Annual Review of CyberTherapy and Telemedicine

Advanced Technologies in the Behavioral, Social and Neurosciences

Editors-in-Chief

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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* (5^{th} 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 inaugural volume of *Annual Review of CyberTherapy and Telemedicine*. This peer-reviewed journal covers a wide variety of exciting topics of interest to the mental health, neuroscience, and rehabilitation communities. *Annual Review of CyberTherapy and Telemedicine* (or ARCTT, as some have already abbreviated 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. As such, the journal will study the effects of advanced technology usage in therapy and training and how this technology can be used effectively to reduce the cost of healthcare delivery. The focus of this journal will be primarily on clinical and experimental studies that examine therapeutic efficacy, objective outcomes assessment, and cost effectiveness in healthcare delivery systems. There are many other excellent sources that focus on engineering and systems integration.

There is a growing interest in investigating whether technologies such as those available through Internet access or telephone conference calls can provide mental healthcare services to a wider population at a reduced cost. Other investigators are attempting to use virtual reality, advanced multimedia, and other advanced computer imaging technologies to treat mental illnesses such as childhood autism, attention deficit/hyperactivity disorder, and schizophrenia. Delivering mental healthcare and rehabilitative services over the Internet is being explored in over twenty major institutions in the United States and around the world. This journal will be a forum for the publication of clinical studies and new ideas that address how these new technologies can be used to assess, diagnose, and treat individuals more effectively and at a reduced cost.

The quality and significance of the excellent work being presented in this volume reaffirms that cybertherapy can play a significant role in healthcare. It is our specific intention to bring together the best clinicians and researchers so that we may further strengthen and advance the efforts to improve healthcare and take advantage of the remarkable technological change that is occurring.

The editorial board is composed of a distinguished group of healthcare providers and researchers who are actively engaged in teaching, research, and clinical investigation using the Internet, multimedia, and virtual reality systems. I would like to thank the editorial board for their support and expert assistance in the preparation of this exciting journal. We hope you find this volume to be an intellectually stimulating experience.

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

Editorials

We are at the beginning of a second wave of cybertherapy applications in health care. Treatment of specific phobias (such as fear of heights, fear of flying, fear of driving, fear of public speaking, and claustrophobia, etc.) and neuro-psychological evaluation and testing, are some of the more notable uses and applications of cybertherapy in the first wave in health care. Well over three hundred publications exist from at least fifteen centers around the world addressing these two areas. Early results – many of which will be discussed in this volume - seem to indicate that cybertherapy is not only effective, but has multiple advantages over conventional therapies. In addition, it seems to make intuitive sense that this approach will work.

According to different analysts, during the next ten years a new infrastructural paradigm will emerge, the 'Ambient Intelligent Space'. This is the collection of infrastructural technologies, applications and services that will enable the seamless interoperation of the applications and services of Ambient Intelligence: a pervasive and unobtrusive intelligence in the surrounding environment supporting the activities and interactions of the users. With the diffusion of the "Ambient Intelligence" paradigm, new and more usable cybertherapy applications will appear, reducing the distance between the patient and the health care system.

Several barriers remain however. Before a wider acceptance of this new technology occurs it is crucial that clinical trials and comparison of outcomes are published and are evaluated by peer-reviewed groups. Moreover, Internet networks and PC-based systems, while inexpensive and easy-to-use, still suffer from a lack of flexibility and capabilities necessary to individualize environments for each patient. On the other hand, in those circumstances the clinical skills of the therapist remain the most important factor in the successful use of cybertherapy applications. It is clear that building new and additional applications is important so therapists will continue to investigate applying these in their day-to-day clinical practice.

Possible scenarios for success could involve multi-disciplinary teams of engineers, computer programmers, and therapists working in concert to attack specific clinical problems. Information on advances in IT technology must be made available to the health care community in a format that is easy-to-understand and invites participation.

Finally, it is important that the technically oriented members of the team understand the aims, requirements, and scope of the therapeutic intervention so they may effectively bring advanced computing tools that specifically address the problem. Future potential applications of cybertherapy are really only limited by the imaginations of talented individuals. The second wave is expanding rapidly, and the international community has already provided the basis upon which continued growth and development will occur. The studies contained within this volume and the results presented here are good proof that this process is possible.

