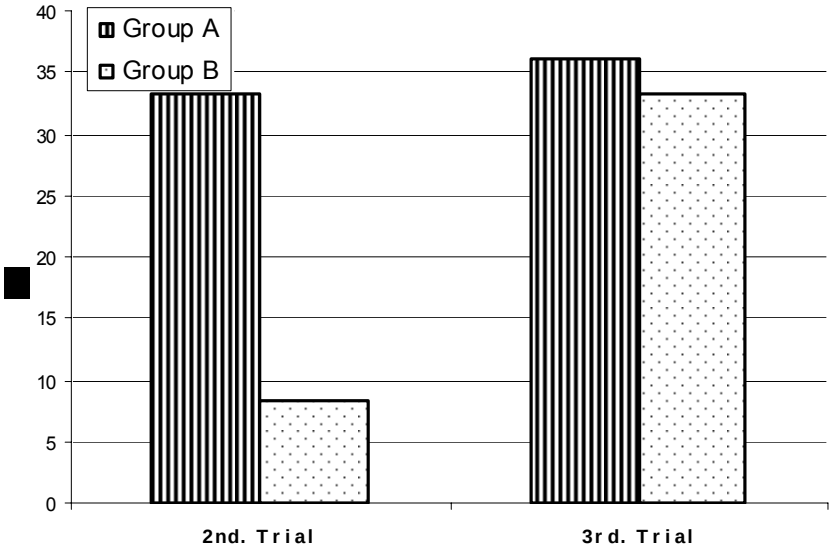

Figure 4. Presence index.

associated. On the other hand, a low degree of presence is also associated with a low stress measure.

Galvanic Skin Response

GSR was recorded for all subjects to obtain an objective estimator of stress. A baseline period of 90 seconds was recorded before starting each trial. The average value of GSR over this period has been taken as GSR baseline, and this value is used to express GSR in a relative way, skipping the great inter-individual variability of raw GSR. So, we use GSR* defined as Galvanic Skin Response.

$$\Delta GSR = \frac{(GSR - GSR\ Baseline)}{GSR\ Baseline}$$

Figure 5 shows the tonic level of ΔGSR averaged for each group of subjects, every ten seconds. In continuous lines, the three trials for Group A are represented, and in dashed lines, the three trials for Group B.

The first remarkable finding is the sheer rise after the first ninety seconds, just at the beginning of each trial. This rise is clear in the three trials and the two groups of subjects, but in Group A it is noticeably larger. It is obvious that GSR, as an arousal indicator, increases when each trial begins. The differences between Groups A and B can not be explained by the special significance that the simulated situation has for Group A subjects, because that difference also appears in the control trial, which has no relation with medical activities. As commented previously, Group A reported less experience with computers than Group B. This could be the reason for this higher GSR during the trials.

In Group B, a slight decrease of GSR tonic level can be seen in Trials 2 and 3, while not in the control trial. On the other hand, Group A presents the opposite effect. But the high variability of these signals undermines this phenomenon in itself. Larger groups are necessary in order to confirm or discard this effect.

Anyway, it is clear that average tonic levels of GSR are not good estimators of stress or presence. In this case, the tonic level of GSR can only be used as a generic arousal index. Although it can sometimes be confused with an erroneous stress or presence index, control trials confirm that this is not the case.

Postural Movements

During Trials 2 and 3 all significant movements of subjects were annotated. Although it is diffi-

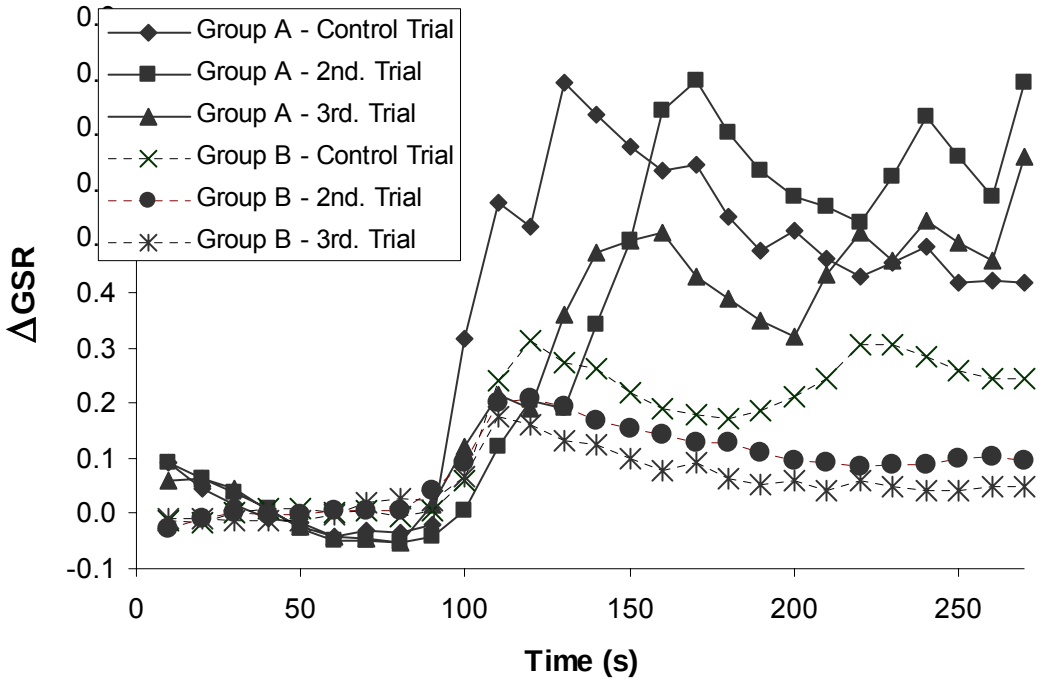

Figure 5. Galvanic Skin Response

cult to quantify this kind of behavior, it was clear that Group A subjects made more significant movements than Group B while in the simulator. They include pointing to virtual objects, head movements, and a sharper attitude with the assistant when the virtual patient state was more complicated.

Group B subjects, however, were much more static during the experience, especially during the second trial. This leads to suggest that presence was greater for Group A than for Group B.

DISCUSSION

Subjects from Group A, specialists in critical care with first hand experience similar to this virtual experience, report a high degree of presence in both environments. However, subjects from Group B, without such experience, have a high degree of presence only in the stressful environment. Hence, the information available in the virtual world has a different meaning for the former than for the latter, even when all of them have enough knowledge to act within the virtual world in a proper way.

We hypothesize that relationships between the virtual world and experience in the real world could play a very important role in eliciting some emotional engagement, which leads to increased presence.

In addition, a strong correlation has been found between increment of stress and presence. It seems to be clear that both variables are closely related. In fact, it has been argued that presence could be a stress generator if the virtual environment is stressful,[4,5] which is a very reasonable assumption. However, Group B presents very different degrees of presence in both quiet and noisy environments, and there is no good reason for this phenomenon if we only take into account the differences between the two environments. It can be argued that traffic noise makes the second environment more realistic, as it presents multimodal stimuli, but the first one also has visual and auditory stimuli, and the interaction with the assistant is based on a conversational interchange. In addition, sound is coherent with the virtual world in both cases.

On the other hand, it can also be argued that noise and consequent difficulty in communicating with the assistant is a clear stressor, and so, the increment of stress in Group B within the noisy environment could be explained by the noise itself. Then, the increment of presence in this last case could be caused by the stress, and not vice versa.

Postural movements seem to be an interesting indicator of presence, as pointed out by other authors.[9,10] Trials in which a high index of presence was measured correspond to those in which subjects made more involuntary movements. However, it is necessary to define a procedure to quantify this behavior in order to obtain a reliable index of presence.

Regarding objective measurements based on psychophysiological signals, the use of averaged GSR to assess the emotional state can be found in the literature.[10,11] In this paper, the relationship between averaged GSR, stress, and presence has been explored. It has been shown that averaged GSR can not be used as a stress or presence index. Here, it seems that GSR is just a generic arousal index. The relationship between this arousal and stress or presence is not clear. This has been proven by means of a control trial.

CONCLUSIONS AND FUTURE WORK

In this paper, a pilot study on the relationship between significant information, presence, and stress has been presented. Our results suggest the importance of significant information when a high degree of presence or stress is needed in a VR training simulator.

Our results suggest a strong and close relationship between increments of stress and presence, because each one could be cause and consequence of the other. This is an interesting finding because we can include some stressors in VR simulators in order to improve their presence elicitation. However this must be the objective of further research because, as suggested in Mosbruger,[12] some kinds of stress can provoke frustration and decrease the sense of presence.

Experience in the use of computers could be an important variable that has not been strongly controlled in this experiment. Further research should treat this issue very carefully. In addition, stress sources must be better isolated in order to ensure their apparent role in the measured presence. Moreover, larger groups should be considered. The work presented here is just a pilot experiment, and all these results should be considered cautiously.

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Effect of performance demands and constraints within virtual environments

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Abstract: *In recent years, clinical studies have begun to demonstrate the effectiveness of virtual reality (VR) as an intervention tool in rehabilitation. There are, however, a number of important issues that must be addressed in order to determine how widely VR-based intervention should be applied, and the ways in which specific patient populations can benefit from its unique attributes. One of the unresolved issues relates to how the characteristics of a given virtual environment affect a user's performance and therapeutic goals. The objective of this study was to compare the sense of presence, performance, and perceived exertion experienced by users when they engaged in two games performed within video-projected virtual environments that differed in their level of structure and spontaneity. VividGroup's Gesture Xtreme (GX) VR and the rehabilitation-oriented application of GX marketed as IREX (Interactive Rehabilitation and Exercise) were used to deliver the virtual environments. Thirty healthy male and female participants, aged 21 to 35 years, experienced the same two virtual games on both platforms. A mixed design, within and between subjects ANOVA was used to examine the effect of movement constraint and gender as well as the interaction between these variables on the sense of presence, performance, and perceived exertion. No main effect or interaction effect was found for the sense of presence, assessed using the Presence Questionnaire (PQ), although significant differences were found for several of the PQ sub-scales. A main effect was found for perceived exertion for both games, but in the opposite direction. We conclude that it is possible to provide users with a satisfactory level of presence and enjoyment using both structured and non-structured paradigms. However, user characteristics such as gender, as well as the therapeutic objectives, should be taken into account when selecting a suitable application.*

INTRODUCTION

In recent years, clinical studies have begun to demonstrate the effectiveness of virtual reality (VR) as an intervention tool in rehabilitation. Among its advantages is the opportunity for experiential, active learning which motivates the participant.[1-2] VR also offers the capacity to individualize treatment needs while providing increased standardization of assessment and retraining protocols. Virtual environments can also provide repeated learning trials and offer the capacity to gradually increase the complexity of tasks while decreasing the support and feedback provided by the therapist.[3]

METHODS

Participants

Thirty participants (14 men and 16 women) aged 21-35 years (mean age 25.4 ± 3), all university students, volunteered to participate in the study.

VR Platforms

The non-structured application was applied using VividGroup's Gesture Xtreme (GX) VR system (www.vividgroup.com), a projected video-capture VR platform originally developed for entertainment purposes that has been adapted for use in rehabilitation.[10] This system has been recently used in rehabilitation for the treatment of motor and cognitive impairments.[7,8,10,11] Participants stand or sit in a demarcated area viewing a large monitor that displays games such as touching virtual balls, as shown in the left panel of Figure 1. A single camera vision-based tracking system captures and converts the user's movements for processing: the user's live, on-screen video image corresponds in real time to his movements. The users can interact with graphic objects as depicted in this environment. No additional equipment needs to be worn by participants and any part of body can interact with the VE, which allows the user to respond in a relatively unstructured and spontaneous manner.

The structured application was applied using the IREX platform Interactive Rehabilitation and Exercise (IREX), a rehabilitation-oriented application of GX. Since it was developed with the option to train a specific movement (such as shoulder abduction, in order to increase the range of motion of a specific joint or to increase the endurance) prior to the VR experience, a virtual model demonstrates the desired movement and again during the virtual experience (see the right panel of Figure 1). Once the user is familiar with the required movement, he is ready to engage with the VE. During the experience a graph comparing the desired movement to actual performance is located at the bottom of the screen in order to encourage the user to perform the desired movement. Since interaction should be only with the "affected" arm, the user wears a red glove on one hand and the movements are performed in a highly structured manner.

Virtual Environments

Two of the virtual environments (games) that were used are run on the GX and IREX VR platform, and have been described in detail elsewhere:[10]

(1) Birds & Balls - wherein the user sees himself standing in a pastoral setting as different colored balls fly towards the user. Depending on the intensity of contact by any part of the user's body, the balls will either "burst" or "transform" into doves and fly away. Performance was rated by the mean response time (RT) of touching the balls for the GX platform and percent of success for the IREX application.

(2) Soccer - wherein the user sees a video reflection himself as the goalkeeper in a soccer game. Soccer balls are shot at him, and his task is to hit them in order to prevent them from entering the goal area. Performance was rated by the percent success of repelling the balls for both applications. For these games, the third minute (out of a total of 4 minutes) of each VR experience was analyzed, since it should reflect the participant's best performance (after participants had practiced but prior to the onset of fatigue).

Outcome Measures

Presence Questionnaire (PQ) (translated from Witmer & Singer, 1998)[12] was used to assess presence. It is composed of 19 questions in which participants use a seven-point scale to rate various experiences within the VE; the maximum total score is 133 points. The items assessed different aspects of presence: involvement/control, intuitiveness, interface quality, and resolution.

Scenario Presence Questionnaire (SPQ), (based, in part, on a translated version of Witmer and Singer's Presence Questionnaire[12]) was administered after every environment. The six items assessed the participant's (1) feeling of enjoyment, (2) sense of being in the environ-

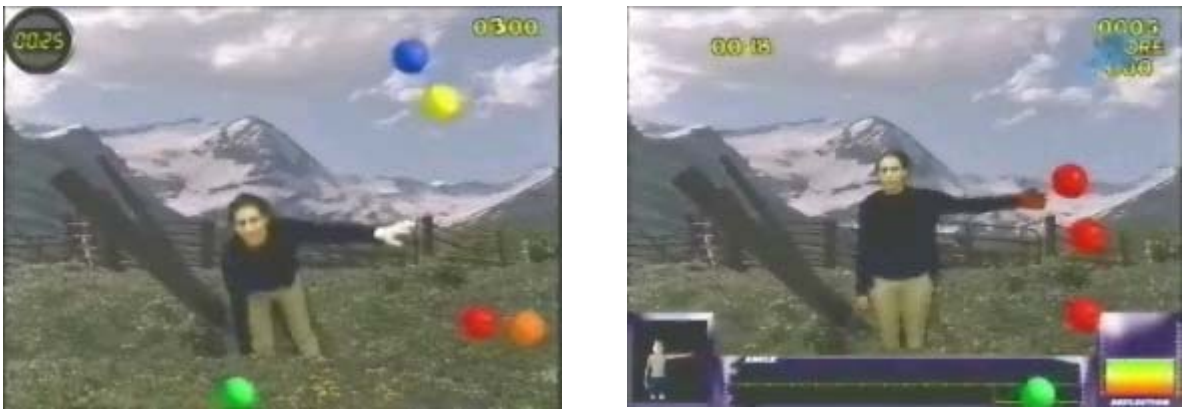

Figure 1. The Birds & Balls environments as used within the non-structured (left) and structured (right) applications.

ment, (3) success, (4) control, (5) perception of the environment as being realistic and (6) whether the feedback from the computer was understandable. Responses to all questions were rated on a scale of 1-5. These questions were combined to give a global response to the experience for a maximum score of 30. This 6-item questionnaire was formulated as an abbreviated alternative to the longer Presence Questionnaire.

Borg's Scale of Perceived Exertion[13] was used to assess how much physical effort the participant's perceived that they expended during each VR experience. This is a 20-point scale that participants rated from 6 (no exertion at all) to 20 (maximal exertion).

PROCEDURE

Participants signed an informed consent and then filled in a demographic questionnaire. They experienced both games using the first application. After each game they filled out the SPQ and rated their perceived exertion on Borg's scale for the specific scenario. After completing the two environments for a given VR application, participants completed the Presence Questionnaire. The same procedure occurred for the second platform while the order of the platforms was counterbalanced.

DATA ANALYSIS

A mixed design, within and between subjects ANOVA was used in order to examine the effect of the type of VR application (delivered via GX versus IREX) and the user characteristics (i.e. gender) as well as the interaction between these variables on the sense of presence, performance, and perceived exertion.

RESULTS

As a first step for analysis we examined whether the order of experiencing the VR platforms influenced the results. There were no significant differences due to the order in which the VR applications were experienced by participants for any of the outcome measures.

The Sense of Presence

No main effect or interaction effect was found for the total PQ, however for three of the four subscales of the PQ interaction effects were found: For the Involvement/Control PQ subscale, an interaction effect for application and gender was found ($F(28)=6.7$, $p=.015$); for the Resolution subscale, an interaction effect for application and gender was found ($F(28)=4.3$, $p=.047$); and for the Interface Quality subscale, a main effect for type of application ($F(28)=15.3$, $p=.001$) and an interaction effect for application

	Non-structured movement			Structured movement		
	male N=14	female N=16	total population N=30	male N=14	female N=16	total population N=30
PQ total (19-133)	93.3 ± 15	95.6 ± 11.4	94.6 ± 18.4	100.3 ± 17.3	92.5 ± 19	96.2 ± 18.4
Involvement/ control (11-77)	56.7 ± 9.1	60.2 ± 7.3	58.6 ± 8.2	59.6 ±10.1	53.8 ± 11.07	56.5 ± 10.8
natural (3-21)	12.4 ± 3.5	14.5 ± 2.6	13.5 ± 3.2	13.7 ± 3.04	13 ± 4.2	13.3 ± 3.6
resolution (2-14)	7.8 ± 2.8	8.8 ± 3.1	8.4 ± 3	9 ± 3	8.7 ± 3.8	8.8 ± 3.4
quality (3-21)	16.3 ± 3.7	12 ± 3.5	14 ± 4.2	18 ± 3.2	17.1 ± 3.1	17.4 ± 3.1
SPQ (6-30)						
Birds and Balls	24.1 ±2	26.2 ± 2.5	25.2 ± 2.5	19.2 ± 3.8	19 ± 4.4	19 ± 4.1
Soccer	21.3 ± 3.4	21.7 ± 5	21.5 ± 4.2	21.7 ± 4.5	24 ±4.6	23 ± 46

Table 1. Results from the Presence Questionnaire (PQ) and the Scenario Presence Questionnaire (SPQ) comparing participant responses when using virtual environments in non-structured and structured paradigms.

and gender was found (F(28)=4.2, p=.048). The scores of the total PQ and it's subscales for both the non-structured and structured movement applications appear in the table.

Scenario Presence Questionnaire

Birds and Balls **-** A main effect for the type of application was found (F(28)=45.1, p=.000). Using the non-structured application, the participants felt a significant higher sense of enjoyment, control, and realism versus the structured mode while playing Birds and Balls (see Table 1).

Soccer - No main effect or interaction effect was found for playing soccer using a non-structured versus a structured application (see Table 1).

Performance

Due to technical difficulties and different outcome measures for the Birds & Balls game on the two platforms, comparison between the movement constraints within the VE was not possible. Therefore, only the percent of success playing Soccer was compared. A significant main effect for the type of application was found (F(28)=159.7, p<.0001). Using the non-structured movement the percent of success of stopping the balls from going into the goal was 49.8 ± 9.7 while the percent of success for using a structured movement was 92.4 ± 15.8. This difference was found to be significant (t(29)=12.6, p<.0001). Performance during Soccer for the structured application may have been higher since the balls are presented close to the user's hand; they are not randomly distributed as for the non-structured application.

Perceived Exertion (Borg Scale)

A main effect for the type of application was found for both games (Birds and Balls (F(28)=12.05, p=.002), Soccer, (F(28)=16.02, p=.000)) however in the opposite direction, as shown in Figure 2.

While playing Soccer using a structured application, a moderate positive correlation was found between the percent of success and the Scenario Presence Questionnaire (r = .46, p<.05). In other words, the more the participant succeeded in blocking the soccer balls from entering the goal, the more enjoyment and control he felt. In addition, a moderate negative correlation was found between the perceived exertion while playing Soccer with a structured application and Scenario Presence Questionnaire (r = -.38, p<.05) (i.e. the more the participant felt enjoyment, control, the less exertion he perceived while playing Soccer).

CONCLUSIONS

These results support the use of either structured or non-structured movement in therapy.

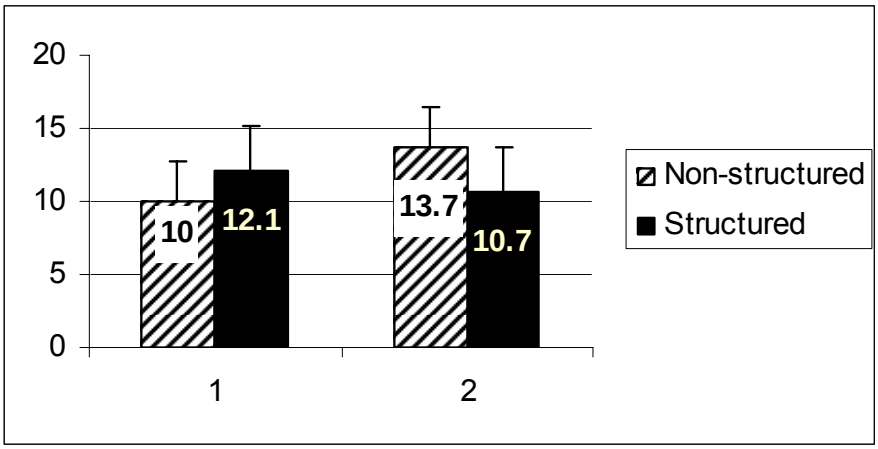

Figure 2. Comparison between the perceived exertion when using virtual environments in non-structured and structured paradigms.

Selection of one or the other should depend upon the therapeutic goals for remediation of neuromuscular deficit. Both movement options used in this study, structured and non-structured, enhance the therapist's repertoire of VR intervention tools to maximize rehabilitation. In addition, the results support the influence of user characteristics such as gender.

It is important to note that, in addition to the results presented here, our impression is that there are many subtle and not-so-subtle differences between the structured and the non-structured movement paradigms which may be relevant for therapy. For example, motor planning capabilities may only be evident when movement demands become more complex (i.e. when using both hands as well as other parts of the body). This is possible only via the non-structured applications (GX Platform) because it encourages the user to react to simultaneous, randomly distributed stimuli.

We have also noted that a more non-structured movement paradigm enables a therapist to identify underlying motor problems that would not be observed with conventional structured treatment and assessment. For example, the paretic limb of a patient who has had a stroke may be capable of movement when activated in isolation but become clumsy or slow when activated with the rest of the body. These and other issues will be examined in future studies.

Now that a variety of virtual environments are available for use in rehabilitation, it is imperative to identify how variations in performance demands and constraints affect their suitability for intervention of specific cognitive and motor deficits. This study is one of the first to address the effect of one important therapeutic parameter: the effect that ¾ spontaneity versus rigidity on ¾ performance has on participant responses and behaviors. The next step will be to examine these effects in patients with motor and/or cognitive deficits. It is possible to provide users with a satisfactory level of presence and enjoyment using both structured and non-structured movements. User characteristics such as gender must be taken into account since they, along with movement constraints, influence the user's sense of presence. Further study is needed to explore interactions between performance and presence, and between perceived exertion and performance.

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Robotic Therapy at an Elderly Institution using a Therapeutic Robot

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Abstract: *This paper describes mental commit robots that provide psychological, physiological, and social assistance to human beings through physical interaction. These robots look like real animals such as cats and seals. The seal robot was developed especially for therapy. The seal robots have been applied to assisting the activity of elderly people at a health service facility for the aged. In order to investigate the psychological and social effects of the seal robots on the elderly people, we evaluated the elderly people's moods by face scales (which express a person's moods by illustration of faces) and the Profile of Mood States (which measures a person's moods via questionnaire). Seal robots were provided to the facility for three weeks. Our study shows that the feelings of the elderly people were improved by interaction with the seal robots.*

INTRODUCTION

Aged Society

Due to the improvement of our living environment, dietary life, and medical progress, people are now living longer than they ever have before. According to the United Nations, a ratio of people 65 years old and over against total population of a country exceeding 7% indicates an aging society. A ratio exceeding 14% indicates an aged society. Figure 1 shows change of the ratio of most advanced countries. Countries other than the U.S. are currently aged societies.[1] Moreover, an increasing ratio is predicted for the future. Therefore, the number of elderly people who need nursing because of dementia, disabilities which keep them bedridden, etc., is increasing. There are many people who will stay in an elderly institution for a prolonged period of time. Moreover, the physical and mental poverty of nursing staffs, caused by manpower shortages and increased loads, is becoming a sizeable problem. The mental stress of nursing causes Burnout Syndrome,[2] which causes members of the nursing staff to feel irritated and lose sympathy with patients. Therefore, it is important to improve the quality of life (QOL) of elderly people because this helps them to live their life healthily and independently. It also saves social costs for elderly people.

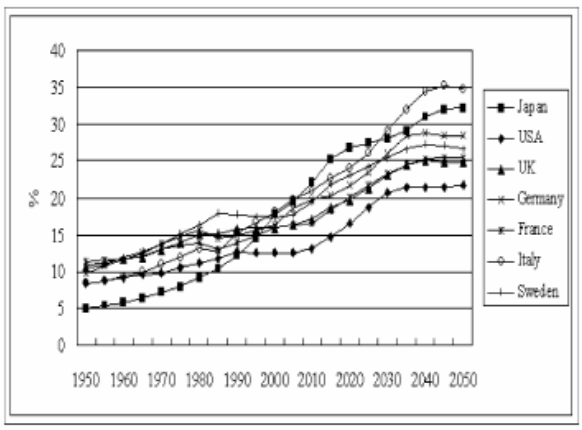


Figure 1: Ratio of people 65 years old and over against total population of most countries

Animal-Assisted Therapy and Activity

It has been said for many years that interaction with animals heals the human mind. In recent years, the positive effects of animal/human interaction upon humans has been researched and scientifically proven. Friedmann investigated the one-year survival rate of patients who were discharged from a coronary care unit. The survival rate of people who kept pets was higher than that of those who did not.[3] Baun reported that blood pressure lowered when people were stroking their dogs.[4] Garrity investigated elderly people who were socially isolated and had lost their partner within the past year. The morbidity rate of depression of people who did not keep any pets was higher than that of those who did.[5]

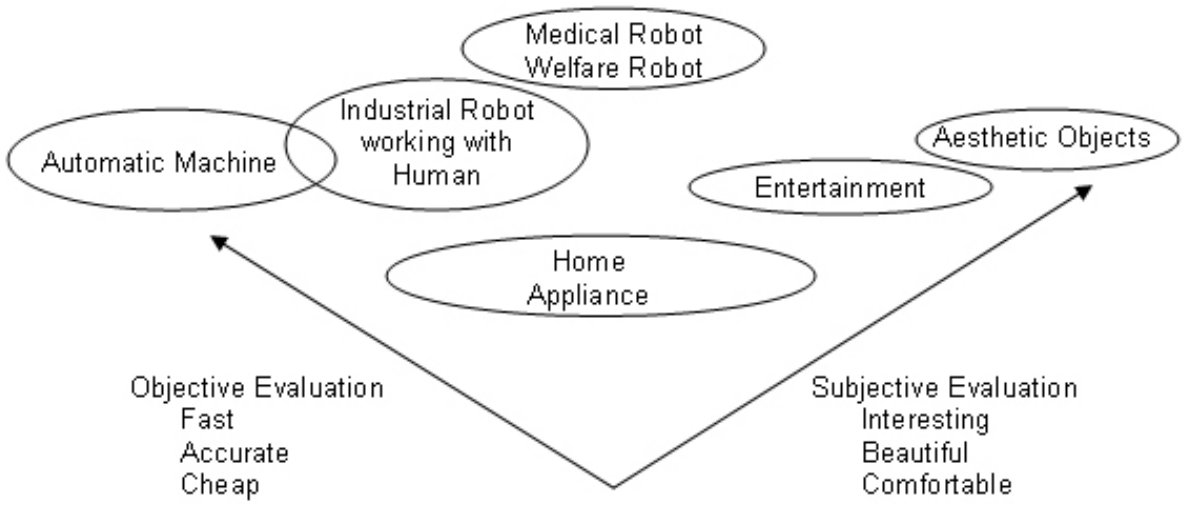


Figure 2. Objective and subjective evaluations classified by application in the design of artificial objects.

The effects of animals have also been applied in medical settings. Especially in the United States, animal-assisted therapy and activity are becoming prevalent at hospitals and nursing homes. There are clear goals for animal-assisted therapy. A doctor, nurse, or social worker develops a therapy program in cooperation with volunteers. Animal-assisted activity also occurs when patients interact with animals during leisure time, when attention is not paid to the special goals of the treatments. The activities depend on volunteers. Following are three effects that are expected as a result of animal-assisted therapy and activity:

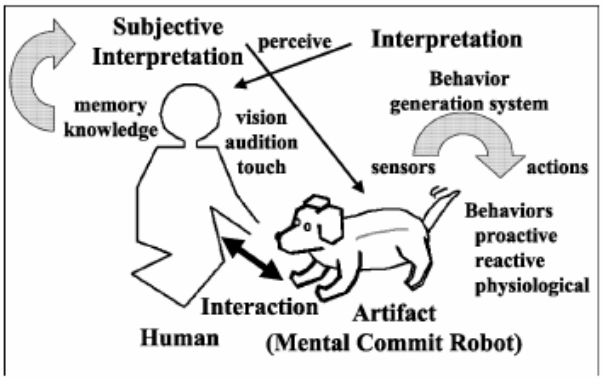


Figure 3. Subjective interpretation through interaction.

1. Psychological effect (e.g. relaxation, motivation)
2. Physiological effect (e.g. improvement of vital signs)
3. Social effect (e.g. activation of communication among inpatients and caregivers)

In addition to these effects, animal-assisted therapy at nursing homes also acts as rehabilitation therapy for elderly people who have decreased in moving ability. It also provides an opportunity for laughter and enjoyment to a patient who has few remaining joys in his life.[6] Moreover, there have been cases where the therapy has improved the mental state of elderly people who had dementia. However, most hospitals and nursing homes, especially in Japan, do not accept animals, even though they admit the positive effects of animal-assisted therapy and activity. They are afraid of the possible negative effects of animals such as allergies, bites, and scratches which might cause infection.

Mental Commit Robot

Robotics have largely been used in the field of automation in industrial manufacturing. Most of these machines optimize practical systems in terms of objective measures such as accuracy,

speed, and cost (Figure 2). Therefore, humans give machines suitable methods, purposes, and goals. Machines are passive tools of humans.

We have been researching different robots from such machines. If a robot were able to generate its own motivation and behave voluntarily, it would be able to influence its interactions with humans. At the same time, the robot would not be a simple tool for human use, nor be evaluated only in terms of objective measures. We have been building animal-type robots as examples of artificial emotional creatures[7-18] since 1993. The animal robots have physical bodies and behave actively while generating goals and motivations. They interact with human beings physically. People recognize the robots and subjectively interpret their movement based on knowledge and experience (Figure 3).

When we engage physically with an animal-type robot, it stimulates our affection. Then we have positive emotions such as happiness and love, or negative emotions such as anger and fear. Through physical interaction, we develop attachment to the animal robot while evaluating it as intelligent or stupid by our subjective measures. In this research, animal-type robots that produce such mental effects in human beings are referred to as "mental commit robots." We have developed dog and cat robots as familiar animals to humans, and a seal robot as a non-familiar animal.

When people in public evaluated the dog or cat robots, they became severe in their subjective evaluation because they compared the robots with their mental images of real animals. On the other hand, in the case of seal robot, people accepted it as it was without criticism. Therefore, the seal robot was more acceptable to the public.

Robot Therapy

The seal robot was improved so it could be used in therapy at hospitals and elderly institutions. The seal robot had been used in child therapy at a university hospital for four months in 2000.[14,15] This was referred to as robot-assisted therapy (RAT). The children's moods improved as they interacted with the robot. Moreover, the robot encouraged the children to communicate with each other and their caregivers (Figure 5). In one striking instance, a young autistic patient recovered his appetite and speech abilities during the weeks when the robot was at the hospital. In another case, nurses noted the rehabilitative benefits for a long-term patient, unable to leave her bed, who was willing to stroke and pet the seal robot (Figure 6).

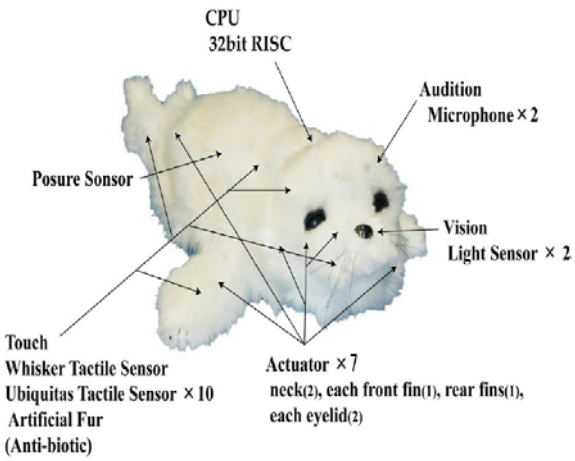


Figure 4. Seal robot "Paro."

In addition, we have used seal robots in robot-assisted activity (RAA) for elderly people who visit a day service center.[15-18] The day service center is an institution that aims to decrease the nursing load on the family by taking care of the elderly people during the day.

Figure 5. Interaction between a child inpatient and the seal robot, and social interaction between children.

Figure 6. Interaction between a child inpatient on a bed and seal robot.

Figure 7 shows a scene of usual life of elderly people at the day service center. They didn't communicate with each other much, even if a caregiver talked to them and tried to foster communication. The atmosphere of the day center was dark. One of the main reasons for this was a lack of a common conversation topic, as the various people lived unrelated lives.

After Paro's introduction to the elderly people, interaction with the seal robots improved their moods, made them more vigorous, and encouraged them to communicate with each other and their caregivers (Figure 8). Moreover, results of urinary testing showed that interaction with Paro reduced stress levels in the elderly. In an interesting instance, an elderly lady who seldom talked with other people became quite communicative with others when she was interacting with the seal robot. In addition, the seal robot influenced people who had dementia. One example is an elderly lady who did not try to behave independently, and often forgot things that she had just done. When she was interacting with the seal robot, she often laughed and seemed brighter than usual. Another example is an elderly lady who tended to want to return home, but who kept staying at the day service center to play with the seal robot, and looked happy. We also investigated the nursing staff's mental distress as a result of taking care of the elderly people. The results showed that their mental distress decreased because the elderly people spent their time by themselves with the seal robots.

Figure 7. Scene of the usual life of elderly people at the day service center.

Figure 8. Interaction between elderly people and a seal robot at a day service center.

Furthermore, some animal-type robots (such as Furby, AIBO,[19] NeCoRo, etc.) have been commercially released by several companies in recent years. There have been studies conducing RAA with these robots. For example, Yokoyama introduced AIBO to a pediatrics word, and observed the interaction between the children and AIBO.[20] He pointed out that the stimulus received from AIBO was effective at the beginning, but its stability was quite weak compared with the living animal. In other words, if we meet AIBO or an animal for the first time, for a while we will be stimulated and move. However, the

relaxed effect that comes as a result of stroking a dog for a long time is not felt when interacting with AIBO.

In this paper, we used seal robots to assist the activity of elderly people at a health service facility for the aged in order to investigate the psychological and social effects of the seal robots on the elderly people who stayed at the facility. We also compared the effects of the seal robot and those of a placebo seal robot that had a less active motion generation program.

SEAL ROBOT AND PLACEBO SEAL ROBOT

Specifications of Seal Robot

A seal robot, Paro, was developed for physical interaction with human beings (Figure 4). Paro looks like a baby harp seal, which has white fur for three weeks after its birth. As for perception, Paro has tactile, visual, auditory, and posture sensors beneath its artificial soft, white fur. In order for Paro to have a soft body, a tactile sensor was developed and implemented. As for action, Paro has seven actuators: two for each eyelid, two for the neck, one for each front fin, and one for the two rear fins. Paro weighs about 3.0 kg.

Paro has a behavior generation system that consists of two hierarchical layers of processing: proactive and reactive processes (Figure 9). These two layers generate three kinds of behaviors: proactive, reactive, and physiological behaviors.

(1) Proactive Behaviors: Paro has two layers to generate its proactive behaviors: a behavior-planning layer and a behavior-generation layer. Considering internal states, stimuli, desires, and a rhythm, Paro generates proactive behaviors.

(a) Behavior planning layer: This has a state transition network based on internal states of Paro and Paro's desire produced by its internal rhythm. Paro has internal states that can be named with words of emotions. Each state has a numerical level and is changed by stimulation. The state decays with time. Interaction changes its internal states and creates Paro's character. The behavior-planning layer sends basic behavioral patterns to behavior-generation layer. The basic behavioral patterns include some poses and some motions. Here, although "proactive" is referred, Paro's proactive behaviors are very primitive compared with those of human beings. We implemented behaviors similar to that of a real seal in Paro.

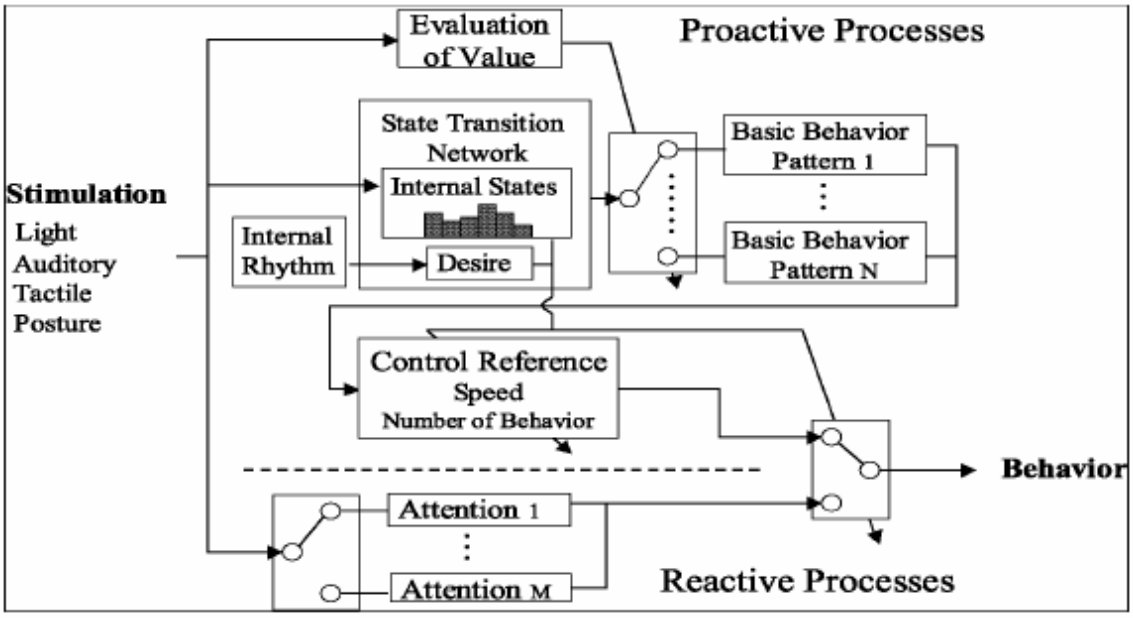


Figure 9. Paro's behavior generation system.

(b) Behavior generation layer: This layer generates control references for each actuator to perform the determined behavior. The control reference depends on the strength of internal states and their variation. For example, parameters change speed of movement, and the number of the same behavior. Therefore, although the number of basic patterns is countable, the number of emerging behaviors is uncountable because numeral parameters are various. This creates life-like behaviors. In addition, for attention the behavior-generation layer adjusts parameters of priority of reactive behaviors and proactive behaviors based on strength of internal states. This function contributes to Paro's situated behavior, and makes it difficult for a subject to predict Paro's actions.

(c) Long-term memory: Paro has a function of reinforcement learning. It puts a positive value on preferable stimulations such as strokes. It also puts negative values on undesirable stimulations such as being beaten. Paro puts values on relationships between stimulation and behaviors. Gradually, Paro can be shaped to preferable behaviors of its owner.

(2) Reactive behaviors: Paro reacts to sudden stimulation. For example, when it hears a sudden loud noise, Paro pays attention to it and looks in its direction. There are some patterns of combination of stimulation and reaction. These patterns are assumed as conditioned and unconscious behaviors.

(3) Physiological behaviors: Paro has the rhythm of a day. It has some spontaneous desires such as sleep based on that rhythm.

Specifications of Placebo Seal Robot

We often lose interest in toys when we find their mechanism. Therefore, we considered the following hypothesis:

The robots that execute only defined simple motions will have their motions predicted by people, who will lose interest in the robots. Moreover, the robots also stop having effects on those people.

According to this hypothesis, we changed regular Paro's program, and made a placebo Paro as follows:

Proactive behaviors: Repetition of following five kinds of actions.

(1) Blink
(2) Swing rear fins to right and left
(3) Swing both front fins forward and backward
(4) Swing head to right and left
(5) Cry. Return to (1)

Reactive behaviors: Following simple reactions against stimuli.

(1) Cry (sound is different from proactive motion's cry)
(2) Raise head

ROBOT-ASSISTED ACTIVITY FOR ELDERLY PEOPLE

We used Paro in robot-assisted activity for elderly people at a health service facility for the aged in order to investigate its effects on the elderly. The health service facility for the aged is an institution that provides several services, such as long-term care at the institution, day care, and rehabilitation for elderly people. People who need nursing can stay there for a certain period of time. During their stay at the institution they are provided with daily care and trained to spend their daily life independently in order to rehabilitate them into society. When we

Figure 10. Scene of usual life of elderly people at a health service facility.

began the study at the institution, about 100 elderly people were staying there. Moreover, about 30 of them had dementia. People who did not have dementia stayed in A and B building, while people who had dementia stayed in C building, where they were isolated from other people.

Figure 10 shows a scene of usual life of the elderly people who stayed at A and B building, which had a dark atmosphere.

The elderly did not communicate with each other much. The reason was a lack of common conversation topics. Moreover, the caregivers were too busy taking care of all the patients, and so they did not spent much time with each person.

Before starting the robot-assisted activity, we explained the purposes and procedures of the study to the elderly people who stayed in A and B building, and received their approval. As expected, the elderly people in A and B building were staying at the day center for a variety of reasons. Some people, however, could not participate in the study. A nursing staff that was well versed in the usual states of the elderly people evaluated them, and decided who could be investigated. After the evaluation, there were 23 subjects. 12 subjects stayed in A building, and 11 subjects were in B building. Their basic attributes are shown in Table 1. (Note: AV means their average age. SD means their standard deviation.)

Types of Activity

The regular Paro robot was provided to the subjects who stayed in B building, and the placebo was provided to the subjects who stayed in A building. In order to prevent the members of each group from interacting with the other group's Paro, each group interacted with their Paro in a different place in the institution. Moreover, we kept secret from the subjects the existence of two different kinds of Paro robots. Each group interacted with their Paro for about one hour at a time, four days a week, for three weeks. We prepared a desk upon which to set Paro in the center of people, and the subjects were arranged as shown Figure 11. However, not all the subjects could interact with Paro at the same time. Therefore, we moved Paro among subjects in turn, and we ensured that each subject's interaction time with Paro was the same.

	A	B
Total number of people	12	11
Male	4	2
Female	8	9
Age(AV±SD)	84.6±7.0	85.5±5.4

Table 1. Basic attributes of 23 subjects.

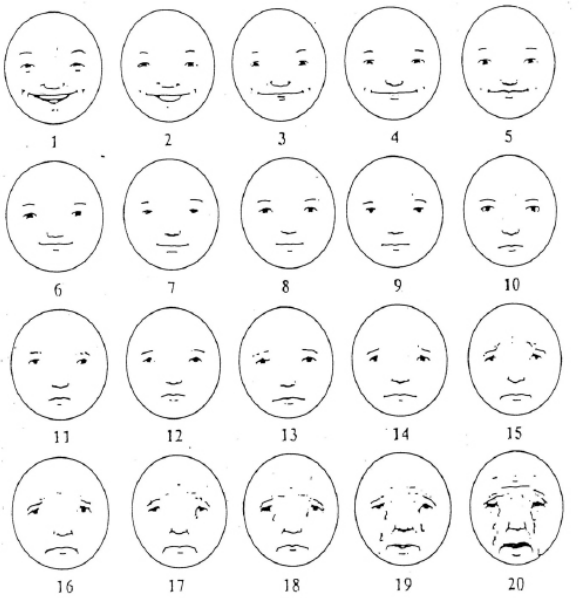
Evaluation Methods

In order to investigate the elderly people's moods before and after the introduction of Paro to the institution, the following kinds of data and information were collected:

(1) Face scale[21] (Figure 12)
(2) Profile of Mood States (POMS)[22]
(3) Comments of the nursing staff

Figure 11. Interaction between elderly people and Paro at a health service facility.

The Face Scale contains 20 drawings of a single face, arranged in serial order by rows, with each face depicting a slightly different mood state. A graphic artist was consulted so that the faces would be portrayed as genderless and multiethnic. Subtle changes in the eyes, eyebrows, and mouth were used to represent slightly different levels of mood. They are arranged in decreasing order of mood and numbered from 1 to 20, with 1 representing the most



INSTRUCTIONS: The faces above go from very happy at the top to very sad at the bottom. Check the face which best shows the way you have felt inside now

Figure 12. Face scale.

positive mood and 20 representing the most negative mood. As the examiner pointed to the faces, the following instructions were given to each patient: "The faces below go from very happy at the top to very sad at the bottom. Check the face which best shows the way you have felt inside now."

The POMS is a well-respected questionnaire which measures a person's moods.[22] The POMS is used in a variety of research fields such as medical therapy and psychotherapy. It can measure six mood states at the same time: Tension-Anxiety, Depression-Defection, Anger-Hostility, Vigor, Fatigue, and Confusion. It has 65 items concerning moods. Each item was evaluated by five stages of 0-4: 0 = not at all, 1 = a little, 2 = moderately, 3 = quite a bit and 4 = extremely. 58 of 65 items were classified into the six mood states, and we calculated the total scores of each mood state. (Note: Seven items are dummy items.) Then we translated the total scores into standard scores using a special table.

RESULTS OF ROBOT-ASSISTED ACTIVITY

The face scale and the POMS were applied to the subjects a week before the introduction of Paro, and at the second and third week after Paro's introduction.

As for the face scale, we obtained data from seven people in the regular Paro group, and from eleven people in the placebo Paro group. Figure 13 shows average face value. Average scores of the regular Paro group decreased from about 9.0 (before introduction) to 7.0 (third week). Moreover, the average score of the placebo Paro group also decreased from about 7.0 (before introduction) to 6.3 (third week). Therefore, interaction with both the regular and placebo Paro improved the mood of the subjects.

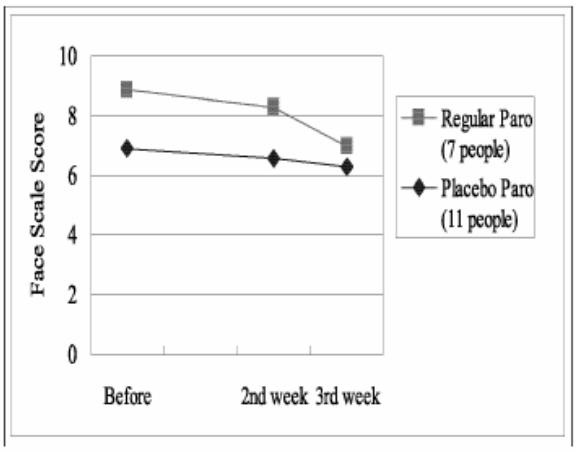


Figure 13. Average face scale scores of elderly people for four weeks.

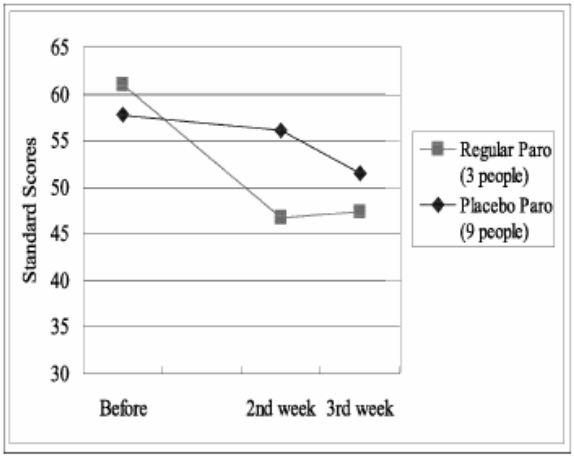


Figure 14. Average standard POMS scores of "Depression-Dejection" in the elderly people for four weeks.

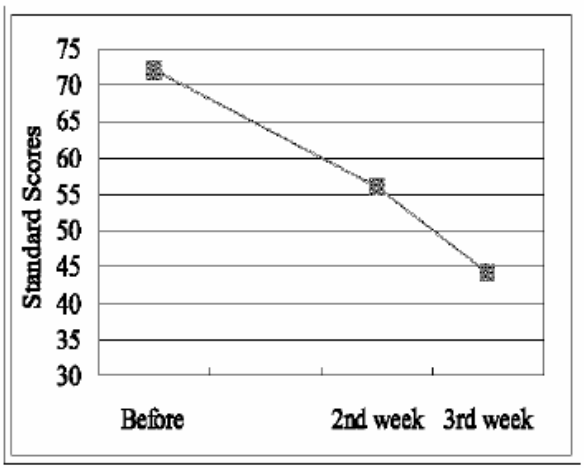


Figure 15. Standard scores of POMS "Depression-Dejection" in an elderly person for four weeks.

As for the POMS, we obtained data from three people in the regular Paro group and nine people in the placebo Paro group. Figure 14 shows average standard scores of Depression-Dejection. Here, 50 standard points means average score of Depression-Dejection of Japanese people over 60 years of age. Average standard scores of the regular Paro group decreased from about 61 (before introduction) to 47 (third week). Moreover, the average standard score for the placebo Paro group also decreased from about 58 (before introduction) to 51 (third week). Therefore, interaction with both the regular and placebo Paro decreased the levels of depression and dejection of the subjects.

Figure 16. Old man who was singing songs to Paro.

In one striking instance, Figure 15 shows the result of a male subject aged 96 years old. He was usually not sociable, and caregivers could hardly communicate to him. Before the introduction of Paro, his standard score of "Depression-Dejection" as measured by the POMS was very high. However, after the introduction of Paro, he came to like Paro very much. He often laughed and sung songs to Paro when he was interacting with the robot (Figure 16). He also made the surrounding people laugh. Caregivers were surprised by his change. Moreover, his standard score dramatically decreased to 44 in the third week after Paro's introduction.

Figure 17. Elderly people who tried to feed snacks to Paro.

Average standard scores of other factors such as "Tension-Anxiety," "Anger-Hostility," "Fatigue," and "Confusion" also decreased. However, these scores didn't change as much as "Depression-Dejection." Scores also decreased for "Vigor." We think this shows that people relaxed and calmed down by interacting with Paro. The nursing staff observed that both groups of subjects were waiting for Paro and participated with Paro willingly. Paro increased their laughing, and encouraged the subjects to communicate with each other and the nursing staff. Moreover, some elderly people tried to feed snacks to Paro (Figure 17). In an interesting instance, an elderly woman who liked Paro very much made a song about the baby seal and sang it to the robot. She looked very happy after she did this.

DISCUSSIONS

We investigated the effects of Paro on elderly people who were staying in a health service facility for the elderly. Then we compared the effects of the regular Paro against those of the placebo Paro. Contrary to our expectations, face scale scores of both the regular and placebo Paro groups improved, and their standard scores of Depression-Dejection of POMS decreased after introduction of Paro. This shows that both regular and placebo Paro improved elderly people's moods. Paro was especially effective at alleviating their depression.

Before the study, we expected that people would lose interest in the placebo Paro because its reaction was very simple. We were, however, mistaken. Subjects of the placebo Paro group kept interacting with their Paro and didn't notice that the placebo Paro's reaction was simple. Why didn't subjects lose interest in placebo Paro?

We considered the following two reasons:

(1) It was difficult for subjects to notice that placebo Paro's reaction was one pattern. Subjects interacted with Paro in groups of two or more people at a time. Therefore, each subject's interaction time with Paro was not long enough for them to notice that its reaction was one pattern.
(2) They were not interested in the mechanism of Paro.

In general, elderly people's curiosity is lower than that of young people. Therefore, they didn't try to investigate mechanisms that made Paro work, and didn't notice that placebo Paro's reaction was simple.

In this research, we used the POMS questionnaire because it can measure six mood states accurately. However, it had many items, and some subjects refused to answer them with the passage of time. We will make more simple questionnaires to measure the moods of elderly people in future research.

CONCLUSIONS

We applied seal-type mental commit robots called Paro in robot-assisted activity for elderly people at a health service facility for the aged. The study was carried out for a total of four weeks. Then we compared the effects of the regular Paro against those of a placebo Paro. The results show that interaction with both the regular and placebo Paro had positive psychological and social effects on elderly people.

Physiologically, we used urinary tests to objectively find that robot-assisted activity decreased stress reaction in the elderly clients. The details are described in Saito et al.[23] We are currently conducting a study that investigates the long-term effects of interacting with Paro on the elderly people at the same facility. The elderly people have been interacting with Paro for over 5 months. Interaction with Paro has improved their moods and encouraged them to communicate with each other. Moreover, they have maintained an interest in Paro, and they look forward to seeing Paro every time. Full details of this study will be presented in a later paper.

We plan to have further studies and to research different conditions and situations. Moreover, we will investigate the relationship between functions of a mental commit robot and its effects on elderly people in robot-assisted activity.