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

Critical Reviews

Exploring the Potentials of Robotic Psychology and Robotherapy

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Abstract: *This article presents a review of interdisciplinary studies on robot-mediated communication analyzed in the context of newly developed concepts of robotic psychology and robotherapy. The results show how interactive robotic creatures in general, and the robotic cat NeCoRo (Omron Corporation, Japan) in particular, can be perceived as human companions and used as diagnostic and therapeutic tools in psychological and clinical practice.*

INTRODUCTION

We live in a fascinating time, one where science fiction is becoming a normal part of our daily life. Over a quarter of a century ago, the concept of *virtual presence*, or as we used to call it, virtual reality (VR[1]), transformed itself from a pure technological miracle to an effective tool of contemporary psychology and psychotherapy.[2] But today the next computer innovation–robotic animal-like creatures–have drawn the attention of researchers, as it offers the opportunity to apply cutting edge technology to improve the quality of human life. Just recently robotic psychology ceased to be only a fictional invention, and became the original direction of psychological studies and practical applications. In this kind of research, robotic creatures become a mediator between social situations and individual life experiences.

THERAPEUTIC POWER OF ROBOTIC CREATURES–MEDIATED COMMUNICATION

Analysis of the various features of the communication between a person and the robotic cat NeCoRo became a primary goal of the first phase of our robotherapy study.[3] The robotic cat NeCoRo, manufactured by Omron Corporation (Japan, 1999), belongs to a class of interactive simulation robots and has three distinctive characteristics defining it as a communicative mediator, which can be used in psychological practice as diagnostic and therapeutic tool.

First of all, the robotic cat NeCoRo is designed to imitate emotional, cognitive, motor, and other mental traits and states normally experienced by humans. Therefore, NeCoRo is considered to be a good model for a person's companion or artificial partner.[4]

Secondly, NeCoRo is the first of the existing self-developing, artificial, animal-like creatures covered with synthetic fur that gives a person an opportunity to communicate with it on various levels such as tactile-kinesthetic, sensory, emotional, cognitive, and social–behavioral.

Third, due to the first two characteristics, NeCoRo simulates a real cat's behavior, and in some cases might be a suitable substitute for a real-life pet. As we know, pet-therapy[5,6] is a developing approach used to treat mood disorders, negative emotional conditions, loneliness, and depression. Children with emotional disturbance, some elderly people with cognitive impairment, and adults with certain mental health problems are known to have a particularly hard time while trying to communicate their thoughts, feelings, and emotions to others. However, this difficulty may be overcome through playing games, engaging with toys, and interacting with pets, or, in our study, with robotic pets. Examples of interactive artificial creatures that might be of interest for robotherapy purposes are the cat NeCoRo, the robot-seal Paro, the robot-dog AIBO, and the robotic horse Karakuri. These robots incorporate an attractive combination of attention-grabbing toy and favorite pet or likable animal. This beneficial combination gives these robotic creatures appealing companionship value and therapeutic power.

RESULTS OF STUDYING ROBOTIC CREATURES – MEDIATED COMMUNICATION AND THEIR PRACTICAL APPLICATION

In some therapeutic situations, robotic creatures may be preferred over real cats and dogs. For instance, robotherapy might be adequate for persons with cognitive and emotional disorders, for elderly and children with special needs, people with allergic reactions to real pets, or professionals who experience sensory deprivation and stress while functioning in a certain type of environment, such as a spaceship or submarine. For many of these situations, real pet-therapy would be very desirable and useful, but inadequate and some times impossible. However, robotherapy seems to be accessible, acceptable, and secure for age groups and populations with differing health and mental conditions. Furthermore, our preliminary research[4] showed that person-robotic cat interactions are beneficial for a person's emotional, cognitive, and physical well-being. According to participants' reports and results of direct observations, in most cases robotherapy stimulates positive emotions such as curiosity, joy, pleasure, and tenderness.

Cultural differences in person-robot interactions:
Positive outcomes of robotherapy were revealed in our recent cross-cultural American-Japanese study.[7] Results demonstrated that person-robotic cat interactions trigger an equally positive effect in both cultures. At the same time, it was discovered that technology-mediated communication has significant cultural specifics. For instance, there were no cross-cultural differences on a subscale of manipulations with the robotic cat, which includes such items as holding the cat, shaking its paw, picking robot up, turning it over, etc.[3] However, it was found that American participants enjoyed touching the cat, the way it responds with `meow` sounds, and when the cat cuddles while being stroked more than Japanese participants. Cultural differences were discovered for the cat's characteristics such as "it listens when I talk to it." Americans liked when the cat listened to them more than the Japanese did. It was found that the behavioral characteristic of looking into the robotic cat's eyes has the most distinct cultural connotation. Japanese participants avoided eye contact with NeCoRo and they did not like it when the robotic cat looked at them.