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Traffic safety Investigations by Means of an Augmented Reality Driving Simulation: Neurophysiological Measurements in Sleep Deprived Subjects

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Abstract: *The fact that driving performance gradually declines when individuals are driving a monotonous route for a longer period of time is well-known. This effect of decreased driving performance is dramatically amplified when subjects have experienced sleep deprivation prior to the actual driving. The overall consequences of these performance decrements have been a major concern in society. It is widely accepted that fatigue and drowsy driving account for a large and most probably underestimated number of hazardous accidents. For methodological reasons, an estimate of prevalence continues to be difficult, but the use of a virtual driving situation provides a promising method of understanding the underlying psychophysiological mechanisms.*

In the present study a real car based static augmented reality driving simulator was used in 41 subjects to investigate the performance and the vigilance state of professional and "normal" drivers after sleep deprivation. To monitor vigilance, electroencephalography (EEG) was employed.

INTRODUCTION

Drivers who are impaired due to fatigue, illness, or use of medication are thought to have an increased accident risk. However, there is no consensus in the literature on the relation between different impairments and traffic accidents. One estimates that around 30 % of all accidents involve driver impairment such as drowsiness, alcohol/drug consumption, or illness as a primary or secondary cause. This problem is common throughout Europe and accounts for 15,000 fatalities annually and 450,000 injuries in Europe alone. Whether a restrictive policy prevents accidents remains controversial, especially when conclusive evidence is lacking (e.g. in some countries there is a complete prohibition on insulin-using drivers operating certain categories of vehicles). It is generally accepted that the ability of disabled people to drive a vehicle considerably enhances their work rehabilitation chances. Facing these issues, there is a demand to employ more accurate and reliable assessment methodologies to evaluate driving performance. It is especially important to investigate the driving behavior of impaired drivers and to characterize typical patterns that could indicate increased risk of an accident. In the present study, the intervention of a driver warning system (DWS) during driving performance was used to analyse the vigilance state in sleep deprived subjects. EEG monitoring was conducted as widely accepted gold-standard for monitoring vigilance.[1] The use of a real car based static augmented reality driving simulator allowed neurophysiological access under laboratory conditions. The goal was to define a typical EEG response pattern (spectral changes after intervention of the DWS) indicative for sleep deprived subjects.

MATERIAL AND METHODS

Participants

The participants were selected to cover various types of drivers (passenger cars) regarding driver profile, driving experience, and age. Before inclusion in the study, each subject performed a test drive in the presence of a physician in order to identify kinetosis-sensitive subjects. Information about possible adverse effects in the driving simulator was provided before the subjects gave their informed consent. Furthermore, they were given instructions on how to prepare for the experiment: Partial sleep deprivation during the night before the experiment (get up at 2.00 a.m. when the experiment started at 8. a.m.), and the avoidance of coffee, tea, or energy drinks.

Experimental setup

To create realistic traffic scenarios in a laboratory environment, a passenger car simulator (Deforest Company) was used. The simulator provided:

- Computerized vehicle emulating the complete functionality of a modern city car
- PC-based visual system providing complex road and traffic scenarios
- PC-based audio and infra-sound system

Neurophysiological measures

Electroencephalographic activity was continuously recorded (bandpass 0.3 – 70 Hz) from 17 Ag/AgCl electrodes using a 32 channel cap (Easycap) based on the 10/ 20 system (F3, F4, C3, C4, T3, T4, T5, T6, P3, P4, Fz, CPz, Pz, A1, A2, O1, O2). Data were sampled at 250 Hz using BrainVision recorder software and a Brainamp amplifier (Brain products). All electrodes were referenced to Cz; for data analysis they were re-referenced to the linked earlobes (A1, A2). Horizontal eye movements were monitored from electrodes placed lateral to the right and left eye. Electrodes for the vertical axis were placed above and below the left eye. The DWS actions “drowsiness warning” and “fatigue countermeasures” were recorded along with the on-going EEG. The acoustic signal of the “fatigue countermeasures” and the confirmation reaction (button-press) were stored for further analysis.

A computer algorithm was used to attenuate eye artifacts contaminating the EEG signals.[2] The algorithm was applied to all EEG traces. Additionally 30 sec. EEG-time epochs were analysed and controlled for other artifacts (e.g. muscular origin). The EEG signals were quantified by use of fast Fourier transformation. FFT was calculated on the base of 2 sec. segments resulting in power values (μV^2) averaged for each defined frequency band: theta: (4 - 7.5 Hz); alpha: (8 – 12 Hz); beta 1: (12 – 18 Hz); beta 2: (18 – 30 Hz). The obtained absolute power values were transformed into relative power values based on the frequency range between 4.0 and 32 Hz. Further evaluation of spectral data followed two approaches. First, the numerical quantification of the “drowsiness warning” intervention focused on the pre/post-comparison of the 15 sec. segment before the drowsiness warning with segments (15, 30, 60, and 120 sec. duration) after the warning. These segments were also obtained by averaging artefact-free 2 sec. segments for each frequency band and segment. Relative power was chosen to minimize individual differences across subjects in absolute power magnitude.

Statistics

Data was analyzed using descriptive statistical methods. Two-tailed one-way between subjects ANOVAs were used to determine significant differences between the two age groups or between task conditions at every time point of

Figure 1. COAT driving simulator.

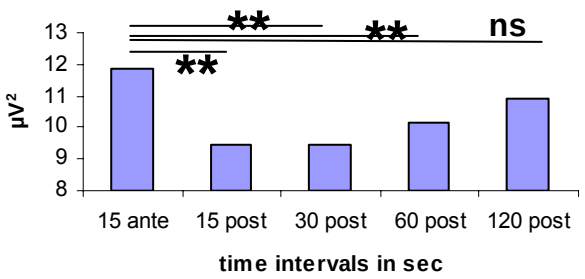

Figure 2. Plot of alpha power values at O1 before and after the DWS intervention (n=41; ** p < 0.01).

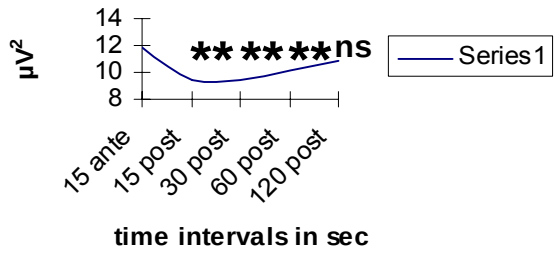

Figure 3. Fitted curve of pre-post alpha power (8-12 Hz) changes over time after DWS intervention at O1. Note the wash out of the induced effect (n=41;** p < 0.01).

measurement. An increase or decrease of physiological values relating to the baseline was analyzed using paired *t*-tests.

RESULTS

Averaged relative power spectra in predefined frequency bands were analyzed before and after the intervention by the DWS. This approach was chosen to evaluate whether and how long the DWS under study was able to improve vigilance using EEG criteria. Even if the inter-individual differences in EEG morphology are remarkable, the goal of the approach was to look for more general responses that exhibit significance for the whole group.

Alpha Band

Figure 2 shows the development of the alpha power for various intervals after DWS-intervention (n=41). The example refers to electrode O1 but the illustrated effect is also true for nearly all temporal, parietal, and occipital leads. Frontal electrodes did not indicate an effect on alpha activity for the whole group, but subgroup analysis could show a relevant change here. The time course of the alpha changes over time for the whole group is illustrated in Figure 3. It indicates that at 120 sec. post-warning the effect is already diluted, and the pre-post comparison no longer reveals a significant change.

Beta Band

Interestingly, the beta 2 frequency band (power values between 18 and 30 Hz) was also a very consistent parameter, changing in response to the DWS intervention. As shown in Figure 4, the washout of the beta 2 changes took slightly more time compared to the changes of the alpha frequency band. The effect was observed at all temporal and occipital leads. Other frontal leads were excluded since an overlay by artifacts induced by muscle activity could not be sufficiently excluded. The quantitative beta 2 data correspond very well with the visual observations as shown in Figures 1 & 2. The partially high amplitude theta or alpha activity is exchanged by a further desynchronized faster low amplitude beta activity. The analysis of the beta 1 frequency band (12-18 Hz) does not reveal significant group effects (n=36). One reason for this might be the inclusion of the 12-14 Hz range that individually decreases after DWS intervention and might compensate the effect.

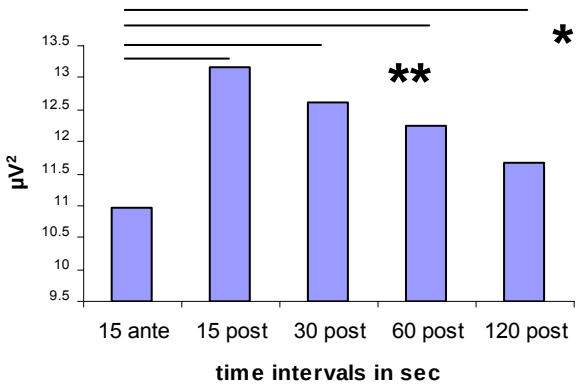

Figure 4. Development of beta 2 power (18-30 Hz) values after DWS intervention at O1. Note that there is still a significant effect in the 120 sec. post intervention segment (n=41;** p < 0.01; * p).

Theta Band

Finally, evaluation of the theta frequency band was performed. Several subjects showed a marked decrease of theta activity after DWS intervention. But the theta effect in the whole group revealed contrasting data (Figure 5). There was an increase of theta power reaching a maximum in the 30 sec post-DWS epoch; afterward a washout took place. Since significance was only reached over central leads we think that the effect is probably not mediated by increasing artifacts (no significant effects at fronto-temporal leads). In contrast, we suggest a theta generation that reflects the mental effort to deal with the situation and react correctly.

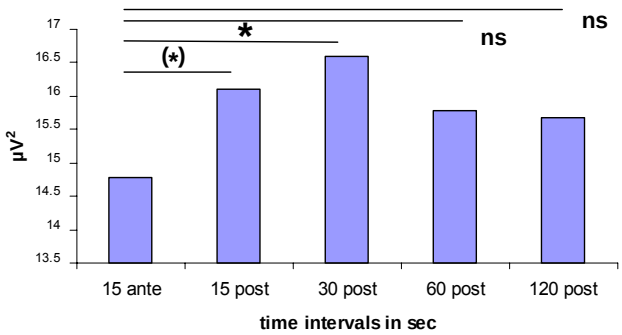

Figure 5. Theta power values in various pre and post DWS-intervention segments. Note the transient theta increase (C3; n=41;* $p < 0.05$; (*) $p < 0.1$).

DISCUSSION

In the present study electroencephalographic activity was investigated in sleep-deprived subjects during performance in a driving simulator. The use of EEG parameters is well documented to estimate vigilance and awareness during monotonous performance.[3-5] For analysis, two different approaches were chosen. First, the development of absolute and relative power spectra was calculated over time using 30 sec. segments covering the complete test session, including baseline. Second, spectral power values were calculated in respect to the interventions by the drowsiness warning. Within the latter approach, power spectra for various time intervals between 15 sec. and 120 sec. pre and post drowsiness warnings were calculated and compared. Despite the marked inter-individual differences in EEG morphology, statistical evaluation of the pre-post comparison revealed robust spectral EEG changes induced by the driver warning system (DWS).

Prior to the DWS intervention, most of the subjects showed a widespread alpha baseline activity (8-12 Hz), which indicated drowsiness since eyes were open during the driving performance. Some of the subjects even revealed a high amplitude anterior accentuation of alpha activity, reflecting a further decrease of vigilance. Another subgroup showed a dominating theta activity with fluctuating alpha activity, corresponding to sleep stage I. All these groups consistently decreased in alpha power in response to the drowsiness warning. There was a remarkable washout of this effect within a few minutes. Since the anterior distribution of alpha activity varied inter-individually, the most robust electrodes for the described observation were located at temporal, central, and occipital positions.

After baseline measurement, beta activity decreased over the course of the driving performance (as illustrated by continuous spectra) reaching a low level prior to the DWS intervention. Thus the pre-post comparison revealed a marked beta increase, most consistently observed in the beta 2 frequency band (18-32 Hz). Corresponding to the changes in the alpha activity, the beta effect dropped a few minutes after the intervention. The described spectral changes were repeated individually several times when the drowsiness warning was successively engaged. This supports the estimation of a robust finding, even if some subjects did not show any change in the alpha range. Interestingly, the expected changes in the theta frequency band were not consistently observed. In a subgroup a marked decrease was observed, but this effect did not outlast the statistical analysis regarding the whole group. In contrast, there was even a significant increase of theta activity (grand average) in response to the drowsiness warning at frontal and central leads. This paradox effect might be partially due to the increase of artifacts since frequently subjects start to move; the number of eye movements/blinks are increased and might contaminate spectra as well. Nevertheless, it cannot be excluded that theta generation is also part of an arousal reaction.

In summary, the study provides evidence that the use of a real car based static augmented reality driving simulator is a valuable approach to develop psychophysiological probes indicative for drowsiness during driving. In the present report the introduced electrophysiological probe specifies the extent and the duration of a DWS mediated effect on vigilance.

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Clinical Observations

3-D Sound and Virtual Reality: Applications in Clinical Psychopathology

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Abstract: *The aim of this study was to provide information about the importance of auditory feedback in a VR system planned for clinical use, and to address the different factors that should be taken into account when building a bimodal virtual environment. We conducted an experiment in which we assessed spatial performances in agoraphobic patients and normal subjects, comparing two kinds of virtual environments, visual alone (Vis) and auditory-visual (AVis), during separate sessions.*

Subjects were equipped with a head-mounted display coupled with an electromagnetic sensor system, and immersed in a virtual town in which they could move forward by pressing a mouse button. Subjects had to turn on their own vertical axis in order to change the direction of heading in the virtual town. Their task was to locate different landmarks and become familiar with the town. In the AVis condition subjects were equipped with the head-mounted display and headphones, which delivered a soundscape updated in real time according to their movement in the virtual town. The sounds were produced through tracked binaural rendering (HRTF).

The two groups of subjects exhibited better scores of presence in the AVis condition, although patients exhibited more cybersickness symptoms than normal subjects in this condition. While normal subjects preferred the AVis condition, expressing a better sense of realism, patients did not mention such a preference. Overall, this study might reflect the multisensory integration deficit of anxious patients and underline the need for further research on multimodal VR systems for clinical use.

INTRODUCTION

The special feature of VR as compared to traditional displays is that the environments it provides are places where as many senses as possible are meant to be active. “Multisensory” is a keyword for virtual reality. The number of sensory modalities through which the user is coupled to the virtual environment is a main factor contributing to the feeling of presence. In spite of that, VR technologies rarely integrate the auditory modality, which is the only sense through which we can communicate with the whole space around us.

Psychiatric patients commonly report a hypersensitivity to auditory stimuli, while pure tone audiograms show generally normal hearing. Sound tolerance is influenced by stress and exhaustion, and specific sounds can cause physical pain and irritability.[1] There is a correlation between a tolerance of loud noises and anxiety,[2] and strong emotional reactions can easily be elicited in reaction to auditory stimuli.[3] It is therefore all the more interesting to more realistically integrate the auditory modality when working with anxious patients, and to understand how it can be used for therapeutic purposes.

Several studies have led to the observation that patients with agoraphobia, panic disorder, or space and motion discomfort (SMD) may have a problem with multisensory integration: subjects with symptoms of panic disorder and agoraphobia experience destabilization under conflicting sensory conditions while maintaining upright posture.[4,5,6] Previous studies creating conflicts between vestibular and visual information with a VR setup have attempted to demon-

strate that the abnormal central processes of multisensory integration in maintaining balance in anxiety disorders was not restricted to balance control.[7,8] By integrating the auditory modality into a VR setup, it becomes a more general question as to whether multisensory integration in anxiety can be addressed. Without any additional sensory conflict than the one which is inherent to a VR set-up (due to the delay in feedback between action and consequences of actions in the virtual environment), how do anxious patients cope with interactive auditory modality? Would the introduction of the auditory modality generate sensory enhancement or sensory overload?

The study we present here involves technologies, models, and applications linked to the introduction of 3D sound in virtual or augmented reality environments. Auditory augmentation of visual environments is known to improve feelings of presence and immersion. It also appears very promising in terms of creating user-friendly information systems accessible to everyone. To create such an environment and the corresponding content, several concepts and technologies need to be researched, developed, and/or integrated. The introduction of a 3D sound modality also addresses the need for a better understanding of multisensory integration mechanisms. This includes complementary or conflicting perception between the auditory and visual senses, as well as idiothetic cues (cues generated through self-motion, including vestibular and proprioceptive information). These last aspects are important since many applications can now involve user navigation in a virtual or augmented world, or perception-action cues can be provided by interactive devices.

The most natural audio technique for virtual reality applications is the binaural rendering on headphones that relies on the use of HRTFs (HRTF refers to Head-Related Transfer Function, which is a set of filters measured on an individual or artificial head and used to reproduce all the directional cues involved in auditory localization). This technique still needs some studies to overcome its implementation cost and individual adaptation limitations (a fully convincing spatial rendering requires the use of HRTFs measured on the listener's head).

Incorporating real-time updated 3D sound with virtual reality technologies therefore addresses several practical issues. If there is a consensus on the fact that presence is improved by 3D sound, little is known about how an auditory virtual environment (VE) should be designed so that it does not interfere with the visual VE. We thus conducted a study to provide information on the importance of auditory feedback in a VR system planned for clinical use, as well as information about the different factors which should be taken into account to build a multimodal VE (sense of realism, presence, and coherence between the visual and auditory VE).

If agoraphobic patients are effectively more sensitive to sensory conflicts than normal subjects, multisensory feedback in VR could represent a challenge for them. However, since presence during a bimodal stimulation should be higher, this might provide an interesting way to both convey supplementary spatial information and engage patients in a task. We conducted a study in which we compared navigation performances in a virtual town in two immersive conditions: visual alone (Vis) and auditory-visual (AVis). We intended to test the emotional and behavioral reaction of patients sensitive to space and of normal subjects in order to develop new procedures and find an integrated approach to work with visual and auditory stimuli in VR.

MATERIAL AND METHODS

Design

All subjects included in the comparative study took part in two sessions of virtual navigation. The order of sessions was counterbalanced so that the same number of subjects began the trial with AVis and Vis conditions. Sessions were performed at least one week apart. After each session, subjects had to complete several questionnaires and two memory tests related to their experience. In the first test they were presented with a survey view of the virtual town and had to locate the different landmarks they were asked to find during navigation. In the second test they were submitted to a two-choice forced recognition task, during which they were presented with 10 pairs of snapshots and were required to chose between a view taken in the

virtual town they had experienced and a view taken in another town.

The measures taken during the navigation were the number of landmarks found (score out of 11) and the time spent in the virtual town. The measures taken after navigation included the number of correctly localized landmarks on the survey view of the virtual town (score out of 12) and the number of correct answers to the two-choice forced recognition task (score out of 10). Participants were debriefed after each session but were not informed about the content of the following session. At the end of the second session and after the debriefing they were informed of the differences between the two conditions if they had not noticed them.

Procedure

Subjects were equipped with a head-mounted display coupled with an electromagnetic sensor system. They were immersed in the virtual town in which they could move forward by pressing a mouse button. Subjects had to turn on their own vertical axis in order to change their direction of heading in the virtual town. Their task was to locate different landmarks (movie theater, swing, bus stops) and become familiar with the town. In the AVis condition subjects were equipped with the head-mounted display and headphones, which delivered a soundscape updated in real time according to their movement through the virtual town. The sounds were produced through tracked binaural rendering (non-individual HRTF) and were dependent upon the subject's movements.

Subjects

Patients were individuals suffering from agoraphobia as their main complaint. Seventeen patients were referred to us for the study at the local day hospital (12 females, 5 males). Two of

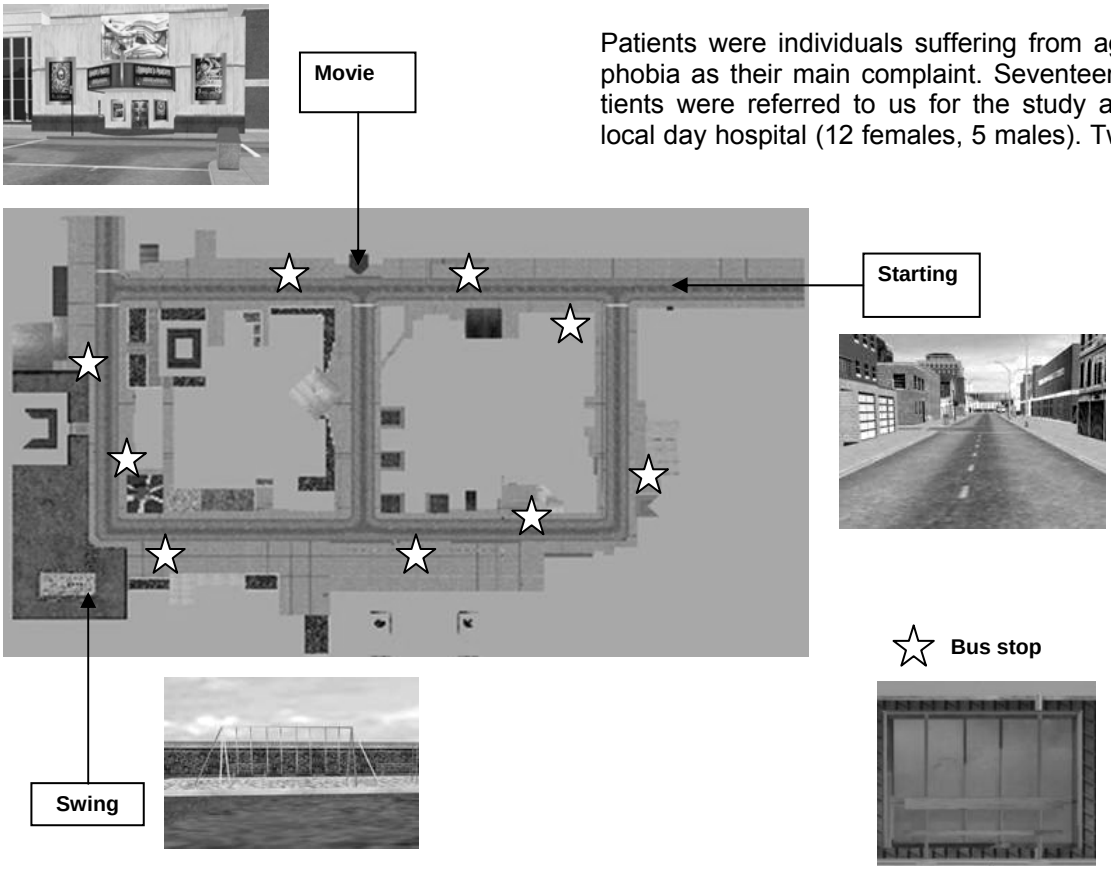

Figure 1. Survey view of the Visual Environment in Vis and AVis conditions.
The subject's task is to find the movie theater, then the swing, then count how many bus stops are in this virtual town. The subject stops navigating when he/she thinks that he/she is familiar with the town and that he/she has localized all the targets.

them were excluded from the following analysis since their fear of empty spaces was so severe that they could not accomplish the task. Five patients stopped the protocol after the first session (3 females, 2 males). The remaining 10 patients completed the project (7 females, 3 males). Nine control subjects (7 females, 2 males) were included in the study. The mean ages of the anxious and control samples were 35.3 (SD 10.2) and 32.7 years (SD 10.6), respectively. The control participants were not afflicted with any mental disorders. A semi-structured interview based on the Mini International Neuropsychiatric Interview was administered to all the participants to ensure that they met these criteria.

Questionnaires and Interview Measures

The state portion[9] of the STAI was used to measure the anxiety levels upon arrival at the laboratory and after completion of the experiment. A 22-item cybersickness scale was used to assess the level of discomfort after exposure to VR. It was comprised of a list of symptoms and sensations associated with autonomic arousal (nausea, sweating, pounding heart, etc.), vestibular symptoms (dizziness, fainting, etc.), respiratory symptoms (feeling short of breath, etc.) and could also be used to estimate signs of somatisation (tendency to complain of a large number of diverse symptoms). Items were rated on a scale from 0 to 4 (absent, weak, moderate, strong). The presence questionnaire from the I-group[10] was presented after completion of the experiment.

Visual and Auditory Stimuli

The 3D visual environment was based on a 3D model developed by Sense8 Corp (San Rafael, CA). It was composed of noticeable landmarks, several streets and alleys, and was rendered using Virtools Dev 2.5 (Virtools SA, Paris, France). This software has limited features in terms of auditory design, which consists mainly of stereo-rendered sources, even though specific plug-ins may be also implemented. In order to allow the maximum flexibility with regards to sound design, we used the Spat~ sound rendering engine[11,12] and the ListenSpace auditory scene authoring tool;[13] both developed at Ircam. A specific network interface was developed in order to connect Virtools with ListenSpace and Spat~, enabling the transmission of position coordinates and rotation angles of the user's head in the virtual world. The sounds were produced through tracked binaural rendering (HRTFs) and were dependent upon the subject's movements.

The model used for the audio environment was almost static; sound sources and their activation zones did not move. Only the movement and position of the subject drove audio events and their spatialization according to their relative coordinates. Two types of auditory elements were used; *binaurally rendered monophonic sources* and *ambisonics sound scenes* (Figure 2). *Binaurally rendered monophonic sources* were put at precise locations in the scene. The ListenSpace environment made it possible to program the position of these sources, and to define the small activation areas where the sources could be heard. *Ambisonics sound scenes*, linked to large activation areas, were added to the soundscape. Ambisonics is a four-channel audio format that embodies spatial information of a sound scene according to the three directions of space (left/right, front/back and up/down), thus allowing full immersion of the listener inside an auditory environment. The ambisonics sound scenes were recorded using the dedicated ST 250 Soundfield microphone in an urban environment, which worked well with the visual context of the experiment. These sound scenes were decoded in real time for reproduction over headphones according to the listener's position in the virtual space. The large activation areas covered the whole town, so that the subject was either at the center of one sound scene or in a cross-fade region between two sound scenes. The cross-fade mechanism was tuned to ensure smooth transitions between the four sound scenes.

Virtual Reality Set-Up Specifications

We used a V8 head-mounted display (Virtual Research Systems, Santa Clara, CA). The LCD displays had a monocular field of view of 48° by 36°, with an array of 640x480 (true VGA) color triads (pixels), refreshed at 60 frames per second. The subject's head orientation was measured by an electromagnetic sensor system (Fastrak Polhemus) which has an update rate of 120 Hz. The image generator (2.4GHz Pentium IV with 512 megabytes of RAM and an NVIDIA

Quadro4 750 XGL graphics card) took the head angular position information from the tracker and sent the corresponding image to the display and to ListenSpace (Pentium IV 2.4GHz), which calculated the position of the sound sources with respect to the head angular position information and sent them to the Spat~ (Mac 1GHz), which generated the sound. The Mac was equipped with a Hammerfall DSP system. Sennheiser HD570 circum-aural open headphones were used in the AVis condition.

Statistical Analysis

To assess the effect of auditory modality in the procedure, repeated measures ANOVAs (2 x 2) were performed on the different scores as the dependent variable, with condition (Vis and AVis) as a within-subjects factor and with group (patients and control) as between-subjects factor. The effect of VR session on state anxiety was evaluated with repeated measures ANOVAs (2 x 2 x 2). To check for a potential presentation order of conditions effect on the different variables, repeated measures ANOVAs (2 x 2) were performed on the different scores as the dependent variable, with presentation order of conditions (Vis first and AVis first) as a between-subjects factor and with condition (Vis and AVis) as a within-subjects factor. Non-parametric statistical tests were used when needed.

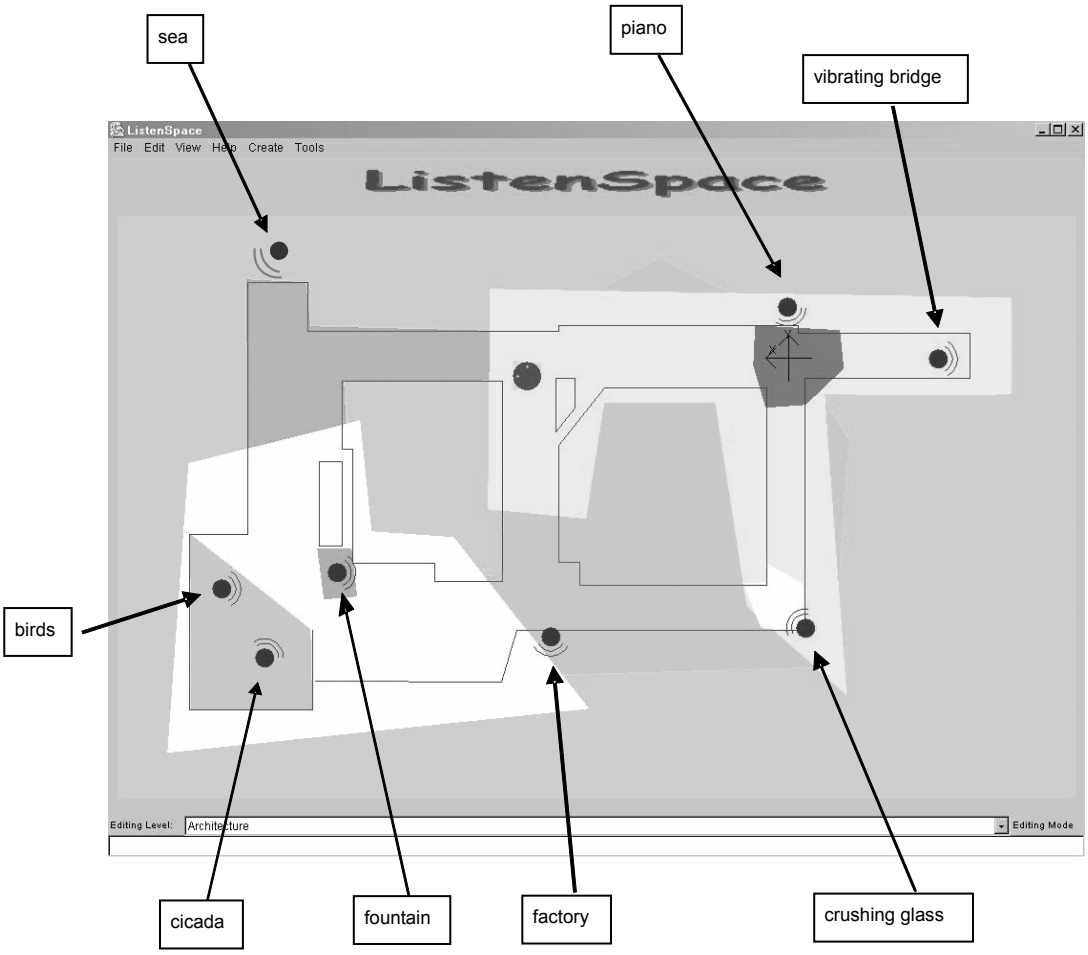

Figure 2. Auditory environment in AVis condition.
The sounds are played according to the computed position and distance of the subject with respect to the source when he/she enters an activation area. Large activation areas: ambisonic sounds scenes (four channel audio format) recorded in a urban environment. Small activation areas: binaurally rendered monophonic sources.

RESULTS

Of the 17 recruited patients, two females had to be excluded because of strong emotional reactions. Interestingly, the protocol served as a therapy session for the two of them, who eventually managed to perform part of the navigation task at the end of the second session (with 2 landmarks found). Five patients completed only one session. Two did an AVis condition (2 females) and 3 did a Vis condition (1 female, 2 males). Only the 10 patients who completed two sessions were included in the comparative analysis (see Table 1).

Presence

The two-way ANOVA with condition as a within-subjects factor and with group as between-subjects factor on presence scores indicated a main effect of condition ($F(1.17)=7.3$, $p=0.01$). Presence scores were higher in the AVis condition in both groups of subjects (Table 1). The analysis of variance with condition as a within-subjects factor and with presentation order of conditions as a between-subjects factor indicated only a main effect of condition ($F(1.17)=9.29$, $p<0.01$). However, the interaction between presentation order and condition was marginally significant ($F(1.17)=4.1$, $p=0.06$). Indeed, presence scores increased during the second session only in Vis first presentation order. In AVis first presentation order, presence scores decreased during the second session (for Vis first, Vis=39.6, SD=15.2, AVis=41.7, SD=18.7; for AVis first, AVis=41, SD=15, Vis=30.7, SD=14.7). This observation is in agreement with the finding that auditory modality improves the sense of presence, since removing it has the opposite effect.

Cybersickness

The ANOVA with condition as a within-subjects factor and with group as a between-subjects factor on cybersickness scores showed an interaction between the factors group and condition ($F(1.17)=10.6$, $p<0.01$). Cybersickness scores significantly increased in AVis condition in patients group. It is unlikely that these scores represent signs of somatisation since there is no difference between the two groups of subjects in the Vis condition. The analysis of variance with condition as a within-subjects factor and with presentation order of conditions as a between-subjects factor indicated only a main effect of condition ($F(1.17)=6.1$, $p<0.05$).

State Anxiety Levels

The two groups differed in all measures of state anxiety (Table 2). A three-way analysis of variance with two repeated measures on condition and the two state anxiety scores (before and after the VR session) was performed between the two groups (2 x 2 x 2). The analysis indicated a main effect of group ($F(1.17)=12.9$, $p<0.01$) but there was no interaction between the different factors, suggesting that state anxi-

Table 1. Means and (SD) of the scores to the different measures related to VR according to the group and the condition.

	Vis condition		AVis condition	
Measure	Control group (n=9)	Patients group (n=10)	Control group (n=9)	Patients group (n=10)
Time in VR (in sec)	474 *(206)*	509 *(194)*	469 *(170)*	428 *(211)*
Landmarks found during navigation (Max=11)	9.7 *(2.9)*	8.6 *(2.9)*	10.4 *(1.1)*	8.9 *(3.8)*
2-choice forced recognition (Max=10)	6.9 *(2.0)*	7.7 *(1.4)*[a]	7.3 *(1.1)*	6.6 *(1.6)*[a]
Correctly localized landmarks (Max=12)	7.3 *(2.6)*[b]	5.0 *(3.3)*[b]	6.9 *(2.8)*	5.1 *(3.3)*
Cybersickness	5.2 *(5.3)*	6 *(7.8)*	4.6 *(6.2)*	18.8 *(14.6)*
Presence	32.4 *(13.1)*	38 *(17.2)*	40 *(14.1)*	42.6 *(19.2)*

	Control Group (n=9)				Patient Group (n=10)			
	Vis condition		AVis condition		Vis condition		AVis condition	
Time	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Before the session	23.7	2.7	23.4	2.7	29.6	7.6	33	8.6
At the end of session	22.7	4.2	24.4	5.1	32.4	10.2	37	10.8

Table 2. State anxiety levels at the beginning of and after completing a session

ety levels before and after the VR session were not different for any of the groups.

Navigation in Vis and Avis Condition

No difference between the groups or between the conditions was found in the two measures taken during navigation (time spent in VR and number of landmarks found). The analysis of variance with condition as a within-subjects factor and with presentation order of conditions as a between-subjects factor indicated an interaction between presentation order of conditions and condition on time spent in VR ($F(1.17)=11.6$, $p<0.01$). Indeed, time spent in VR always decreased during the second session, but time spent in VR during the first session was much shorter in the case of AVis first (for Vis first, Vis=573, SD=149 sec, AVis=438 sec, SD=162; for AVis first, AVis=462 sec, SD=220, Vis=403 sec, SD=209). Since time spent in VR is a measure of time to find the landmarks and to feel familiarity with the town, this indicates that AVis condition does facilitate more efficient spatial exploration.

Correctly Localized Landmarks (After Navigation)

No difference between the groups or between the conditions was found. The analysis of variance with condition as a within-subjects factor and with presentation order of conditions as a between-subjects factor indicated an interaction between presentation order and condition ($F(1.17)=12.9$ $p<0.01$). Performance always increased for the second session, but the increase is higher when the first session was in AVis condition (for Vis first, Vis=5.1, SD=3.3, AVis=6.5, SD=3.1; for AVis first, AVis=5.3, SD=3.3, Vis=7.2, SD=2.7).

Two-Choice Forced Recognition (After Navigation)

No difference between the groups or between the conditions was found with either analysis of variance. However, the interaction between group and condition was marginally significant ($F(1.17)=3.04$, $p=0.09$). While normal subjects' performance tended to increase in AVis condition, patients' performance tended to decrease in comparison with performance in Vis condition. No presentation order effect could explain this observation.

DISCUSSION

In the present experiment, we compared navigation in a visual VE with navigation in an auditory-visual VE in two samples of subjects. As expected, presence scores were significantly higher in AVis condition. Presentation order of conditions was not at stake in this result, since the order of sessions was counterbalanced across subjects. However, analysis of the effect of presentation order pointed to a beneficial effect of auditory modality: time spent in VR to find the landmarks was shorter in AVis first order, and the increase in the number of correctly localized landmarks at the end of the second session was higher in AVis first order.

The two groups behaved differently with regard to the two conditions. While normal subjects did not exhibit more signs of cybersickness in AVis condition, the level of discomfort of anxious patients was significantly higher in this condition. In addition, anxious patients had poorer performances at a visual recognition test in AVis condition. These results are in agreement with the hypothesis of a multisensory integration deficit in this population. The attempt to continuously adjust the relative weighing of auditory, visual, and idiothetic information may have

caused an attention load which prevented allocation of attention resources to the VE.

In the setup we used, the imperfect mapping between the motor outflow and the multiple sensory feedbacks (movement of the head and its visual and auditory feedbacks) could be the cause of the increased symptoms of cybersickness in the AVis condition. It exhibited the significance of mastering the delay between sound and images updating so that no supplementary conflict is introduced.

The present experiment confirmed the importance of 3D audio for the construction of a virtual space. Control subjects said that the experience was more compelling when 3D auditory information was delivered during the virtual navigation, while several patients reported that the two worlds (auditory and visual) could not fulfill a sense of realism when presented together. The visual world we were using was composed of rich textures attempting to model a realistic urban environment. The auditory world was mainly composed of ambisonic sounds recorded in a city, which corresponded to highly textured sounds. In spite of the equivalent richness of both channels, anxious patients tended to perceive them separately. If this mode of perception can be linked to a sensory overload originating from their high sensitivity to multisensory information, a question remains at the semantic level with regards to the sensation of coherence between the visual scene and the auditory scene.[14] Focusing on this issue, we are currently conducting an experiment in which the visual environment is purely symbolic. Assuming that patients would not have a dual mode of perception in a symbolic VE, it might be possible to unravel primitives that might be sufficient to elicit emotional reactions, presence and rehabilitation.

Computationally, it is currently easier to achieve high resolution and realism in an auditory VE than in a visual VE. In an attempt to address this issue, we conducted a trial on four patients who were asked to navigate blindfolded in an auditory only VE and were surprised to observe that time of immersion tremendously increased (patients were willing to explore the VE as long as possible) while navigation was efficient (all auditory landmarks were found). Furthermore, realism was judged as very high and patients produced an accurate graphic reproduction of layout of auditory landmarks. This condition seems promising for research in therapeutic methods in which VR should not limit its aim to copying reality, but should invent new ways to engage the immerged subject. Applied research with virtual sound has been performed in the last decade in order to allow the visually impaired to develop more accurate and extensive knowledge of spatial layout.[15,16] Hopefully this kind of VR will provide therapeutic benefit for all kinds of populations.

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Virtual Driving in Individuals with Schizophrenia

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Abstract: *Driving is an everyday, complex behavior that requires multiple cognitive processes including visual perception, divided attention, and working memory. Schizophrenia is a psychiatric disorder that often affects these cognitive processes critical to driving. We constructed a desktop driving simulator to test how well individuals with schizophrenia would respond to a variety of everyday driving situations relative to healthy participants.*

Patients and age-matched controls were confronted with a simulated two-lane road with traffic and were instructed to obey all traffic laws, including the speed limit. After two rehearsal driving periods of 5 minutes, participants drove a 5-minute experimental route. At the end of the experimental drive, as the subject approached an intersection, a car stopped at a STOP sign illegally entered the intersection, stopped, and blocked the driver's path. The driver attempted to avoid a collision.

Overall behavioral measures included driving speed, stopping distance, weaving, and near-misses. The results indicate that individuals with schizophrenia made significantly more white line errors, and had a trend toward more yellow line errors and collisions. Additionally, patients drove significantly slower than control participants. This slow driving speed by the patients could be a byproduct of the negative symptoms or cognitive problems associated with the disease, or may result from medications. Alternative explanations for this performance difference, such as compensating for slow cognitive processing or recruitment from other brain areas, are also discussed.

INTRODUCTION

Driving is a day-to-day behavior requiring multiple cognitive processes. When driving, one must be able to perceive the environment accurately in order to drive safely. Also, a driver must be able to attend to multiple stimuli. For example, it may be necessary to pay attention to the brake lights of cars in front of the driver as well as signs and other cars on the road. Additionally, working memory is often crucial for driving because the driver must remember street names and goal locations.

A problem in psychiatric illnesses is that impaired functioning and driving skills are often not apparent to physicians, family members, or the patients themselves until they are involved in traffic accidents.[2,5] Schizophrenia is a psychiatric disorder that often affects cognitive processes essential for driving. Schizophrenia typically disrupts the ability to identify reality, recall situations, concentrate, make judgments, interact with others, and think clearly.[16]

Many studies indicate that schizophrenia impairs many of the cognitive processes involved in driving;[6,8,10] however, it is still unclear which symptoms of the disease are the most debilitating for everyday functioning, and how this disease affects driving skills.[8] For example, it is well-documented that patients with schizophrenia suffer from working memory deficient, divided attention,[7,8] and have longer reaction times than controls.[14] Clearly, a quicker reaction time affects driving through such necessities as the ability to respond quickly if the situation demands it. Individuals with schizophrenia make more errors on complex operations such as distinguishing between figures and the ground.[6] Such skills also seem critical for perceiving driving cues such as distinguishing a pedestrian in the road from a far-off crowd.

Because people with schizophrenia might be predisposed towards less safe driving behavior, the link between mental illness and driving poses an important research question, as the majority of people with schizophrenia live and may drive in the community at large.[2] Prior research suggests that people with schizophrenia have impairments in driving. For example, pa-

tients with schizophrenia have a significantly higher risk of having an accident per mile[5] (two times the number of accidents as controls, per mile driven[16]). However, in a separate study using a sample of mixed psychiatric patients, researchers found no difference from age-matched controls in number of single accidents, speeding, or unsafe yielding.[4]

In the current study we constructed a desktop driving simulator to test driving skills and see how an individual would respond to everyday driving hazards (e.g. children running in front of the car, cars running red lights, a car running a stop sign, etc.). We hypothesized that people diagnosed with schizophrenia would, as a group, display driving impairments.

METHOD

Participants

11 individuals (10 males, 34.9 $\pm$ 11.2 yrs. avg. age) with schizophrenia or schizo-affective disorder and 15 controls (8 males, 24.1 $\pm$ 5.4 yrs. avg. age) were tested. All participants had valid drivers' licenses and were asked specific questions about their driving behavior. For example, we collected information relating to driving frequency, whether the individual restricted themselves to only driving during the daytime, or only to familiar routes. All participants were paid $20 for their participation in the study.

Hardware

The simulator program was run on a PC desktop computer with a 19" LCD Flat Panel display. A Logitech Momo steering wheel with gas and brake pedals served as the input device.

Software

The virtual environment was created and rendered with 3D Game Studio. All World Definition Language code and C-script code was written by Robert S. Astur. Behavioral data of movement, trajectories, speeds, and events throughout the environment were analyzed using code written in C by Robert S. Astur. Throughout the simulation, the participant was situated in the driver's seat, and a speedometer and tachometer appeared on the virtual dashboard.

PROCEDURE

Participants were placed on a simulated two-lane road with traffic and were instructed to obey all traffic laws, including the speed limit, which was 40 mph with a 20 mph minimum. Initially, the participant completed two 'warm-up' runs of five minutes each to acclimatize the driver to the software and hardware. For behavioral measures, white line errors were recorded when the participant crossed the white line on his/her right side of the road. White opposite line errors were recorded when the vehicle traveled over to the opposite lane and crossed its white line. Additionally, a participant made a yellow line error when his/her vehicle crossed the middle line. Collisions were also tallied.

In these rehearsal runs the number of white errors, white-opposite errors, and yellow line errors, as well as number of collisions, were displayed on the screen. Each time the vehicle crossed a line, a tone sounded to notify the participant that they had made an error. Each error had a tone set to a different frequency in order to help the driver determine which error they had made.

After the warm-up driving sessions, participants drove a five-minute experimental route on a rural road with other cars. At the end of the experimental drive, the driver encountered a hazard. Specifically, the driver followed a lead car that passed through an intersection that had two cars stopped perpendicularly at stop signs. This lead car established that both the lead car and the driver had right-of-way through this intersection. After the lead car passed safely through the intersection and the driver approached the intersection, one of the stopped cars illegally entered the intersection, stopped, and blocked the driver's path. The driver was forced to avoid a collision. Immediately after passing through the intersection, a parked car appeared in the driver's lane, and it was again necessary to avoid a collision. Behavioral measures included driving speed, stopping distance, weaving behavior, near-misses, and collisions. Throughout all driving, car position and speed were recorded at 20Hz.

RESULTS

Results for driving errors in both patients and controls are depicted in Figure 2. In terms of

driving errors, individuals with schizophrenia drove more erratically as indicated by line errors. Specifically, patients committed significantly more yellow line errors than controls, t (24) = -2.46, p<.05. Additionally, individuals with schizophrenia had significantly more white line errors than controls, t (24) = -1.992, p<.05, one-tailed. In terms of collisions, people with schizophrenia were approximately three times more likely to get into an accident (an average of 0.3 ± 0.8 for controls, vs. 0.9 ± 1.4 for patients), although this did not reach significance (p=.08, one-tailed).

In terms of driving speed, individuals with schizophrenia drove at a significantly slower median speed than controls, t (24) = 3.130, p=0.05), and at a significantly slower average speed compared to controls, t (24) = 2.523, p=0.02 (see Figure 3). It is of note that the average speed for 6 of the 11 patients (54.5%) was below the minimum posted speed of 20mph.

DISCUSSION

In support of our hypothesis, we observed that people with schizophrenia displayed impairments on the driving simulator relative to control participants. Specifically, patients committed significantly more white and yellow line errors and showed a trend toward more collisions. This increase in white line errors demonstrated that patients were weaving over on the side of the road adjacent to the curb. The fact that patients made more yellow line errors is potentially more disconcerting, as these are indicative of

Figure 1. A screenshot of the virtual driving simulator.

crossing over the center of the road, and such errors may result in swerving into oncoming traffic. In addition, patients were approximately three times more likely than controls to get into a collision.

The weaving errors are noteworthy because in addition to making more driving errors, patients also simultaneously drove significantly slower than the control participants. The speed limit was posted as 40mph, with a 20mph minimum. However, 55% of the people with schizophrenia drove at an average speed that was below the minimum, while 0% of controls drove below the minimum on average. In sum, patients were driving slower but still making more errors than control participants. People with schizophrenia clearly showed impaired driving behavior on our simulator, which suggests that patients' real-life driving may also be impaired.

It is not apparent why people with schizophrenia make more driving errors despite driving slower than normal participants. Schizophrenia is diagnosed through the presence of negative and positive symptoms, and historically research has focused more on the positive symptoms of the disease (false beliefs, hallucinations, bizarre behavior, and disjointed thoughts).[1] Positive symptoms could have an impact on driving skills. For instance, someone who has more hallucinations may have difficulty perceiving the driving environment. However, it has been suggested that negative symptoms (flat affect, poverty of speech, loss of motivation, loss of pleasure in previously enjoyable activities, poverty of thought, and impairments in attention[1]) are actually more accurate predictors of everyday functioning.[7,8,9] Thus, negative symptoms may also be an indicator of a slower cognitive processing speed. It is of note that negative symptoms and cognitive impairment have substantial overlap but are not isomorphic and can be dissociated—one does not necessarily imply the other.

In terms of driving speed, it may be that the patients are driving slower to compensate for their slower cognitive processing. For example, they might be aware of their impairments, choose to slow down, and allow more time to respond to objects in the environment. Thus, slow driving speed may be a byproduct of the negative symptoms of the disease. Whereas it was beyond the scope of the current experiment to correlate this symptomology with driving behavior, we plan to make such correlations in future experiments.

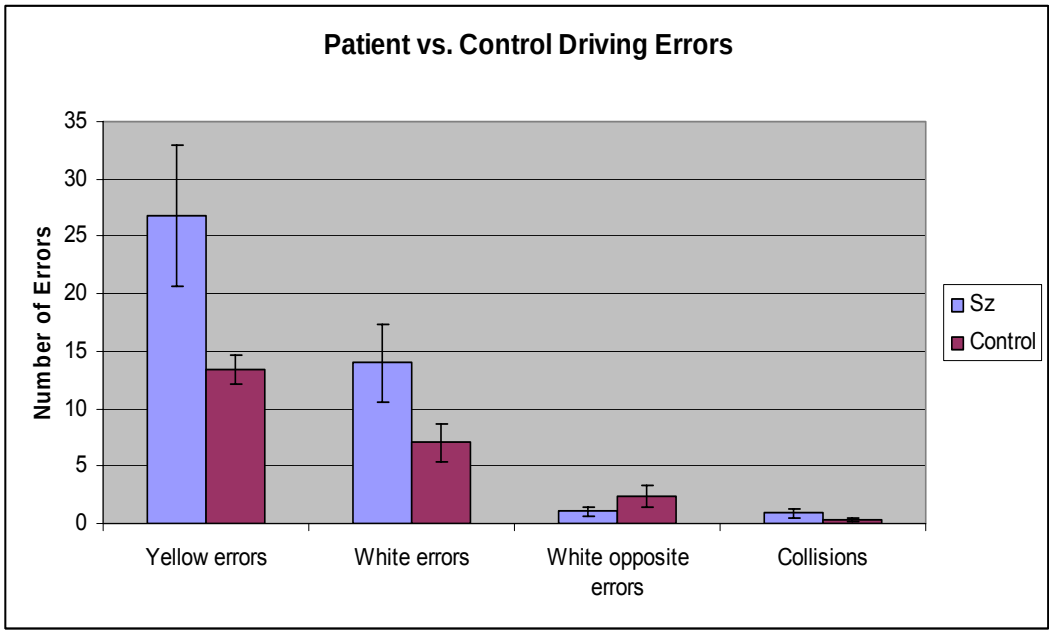

Figure 2. Driving errors for the two groups. Individuals with schizophrenia made significantly more white and yellow line errors and displayed a trend toward more collisions.

In addition to exploring symptoms of schizophrenia, neuropsychological testing may provide insight as to why people with schizophrenia drive differently than control participants. Many neuropsychological tests assess cognitive skills essential for driving, and accordingly, may predict accident risk during driving. For instance, the Trail-Making Test[15] is a timed visual sequencing and speeded set alternation test, which has been shown to predict crashes in older people.[10] Additionally, the Useful Field of View test (UFOV) measures visual processing speed, selective attention, and divided attention.[11] The UFOV is particularly known to accurately and specifically identify drivers involved in vehicle crashes, and to predict car crashes in a 3-year follow-up.[11,12] Additionally, visual perception tasks such as the Motor-Free Visual Perception Test-Revised (MVPT-R)[3] test visual memory, hidden figures, and partial representations have been reported to predict accident risk in elderly drivers.[10] Accordingly, since people with schizophrenia are often impaired in these skills, neuropsychological tests might provide additional or complementary information to that provided by the driving simulator.

Other issues to consider in future driving studies with this patient population are driving experience, computer experience, and patients' medication. For instance, two participants could both describe themselves as driving 'frequently', but one may drive for long periods, while another may drive a few minutes a day for only a few days. Likewise, some participants may have more experience with computer and video games, which might give them an advantage on the simulator. Additionally, it is not clear how the patients' medications affect their driving skills. These factors will be included in future projects. However, these factors notwithstanding, it is important to remember that independent of which specific factors contribute to these driving deficits, individuals with schizophrenia who drive show driving impairments in this simulator on a variety of dependent measures.

In this study, we have demonstrated a safe way to analyze driving skills. Using our simulator, we can program both routine and hazardous scenarios and analyze driving performance. The desktop simulator may potentially identify an impaired driver before that person becomes hazardous to himself and others on the road. Another important research advantage of this driving simulator is its compatibility with non-invasive brain imaging procedures such as functional magnetic resonance imaging (fMRI)

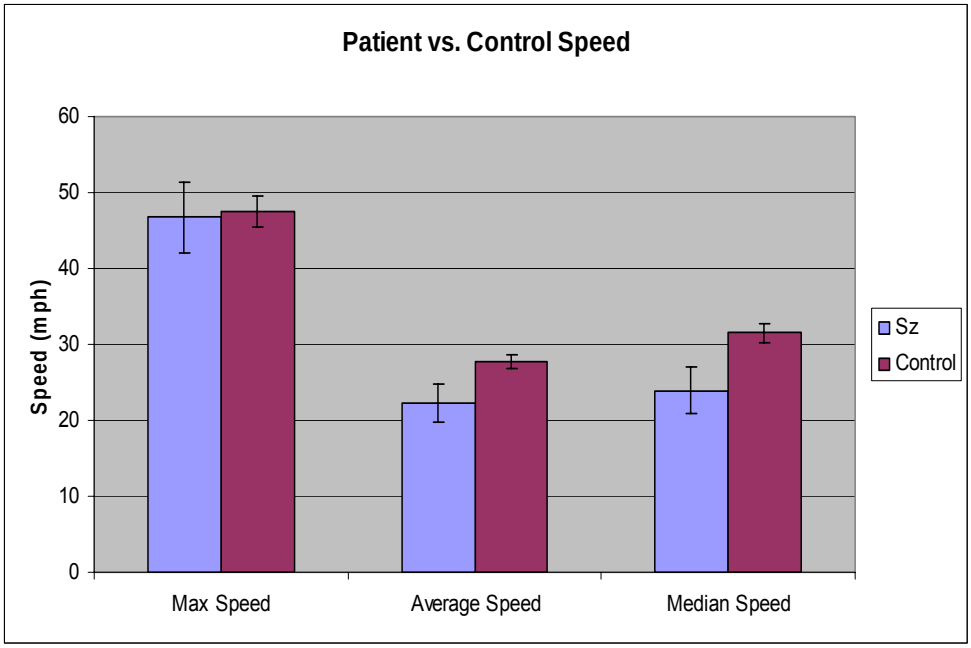

Figure 3. Driving speed for the two groups. Individuals with schizophrenia drove at a significantly slower speed than controls.

and electroencephalography (EEG). fMRI enables researchers to infer brain activity during a task, while EEG allows clinicians to monitor the origin and degree of electrical activity in the brain. Both procedures provide valuable data as to which parts of the brain are being used during complex behaviors such as driving.