Influence of past experience with real pets on person-robot interactions:
Research has shown that past experiences with real pets influence participants' perceptions of the robotic cat more than their experiences with other modern technologies, such as VCRs or cell phones. Both American and Japanese participants with rich experience in communication with real pets enjoyed more manipulative activities with the robotic cat (i.e., picking it up, turning it over, or keeping it on the lap). The more experience participants had with real pets, the more pleasure they took in how the robotic creature expressed it's "enjoyment" during interactions through cuddling, making sounds, and moving its tail. Statistical analyses of differences between participants showed that pet-lovers like stroking the NeCoRo cat, and enjoy it when the robot actively responds to their touch. They liked it when the cat was active and enjoyed its interactive features. The more people liked live pets, the fonder they were of their interactions with the robotic cat. Pet-lovers evaluated the cat NeCoRo as exciting to play with and gave higher scores on a subscale of tactile interactions such as rubbing it behind the ears, stroking its back with the palm, and touching the cat's tail.

Influence of past experience with modern technology on person-robot interactions:
As our data demonstrates,[7] experience with new technology, such as cellular phones, had a significant cultural influence. However, the use of technological innovations in daily life does not guarantee an acceptance of robots. Though Japanese youngsters appeared to be far more advanced than their American counterparts in using modern technology, young Japanese were less interested in general in interactions with the robotic cat. It seems that young Japanese participants were not as excited about communicating and playing with the robotic cat as were their American peers. It is possible that Japanese young people perceive the robotic cat as a technological tool rather than an artificial prototype of a living creature. However, in all three age groups (elderly, young adults, and children), love for pets appeared to be a key factor in acceptance of the animal-like robot as an artificial emotional creature and human artificial partner.

Influence of individual differences on perception of person-robot interactions:

Our preliminary research suggested that communication with the robotic cat reflects individual differences. Individual style of interaction depends on personality characteristics, individual preferences in communication modalities (i.e., verbal vs. tactile-kinesthetic), and level of activity. Assessment of overall satisfaction with the robotherapy session illustrated that active participants who initiate interactions with the robotic cat generally evaluate their communication as exciting and interesting. Those who perceived NeCoRo as boring showed low interest in tactile encouragements such as touching or stroking the body of the robotic cat, its paws or tail, or rubbing it behind the ears. Individual cases distinctly illustrate research data.

Alice actively involves the robotic cat in a gaming situation:

Twelve-year old Alice evaluated interactions with the robotic cat as most pleasurable and enjoying. On a scale of overall satisfaction she gave the highest score. Alice initiated interactions with the robot and got involved with it in a variety of activities. Alice determined the robot’s character as very friendly, and provided the following explanation for her choice: "The robotic cat is friendly because he responds to my touch. I like to play with him, stroke him and watch how he responds to me." Alice’s evaluation of the robot's character and interactive patterns reflects her individual communicational style. Alice was an initiator and a creator of special gaming situations from the very beginning. Starting by cautiously touching and stroking the robotic creature, she soon began to play with the cat by expressing love and pleasure from their partnership. Alice was so attached to the robotic cat that she rubbed her nose against NeCoRo’s nose, tried to capture the cat's attention by looking into its eyes, lifted the robot in the air, and, finally, lovingly hugged and kissed the robotic cat. At the end of the 15-minute session Alice learned enough about the robot’s skills and modes to stimulate responses preferable both for her and “her” cat at any time. She was also very sensitive and responsive to the robot’s reactions and never tried to force the cat into activities beyond its abilities. During the session Alice expressed a rich variety of positive emotions toward the robotic cat, demonstrated high tactile and manipulative scores, but a poor level of verbal communication.

Kevin maintains a personalized dialogue with the robotic cat

Kevin, a small 5-year old boy, also found interactions with NeCoRo to be very pleasurable and enjoyable. Kevin was very involved in a game with the robotic cat and gave the highest score on a scale of overall satisfaction of person-robot interactions. But, in contrast to Alice, Kevin chose verbal communication with the robot as the primary type of interaction. Kevin tried to maintain a personalized dialogue with NeCoRo, seeking to capture the cat's attention by looking into its eyes, calling the cat by its name and expressing interest in the cat's opinion about him: “Do you like me? Do you like my haircut?”