Some of our other current projects involve examining people with other neuropsychiatric disorders on the driving simulator. We are studying such disorders as strokes, epilepsy, Alzheimer's disease, mild cognitive impairment, and traumatic brain injury. We are also investigating the effects of abused substances (e.g. alcohol and marijuana) on driving behavior. Future planned studies will use this simulator for cognitive rehabilitation following traumatic brain injury or stroke. We have also begun to use the simulator in an fMRI paradigm where we can study the neural systems involved in driving.

In summary, we created and tested a viable desktop system to test driving skills. The simulator is potentially usable with all individuals – with or without a psychiatric illness. In our pilot project in individuals with schizophrenia, we found that patients displayed impaired driving skills relative to control participants. The patients' difficulties with line errors, collisions, and maintaining a minimum speed could indicate real-time driving impairments, which will be a focus of future research.

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Abstracts from CyberTherapy 2004, January 10-12, 2004, San Diego, CA, USA

Presenter: Robert S. Astur, Ph.D.

Using Virtual Reality to Investigate Functioning of the Hippocampus in Schizophrenia

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Research status: Completed

Everyday life requires us to locate places in our environment and navigate them efficiently. One brain structure that is essential for normal navigation is the hippocampus. Coincidently, the hippocampus is a metabolically fragile structure, and is often damaged as the result of a variety of psychiatric conditions, including Alzheimer's disease, epilepsy, post-traumatic stress disorder, and schizophrenia. For example, it has been shown that individuals with schizophrenia have smaller hippocampi than age-matched controls, and neuronal pathology exist within their hippocampi. By using VR during functional brain imaging, we can examine the extent to which individuals with schizophrenia utilize their hippocampus while they are navigating through virtual environments.

Twelve individuals with schizophrenia and ten age-matched controls were tested on a virtual Morris water task in a functional magnetic resonance imaging (fMRI) paradigm. Participants were virtually placed in a round pool and had to locate a hidden goal area. The virtual environment was created using 3D Game Studio. It was shown to participants via an LCD projector on a screen that the patients viewed using 45-degree mirror glasses while lying supine in the MRI scanner. The participants navigated through the pool to find the hidden platform using an MRI-compatible joystick. Sixteen slices were obtained in the coronal oblique plane perpendicular to the long axis of the hippocampus using a GE Signa 1.5T MRI system.

The results indicate that individuals with schizophrenia display impairments in navigating to the goal area as compared to the age-matched control participants. By examining the brain structures used during virtual navigation, we note that the control participants have significant hippocampus involvement during virtual navigation, whereas the individuals with schizophrenia do not. We also note that individuals with schizophrenia have different patterns of activation in the cingulate cortex, insular cortex, and left middle frontal gyrus relative to control participants.

Hence, it appears that individuals with schizophrenia do not use their hippocampus during navigation to the same extent as controls. It is not immediately clear whether this difference is due to the patients being unable to use their hippocampus normally (i.e. They have a dysfunctional hippocampus, and it can't work normally) or whether other factors such as low motivation may have caused the patient group to use a non-spatial strategy (i.e. They have a normal hippocampus, but were using a strategy that would not activate it). Additional analyses and experiments are underway to disambiguate these two hypotheses.

Our research is unique in that we use VR to investigate the brain processes involved in navigation in an fMRI paradigm that requires immobility of the participant's head. This task is ideal because it is a virtual analogue of a common rodent task called the Morris water task. Given that the hippocampus is damaged in a variety of psychiatric and neurological illnesses, it allows us to use a single task across species to monitor hippocampus functioning as well as the efficacy of pharmaceutical and behavioral therapies aimed at improving memory function.

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Presenter: Rosa Baños, Ph.D.

Virtual Reality as a Psychological Laboratory: Its Utility for Assessing Attentional Biases in Anxiety Disorders

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Virtual reality (VR) is a useful tool in the field of psychology, but its applications have mainly centered on its utility as a therapeutic tool. However, VR could also be very helpful for basic research. It allows researchers to present stimuli and to register responses in a controlled manner and in an environment that "simulates the reality." [1-2] The experimental paradigms used to study cognitive processes in mental disorders have had to sacrifice ecological validity in favor of internal validity. Examples of these paradigms in the study of attentional processes are the "dote probe task" and the "emotional Stroop task." Both tasks try to demonstrate that persons with anxiety disorders preferentially direct their attention towards threatening stimuli.[3]

Words or photographs with different emotional weight are presented to the participants, and the performance of people with anxiety disorders and individuals without these conditions are compared. However, both words and photographs are static stimuli, presented in two dimensions, and lacking any context. Therefore, if the aim of the clinician is to understand how a person with a specific phobia directs their attention in a feared situation, a more reliable result would come from assessing his or her attentional performance in that situation, in contrast to the presentation of words or drawings. Obviously, there would be notable difficulties regarding internal validity if the situations took place in real life, since total control would not be possible, but this problem could be minimized in a VR laboratory where the stimuli could be presented in a controlled manner. Moreover, the presentation of the stimuli could also be done outside the conscious awareness of the individual by jointly using subliminal perception strategies. In this sense, VR allows us to study an issue that is difficult to grasp in the real world.

In order to study the feasibility of VR as a "realistic" laboratory where attentional processes in specific phobia (spiders and cockroaches) can be studied, our team has developed an environment where a house is simulated and a version of the dote-probe task has been introduced. The person has to explore this environment and find several keys that appear during a brief period of time. When they are detected, the individual has to press the bottom of the mouse so the computer can register whether the response is correct and complete within the time required to make the decision. The computer controls the presentation of the stimuli and its exact location. The keys appear in the same location just after a threatening stimulus (spider or cockroach) or a neutral (watch) is presented.

First, the keys are presented after a series of randomized subliminal presentations of the spider/cockroach and the watch. After a break, during which the person stays immersed in the virtual world, he or she is asked to find padlocks, which appear in the same way described for the keys (but the stimuli are presented in a supraliminal way). The differences between groups (phobics and non-phobics) and within the groups will be analyzed. In the present work, the VR scenarios and the experimental tasks are described.

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Presenter: Steve Baumann, Ph.D.

Smoking Cues in a Virtual World
Provoke Craving in Cigarette Smokers as Demonstrated by Neurobehavioral and fMRI Data

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Fifteen cigarette smokers participated in a study of the ability of smoking cues within a virtual world to provoke craving-to-smoke. Subjects were asked to abstain from smoking for at least 12 hours prior to testing, which was confirmed by CO analysis of expired breath. They then completed a questionnaire concerning their smoking history.

Subjects were seated in front of a 21-inch color monitor and given a short practice session. Then they were placed in a VR simulation that did not contain any intentional smoking stimuli and were instructed to explore a sequence of environments with occasional directions from the experimenter. At various points during the simulation, the experimenter brought up a rating scale, and the subjects were asked to rate their urge to smoke on a scale of 0-100.

In the second session various smoking stimuli were placed in the simulation at strategic locations that the subject would likely encounter. These stimuli included opened packs of cigarettes, lighters, ashtrays, advertisements, cigarette vending machines, cigarette cartons for sale, characters smoking and a bar scene. Once again, subjects were asked to rate their urge to smoke at various points during the simulation.

Each session lasted approximately 10-15 minutes. The rating data was automatically saved to an Excel spreadsheet. An overall change-in-craving score between sessions was computed for each subject. Despite a nearly identical mean rating at the beginning of each run, the results showed a 15.7 mean increase in urge to smoke between sessions. Thus, the embedded smoking stimuli provoked a highly significant increase in craving between the two sessions ($p<0.00014$ one-tailed paired t-test).

Six subjects with the highest differential rating between sessions were recruited to participate in an fMRI pilot study several weeks later using a Siemens 3T Allegra scanner. Four subjects were smoking-deprived for at least 12 hours prior to the scan, and two were allowed to smoke as usual. Each subject participated in two VR sessions, one without smoking stimuli and one with smoking stimuli. Echo planar imaging data from the two VR sessions was combined and differences between and within the sessions were studied.

Individual analyses showed activation of normal sensory (visual, sensorimotor) and motor areas, indicating that the imaging technique could detect normal activation in these subjects. Additionally, the individual analyses revealed clear and highly significant activation of multiple areas previously reported involved in drug craving and cigarette smoking. In the deprived smokers there was highly significant activation in the amygdala (2 subjects), hippocampus (1), prefrontal cortex (3), parietal association areas (2), and inferior rectus gyrus (2). In addition, there was highly significant deactivation in widespread areas, especially in the frontal lobes bilaterally. In comparison, there were no areas of significant cortical deactivation in the two control smokers, who were allowed to smoke until the fMRI study began.

This study demonstrates that both self-report and physiological data indicate that appropriate VR simulations can be used to manipulate craving in addicted smokers.

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Presenter: Patrick S. Bordnick, MSW, MPH, Ph.D.

Development and Testing of a Virtual Reality Cue Reactivity Environment for Nicotine Dependent Cigarette Smokers

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Research Status: Completed preliminary clinical trial

Background:
Drug-related stimuli/cues (cigarettes, other people smoking) have the ability to elicit both physiological and behavioral reactions (e.g., craving in nicotine dependent cigarette smokers). Traditional cue exposure methods involve bringing smokers into austere laboratory environments and using videos, still pictures, and paraphernalia to elicit craving and physiological reactivity. While these methods have led to craving and physiological reactivity, their generalizability outside of the lab and utility in clinical setting remains in question. Thus, a virtual reality cue exposure (VRCE) environment was developed to test the reactivity of nicotine dependent cigarette smokers to virtual cues. VRCE combines the elements of VR with specific inanimate smoking cues, environments, social interactions, and other related stimuli in a virtual environment appropriate for laboratory and clinical settings. VRCE combines both computer generated and video images depicting smoking cues (e.g. cigarette packages, ash trays, burning cigarettes) and smoking social interactions (e.g. being offered a cigarette in a social context). VRCE expands upon traditional cue exposure methods by allowing participants to experience "real world" smoking situations in a controlled VR setting. After development and beta testing, the VRCE environment was tested in a clinical trial with nicotine dependent cigarette smokers.

Methods:
20 male and female nicotine dependent smokers participated in the VRCE clinical trial. After a 20-minute deprivation period, cigarette smokers were exposed to both VR neutral stimuli and VR smoking related stimuli using a VFX-3D head-mounted display (HMD) (Interactive Imaging, Rochester, NY) connected to a 2Ghz P-IV PC. The presentation order of inanimate and animate stimuli was counterbalanced to control for the total time in VR. In addition, a Coulbourn Lab Linc V system (Coulbourn, Inc.) was used to measure heart rate, skin conductance level, and respiration during VRCE sessions. We hypothesized that smokers who are exposed to VR smoking-related cues/stimuli will have greater physiological reactivity (heart rate, respiration, and skin conductance) and will report increases in subjective urges and craving compared to VR neutral cues/stimuli.

Results:
Twenty cigarette smokers participated in the clinical trial. Participants smoked at least 21 cigarettes per day, experienced craving, and were in good physical health. Comparisons were made on both craving and physiological measures between the smoking and neutral cue rooms. Data will be presented for all clinical variables including subjective craving reports and physiological data.

Conclusions:
The demonstration of reactivity in smokers to VR smoking cues provides a foundation to develop additional VR environments and test VRCE in clinical treatment studies for efficacy.

Novelty/discussion:
This is the first VR program in addictions to incorporate neutral, inanimate, and animate environments that utilize realistic video images and allow participants to interact with people instead of computer-animated avatars, arguably producing more realistic interactions. VRCE offers a new medium for both clinicians and researchers who work with addictions to bring cue exposure into the treatment setting. The VRCE program will lead to significant advances in understanding craving and other clinical phenomenon that may lead to relapse in cigarette smokers.

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Presenter: Cristina Botella, Ph.D.[1]

Telepsychology and Self-Help: The treatment of phobias using the Internet

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Phobias are one of the most common psychiatric disorders. It is estimated that about 11% of the population suffers from a specific phobia.[6] Currently, *in vivo* exposure is a very effective procedure available for the treatment of phobias.[8,9] However, it is estimated that only 15% of phobics seek treatment.[3] Moreover, many persons who are referred to treatment do not receive it due to a lack of adequately trained professionals. Because of this, we think that it is important to develop strategies that increase the availability, attractiveness, and acceptance of treatment for phobias. Making the treatment easily available can be a good way to achieve these objectives.

Some studies have already been done that explore the possibility of using the Internet to provide help. The Internet has been used to reduce risk factors for eating disorders,[4,11] to apply treatment for recurrent headaches,[10] and to apply a program for posttraumatic stress disorder.[5] However, there is only one study carried out by our own group in which the whole treatment is totally available on the Internet, including the feared scenarios to apply exposure, where the participation of the therapist is not required. It is therefore a completely self-applied program.[1,2] This study is about public speaking fears, and the feared scenarios consist of real videos with threatening audiences for people who have this problem.

In the present study, a telepsychology system that uses the Internet for the treatment of animal phobias is presented. The program allows a step-by-step self-application of the treatment, controlled by the system itself without any contact between patient and therapist. The system is composed of: a) an assessment protocol that provides the patient with a diagnosis of his or her problem, including the interference it is causing him or her, its severity, and the degree of fear and avoidance it is producing; b) a structured treatment protocol that is organized in separate blocks reflecting the patient's progress. It is thus possible to ensure that the patient does not skip any steps in the treatment (a common problem with traditional self-help manuals), gaining more control over the process; and c) an outcome protocol that assesses treatment effectiveness at every intermediate step as well as at the end of treatment.

The results obtained in a case series analysis with 15 participants are presented. These indicate the benefit of continuing work to develop effective treatments, which are increasingly available to the patient. This means a notable advance in therapeutic cost-benefit. The combination of new technologies together with self-help material seems to be a promising alternative that can help to solve some existing problems in the field of mental health.

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Presenter: Stephane Bouchard, Ph.D.

A Hint on the Relationship Between Fear and Presence

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Context:
In previous studies, we have observed that anxiety and presence are correlated. The purpose of this study is to explore this relationship in order to understand the direction of the causal relationship between presence and emotions felt while in VR. Our hypothesis was that increases in anxiety would lead to a stronger sense of presence.

Method:
The sample consisted of 26 women aged between 27 and 68 years old (M = 45,23; SD = 11,35) and 5 men aged between 32 and 56 years old (M = 43.60; SD = 10,02). The subjects were first SCID-diagnosed to confirm the presence of snake phobia and randomly assigned to one of two conditions. The design was a randomized repeated measures ANOVA with three subsequent immersions: a control immersion (CTRL environment), two experimental immersions, and two conditions. These conditions were (a) a VR immersion in an environment filled with hidden snakes, which should induce anxiety (ANX environment), and (b) a VR immersion in the same environment as in (a) but without any hidden snakes, which should not induce any anxiety (NOANX environment). In the NOANX environment, participants were immersed in a virtual environment depicting a desert with pyramids and temples. They were asked to visit it for five minutes and were told that the environment was safe and contained no snakes. In the ANX environment, participants were immersed in the exact same environment and had to perform the same task, but they were led to believe that the environment was plagued with hidden dangerous snakes. To sum up, participants in the first condition were immersed in the CTRL environment, then in the ANX environment followed by the NOANX environment. For the second condition, the sequence was immersion in the CTRL environment, in the NOANX environment, and in the ANX environment. The immersions in the ANX and NOANX environments were separated by a distraction task consisting of reading of a relaxation text and answering questions about it. Each VR immersion was followed by measures of presence and anxiety. At the end of the study, the participants were trained to use a self-help manual for their phobia in compensation for their participation.

Results and Conclusion:
A manipulation check confirmed that participants were significantly more anxious in the ANX environment than in the other environments. Results of the repeated measures ANOVAs showed that presence was higher in the anxiety provoking environment than in the control or the non-anxious environment, as confirmed by the significant Condition by Time interactions and the interaction contrasts (all p

< .01). The results are discussed in the light of the measurement of presence and the relationship between emotions and presence. It appears that an emotion such as anxiety is increasing significantly the sense of presence in a virtual environment. The opposite relationship still has to be tested. However, it suggests that in addition to hardware and software variables, people's internal states are providing additional cues to create the sense of presence.

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Presenter: Alex H. Bullinger, M.D., MBA

Development and Evaluation of a Modular Psychophysiological Test Battery for Use with Virtual Environments/Augmented Reality Applications

Mara Kottlow Robert Stoermer, MD;
Ralph Mager, MD; Franz Mueller-Spahn, MD; Angelos Amditis, PhD; Alex H. Bullinger, MD

University of Basel, Switzerland

Research status: Completed

Background:
The question, "What do virtual environments of all sorts do to their respective users?" was for years reduced to investigating the various side and after-effects these integrated systems may cause. While these questions still are not obsolete, they are of far less importance due to highly sophisticated technological solutions to the main problems causing these side and after-effects, such as system delays, insufficient and ergonomically poor I/O – devices, etc. Therefore the research focus under the heading "What do VE systems do to their users?" shifted rather slowly towards performance, usability, acceptance, and awareness issues. At the beginning of such studies it became obvious rather quickly that in terms of rating, measuring, and objectifying, usually paper-and-pencil-based tests and/or questionnaires were by and large the only methods of evaluation.

In contrast, what was needed were tools for obtaining objective parameters from VE users that could:

- not be influenced voluntarily by the user
- be regarded as intra-individually stable as well as inter-individually comparable
- serve as "mosaic stones" for more complex psychological constructs like attention, vigilance, stress, etc.
- serve as performance indicators with respect to the virtual task

The few solutions on the market cover only parts of these requirements and most of them are not applicable within VEs and/or have no real-time capabilities. In addition to these few off the shelf systems, there are also a few applications that respective research labs or groups have custom-tailored to their applications.

Keeping in mind the requirements as well as the shortcomings of the existing solutions, in the course of the pan-European research project "Virtual and Interactive Environments for Workplaces of the Future (VIEW)," a modular platform and an independent application test battery for VEs of all sorts was developed.

Method/Tools:
Based on the criteria and methodologies obtained from pilot studies, questionnaires, and guided interviews with developers and users of VEs of all sorts (reaching from industrial design to manufacturing to health-related applications), a concise test battery was developed consisting of:

- a paper-and-pencil-based module, formed by a rapid mixture of standardised questionnaires and self-rating scales
- a real-time psychophysiological module
- a real-time neurophysiological module

This test battery was designed to be able to estimate mental workload, cognitive performance, stress, attention, vigilance, and related constructs. The test battery is modular, so that different parts of it can be used for different types of VE applications, depending upon complexity, hours of continuous use, type of user and environment, cost, etc.

For evaluation purposes, the test battery was used during a variety of VE based pilot applications. The results will be summed up in the course of the presentation.

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Presenter: Mignon Coetzee, Ph.D.

A Low-cost VR Group Support System for People Living with HIV

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University of Cape Town

Research Status: In progress

Social support has been shown to improve the quality of life of HIV/AIDS patients, and HIV/AIDS counseling and support groups have traditionally been used as a means of providing social support to patients. Given the high HIV infection rate, South Africa faces a shortage of counseling resources. This study investigated the possibility of using virtual reality technology to provide emotional and informational support to HIV/AIDS patients. Our system was partly motivated by other systems that have been successfully used to provide support for breast cancer patients (eg. Breast Cancer Lighthouse and Easing Cancer Park). If a low-cost VR support system were effective, it could greatly increase the number of HIV/AIDS patients receiving support.

We developed a low-cost, deployable desktop PC-based system using custom software. The system implements a VR walk-through experience of a tranquil campfire in a forest. The scene contains four interactive avatars that relate narratives compiled from HIV/AIDS patients. These narratives cover the aspects of receiving an HIV+ diagnosis, intervention, and coping with living with HIV+ status. To evaluate the system, seven semi-computer-literate HIV+ volunteers from townships around Cape Town used the system under the supervision of a clinical psychologist. The participants were interviewed about their experiences with their system, and the data was analyzed qualitatively.

In terms of emotional impact, the participants found their experience with the system mostly encouraging, particularly the narratives relating to adjustment and coping. They found it encouraging to hear from other HIV+ individuals rather than from other sources. The participants liked the availability of the computer system, and found it preferable to TV or pamphlets as a source of information due to its interactivity and the control it affords over content delivery. The system was also preferred due to the anonymity it provides those not willing to reveal their HIV+ status. The system highlighted the potential benefits of joining a support group, and motivated some participants to make more use of support groups. In general, participants found using the system to be an uplifting experience, reinforcing their strength in coping with HIV. As compared to other forms of therapeutic intervention, participants reported that they received a similar cathartic experience. The system was considered ideal for patients who, because of their fear of disclosing their HIV+ status, are not receiving support. The participants generally preferred real support groups rather than the VR system, but felt that the system could augment counseling tools, and that it could be of benefit in places where counseling resources were not available, or in cases where joining a support group was difficult.

Our study establishes the usefulness of low-cost VR systems in counseling of HIV/AIDS patients in developing communities. Such systems cannot replace counseling, but can play a role in steering people toward seeking counseling, as well as providing limited support in cases where counseling resources are not available. Our findings, although preliminary, have encouraged the further development of our system by extending the degree of informational and emotional support it provides.

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Presenter: Sophie Côté

The Use of a Pictorial Stroop Task and Psychophysiological Measures in Understanding Cognitive Mechanisms Underlying Virtual Reality Exposure Effectiveness

Sophie Côté, Stéphane Bouchard, Ph.D.

Cyberpsychology Lab of the University of Quebec in Outaouais (Hull, Quebec, Canada)

Research status: Still in progress

Background:
Many efficacy studies have been completed in virtual reality (VR) research with exposure treatment for phobias. Most of them were successful in showing that VR exposure is at least as effective as *in vivo* exposure. However, few studies have been done on treatment mechanisms. In what dimensions is VR exposure effective? Is this technique suggestive enough to elicit fear when the participant knows the stimuli are not real? Is the exposure affecting cognitive processes in the brain? Many subjective measures, such as questionnaires, are available, but they remain very subjective. This is where objective outcome measures become interesting.

Method/Tools:
In this study, 10 arachnophobics went through a VR treatment program. They received seven sessions of cognitive behavioral therapy (CBT) (60 mins each). During the first session, participants were SCID-diagnosed with a specific phobia (spiders), according to the DSM-IV. Subjects suffering from major comorbid disorders, epilepsy, and major heart or vestibular problems were excluded from the study. During the second session, participants received information about phobias and CBT, while the last five sessions were devoted to gradual exposure therapy using virtual reality. Virtual worlds were created using a 3D computer game (Max Payne), modified to offer gradual hierarchies of fearful stimuli (spiders). The virtual reality exposure was conducted with a Pentium IV computer, an I-Glass head-mounted display, and an Intertrax2 motion tracker.

Participants filled out questionnaires assessing spider phobia, anxiety, perceived self-efficacy, and immersion propensity both pre and post-treatment. They also went through a Pictorial Stroop task, in which they had to identify the color of a filter placed over pictures with varied emotion-inducing content (spiders/negative, cows/neutral and rabbits/positive). Finally, subjects went through a behavioral avoidance test, in which they had to press a button to make a platform move forward. On this platform was a tarantula in a transparent plastic box, lid open. During this task, participants' heart and respiratory rate were recorded using CardioPro. After each exposure session, participants filled out questionnaires assessing cybersickness and sense of presence in the virtual environments.

Conclusions:
As the work is still in progress, final data were not available at the time this abstract was written. The use of psychophysiological measures to better understand cognitive mechanisms underlying the effectiveness of VR exposure in the treatment of phobias is relatively rare, even in studies with *in vivo* exposure. Many debates still persist in this field and results are encouraging, but sometimes contradictory. Hopefully, this study can clarify some issues and stimulate the inclusion of more objective and reliable measures, in addition to subjective measures, in the field of virtual reality.

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Presenter: Eamon P. Doherty, Ph.D.

Low-Cost Facial/Mental-Controlled Tele-robotic/Tele-Medicine System for Quadriplegic Persons

Eamon P. Doherty, Ph.D.[1], Gary Stephenson, AMBCS[2], Joel Fernandes[1], Dency Baskaradhas M.S.[1], Pavani Aitharaju[1]

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Research Status:
The facial/mental-controlled telerobotic system research was completed and approved by the university IRB. Our future research includes adding an extra window so a doctor can observe the telerobotic operator, thus making the vocational/rehab tool a telemedicine diagnostic tool.

Background/Problem:
A quadriplegic man wants to be able to work at a local pharmaceutical company as a technician mixing chemicals, but is not allowed to leave his bed due to unhealed wounds. A telerobotic system is needed so that he can work remotely. The system needs to be operated by impulses at the forehead because the man has no use of limbs. The quadriplegic man would also not mind if an additional window was added so his doctor could observe that he is in good physical and mental health and can operate machinery. This tele-display may allow the doctor to concentrate on his other patients who live in remote places and need his care. Telehealth is realized as a growing need in the 21st century. American Richard Grainger, director general of the UK NHS National Programme for IT (NPfIT), is currently spearheading a £2.3bn project (Delivering 21st Century IT Support for the NHS) to overhaul National Health Service IT, and Telemedicine or Telehealth[1] will be expected to supply many patient-centric benefits in this plan.

Methods/Tools:
A visual C++ program was created to operate with a robotic arm, interface board, and a webcam. This system was connected to the Internet. A second laptop was also connected to the Internet and Microsoft Netmeeting was installed. A person was then asked to use a Don Johnston EMG controller or Cyberlink mental interface to select scanned buttons representing robotic arm functions at the other remote robotic arm site and control it real time through the Internet. The person controlling the arm was watching the movements through a video window on the desktop.

Results:
The person was able to operate the robotic arm in a real time environment and do tasks. The delay between the robotic arm movements and video was negligible because the resolution of the video camera was kept low but clear enough to allow the user to do a task. The user was also happy to be able to control something remotely.

Novelty/Discussion:
The test subject asked his therapist and they know of no other telerobotic systems that he can operate. Other telerobotic systems are of a military nature[2] or for the chemical industry.[3] There was one experimental telerobotic arm system at Duke University, but it was still being used in experiments involving monkeys.[4] A low-cost telerobotic system is a novel approach allowing vocational rehabilitation and the potential for tele-medicine diagnostic applications for doctors who cannot readily visit patients in remote places.