Nancy uses defensive strategy in communication with NeCoRo:

As opposed to Alice and Kevin, 10-year old Nancy demonstrated an ambivalent style of interactions with the robotic cat and evaluated her interactions with NeCoRo as boring and scary. Nancy's communicational style with the robot projected her inner fears of rejection and uncertainty. From the very beginning Nancy was detached from the interactions. Her defensive strategy of communication with the robotic cat was quite obvious, as the analysis of direct observations revealed. She expressed verbal criticism toward the robotic cat while trying to hide her fear and confusion by saying: “He is so boring! What am I supposed to do with him? Throw him out the window?” She was very skeptical about NeCoRo and did not know how to respond to the robotic cat, or whether to consider it as a cat or as some technological tool. When Nancy started rubbing NeCoRo behind its ears with two fingers, the cat responded to her touch by slightly moving his head toward her, and, again, Nancy was shocked by the robot's life-like response. She backed up and said: “It's weird! It’s scary.” She expressed nervousness and repeated her attempt to establish communication with NeCoRo only at the end of session. Nancy was ignoring direct interaction with the cat and expressed a distinct fear of being rejected by the robotic cat: “He ignores me... He probably does not like me”, even though she knew that it is just a robot with no intentions and feelings whatsoever.

CONCLUSION

Preliminary results of robotic psychology and robotherapy research have shown that people's communication with technological innovations such as emotional interactive robots is a complex process that is influenced by physiological, psychological, socio-cultural, and environmental factors, as well as the artificial creature's features. Analysis of each element of this complex process is the main goal of robotic psychology.

Accordingly, the use of robotic creatures as a therapeutic tool has to take into account the complexity and ambiguity of the person-robot communicational process.

From a diagnostic point of view, interactions between persons and robotic creatures have symbolic meaning. The distinctive manner of establishing a personal way of communicating with the robotic creature reflects a person's individuality, his/her style of self-expression, and preferable communication and coping strategies. In particular, an artificial creature serves as the mediator between a person, their past experiences and a situation with a high degree of uncertainty. The analysis of this interplay allows us to draw a conclusion about specific states and traits of the participating person and his/her individuality. Analyzed case studies illustrate *diagnostic potentials of robotic psychology* and present robotic creatures as an original projective diagnostic tool that can be utilized for studying both intra and inter-individual differences.

ACKNOWLEDGEMENTS

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The Disappearance of Computing in Health Care

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ABSTRACT: *Human-computer interaction has come a long way since the early days when computer users, working in the DOS environment, copied files on a disk by typing instructions like “DIR/p”. In fact, during the last fifteen years, technology's focus has gradually been shifting away from the computer as such, to the user. A clear sign of this transformation is the development of the modern graphical user interface in which the computer artifact is more and more transparent to the user.*

The next step in this trend is Ambient Intelligence, in which the computer’s 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. This work focuses on both the technological nature of Ambient Intelligence and its relationship with the user. Those in the health care field that want to exploit this potential will need to pay significant attention to a variety of factors that can and will influence the structure of the health service they deliver.

INTRODUCTION

According to different analysts, the IT world is now in the middle of three concurrent trends:[1]

- Pervasive diffusion of intelligence in the space around us through the development of wireless network technologies - WiFi and Bluetooth – advanced mobile communication – 2.5 G and 3G networks – and intelligent sensors.
- Increase of richness and completeness of communications, through the development of multimedia technologies, towards "Immersive Virtual Telepresence" (IVT), including increased attention to the aspects of human perception and of person-machine interaction.
- The emergence of ‘disappearing computing’ based on new information artifacts that represent a merging of current everyday objects (tools, appliances, clothing, etc) with the capabilities of information processing and exchange (based on sensors, actuators, processors, Microsystems, etc). These artifacts will have the capability of communicating amongst themselves using local (typically wireless) networks, as well as accessing or exchanging information at a distance via global networks.

The possible result of these trends is Ambient Intelligence (AmI). AmI, 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, is the next logical step of this process (Figure 1).[1,2]

In fact, 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.*”[12]

How does the emergence of the AmI paradigm influence our vision of health care? This paper will try to answer that question. Specifically, using a scenario-based approach, the paper will outline a possible role of AmI in health care.

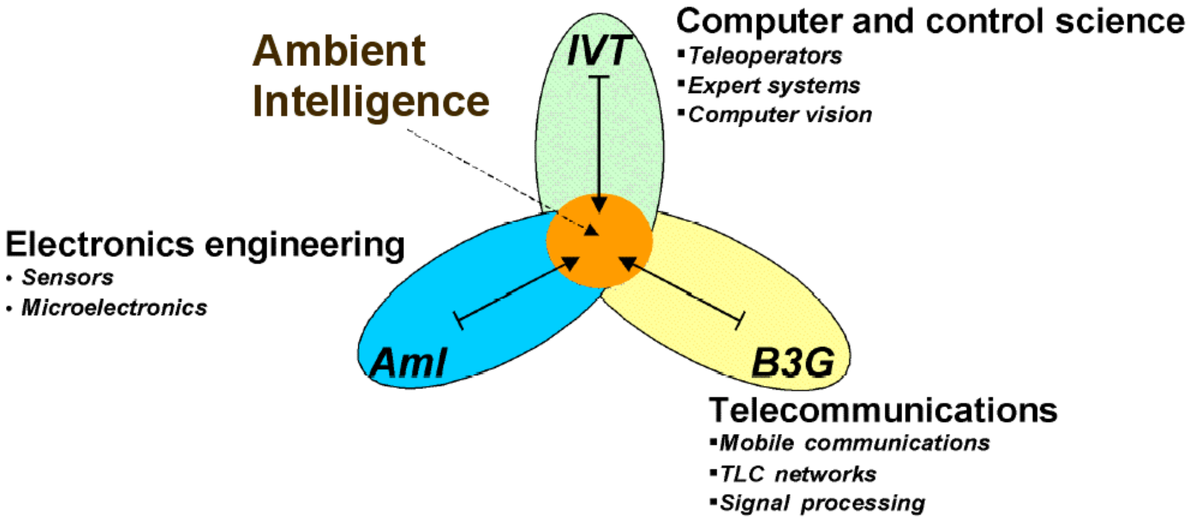


Figure 1. Converging technologies in the "Ambient Intelligence" paradigm (adapted from Davide et al., 2002).

THE EMERGENCE OF AMI SPACE

To date, some e-health applications have already improved the quality of health care, and later they will lead to substantial cost savings.[3,4] For instance, physicians can review radiological films and pathology slides in remote sites, or assist and perform surgery via remote robotics.

However, most of these applications are used for discrete clinical activities, such as scripting, lab testing, patient monitoring, and condition-specific diagnosis and treatment.[5] As recently noted by Fifer & Thomas,[6] "the new question about E-medicine practice may be not 'When will it happen?' but when will the fragmented E-health systems be connected?"

A possible solution to this question comes from AmI. According to the vision of AmI provided by the Information Society Technologies Advisory Group (ISTAG) to the European Commission, all of 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.[7] 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 supports 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.*"

AmI can be seen as the integration of functions at the local level across the various environments. This integration enables knowledge, content organization, and processing. 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.[1]

The most ambitious expression of 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 *Mobile Mixed Reality (MMR):* the information enhancement of a mobile user about a real scene through the embedding of objects (3D, images, videos, text, computer graphics, sound, etc.) within his/her sensorial information.[8] In this scenario, the embedded information is based on factors like location and direction of view, user situation/context awareness (day of the time, business-related holidays, etc.), user preferences (in terms of content and interests), terminal capabilities, and network capabilities.

MMR is based on embedding different objects (3D images, videos, text, computer graphics, sound, etc.) within the sensorial field of a mobile user.[8] Moreover, following the AmI paradigm, any embedded object is context-aware and based on factors like location, direction of view, user situation, user preferences, terminal capabilities, and network capabilities.

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' experiences by providing information for any object surrounding them. They can 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[9] identified the following applications of MMR:

Smart signs added to the real world: Smart signs overlaid on the user's real world may provide information assistance and advertisement based on user preferences.