Conclusion:
It may be possible to assess attitude, motor skills, and general health by watching the user perform a task. It seems that the system may have potential as a telemedicine diagnostic tool in addition to a rehabilitative vocational tool.

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Presenter: Stephanie Dumoulin

The Sense of Presence in Videoconferencing and Emotional Engagement

Stephanie Dumoulin, Stephane Bouchard, Ph.D., Melanie Michaud

Cyberpsychology Lab of the University of Quebec in Outaouais, Hull, Quebec, Canada

Research status: Almost complete

Background:
Videoconferencing is a communication medium that allows therapists to conduct psychotherapy sessions with clients that are far away (e.g. rural areas). Ongoing research in our lab suggests that the development of a therapeutic alliance is

possible but related to the illusion of presence. However, there is no empirical data to document the relationship between presence and the emotional engagement and how it takes place.

The objective of this study is to determine if the extent to which an individual is engaged in an emotionally charged discussion affects presence.

Method/Tools:
The sample consists of 40 participants between 20 and 56 years of age randomly assigned to two conditions: (a) High Emotion First (High-EF; describing a highly emotional event first, followed by the description of a less emotionally involving event), or (b) Low Emotion First (Low-EF; same as the other condition but in the opposite order). For the study, two Vision 5000 systems from Tandberg are used, connected by TCP/IP at a rate of 384 kbits/s.

The first part of the procedure was to identify and rank five positive events that the individual had experienced and then select the most and least emotionally involving ones. The Immersive Tendency Questionnaire and the Attitude Toward Telecommunications Questionnaire were then completed, followed by a 15-minute discussion in videoconference about the first emotionally involving event. The Presence Questionnaire in Videoconference was then completed, followed by a distraction task. Finally, participants discussed the second emotionally involving event for 15 minutes in videoconference and completed the presence questionnaire again.

Results and Conclusions:
The results show that the sense of presence isn't highly affected by the emotional content of the discussion. However, the individuals who felt more comfortable communicating via videoconferencing experienced a stronger sense of presence. Increasing the sample size would allow more power to find a significant Time x Condition interaction between the High-EF and the Low-EF conditions.

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Presenter: Uri Feintuch, Ph.D.

Development of a "Low End" Multimodal Feedback Program for Motor, Cognitive, and Sensory Rehabilitation

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Research Status:
Software design and description; Planned study

Background:
Feedback from tactile and kinesthetic receptors contributes to the haptic sense, enabling us to manipulate objects with precision and smoothness. Cumulative evidence from both neuroscience and clinical research indicates the important role that haptic feedback may play in rehabilitation intervention. Neurophysiological studies suggest that specific haptic stimuli may facilitate plasticity processes required to recover damaged sensory and motor maps in the brain.[1] Moreover, haptic stimuli have been shown to be involved in Cross Modal Transfer, where knowledge acquired in one modality improves performance when employing another modality.[2] The benefits of using haptic feedback as part of therapy for patients with stroke have also been demonstrated.[3] The inclusion of haptic information within virtual environments may enhance performance, relevance, reality, meaning, and presence.

Problem:
The role of haptic feedback in virtual environments and its potential benefits for cybertherapy have not been systematically characterized. Thus, it is not clear which types of impairments (motor, cognitive, sensory) will be most helped by the addition of haptic feedback. To a large extent, this void is due to the high cost and encumbrance of many of the currently available haptic devices. The objective of this study was to develop a "low-end" multimodal (visual, auditory, haptic) feedback program that would enable clinicians to easily design a diverse assortment of virtual environments for the delivery of tasks suited for the rehabilitation of motor, cognitive, or sensory deficits.

Method/Tools:
We have created software that runs on a standard PC desktop and uses an off-the-shelf haptic joystick interface (Microsoft's Sidewinder Force Feedback 2). This user-friendly program enables a therapist or researcher to quickly design audio-visual-haptic environments. The program has two components, an Editor and a Simulator. The therapist uses the Editor to place objects of different sizes and shapes on the screen. These objects are assigned various attributes such as color, sound, movement, and type and intensity of haptic feedback. Juxtaposition of the virtual objects and association of their attributes enables the creation of simple and complex environments (e.g., dynamic mazes). The Simulator is then employed for running experimental trials or for conducting interventions. Although simple to operate, many sophisticated game-like tasks may be designed and used for a gamut of research/treatment goals that test and train participant abilities including:

- cognitive deficits (e.g., executive functioning, spatial orientation, memory)
- motor deficits (e.g., motor planning, motor control)
- sensory deficits (e.g., orientation and navigation skills for people who are visually impaired, proprioceptive deficits for patients following stroke, reeducation for peripheral nerve injuries)
- functional skills (e.g., simulator training for operating a powered wheelchair)

The software will first be tested with a group of healthy subjects and with patients who have had a stroke and whose deficit is primarily sensory. Their ability to perform mazes of varying difficulty under visual-auditory, visual-haptic, and visual-auditory-haptic conditions will be compared to determine the contribution of haptic feedback to task performance.

Novelty:
This software makes the use of haptic feedback widely accessible to the cybertherapy community. It offers a wide array of therapeutic tools which are easy to design and execute. In addition to its immediate clinical applications, we anticipate that this tool will allow for future studies of cross modal tasks, eventually leading to the development of additional, haptic-based therapeutic interventions.

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Presenter: Carlo Galimberti, Ph.D.

Artifact-Based Trust in On-line Interactions 2: Relevance to Telemedicine, On-line Psychologic Counseling, and Therapy

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Research Status: Completed

Background:
The work aims to define how trust is built in on-line interactions. This knowledge can be applied in different situations such as on-line therapy, on-line psychological counseling, and trust based on-line interactions.

Method:
One of the main problems of on-line interactions consists of winning the users' trust. As trust is not only based on previous experiences but also on feelings and impressions emerging during the interaction, the study aims at finding out which elements make a website trustworthy.

In order to obtain basic information about web interaction processes, the project has been divided into two different phases:

- First phase: On-line interactions in laboratory context
- Second phase: On-line interactions 'observed' in real context adopting an ethno-methodological approach

We applied both new and traditional usability methods suitable for the test performed:

- Voice recording of users' comments during the interaction (thinking aloud)
- Interviews (post cognitive walkthrough)
- Questionnaire
- Personal journal
- Simulation game (e-commerce website project)
- On-line questionnaire

Novelty:
On the basis of the collected data, a model was prepared to represent web-based trust building and maintenance processes. In this model, interface elements are the starting point to perceive information regarding the website structure, the catalogue structure, and to obtain information on items included. The information collected allows the user to create a mental model of the whole interaction process instead of just the website. This model is based upon "structure" and "contents."

The mental model is interpreted and applied in order to find out information on the products, on the 'other' speaking through the website, on any other interlocutor, and on the interaction itself. This information is then evaluated according to different criteria:

- Interest
- Satisfaction about the interaction
- Perceived competence
- Perceived transparency

The "Interest" criterion is applied in order to decide whether to continue the interaction or not: it is based on motivation, which considers the cost. "Satisfaction about the interaction" underlines the importance of the usability and accessibility of a site. "Perceived competence" is an element pertaining to the users' mental model of the seller, as is "Perceived transparency."

During this process, users continue the interaction task only when the mental model is clear enough and the different criteria are fulfilled. Interaction tasks are not considered separate and independent, but complementary. In order to reach the goal, confidence and trust must be generated.

The most important innovation of this research is the focus on the whole interaction, on its tasks and the creation of a mental model, rather than only on the result of the interaction process (trust or distrust).

The goal of the second phase of research is to obtain qualitative and quantitative data in order to validate the model and to generalize our findings to various contexts such as telemedicine, on-line psychological counseling, and therapy.

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Presenter: Azucena García-Palacios, Ph.D.

Comparing The Acceptance of VR Exposure vs. *In vivo* Exposure in a Clinical Sample

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Phobias are one of the most common mental disorders. It is estimated that about 11% of the US population suffers from a specific phobia, and around 6% suffer from agoraphobia according to epidemiological studies.[4] Exposure therapy is a well-established treatment for phobias. There are different modalities of exposure therapy. The most successful and commonly used is *in vivo* exposure. This technique offers high success rates (75-95% of patients clinically improve) and long-term effectiveness (one-year follow-up). Because of this, *in vivo* exposure is considered to be the treatment of choice for specific phobia. However, despite the fact that

phobias can be successfully treated, very few phobics ever seek treatment. It is estimated that only 15% seek treatment.[2] Aside from the low percentage that seek treatment, around 25% either refuse the *in vivo* procedure or drop out.[5] The main reason patients refuse *in vivo* exposure is that they are too afraid to confront the feared object or situation. Because of this, we think that although *in vivo* exposure is an effective treatment, new efforts are needed to increase the number of phobia sufferers who seek and successfully complete treatment.

Making the treatment less intimidating would be a good start at increasing the number of phobics seeking treatment. We think VR can help to achieve this goal. VR exposure has some advantages over *in vivo* exposure that may make it less aversive and more attractive to phobia sufferers. The main advantage is the high level of control over the feared object. In VR, the feared situation can be more easily and accurately graded. VR also allows for easier repetition of the exposure tasks. Finally, it is possible to carry out exposure treatment without leaving the consultation room, assuring confidentiality. We think that patients who are reluctant to start an *in vivo* program may be more willing to get involved in a VR treatment. In a former study, we surveyed a sub-clinical phobic sample. The results showed a higher degree of acceptance of VR exposure vs. *in vivo* exposure.[3] The present study surveyed 102 patients who met DSM-IV criteria for specific phobias (animal type, situational) or panic disorder with agoraphobia (a clinical sample). When asked to choose between *in vivo* exposure and VR exposure therapy, 70% chose VR exposure. 23.5% refused *in vivo* exposure, whereas only 3% refused VR treatment. This is the first survey that offers data of acceptance and refusal rates of *in vivo* exposure vs. VR exposure in a sample of clinically phobic individuals. Our findings suggest that VR exposure therapy may prove valuable for increasing the number of phobics who seek treatment and for decreasing the *in vivo* exposure refusal rates. VR exposure can help improve the efficacy of one of the most important techniques in the treatment of anxiety disorders, exposure therapy.

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Presenter: Jeff G. Gold, Ph.D.

A Controlled Study of the Effectiveness of Virtual Realty to Reduce Children's Pain During Venipuncture

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Research Status: In progress

Background/Problem:
Attention plays an important role in the perception of painful stimuli, and several studies have

identified the efficacy of distraction for reducing pain among children who must undergo invasive medical procedures. Numerous methods of distraction have been evaluated, and recently virtual reality (VR) was identified as a potentially effective tool for pain distraction. Due to its highly involving nature, VR may mediate painful stimuli by engaging the user and placing significant demands on the limited cognitive resource of attention. VR has shown promise as a non-pharmacological pain management tool with several populations and medical procedures. One frequently required painful procedure is venipuncture. This procedure involves piercing a vein with a needle for the purpose of a blood draw. Despite its relatively routine nature, venipuncture has been reported to be among the most feared hospital experiences for child patients.

Method/Tools:
This study presents preliminary data on the effectiveness of VR as a child pain distracter during a blood draw. Children (8-12 years old) arriving at the phlebotomy laboratory at Children's Hospital of Los Angeles for the purpose of a blood draw were recruited. Participants completed baseline measures and were then randomly assigned and stratified for age and gender to have their blood drawn in one of four conditions: a control condition (without distraction), cartoon distraction, distraction by a VR scenario presented on a flat-screen computer, and the same VR scenario presented in a head-mounted display system. Visual perception of the needle was controlled across all conditions by a visual occlusion. Child self-reports of needle pain, parent and phlebotomist reports of child pain, and parent and child state anxiety were measured. In addition, children completed a measure of presence and simulator sickness symptoms.

Results:
Preliminary results on 57 participants found that children distracted by VR reported significantly less affective pain than children in the cartoon or flat-screen VR distraction groups. Significant differences between conditions were not found for child or parent anxiety; nor were they found for parent or phlebotomist ratings of child pain. A significant negative correlation was found between child rating of presence and self-reported pain, supporting the theoretical connection between degree of involvement and mediation of pain. No child reported significant levels of simulator-related side effects.

Conclusion:
Although these are preliminary findings on half of the full data set, this study is consistent with previous studies exploring the potential of VR for non-pharmacological pain management. The current study extends previous findings to 8-12 year-olds undergoing venipuncture and supports the pain management potential of this evolving technology. As technological advances in VR continue with resultant enhancements of the experience of presence, virtual reality may turn pain into a virtual unreality.

Novelty/Discussion:
The current research is novel in that it uses a between groups design to test the effects of VR across display conditions (HMD vs. Flatscreen), compared to passive watching of a cartoon and standard care in children. However, we have also added a physical barrier to standard care so that the pain site is occluded from the child's vision. This more conservative test controls for visual occlusion across all conditions (the barrier was used in all groups) and will tell us if the actual attentional component of VR has pain distracting effects beyond what we might observe by simply having the subject wear a blindfold. Basically, we know VR works in this application area, but we need to begin isolating the components that are active ingredients so that we can design cost-effective systems with the highest level of positive impact.

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Presenter: Ken Graap, M.Ed.

Treating Fear of Flying in Virtual Reality: A Controlled Study

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Research Status: Complete

Background:
Standard Exposure (SE) is considered the standard of care in treating specific phobias. However, SE can be difficult to arrange for fear of flying, especially after the events of September 11, 2001. Difficulty gaining access to airport facilities and equipment to conduct SE, difficulties associated with conducting treatment in public locations, and the costs of accompanying persons on flights can make SE untenable. Virtual Reality Exposure (VRE) offers significant advantages in the treatment and research of anxiety and other disorders. Virtual reality (VR) allows users to interact in various ways within a computer-generated virtual world. Use of head-mounted displays (HMD's), motion trackers, and vibration platforms allow one to experience the virtual world as one would experience the real world, resulting in a sense of presence or immersion in the virtual world. VRE's have been utilized in the clinical treatment of anxiety disorders since approximately 1992.[1]

Method:
Seventy-five participants who met DSM-IV criteria for specific phobia (fear of flying) completed treatment after being randomly assigned to VRE, SE, or a wait-list (WL). WL participants were also randomly assigned to either VRE or SE treatment after serving as controls. Random assignment, use of a standardized treatment manual, homogenous inclusion criteria, and blind independent assessment are features of this methodologically rigorous study.

Treatments were delivered in eight individual sessions across six weeks. VRE and SE groups received identical treatment for sessions 1-4, which included assessment and anxiety management skills training. During sessions 5-8, participants engaged in exposure therapy, either at the airport (SE) or in the therapist's office using the virtual airplane (VRE). After completion of treatment, participants were offered the opportunity to take a graduation flight. During the flight, anxiety measures were collected.

Results:
Results indicated that VRE and SE did not differ on standardized questionnaires, willingness to fly, anxiety ratings during flight, self-ratings of improvement, and patient satisfaction with treatment. Both active treatments were significantly better than WL, which showed no difference from pre- to post-treatment.

Six and twelve month follow-up data indicated that participants maintained gains made during treatment. Both groups had similar numbers of respondents and repeated measures ANOVA analyses did not reveal differences between the treatment groups during follow-up.

Conclusions:
The findings support the use of virtual reality exposure for treatment of fear of flying. Exposure *in vivo* did not differ from exposure in VR immediately post-treatment, 6 months, or 12 months post-treatment on any outcome measure, including standardized questionnaires or a behavioral avoidance test (graduation flight). VRE offers significant advantages over SE in terms of treatment logistics and efficiency, without sacrificing the efficacy of SE. Importantly, VR allows treatment to be conducted in the privacy and convenience of an office setting, more control over stimuli, easy repetition of feared scenes, and the opportunity to standardize exposure to a variety of cues across locations.

Novelty:
This study is the largest, controlled study of VRE for fear of flying to date.

Acknowledgements:
This research was supported by NIMH Grant #R42-MH58493-02.

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Presenter: Michael R. Heim, Ph.D.

Avatar Diplomacy

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Research is in progress to use VR for relieving psychological damage suffered by children growing up in war zones. The "pen pals" movement fostered a feeling of international connection and friendship in school-age children, which mitigated the feeling of fearful isolation induced by World War II. While the pen pals movement helped previous generations connect by using pen-and-paper letters exchanged through conventional postal services, today's youth are engaged in video games and use avatars on the Internet. "Avatar Diplomacy" is the guided use of networked virtual environments to connect school-age children through culturally customized avatars in specially designed virtual worlds. The first phase of this project began with research on the aesthetics of Internet virtual worlds conducted from 1997-2001 at the Art Center College of Design in Pasadena, California. Results from this study were presented in several places including VRST 2000 (Seoul, Korea), *Computer Graphics World (January 2001)*, SIGGRAPH 2000, and at UNESCO in Rio de Janiero (May 2003).

What emerged from the first phase of research was a model of avatar encounters not restricted to role-playing games (e.g. *EverQuest)*, nor based on rule-based behavior like most computer video games. The model is not one of competition but one of encountering alien avatars and exploring their features. The model relies on the use of a series of highly focused events (hour long meetings) that are guided by skilled moderators who host the avatar encounters.

The next phase of the project addresses the deployment of a handful of geographically dispersed nodes on different continents where moderated avatar encounters can be launched from participating schools. The results from this phase will determine the shape of the final project to be implemented in international conflict zones. This intermediate phase seeks to establish the role of visualization techniques in customizing avatars. At Beach Cities Health and Healing Center (www.bchd.org), the classes in Meditation and in Tai Chi use a sequence of body-based visualizations to effect the shifts in perception, breathing, and a sense of well-being. While these classes draw on Patricia Carrington's research into Clinically Standardized Meditation (CSM), the visualization techniques used at BCHD are Taoist projections of the imagined physical body. Such image projections share many characteristics with avatar self-projection in virtual worlds.

The upcoming phase of research seeks to determine which imaginative projections work most effectively for the implementation of avatar diplomacy. This phase tests the responses of the first nodes of users to determine the most appropriate avatar designs and activities that will underpin the later implementation of avatar diplomacy. Tools in this phase will be widely available 3D software such as ActiveWorlds Universe and Adobe Atmosphere 3D. As in previous experiments, users will receive instruction on how to design their own avatars using *Avatar Lab, a* subset of *Poser software* (www.curiouislabs.com).

[Note: Many of these references are available on the Web. See links at www.mheim.com under "Articles" and "Books."]

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Presenter: Patricia Heyn, Ph.D.

Virtual Reality Therapy: A Systematic Review of the Effectiveness of Interventions

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Research Status: In progress

Background:
For the past decade the number of new studies published on the proposed applications of Virtual Reality Therapy (VRT) for rehabilitation has increased exponentially. The literature supports the benefits of VRT in the improvement of a wide range of physical, mental, or behavioral disorders.

Problem:
Although there is evidence to support the positive benefits of VRT, there are no studies that systematically review the level of evidence of VRT interventions. The widespread application of such interventions should be preceded by evidence of directly attributable improvements on the desirable physical, mental, or behavioral outcome.

Aim:
The purpose of this study is to quantitatively review the published literature to determine whether VRT is a beneficial therapeutic tool to improve physical, mental, or behavioral disorders.

Methods & Data Sources:
A database from 1980 to July 2003 of published and non-published manuscripts will be compiled by using MEDLINE, PUBMED, CINAHL, PsycInfo, Psyc-Lit, Educational Resources Information Center (ERIC), Rehabdata, PEDro, NIDRR, the Cochrane Controlled Trials Register, Dissertation Abstracts, and the reference list of identi-

fied studies and other reviews will be examined. Key words that will be used in the search are virtual reality, virtual environment, and computer-assisted combined with therapy or rehabilitation, or intervention. Additional key word combinations include cognitive, mental, physical, activity, exercise, fitness, movement, occupational, disorders, neurological, psychiatric, pediatric, behavior, psychological, impairment, function, and disability. Articles not written in English will be excluded.

Study Selection:
To be selected for detailed review, reports have to meet the following criteria: (1) evaluate the effects of a VRT intervention (rehabilitation or therapeutic program) on physical, mental, or behavioral outcomes, (2) describe the clinical population, (3) describe the outcome measures, and (4) report enough data for meta-analysis.

Data Extraction:
Studies that meet the inclusion criteria will be analyzed for methodological quality and for relevant effect size calculation.

Data Synthesis:
For each selected outcome, summary effects will be computed by pooling standardized mean differences as well as raw mean differences. Frequencies and descriptive statistics will be reported.

Results:
Results will be reported on effect size index and confidence intervals. In addition, descriptive information about moderator variables such as the type of VR therapy, duration, level of exposure, clinical population, and mode of VRT will be presented.

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Presenter: Kay Howell, Ph.D., MBA

Advances in Using Simulations to Train Complex Decision-Making in Teams

Kay Howell, Ph.D., MBA

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Advances in cognitive science research have provided great insight into how people learn recommendations for improving learning outcomes. As a result, there has been a proliferation of instructional design theories and models for education and training. While there are numerous theories and models – many of which use different terms – there are fundamental underlying principles which many have in common. For example, cognitive science has long recognized that learning environments that provide opportunities for learners to apply their knowledge to solve practical problems can lead to faster learning, greater retention, and higher levels of motivation and interest. Simulations that allow learners to visualize complex phenomenon and/or provide opportunities for practice and experimentation have proven very effective. Simulations offer a number of advantages compared to training with actual equipment or in the actual job environment. They can be used as practice environments for tasks that are too dangerous to be practiced in the real world. Simulations can also provide increased opportunities for practice on tasks that occur infrequently (e.g., emergency procedures), and they can be used when actual equipment cannot be employed. Simulations can contain embedded instructional features (e.g., feedback) that enhance the instructional experience. Simulations can also represent significant cost savings compared with training on operational equipment. Modern technology is providing increased opportunities to deploy simulations that allow team members who are physically dispersed to train together over a network. Unfortunately, apart from military applications and a few selected industries (e.g., pilot training), simulation-based training is rarely used today because it is difficult to implement in standard instructional environments. Expected improvements in technology, however, have the potential to significantly reduce the cost and complexity of implementing learning-by-doing environments. The combined forces of high-powered computing, unparalleled bandwidth, and advances in software architecture are poised to make realistic gaming and simulation environments more feasible and economical.

Because these tools will be increasingly available, it is important to understand appropriate contexts and methods for implementation.

This session will explore the use of modeling and simulation to enhance team decision-making and performance based on theoretically driven, empirically based guidelines. Teams are used with growing frequency by modern organizations, ranging from business decision-making to national security matters. The complexity and scope of issues to be addressed often requires the efforts of multiple people working together. Thus, the performance of teams and their decision-making abilities have a great impact on the success of organizations. The panel will summarize recent research progress toward understanding decision-making in teams, including research on competencies, tools, and instructional strategies that contribute to team performance. Technologies used to validate the fact that realistic simulations provide a highly effective way to train complex decision-making skills will be examined. The panel will conclude with a discussion of issues and trends related to simulation, including how to make them easier to build and incorporate into learning environments, as well as describe some the current uses of simulation in team training.

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Presenter: Ho-Sung Kim, Ph.D.

A functional Magnetic Resonance Imaging (fMRI) Study of Nicotine Craving and Cue Exposure Therapy (CET) using Visual Stimuli

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Research Status: In process

Objective:
Cue Exposure Therapy (CET) refers to the manual, repeated exposure to smoking-related cues aimed at reducing cue reactivity by extinction. Traditionally, pictures or real objects have been used for CET. In our previous research, comparing the changes of craving before and after exposure to a virtual environment (VE) and still photos, the increase of craving with VE versus pictures was shown to be significantly larger.[1] However, this previous study used subjective questionnaires to measure the changes. In this study, we are planning to find objective evidence of VE's effectiveness in CET using functional Magnetic Resonance Imaging (fMRI). For this, we constructed a VE for to elicit nicotine craving based on the results of the previous study, and compared the activation maps from the VE and moving pictures using fMRI.

Method:
20 subjects who are right-handed are going to be recruited and divided into two groups. One group will be exposed to the VE and the other to moving pictures. Each subject will be required to fill out a questionnaire that asks for the subject's level of nicotine craving before and after the experiment so that the changes can be observed. A 1.5 T GE MRI machine in Hanyang University Kuri Hospital, Korea, will be used to gather fMRI data. Subjects in the magnet will be able to see a visual stimulus (VE or moving pictures) through an MR-compatible head-mounted display (HMD) (Resonance Inc.). The block design will be used and the data will be analyzed with SPM99.

Results:
Although the experiment and the data analysis are still in progress, we are able to predict that the areas which are involved in visuo-spatial attention, memory, and craving will be activated. This includes areas such as right intra-parietal sulcus, posterior hippocampus (bilateral), medial thalamus (bilateral), right ventral tegmental area, right posterior amygdala, right inferior frontal gyrus, and middle frontal gyrus (bilateral).[2] We also predict that these areas show more activation in the VE session.

Conclusion:
We propose a VE that can be used in CET to induce nicotine craving, and our results should show stronger brain activations in the VE than in moving pictures. It might be able to support the belief that virtual reality (VR) is a more effective method of CET. VR can provide a multimodal environment that requires one's cognitive abilities such as spatial attention and memory in order to interact, causing a higher level of craving.

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Presenter: Hunter Hoffman, Ph.D.

Virtual Reality Analgesia During Thermal and Electrical Pain for Longer Durations and Multiple Treatments

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Research Status: Complete

Preliminary clinical evidence suggests that at least for brief (3-6 minute) treatment durations, virtual reality is surprisingly effective at reducing extreme pain. VR has reduced pain by as much as 50% during brief burn wound care and physical therapy treatments. The present laboratory pain pilot study introduced a new laboratory pain paradigm combining thermal and electrical pain to allow the study of longer pain sessions. We explored whether VR works for longer durations with multiple treatments per subject. The virtual environment titled SnowWorld was used. Aiming with her head-position-tracked gaze, the subject shot snowballs at snowmen, igloos, robots, and penguins by pressing a button. During each session, four thermal pain stimuli lasting thirty seconds each were interleaved with four electrical pain stimuli lasting two minutes each, administered over a period of 25 minutes. Using subjective 0-10 graphic rating scales, after each brief stimulus, our healthy 19 year old female volunteer rated three aspects of her pain: 1) the amount of time spent thinking about pain, 2) pain unpleasantness, and 3) worst pain. Comparing thermal pain during baseline (no VR) to mean thermal pain during VR treatment, "time spent thinking about pain" dropped from 9 to 2.5, "pain unpleasantness" dropped from 9 to 2.5, and "worst pain" dropped from 9 to 3.2. Comparing electrical pain during baseline (no VR) to mean electrical pain during treatment (during VR), "time spent thinking about pain" dropped from 9.5 to 1.25, "pain unpleasantness" dropped from 8 to 3, and "worst pain" dropped from 7.5 to 3.4. This pattern of strong pain during "no VR" baseline and large drops in pain ratings while in VR was replicated on several subsequent days for the one subject who received VR. Four control subjects received no VR at all. As predicted, they showed high pain ratings during baseline and throughout their 25 minute sessions, and this pattern of consistent, high pain ratings was found on all six 25-minute sessions per control subject. While small studies are inconclusive by nature, these results are encouraging preliminary evidence that VR reduces pain for longer (clinically relevant) treatment durations, and VR analgesia appears to remain effective with repeated use. Simulator sickness was negligible for this subject, and her rating of presence in VR was consistently

"strong." A larger controlled laboratory study is currently underway.

Novelty/Discussion:
This is the longest duration of VR analgesia by our group to date and introduces a new technique for safely inducing multiple etiology (thermal and electrical) laboratory pain for prolonged treatment periods.

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Presenter: Jeonghun Ku, M.S.

A study of Brain activations and Presence in a Virtual Touching Task using fMRI

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Research Status: Preliminary results

Background:
We often attempt to measure cognitive processes such as complex sensory processing, attentional ability, spatial cognition and memory within the context of a virtual environment (VE). Collectively, these processescontribute to and influence the "feeling of presence." In this study, we investigated the relation between presence and brain activation using functional magnetic resonance imaging (fMRI). We hypothesized that activity in brain regions responsible for sensory integration, as well as attention processing, could be influenced by changes in the presence score. This was based on the conceptual model that VE enrichment through use of multi-modal stimuli could enhance the feeling of presence. To test the hypothesis, we designed an fMRI-compatible data glove that can provide vibrotactile stimulation, and performed fMRI experiments to investigate the changes in brain activity and presence score produced by touching a virtual object with and without vibrotactile feedback.

Methods:
Four young, healthy, right-handed subjects (1 male, 3 female, average age of 25.25 (sd=3.86)) underwent fMRI at 3.0 Tesla magnetic field strength. They experienced seven tasks in pseudo-random order: "seeing" the virtual object, "feeling" the vibrations, self-paced finger "tapping," "Touch 1 and Touch 2" (touching the virtual object with or without vibrotactile feedback), and "Touch 3 and Touch 4" (touching a vibrating virtual object with or without vibrotactile feedback). Brain activity for the group was assessed in a mixed-effect analysis. Using a photo-plethysmograph mounted on the MRI system, heart rate variability (HRV) data was recorded throughout and analyzed to yield the low frequency to high frequency ratio (LF/HF) as a representation of arousal. After fMRI, the subjects completed questionnaires to assess their subjective level of presence (0 to 10) in each task.

Results:
Mean presence scores tended to be higher for tasks that included vibrotactile feedback when compared to those that did not. Mean LF/HF ratios showed a similar effect. For all "touch" tasks, left precentral gyrus (primary motor area), inferior parietal lobule, medial frontal gyrus, and occipital lobe showed activity. Areas known to be involved in sensory integration and attention processing (left anterior cingulate, left middle frontal gyrus, and right insula) showed changes in activity between Touch 1 and Touch 2 tasks, and between Touch 3 and Touch 4 tasks.

Conclusion:
In this study, consistent changes in HRV and brain activation were observed as being related to different feelings of presence in a virtual touching task and linked to the processes of sensory integration and attention. Further investigation, including a larger number of volunteers, is required. Nonetheless, these preliminary re-

sults support the notion that the observed brain activation is consistent with a component of the conceptual model of presence, i.e. “system enrichment,” which can draw one’s attention and increase one’s involvement and feeling of presence. Such experiments additionally provide an important window on the ecological validity of VR applications in clinical psychology.

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Presenter: Jang Han Lee, Ph.D.

Design and Implementation of Virtual Reality System to Assess and Train the Patients of Unilateral Visual Neglect

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Research status: In progress

Objective:
The aim of this study is to implement a virtual reality (VR) system that can assess the state of disease and train hemispatial neglect to affect visual stimulation. The virtual environment provided by the system is maternalized with three-dimensional computer graphics that are similar to the branch road. There is a target ball which guides the subject’s gaze while the target ball moves randomly to the right or left of the user's viewpoint. In this experiment, the patients should chase the movement of the ball. The task level is utilized in order to assess the patient’s characteristics from this result. The training task level is predetermined.

System:
The VR System consists of Pentium IV PC, DirectX 3D Accelerator VGA Card, head-mounted display (HMD) (Eye Trek - OLYMPUS), and 3DOF Position Sensor (Intertrax2) The PC with 3D Accelerator VGA Card generates real-time virtual images for subjects to navigate. The position sensor transfers a subject's head orientation data to the computer.

Virtual Environment:
We built the branch road so that the ball is located in the center of the road. The subject's gaze is guided as the ball moves in a random direction. The ball changes color if the patient looks at the ball. This change awakens the visual attention of the patient.

Tasks in the Virtual Environment:
Our program is composed of three stages with four levels for differentiating the training according to the characteristics of the patient. The level is distinguished by the speed of the ball. If the patient succeeds at the same level three times, then the patient moves on to the next level. There are three cues in each level and each cue happens according to each time passage. Patients pass to the next stage if they succeed in all four levels. The three stages are differentiated by visual angle.

Results:
Left side neglect patients show a neglect expression angle more deviated toward the left side than normal subjects. This result supports the correlation of the VR system with neglect evaluation tools such as the line bisection test and the letter cancellation test. Attention time and scanning time are increased in the left side neglect patient who has a deficit in attention, midline orientation, and neck rotation ability. If a patient steadily works with the training program, we expect that the symptoms of the patient will improve.

Novelty/Discussion:
The VR system has more benefits than previous neglect evaluation tools. This system provides high ecological validity by using three-dimensional computer graphics that are similar to the real world. It also assesses data that can be acquired while the patient reacts immediately to various stimuli. The data is used to diagnose the condition of the patient. However, statistical analysis regarding the data is difficult because subjects are scarce. Thus, we will progress the clinical test continually in the patients with unilateral neglect.

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Presenter: Fabrizia Mantovani, Ph.D.

Narrative Dimension, Sense of Presence and Emotional Involvement: An Experimental Analysis

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Research status: In progress

Background:
A number of studies in the field[1] have clearly shown that virtual reality (VR) can be a powerful tool within a psychotherapeutic intervention. In particular, a critical feature for a clinical virtual environment, now under investigation by the European Project EMMA – Engaging Media for Mental Health Applications (http://www.emma.upv.es/), is its ability to induce presence and emotions in users.[2] A recent model of presence[3] described it as a defining feature of the self, related to the evolution of a key feature of any central nervous system: the separation between an external world and the internal one. If in simple organisms this process involves only a correct coupling between perceptions and movements (movement tracking), in humans it also requires the shift from meaning-as-comprehensibility to meaning-as-significance, with meaning-as-significance refering to the value or worth of the event for us. For a patient, "his or her events" are only the ones that are meaningful for him or her. Following this vision, an important role in inducing a high level of presence could be played not only by system-related features such as graphic realism, level of immersion, and interaction devices, but also by the setting of the VR experience within a meaningful narrative context, favoring user identification and involvement. However, few systematic and controlled studies aimed at investigating the complex relationships of these dimensions have been carried out.

Method/Tools:
The main objective of the presented research is the study of the influence of narrative dimension and level of immersion on sense of presence, emotional involvement and psycho-physiological arousal, in response to a virtual reality experience. 40 subjects (female university students between 20 and 25 years old) took part in the study. Experimental design (a 2x2 between subjects design) included two independent variables: 1. presence vs. absence of narrative context and 2. immersive (head-mounted display) vs. non-immersive condition. Dependent variables were a sense of presence, measured through the ITC-SOPI questionnaire;[4] emotional experience, measured through Positive and Negative Affect Scale (PANAS);[5] and psycho-physiological indexes such as heart rate (HR) and galvanic skin response (GSR).

Conclusions:
Preliminary data support the vision of VR as an advanced imaginal system, i.e., an experiential form of imagery that could be as effective as reality in inducing emotional responses. The possibility of structuring a large amount of life-like or imaginary controlled stimuli and simultaneously monitoring the possible responses generated by the user of the virtual world may offer a considerable increase in the likelihood of therapeutic effectiveness, as compared to traditional procedures. However, the data also suggest that the clinical skills of the therapist, and

in particular his or her ability in creating a narrative context (clinical protocol) for the experience, remain a critical factor for the successful use of VR systems.

Acknowledgement:
The present work is supported by the European Commission, in particular by the IST program: Project EMMA- Engaging Media for Mental Health Applications, EMMA (IST-2001-39192), http://www.emma.upv.es. We are grateful to all our partners in the project for their contribution in developing the ideas presented in this work.

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Presenter: Melanie Michaud

Manipulating Presence and Its Impact on Anxiety

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Research status: Almost complete

Background:
Current studies in our lab, as well as those at other centers, have reported significant correlations between presence and anxiety. But the direction of the causal relationship between the two constructs remains to be tested: does presence in VR lead to anxiety, or does anxiety lead to presence in VR? The aim of this study is to experimentally manipulate the sense of presence to test the level of anxiety felt by phobics when immersed in a virtual environment.

Method:
The sample consisted of 40 people afraid of heights who had to perform a feared task for 10 minutes while immersed on a virtual bridge. The task involved contemplating a 15-story building under construction, selecting which floor to exit, taking the elevator to the selected level, exiting the elevator and walking on a scaffold crossing the streets, hitting a plank and watching it while it falls, seeing an airplane, and turning back.

The participants were randomly assigned to two conditions: (a) High Presence First (High-PF; the task was conducted in a setting that maximized presence), and (b) Low Presence First (Low-PF; the task was conducted in a setting that disrupted presence). The study used a repeated measure factorial design where the tasks were performed once in each setting, with reversed order between the conditions (High-PF and Low-PF). To maximize presence, participants were immersed in VR with a dark cloth covering a Cy-Visor head-mounted display (HMD) in a dark and quiet room. In the other setting, the HMD was not covered by a black cloth (participants could see the room around them), the lights were turned on, and music was playing in the background.

The following questionnaires were used: the Immersive Tendencies Questionnaire (assessing subjects' predisposition to feel immersed in VR), the Simulator Sickness Ques-

tionnaire (measuring cybersickness), the Presence Questionnaire, the State-Trait Anxiety Inventory and the Acrophobic Questionnaire.

The equipment used included an IBM Pentium IV[MD] computer with an ATI-9700 graphics card. A Cy-Visor with a large resolution (1.44 millions Pixels) and an Intertrax-II tracker by Intersense were also used. Finally, the virtual environment was created using the Max Payne 3D game editor. A 15-floor building constitutes the environment where the subject can take an elevator.

Results and Conclusions:
Our results showed that subjects are more anxious in the High Presence condition. This is interesting in the context of other results in our lab suggesting that anxiety also affects presence. Thus, there seems to be a synergistic effect between anxiety and presence. Further studies should assess whether this effect also applies to other emotions (e.g., sadness, joy) and if the synergistic effect follows a linear relationship or is subjected to floor and ceiling effects.

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Presenter: Matthew Parrott

A Methodology for Designing Specific Animal Phobia Stimuli for Virtual Reality Exposure Therapy

Matthew Parrott[1], Doug Bowman, Ph.D.[1], Tom Ollendick, Ph.D.[2]

[1]Department of Computer Science, Virginia Tech
[2]Department of Psychology, Virginia Tech

Research Status: In development

Background/Problem:
To effectively treat phobias, therapy techniques must be capable of producing an emotional response within a patient.[1] A sense of presence induces anxiety when using virtual reality exposure therapy, even when there is no actual threat.[4] To maintain presence, virtual stimuli must replicate the complexities, scale, and appearance of real world stimuli.[3] Because of the constraints of real-time systems and production requirements, stimuli attributes must be prioritized and abstracted. However, no systematic approach to creating virtual stimuli currently exists. Our presentation demonstrates a potential design methodology within the context of a larger project treating snake phobia through virtual exposure therapy.

Methods/Tools:
The methodology follows an iterative approach of prioritizing, abstracting, modeling, and evaluating. Prioritizing involves analyzing the real-world stimulus with exposure therapy data to identify key fear-inducing features. During the abstraction process, simplified design analogies distill these key elements into manageable concepts. A system is then modeled around these analogies to reproduce the stimulus within the virtual environment. Finally, phobic patient testing evaluates the believability of the stimulus. Key elements that need to be added or improved are considered, and the iterative process is continued until an acceptable level of anxiety production is achieved.

Novelty:
Key elements identified within the real-world stimulus included locomotion, tongue flicker, decision-making, interaction with objects, and scale patterns. Phobic patients often commented that the way a snake moves is a major factor in inducing fear. Accordingly, priority was placed upon the movement model used. A spring and mass analogy was used to approximate the muscles used in the snake's movement. Synthetic intelligence techniques were used to produce realistic behavior while maintaining therapist control. While previous animal phobia treatment VEs included animated animal stimuli,[2] it did not include behavioral algorithms. Stochastic patterns enhanced the organic quality of many features, such as the timing of the flickering tongue. The therapist was also given control over key behavior animations, such as the snake raising its head and smelling the air to gather information about the environment.

Conclusion/Results:
Using a systematic approach produces virtual stimuli which are effective in generating fear in patients with specific animal phobias. Test sub-

jects reported fear levels as high as nine on the Subjective Units of Discomfort (SUD) scale. In addition, four broad areas of design heuristics emerged. These include the stimulus' appearance, movement, behavior, and interaction. Behavior is distinguished from interaction in the sense that behavior is object intelligence while interaction implies some form of input from a user or the environment.

It is vital that the object react naturally with the environment and vice versa. Although the snake does not appear entirely realistic to the non-phobic user, it does exhibit the key qualities that induce fear, making it appear far more realistic to phobic patients. Thus, proper prioritization of attributes allows for a more effective stimulus design.

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Presenter: Matthew Parrott

An Immersive Virtual Environment for the Treatment of Ophidiophobia

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[2]Department of Psychology, Virginia Tech

Research Status: In development

Background/Problem:
Virtual reality exposure (VRE) therapy has been shown to be an effective treatment for specific phobias.[3] This project uses VRE in the treatment of ophidiophobia (fear of snakes). The reproduction of the effectiveness of graded exposure therapy required a comprehensive gradation of exposure and therapist input to tailor the environment for the needs of specific patients.

Methods/Tools:
Our team developed Snake Phobia SVE using the Simple Virtual Environment Library (SVE). SVE is an application programming interface (API)[2] that allows researchers to rapidly develop immersive virtual environments. It includes useful extensions for controlling hardware such as head-mounted displays (HMDs), tracking systems, and input devices. Richly detailed environments were created to maximize the patient's sense of presence and thereby improve the success of the VRE.[3] A unique device produced by Measurand known as ShapeTape allows users to hold and manipulate a virtual snake. The ShapeTape consists of a long plastic strip embedded with fiber-optic sensors. The virtual snake duplicates the ShapeTape curvature.

Novelty:
Designing realistic stimuli was a major focus of the project. Combining synthetic intelligence, physics-based movement, advanced modeling and texturing, and therapist control, we created a stimulus that was effective within the constraints of a real-time system.

Previous VRE environments have made use of tactile props to enhance emotional response.[1] The input of the props is often limited to position tracking. Our project extends the idea of a prop as an input device with the ShapeTape. Our application is unique because the articulation of the prop is duplicated within the environment.

Because the user is under stress, a system of navigation needed to be developed to allow the user to move freely and accurately, even when experiencing fear. We used a system of collision detection and control paths to allow the user to move freely yet remain in desired areas.

The first scenario involves patients viewing graded posters of snakes in a museum setting. Then the patient progresses through a scenario featuring snakes in three glass cages. Each snake is larger and more aggressive than the last. The next scenario occurs outdoors in a nature trail setting. Here, the graded attribute is the confrontation style; patients must confront the snake in increasingly uncontrolled ways. The final scenario requires the patient to actually handle the snake through a tactile prop. Such a wide range of interaction is generally not exhibited in VRE applications.

Conclusion/Results:
A pilot user test found the environment effective in stimulating intense fear in a near-phobic patient. The therapist also found that the system complemented existing exposure techniques, supporting the theory that producing a robust environment allows for a comprehensive treatment scheme. Current work includes designing an interface for the therapist, adding ambient sound, and conducting clinical trials to empirically determine effectiveness.

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Presenter: Patrice Renaud, Ph.D.

The Recording of Oculomotor Responses in Virtual Immersion: A New Clinical Tool to Assess Approach and Avoidance Behavior Dynamics

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Research status: In progress

Background:
Virtual reality (VR) therapy relies heavily on what patients pay attention to while immersed. Because the content of the attention's focus is so central in the use of VR as a method of inducing therapeutically relevant psychological states, it appears obvious that controlling what intervenes in the perceptual motor loop is important. We developed a method that controls oculomotor activity relative to selected virtual objects' visual features. Moreover, we are applying this method to study approach and avoidance behavior dynamics, i.e. fluctuations of the oculomotor responses as a function of time. Two separate studies are conducted using our method, one aiming at assessing avoidance behavior with arachnophobic subjects facing virtual spiders, and another aiming at assessing sexual preferences with subjects of different sexual orientations interacting with virtual naked models.

Methods:
Our method relies upon a technological setting including what is usually necessary to present immersive virtual environments, as well as equipment dedicated to eye-movement tracking from within a head-mounted display (HMD). A special mounting built from a monocular infrared eye-tracking system, combined within a binocular HMD, is used to track eye-movements. Head-movements are recorded from a magnetic tracking system rendering the 6 degrees-of-freedom (DOF) of translation and rotation. Our method performs gaze analysis by the way of virtual measurement points (VMP) placed on virtual objects for the analysis of eye-movements in relation to specific features of these objects. Gaze radial angular deviation (GRAD) from the VMP is given by the combinations of the 6 DOF developed by head-

movements and the x and y coordinates rendered by the eye-tracking system. The VMP is locked to virtual objects and moves jointly with them. While the variations in the 6 DOF developed by head-movements define changes in the global scene presented in the HMD, the 2 DOF given by the eye-tracking device allow the computation of the exact position of the line of sight relative to the VMP. As other physiologic signals, we also measure the subject's distance from the VPR, the pupil size diameter, and the blinking response.

The 3D stimuli that we used are virtual spiders (in the arachnophobia study) and naked human models (in the sexual preferences study).

Results:
Preliminary results from the arachnophobia and sexual preferences studies will be presented. These results will consist in analyses performed on time series coming from oculomotor responses recorded in immersion.

Novelty:
These results are an extension of our past studies where the goal was mainly to make sense of the perceptual and motor dimensions of virtual immersion.[1,4,5] Nevertheless, they help to circumscribe more precisely the perceptual motor dynamics by adding measures of oculomotor activities and by looking at how these measures relate to the valence and affordance of virtual stimuli.[2,3]

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Presenter: Giuseppe Riva, Ph.D.

The VRTherapy Project: Free Virtual Reality Tools for Mental Health Therapists

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Research status: In progress

Background:
In the last five years there has been a steady growth in the use of virtual reality (VR) in health care due to the advances in information technology and a decline in costs. Much of this growth however, has been in the form of feasibility studies and pilot trials. Why is the impact of VR in health care still so limited? There are three possible answers. First, there is a lack of standardization in VR devices and software. Secondly, there is a similar lack in standardized protocols that can be shared by the community of researchers. If we check the clinical literature, we can find only four published clinical protocols: for the treatment of eating disorders (1), fear of flying (2), fear of public speaking (3) and panic disorders (4). Finally, the costs required

for the set-up trials are somewhat daunting. According to the European-funded project VEPSY Updated, the cost required for designing a clinical VR application from scratch and testing it on clinical patients using controlled trials may range between US$150,000 and US$200,000.

Tools:
The significant advances in PC hardware that have been made over the last five years are transforming PC-based VR into a reality. The cost of a basic desktop VR system has decreased by thousands of dollars since that time, and the functionality has improved dramatically in terms of graphic processing power. A simple immersive VR system now may cost less than US$6,000 without the software.

To support the use of VR in mental health care, the Applied Technology for Neuro-Psychology Lab, in cooperation with the VEPSY Updated project, the VRHealth Company and the Interactive Media Institute launched the VRTherapy Project (http://www.cybertherapy.info; http://www.vrtherapy.org), whose main goal is to provide free advanced VR software to qualified therapists. The first available VEs will support the treatment of Panic Disorders. In particular, it will be possible to download the following off of the project's site:

- pre-tested virtual environments (VEs) together with their therapeutic protocols and the results of their use in controlled clinical trials;
- customizable virtual environments. The therapist, using an on-line interface, will be able to add his/her own images.

The distributed software will be available for both PCs and Pocket PC/PDAs.

Conclusions:
In most circumstances, the clinical skills of the therapist remain the most important factor in the successful use of VR systems. It is clear that the free availability of different virtual environments is important so therapists will start to apply these tools in their day-to-day clinical practice. The VRTherapy projects aims at supporting this possibility.

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Presenter: Albert A. Rizzo, Ph.D.

Data, Development Issues and Future Visions from the USC Integrated Media Systems Center Virtual Environments Laboratory

Albert A. Rizzo[1], Todd Bowerly[2], Maria Schultheis[3], J. Galen Buckwalter[1], Robert Matheis[3], Greg Reger[2], Ulrich Neuman[1], and Cyrus Shahabi[1]

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The Virtual Environments (VE) Laboratory at the University of Southern California (USC) continues to evolve its research program aimed at developing graphics-based virtual reality (VR) technology applications for the study, assessment, and rehabilitation of cognitive and functional processes and pain distraction in children. Our development work also includes 360 Degree Panoramic Video environments designed

to address anger management and social phobia. We will review the status, issues, and results from studies using the Virtual Classroom, Virtual Office, Virtual Pain Distraction Scenario and our Panoramic work.

Highlights to be presented include:

1. Virtual Classroom – Development of a package of 11 cognitive tests, a head-tracked performance record visualization tool, and issues surrounding commercial development. This will also include a presentation of the latest version of our Psychological Corporation application and early results from the prototype testing and standardization trials.

2. Virtual Office – Review of the data from a completed study at the Kessler Medical Rehabilitation Research Center comparing traumatic brain-injured subjects with normal controls on an ecologically valid measure of everyday memory performance.

3. Virtual Home – Demonstration of a NEW environment created with advanced gaming development toolkits that are being applied at two sites to study prospective memory patients with TBI and Parkinson's Disease.

4. Pain Distraction Scenario – Data from an "art-based" VR scenario being tested with children who are fearful of venipuncture procedures.

5. Panoramic Video Applications – Latest development status of anger and social phobia applications that involve "blue-screen" capture of human characters that can be realistically pasted into fixed scenario backgrounds. This will include a discussion of projects at two sites that are testing emotional arousal in the anger management scenarios.

6. Commercial Trials and Tribulations – This part of the talk will cover some of the issues we have encountered with efforts to develop commercial applications. This non-traditional presentation will cover a wide range of topics, with key findings and observations in each area being briefly reviewed.

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Presenter: Genevieve Robillard, M.Sc.

The Relationship Between Anxiety and Presence

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Research status: Complete

Background:
Virtual reality (VR) can be used to provide therapeutic exposure to phobogenic stimuli for phobic clients. Some researchers use the intensity of emotional reactions in VR as indices of the sense of presence, while others argue that presence and emotions are totally independent concepts (i.e. orthogonal constructs). The goal of this study is to assess the relationship between anxiety and presence in order to shed some light on this debate.

Method/Tools:
Thirteen phobic participants and thirteen non-phobic control participants were immersed in a ten-minute phobogenic task. The virtual environments were generated on a Pentium III® 866 Mhz PC and displayed in an I-Glass® head-mounted display (HMD). Tracking was provided by an Intertrax^2® tracker.

Results:
Results indicate evidence of a synergistic relationship between presence and anxiety, as well as a greater tendency for phobics to experience both anxiety and presence. Correlations and regressions also show that anxiety is associated with presence. A linear regression was per-

formed with mean Presence (dependant variable) and eight variables (e.g. anxiety, immersive tendencies). Results indicate that Anxiety self-ratings were the most important predictor (part correlation = .33). A stepwise regression was performed with mean Presence self-rating (dependent variable) and the eight other variables. It was found that the optimal model used only mean Anxiety to predict mean Presence (part correlation = .741). Stepwise regression was performed with mean Anxiety as the dependent variable. This time, the FSS-II-F *Total* scale was entered to represent the pre-exposure anxiety scales, and the ITQ-F scales and post-exposure scales were entered in a stepwise fashion. The optimal model produced by this procedure included three predictors: FSS-II-F Total, mean Presence, and ITQ-F Total with part correlation coefficients of .251, .506, and .287 respectively. Anxiety is highly correlated with Presence, and it is the best predictor of Presence.

Conclusion:
These results indicate that anxiety at the time of the VR experience is closely related to sense of presence. We also agree with the contention that emotion and presence are conceptually distinct, but these results indicate that they are linked empirically and not orthogonally. Although this study has demonstrated an empirical link between emotion and presence, the underlying reason for this link remains unclear. There are at least three causal models that are consistent with this study's results that will be suggested. Further research is required to distinguish between these models. Experiments are planned in which anxiety and presence will be manipulated independently to show if either factor causes the other.

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Presenter: Catherine Sabourin

The impact of instructions on the feeling of presence during virtual immersions

Catherine Sabourin, Stéphane Bouchard, Ph.D.
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Research status: In progress

Background:
The application of virtual reality in the treatment of mental disorders is quite recent and it already seems to be an efficient method, especially for treating anxiety disorders. However, to be efficient it is necessary that the client feels immersed and present in the virtual environment. For this reason, therapists are using different strategies to foster presence, such as providing context for the immersion (e.g., you are going to take a flight from San Diego to Los Angeles) or making suggestions (e.g., be careful not to fall off the cliff, the audience is listening to you now). The goal of this study is to assess the effect of different types of instructions on the feeling of presence: minimal instructions, the addition of a story context, the addition of suggestions about senses "felt" during the immersion, or a combination of all three. Our hypothesis is that giving a context to the immersion and making suggestions about the senses stimulated during the immersion should increase the feeling of presence.

Method/Tools:
The virtual immersion was conducted using a Windows-based environment running on a Pentium III (866 MHz) equipped with a ATI Radeon 64 video card, an I-Glass VGA head-mounted display (HMD) (640 X 480), an Intertrax2 motion tracker, and a joystick. The virtual environment was created by modifying the map *The Temple of Horus* from the 3D game *Unreal Tournament*. During the experiment, participants had to visit a practice virtual environment for two minutes to become familiar with how to use the controls, and then follow a guided tour of the Temple of Horus for five minutes. Four experimental conditions were provided for the guided tour: (a) minimal instructions (MIN; "Please visit the Temple of Horus by following the candles that are lit to guide you"); (b) minimal instructions and a story that gives a context to the immersion in the virtual environment (STORY; a description of the Egyptian god Horus and the history of his temple); (c) minimal instructions and suggestions about the senses stimulated by the virtual environment (SUGG; e.g., "be careful not to fall when going down the stairs, it is slippery"); (d)

minimal instructions, information about the context of the visit, and suggestions about the senses stimulated by the virtual environment (ALL). Participants were randomly assigned to one of the four conditions and completed measures of immersive tendencies, presence, realism, and cybersickness.

Results and Conclusions:
The preliminary results of this study (still in progress, N=57 adults from the normal population) failed to show any significant differences on the measures of presence between all four conditions. Thus, it seems that what is said by the experimenter during an immersion in a virtual environment may not have a strong impact on the participant's feeling of presence. These results highlight the importance of factors that are contributing to feelings of presence, such as quality of the interface, possibilities of interacting with the virtual environment, or the number of senses stimulated by the virtual environment.

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Presenter: Cristian Sirbu, Ph.D.

How Active are Fear Structures During Exposure in Virtual Environments? A Test of Emotional Processing Theory in Acrophobia

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Background:
According to a 1979 publication by Lang, fear is represented in memory as informational structures including (1) information about feared stimuli, (2) information about verbal, physiological, and motor responses, and (3) information about meaning. The effective treatment for specific phobias involves modification of these informational fear structures through "emotional processing" (activation and modification of the structures through guided exposure and the provision of information incompatible with the preexisting beliefs). An important parameter for emotional processing is the degree of activation of the fear structures during exposure, which depends on the number of systems involved. An optimal level is achieved when every response system is active, with the patient expressing physiological arousal, self-reported fear and avoidance.

The efficacy of virtual reality exposure therapy for the treatment of specific phobias is well-documented in the literature. Although the outcomes are compelling, the literature is lacking regarding the degree to which the exposure to virtual environments produces activation of the fear structures, an important precondition for emotional processing.

Based on these assumptions, this in progress study presents a procedure for the assessment of activation of fear structures during exposure to a virtual environment designed for the treatment of acrophobia.

Method:
Fifteen subjects diagnosed with acrophobia using ADIS-IV and fifteen control subjects without acrophobia were involved in the study.

Two levels of exposure to stimuli from a virtual environment were used. First, subjects were exposed to a pictorial Stroop task using pictures associated with heights and neutral pictures, both taken from virtual environments. For the pictorial Stroop task, the degree of activation for fear structures was operationalized as the interference and the physiological activation during the task. Second, subjects were exposed to a Virtual Reality Behavioral Avoidance Test (VR-BAT) (using the same environment the picture was taken from for the Stroop task). During the test, the degree of activation in the fear structures was operationalized as the number of steps completed (a measure of avoidance), the self-reported fear (Subjective Units of Distress), the level of confidence, and the physiological activation.

For control purposes, subjects were also exposed to an *In Vivo* Behavioral Approach Test (IV-BAT). In this case, the degree of activation of fear structures was investigated using the same self-report measures as in the VR-BAT.

Results:
Compared to the control group, the acrophobics showed increased interference and physiological reactivity during the Stroop task, as well as increased avoidance, self-reported fear, and physiological arousal during the virtual and *in vivo* BAT. The degree of reactivity was similar in the virtual environment to the real one.

Conclusions:
Exposure to virtual environments produces a level of activation for fear structures comparable to the level elicited by *in vivo* exposure. Based on these results, a procedure for designing virtual environments able to induce an optimal level of activation for fear structures is presented. Implications for optimization of treatment using virtual environments, in terms of the duration of exposure and selection of the most relevant stimuli, are discussed.

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Presenter: Julie St-Jacques

Long-Term Effectiveness of *In VR* Exposure for Phobic Children

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Research status: Complete

For approximately 10 years, clinical psychology has seen the emergence of a new avenue of treatment: virtual reality (VR). This technology has been used to treat anxiety disorders, among other things. There is now a growing body of scientific evidence assessing the effectiveness of virtual exposure for the treatment of arachnophobia in adults. This alternative treatment offers multiple advantages: it favors confidentiality, it is safer, and it could be less expensive. Since preliminary data of this VR treatment for arachnophobia in children was presented last year, the focus of this presentation will be on the long term effects evaluated six months after the end of the program.

The goal of this study is to assess the effectiveness of VR exposure for arachnophobia in children. This study relies on a single case design with multiple baselines across subjects. The sample consists of seven females and one male. The subjects, aged between 8 and 16 years old, were SCID-diagnosed to confirm the presence of arachnophobia. Participants were randomly assigned to one of three baseline levels: three, four, or five weeks. Participation in the study involved six sessions of approximately 75 minutes; five of the sessions occurred weekly. The first session confirms that all of the participants meet the inclusion and exclusion criteria of the study. The second session provides participants with the information necessary to successfully complete the program (informed consent, information about phobias and avoidance, etc.). The last four sessions consist of VR exposure. The exposure was administered using a standardized treatment protocol. Self-monitoring of fear of spiders was conducted weekly by the children and their parents before, during, and after the treatment. At pre-treatment, post-treatment and six-month follow-ups, the participants filled out a series of questionnaires: the Immersion Tendency Questionnaire, the Depression Self-Rating Scale, the Fear of Spider Questionnaire, and the Fear Survey Schedule.

Results are very positive and suggest that: a) virtual reality exposure might help children, b) the gains are maintained over time, c) it is safe to conduct virtual reality with children (an issue sometimes raised by Ethics Review Board), and d) larger group-based studies are warranted.

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Presenter: Dorothy Strickland, Ph.D.

Evaluating a Video Enhanced Virtual Reality Program for Teaching Restaurant Social Skills to Children with Autism

Dorothy Strickland, Ph.D.

Do2Learn, Raleigh, NC, USA

While virtual reality has been used for various training applications, few studies have measured its effectiveness in teaching social interactions. This research used web-delivered gaming technology to create virtual worlds where children with Autism Spectrum Disorder (ASD) interacted with avatars to practice appropriate restaurant social skills. Videos of similar real world situations were introduced within the virtual sequences to reinforce the lessons and aid in generalization, a known problem for individuals with ASD. Before training, two unknown restaurant social skills were identified for each of six children with ASD, aged 7 to 16. After virtual world training, all six children correctly performed the two new social skills while in the virtual restaurant, and four children exhibited appropriate social interactions in post-training real-world restaurant settings.

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Presenter: C. Barr Taylor, M.D.

The Use of an Internet-Based Program to Prevent Eating Disorders

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Research Status: Completed clinical trial; work in progress

Background:
Although prevention of both eating disorders and obesity is strongly recommended, combining eating disorder and obesity prevention interventions for defined populations, such as middle and high school students, is complicated. For instance, population-based interventions must be appropriate for all students in the classroom, including those who do not have risk factors for either eating disorders or obesity, and the intervention should not stigmatize any students. This paper discusses two studies aimed at developing universal and targeted interventions that aim at preventing eating disorders and obesity.

Methods:
Both studies involved all 10th grade students enrolled in an all-girls public school in Northern California. In both studies, all students completed *Student Bodies*, an 8-session on-line psychoeducation program linked to a discussion group. The program provides didactic information, encourages self-monitoring and journaling, and is linked to a moderated discussion group. Students are assessed before and after treatment using standard self-report instruments to assess eating disorder attitudes and behavior. In the first study, students were randomized by class to the intervention (n=102) or control (n=51); parents were provided with an on-line discussion group and handout. In the second study, all students taking health education were assessed on-line, and provided feedback and recommendations as to the intervention appropriate to their risk level.

Results:
In the first study, students in the intervention reported a significant reduction in restrained eating (an indication of eating disorder risk), but the effects were no longer significant at follow-up. They also reported a significant increase in knowledge. Parents using the on-line program reported a significant increase in their being less critical to others and in their own outlook on life as compared to the control group. In the second study, 174/188 students elected to participate in this study and were assessed online. The algorithm identified 111 no-risk (NR), 36 eating disorder risk (EDR), 16 overweight risk (OR), and 5 both risks. Fifty-six percent of the EDR and 50% of the OR groups elected to receive the recommended targeted curricula. Significant improvements in weight and shape concerns were observed in all groups; effect sizes in the high-risk participants were in the moderate range (0.3-0.7). Of the 11 students who reported self-induced vomiting and/or laxative use at baseline, seven denied self-induced vomiting or laxative use and three participants

fell below the threshold level at follow-up. One participant reported continued self-induced vomiting, but reported that she had initiated psychotherapy because of her participation in the program.

Conclusions:
An Internet-delivered program can be used to assess risk and provide simultaneous universal and targeted interventions in classroom settings. Participation in the intervention is associated with significant improvement in eating disorder attitudes and behaviors.

Novelty:
These and earlier studies are the first controlled studies of on-line eating disorder prevention programs and the first to address issues of on-line risk assessment and allocation to intervention based on risk. They demonstrate the feasibility of combined universal and targeted interventions for defined populations.

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Presenter: Sharon Tettegah, Ph.D.

Assessing Perceptions and Empathy of Victims in Educators

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Introduction:
This study presents preliminary data from clinical trials currently under investigation using web-based and a supercomputing Access Grid to assess perceptions of victims and victim empathy of pre-service teachers. The Access Grid is an experimental system that brings people together by linking high speed hardware, cutting-edge applications, multimedia displays, and high-end audio and video technology into an efficient and persistent computing and communications technology (http://www.accessgrid.org).

Multimedia can be a powerful means of delivering representations of social behaviors. Little research has examined student perceptions of victims and victim empathy of pre-service teachers. Much work has been done on victim empathy of sex offenders and empathy as an interpersonal phenomenon, but little has focused on the necessary understanding of empathy and perceptions of student victims in classroom environments.[4,5] This study investigates (1) perceptions of the victim; (2) the level of empathy that pre-services teachers have for the victim; (3) the strategies of action suggested by the respondents; and (4) the type of behavioral change focused on by the respondent.

Methods and Tools:
This exploration reports preliminary results from narratives based on actual school experiences that have been turned into animated multimedia vignettes. Seventy-eight pre-service teachers were exposed to a multimedia animated vignette narrative depicting a discrimination situation in a classroom environment.[2] The pre-service teachers responded to the narratives by assuming the role of one of the characters.[1] In

1998 Creswell wrote about case study sampling as "bounded by time and place." Utilizing a case study approach allows for a better understanding of the text in a quantitative and qualitative manner.[4]

Results:
The results are reported by the following categories: expression of concern, empathy, strategy, focus of behavioral change, and management focus. The respondents expressed concern for: Scott: 29%; Jamilah: 4%; Mr. Young: 46%; Ms. Litts: 11%; the class: 83%; and themselves: 6%.

Who does the respondent express empathy with? In whose position is the respondent able to imagine themself? The respondents empathized with: Scott: 11%; Jamilah: 14%; Mr. Young: 6%; Ms. Litts: 14%; and the class: 6%.

What are the strategic actions suggested by the respondent? How do they suggest they would deal with the immediate situation? Immediately the respondents: Express concern: 63%; Thank Mr. Young: 9%; Assure Mr. Young: 51%; Apologize: 34%; Take a side: 3%; Doubt the claim: 3%; and Invite parental input: 34%. Long-term they: Hold a class lesson and/or discussion: 89%; Talk to Scott: 49%; Isolate and/or discipline Scott: 14%; Force Scott to apologize to Jamilah: 6%; Treat as an isolated incident: 6%; Make a conscious effort to not isolate Scott, Jamilah, or the incident: 20%; Talk to Jamilah: 20%; Empower: Jamilah 14%; Talk to Scott's parents: 31%; Hold a group meeting with concerned parties: 6%; and Follow-up: 14%.

What type of behavioral change does the respondent focus on? The respondents concentrated on: Proper conduct: 51%; Correct information: 29%; Proper speech: 20%; Proper thought: 14%; and Fostering empathy: 9%.

What interpersonal situation is the respondent most concerned with managing? With whom does the respondent focus their managerial expertise? The respondents focused on: Scott: 46%; Jamilah: 17%; Mr. Young: 74%; Ms. Litts: 3%; The class: 89%; and Scott's parents: 20%.

Conclusions:
The findings from the data set are extremely important in understanding our approach towards teaching and learning. It also helps us to understand how educators think about problem-solving with issues that are related to understanding perceptions of victims and victim empathy, as well as other issues which occur in the classroom and school environments. Further analyses can reveal more on the nature of empathy towards students that are victims in the classroom environment.

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Presenter: Cheryl Y. Trepagnier, Ph.D.

Design Trials of the Virtual Buddy: Progress Report

Marc M. Sebrechts, Ph.D.[1], Maya Coleman, M.A.[1], Andreas Finkelmeyer M.S.[1], Rameshshandra Ramloll, Ph.D.[2], Linsey Barker[2], Corinna Lathan, Ph.D.[3], DC; Maxwell Vice[3], Matthew Pettersen[3]

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Research Status: In progress

Background:
Face processing impairment is common in autistic spectrum disorders (ASD)[1,3]. The objective of this design project is to produce an environment for delivery of an early intervention to train social gaze based on the hypothesis that the inability to process nonverbal communication contributes to the depredations of autism.[2]

Method:
An arcade 'police helicopter' (the pod) has been adapted. The child's gaze, sensed by an ISCAN tracker, is the input. Visual, auditory, and vestibular stimuli (rides) are provided as enticements and rewards for gains in more functional social gaze in a voluntary play context. Positive consequences will ensue when the child gazes at the Virtual Buddies' faces and when that gaze shows an interpretation of face-borne information (e.g., following the Buddy's gaze direction). Issues of concern in the design of this environment include appeal, ease of entry and egress, and adequacy of positioning for successful tracking. Nine 'neurotypical' children and four children with ASD or suspected ASD, mean age of four and each accompanied by a parent (with one exception), have participated. Questionnaire and Likert scale responses were obtained from the 12 adults, and most of the children (who, however, treated the scale as a binary choice). Data is being compiled and analyzed. A semi-automated calibration (semi-autocal) routine has been devised. Once a good eye image is visible, the investigator triggers semi-autocal: the monitor goes blank and a small figure appears in the next location. After 250 ms. gaze coordinates are automatically acquired and the video display resumes. This is done to collect each of the five points required for Iscan calibration, and it is spread out over time to reduce the risk of boredom. Appealing video has contributed to capturing and holding the child's attention, and thus acquiring eye-tracking data. The next pod iteration will include changes in the relative angle of the tracking camera and the car seat, and means for encouraging stable head position (e.g., a light pressure switch embedded in the seat back, so that the video is enabled or brightens only when the child's back is in contact with the seat back).

Results:
Data is continuing to be acquired and reviewed. While all children report enjoying the ride, they differed in respect to how often and how long they wanted to experience it. Repetition of video material quickly lost the attention of 'neurotypical' children, but not of children with ASD. Tolerance for calibration was low, requiring careful management.

Conclusion:
A preliminary inference is that it will be important to use rewards including preferred video for each child with ASD, not just to reinforce target behavior, but also to maintain the child's participation. Buddies will introduce, praise, enthuse, and provide the gaze training opportunities that video and other preferred experiences and objects will need to reward differentially.

Novelty:
In relation to the conceptual presentation offered last year we will present data, including some video, from 13 'models' of the end user, resulting in changes, recommendations for change, and the validation of the concept.

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Presenter: Veronique Vaillancourt Ph.D.

Use of Audio VR to Evaluate Functional Hearing Abilities in the Workplace

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Many jobs are hearing-critical and have several features in common: they are often performed in noisy environments and involve a number of auditory skills and abilities, such as verbal communication, sound localization, and sound detection. If an individual lacks these skills and abilities, it may constitute a safety risk for this individual, as well as for fellow workers and the general public. Predictions of performance on these auditory skills are often based on diagnostic measures of hearing, such as pure-tone audiograms. These measures are unable to provide accurate predictions of real life performance with the auditory skills necessary to perform hearing-critical jobs. In our research, we have used more direct measures of functional speech perception in noise (Hearing in Noise Test: HINT) and sound localization in noise (Source Azimuth Identification in Noise Test: SAINT) for screening applicants for hearing-critical jobs. These screening tools can be used under headphones or in a sound field (using loudspeakers). Since, it is not always possible to have access to a sound-proof room large enough to use loudspeakers, and since the sound field testing is sensitive to wall reflections, the use of headphones is a preferred method. In order to reproduce the direction of noise and sound stimuli (speech or environmental sounds) and to make use of the binaural hearing system under headphones, we used audio VR technology. With this more accurate approach, it is now possible to test functional hearing abilities in clinical settings and make judgments on the ability of people to perform real world auditory tasks. Validation data (N of subjects= 90) in a Canadian Coast Guard environment will be presented.

Project funded by Fisheries and Oceans Canada, Contract F7053-000009.

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Presenter: Mattias Wallergård, MScEE and Licentiate in Engineering

Can People with Brain Injury Transfer Route Knowledge from a Virtual Environment to the Real World?

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Research status: In progress

Virtual environments (VEs) are presumed to have the potential to complement conventional training tools in brain injury rehabilitation.[2] Possible application areas include the assessment of process skills and training in daily living tasks such as shopping, cooking, and using a telephone. Studies by Cromby, Standen, Newman, Tasker,[1] and Mendozzi et al.[3] suggest that it is possible for people with cognitive impairments to transfer skills from a VE to the real world. However, there is a need for further research to understand how and to what extent people with brain injury can use skills learned in a VE in a real situation. To learn more about this, we are currently conducting an experiment that aims to investigate how people with brain injuries can transfer route knowledge from a spatial navigation task in a VE to a real environment.

Six able-bodied people and six people with brain injuries participated in the experiment. The task of the subjects was to find their way to a certain location in the Department of Rehabilitation at Lund University Hospital after having practiced in a virtual version of the environment. The VE was built using the 3D game editor WorldCraft, and the experiment was done using a standard PC and a regular monitor. Video recording, in combination with a retrospective verbal protocol technique, was used to obtain information on the subject's cognitive process. This means that the subject commented on his actions while watching the video recording from the trial.

So far, the experiment has been conducted with six able-bodied subjects and three people with brain injury. All able-bodied subjects managed to find their way without getting lost or hesitating on the way. The first brain injury subject had

mild memory and concentration problems. He managed to find his way without any problems. The second brain injury subject had mild memory and attention problems. He got confused and hesitated at two occasions but managed to find his way to the location. Finally, the third brain injury subject had severe memory problems. She hesitated on two occasions but managed to solve the navigation task.

The most interesting result so far is that the third brain injury subject managed to find her way. Her occupational therapist was utterly convinced that she would fail due to her severe memory deficit. Our hypothesis up until now has been that only brain injury patients with mild and moderate cognitive deficits can transfer skills from a VE to the real world, but now we are starting to believe that even patients with severe disabilities might benefit from VE training.

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Presenter: David G. Walshe, Ph.D.

Can MVA Victims with Driving Phobia be Immersed in Computer Simulated Driving Environments?

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Status: Ongoing

In an earlier study we showed the effectiveness of using computer-generated environments in exposure therapy for the treatment of driving phobia following motor vehicle accidents (MVA). Seven treated patients showed a marked reduction in driving phobia severity ($p=0.008$) as well as reductions in PTSD severity ratings ($p=0.008$) and depression severity ($p=0.031$)[1]. However, 50% of the cohort of patients screened in this study did not immerse in the simulated environments and therefore could not undertake therapy. This sets limitations on the use of virtual reality exposure therapy (VRET) as a treatment modality for driving phobia.

Objective:
To investigate if an acceptable immersion rate (>80%) can be achieved for subjects with driving phobia in computer generated environments involving modifications in the VR program and augmented reality through: projection of images onto a large projector screen, visualizing the screen through a windscreen and increasing vibration sense through stronger subwoofers.

Design:
12 patients referred from the Emergency Department of a general hospital or from a general practitioner following a motor vehicle accident who met DSM-IV criteria for Simple Phobia/ Accident Phobia were exposed to a Virtual Driving Environment (Hanyang University) and computer driving games (London Racer/Midtown Madness/Rally Championship). Patients undertook a thirty minute trial session in driving environments of graded difficulties in a darkened room. Subjective Units of Distress (SUD) ratings and heart rate measurements were taken at five minute intervals. "Immersion," i.e. a sense of presence with heightened anxiety in the driving simulations, was operationally defined as in our earlier study as an increase in SUD ratings of

>3 and/or an increase of heart rate >15 BPM in the computer driving simulation.

Results:
Results will be presented at the Cybertherapy Conference together with video presentations of the VR/GR environments.

Novelty:
This is a novel study in the area of VRET for driving phobia. Findings have implications for the clinical use of VRET in driving phobia.

1. Walshe DG, Lewis EJ, Kim SI, O'Sullivan K, Wiederhold BK. Exploring the Use of Computer Games and Virtual Reality in Exposure Therapy for Fear of Driving Following a Motor Vehicle Accident. CyberPsychology & Behavior 2003; 6 (3): 329-334.

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Presenter: Leo Sang-Min Whang, Ph.D.

On-line Game Addiction as a Luxury Syndrome: An Immersion of the Digital World as a Consumption of Digital Product

Leo Sang-Min Whang, SeJin Heo, MiYeon Hur

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Research status: Complete

Excessive participation in the on-line gaming world is defined as game addiction. However, this immersion in the on-line game world characterizes not so much the addiction to the "on-line game world" product, as it does an immersion in the digital world itself. This phenomenon seems to cover not only the excessive use of the on-line game as a digital product, but active participation in the digital world. We assume the excessive use of on-line games is directly related to the phenomena of 'luxury syndrome.' This research investigated how recognition of the commercial value of on-line game worlds and their ability to satisfy the needs of game users is related to the users' degree of participation in the on-line game world.

We conducted an on-line survey on one of the most popular on-line games in Asia, *Lineage*. We used an "on-line game immersion" scale based on Young's Internet Addiction Scale, and surveyed 4,679 game users. Out of the total participants, the levels of participation in the on-line game world were classified as excessive immersion, potential immersion, and non-immersion. Out of the subject pool, 7% were classified into "excessive immersion," while 12% had been diagnosed as non-immersive, and the rest of participants were sorted as being potentially immersed. The degree of immersion in the on-line game world showed a strong relationship between game users' recognition of the on-line game as the digital world and their behavior characteristics. Between the two extreme groups, the results show significant differences in terms of the perceiving value of on-line game worlds. The two groups are markedly distinguished regarding the psychological desire for a human relationship fulfilled by the experiences in the on-line game world.

This research presents a different point of view, which accounts for game addiction as one of the various lifestyles designating a new type of life in digital space, not the degeneration of personal adaptive function. Consequently, the immersed behavior, like on-line game addiction, is regarded as a behavior characteristic of "luxury syndrome." Further study is needed to investigate interventions for game addicts in the cyber world. We suggest further research on how the degree of immersion in the digital world influences various human behaviors and changes in thinking.

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Presenter: Brenda K. Wiederhold, Ph.D., MBA, BCIA

Clinical Analysis of 350 Patients Completing VR Therapy

Brenda K. Wiederhold, Ph.D., MBA, BCIA[1], Stephane Bouchard, Ph.D.[2], Genevieve Robillard, M.Sc.[2]; and Mark D. Wiederhold, M.D., Ph.D., FACP[1]

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In August 1997, the Virtual Reality Medical Center (VRMC) began treating patients with fear of flying using a combination of VR, physiological monitoring, and feedback. We completed the first controlled study in 1999 comparing VR treatment to imaginal exposure (visualization) for fear of flying. Since that time, we have expanded our clinical services to include VR and physiology to treat a number of specific phobias, social phobia, panic disorder, and agoraphobia. In addition, we now maintain active research programs using VR, simulations, robotics, the Internet, and other advanced technologies in many diverse areas including: eating disorders and obesity, distraction during painful medical and dental procedures, teen smoking prevention, cue exposure, rehabilitation, attention-deficit hyperactivity disorder, autism, and quality of life applications for those with long-term illnesses. We also utilize simulation and VR for training in such wide-ranging areas as combat casualty care and teenage driving education.

This presentation will focus on our initial analysis of data from anxiety disorder patients who have completed VR therapy at the VRMC.

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Presenter: Mark D. Wiederhold, M.D., Ph.D., FACP

Training Combat Medics Using VR

Mark D. Wiederhold, M.D., Ph.D., FACP; Brenda K. Wiederhold, Ph.D., MBA, BCIA

The Virtual Reality Medical Center, San Diego, CA, USA

Past success using virtual reality to support training in the military has encouraged the continued exploration of new areas that would benefit from virtual training. We are exploring how virtual reality and other simulations can be applied to train combat medics for combat casualty care. Significant questions on training transfer remain to be answered, and a variety of training methodologies including virtual reality, patient mannequins, live animals, or a combination thereof are undergoing evaluation and testing. Issues such as the development of metrics that measure successful transfers of training to the real world are being addressed by military, academic, and industrial groups. We are evaluating training transfer using simulation and virtual environments where the trainees' physiological signals, focus of attention, and concentration are measured. Understanding the psychological and physiological state of the trainee during training exercises may provide a useful metric for gauging successful transfer of information to be used in real world situations.

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Presenter: Beth Yost

Learning to Interact with People with Disabilities Using Virtual Environments

Will Lee, M.S., Doug Bowman, Ph.D.

Department of Computer Science, Virginia Tech

Research Status: In Progress

Background/Problem:
Virtual environments (VEs) have shown potential for teaching social skills to children with Asperger's Syndrome, a mild form of autism[1] and for treating phobias.[2] However, there has been little research on using VEs to teach social skills to people without autism or phobias. Our goal was to design and implement a learning environment for teaching social skills to average people and to evaluate the usefulness of that

application. To that extent, because of the typical misconceptions due to lack of previous exposure and the stereotypes surrounding disabilities, we chose to create an environment teaching participants how to interact with disabled people.

Method/Tools:
We developed our environment using the Simple Virtual Environment Library (SVE).[3] The implemented environment consisted of an outdoor park, a virtual person who is blind, and a guide dog. Users are guided by verbal and physical responses from the virtual person through a series of four "do" and "don't" guidelines. To evaluate the usefulness of the application, we used a between subjects single-factor design with twelve participants randomly assigned to one of two display conditions. The display type was either a desktop PD or a head-mounted display (HMD).

Conclusion /Results:
The results of a free recall question showed that the highest percentage (67%) of participants learned not to play with a guide dog. All participants reported that they were more likely to remember the guidelines after interacting with the virtual person than if they were given paper guidelines. However, when asked how comfortable they were interacting with a person who was blind, there was no significant difference between ratings provided before and after the use of the application. More was learned using the desktop than the HMD, but not significantly more.

Based on the results, we believe that people are more likely to remember the lessons after having used the application. Although the novelty of the HMD affected the perceived impact levels, the more familiar desktop displays resulted in better performance. The novelty of the HMD may have distracted the users from the task of learning social skills. Additional research is planned to determine if higher levels of interactivity result in better learning of social skills and if, based on the idea of near transfer, users would interact appropriately when confronted with a person that is blind.

Novelty:
The potential impact of this is that, providing it is useful for populations with normal mental capabilities, it could be extended to teach social skills to people not able to physically interact with other populations. For example, the treatment of a sexual abuser could involve interaction with virtual children.

1. Cobb S, Beardon L, Eastgate R, Glover T, Kerr S, Neale H, Parsons S, Benford S, Hopkins E, Mitchell P, Reynard G, Wilson J. Applied Virtual Environments to Support Learning of Social Interaction Skills in Users with Asperger's Syndrome. Digital Creativity 2002; 13(1): 11-22.
2. Hodges L, Anderson P, Burdea G, Hoffman H, Rothbaum B. Treating Psychological and Physical Disorders with VR. IEEE Computer Graphics and Applications 2001; 21(6): 25-33.
3. Kessler G, Bowman D, Hodges L. The Simple Virtual Environment Library: An Extensible Framework for Building VE Applications. Presence: Teleoperators and Virtual Environments 2000; 9(2): 187-208.

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