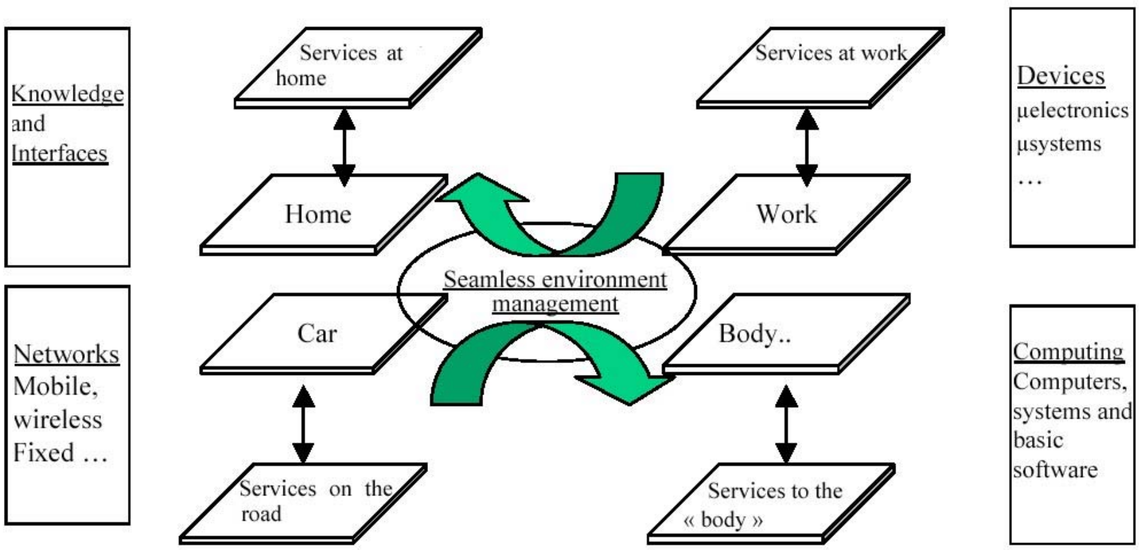
Information assistant (or "virtual guide"): The virtual guide knows where the user is, his/her heading, and the properties of the surrounding environment. Interaction can be achieved through voice or gestures, and the virtual guide can be animated and provide assistance in different scenarios based on 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 VR or an augmented reality scenario, so that a user can see the avatar of another user coming into the scene and a 3D video conference can be carried out. 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 the future, the terminal 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.

Further developing these points, ISTAG introduced the concept of AmI Space. AmI Space is com-

Figure 2. The AmI Space (adapted from ISTAG, 2002).



posed of networked (using a changing collection of heterogeneous networks) embedded systems hosting services which are dynamically configured distributed components (see Figure 2). AmI Space can be seen as the integration of functions at the local level across various environments, enabling the direct natural and intuitive dialogue of the user with applications and services spanning collections of environments - including the cyberspace level - allowing knowledge and content organization and processing.[10]

In particular, the AmI Space should offer capabilities to:

- *Model the environment, with 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 windows interface with a more natural interface based on 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.

Within this frame, Immersive Virtual Telepresence (IVT) and wireless technologies will play a fundamental role in helping the AmI vision cope with the need for natural user interfaces and ubiquitous communication. The former will enable the user to interact with the AmI and to control it in a natural and personalized way through voice and gestures. The latter will provide the underlying network and will also enable electronic devices to communicate with each other as well as the user.

However, the AmI requirements are not just technological. ISTAG identified a series of necessary characteristics that will permit the eventual societal acceptance of AmI.[7] AmI should:

- facilitate human contact;
- be orientated towards community and cultural enhancement;
- help to build knowledge and skills for work, better quality of work, citizenship, and consumer choice;
- inspire trust and confidence;
- be consistent with long term sustainability at personal, societal, and environmental levels;
- be controllable by ordinary people (i.e. the 'off-switch' should be within reach). These technologies could very easily acquire an aspect of 'them-controlling-us!'

Moreover, the various AmI markets will require specific contents to be successful. Particularly there is a need for content-oriented tools and services to support multi-cultural content generation, its engineering, and management.

AmI IN MANAGED CARE

"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. However, the most recent research findings underline the possibility that distributed communication media could become significant enablers of consumer health initiatives. In fact, in comparison with traditional communication technologies, AmI offers greater interactivity and better tailoring of information to individual needs. In other words, AmI can be considered a process and not a technology, including different complementary areas: health care information provision, administrative and clinical data collection, and therapy and assessment provision. In particular, new and emerging technologies will provide personalized, intelligent, and helpful technology that can promote recovery and sustain independence and quality of life. This vision is well-described by the "GRID" concept:[11] a coordinated, resource-sharing and problem-solving dynamic in multi-institutional virtual organizations supported by technologies and data management services that guarantee secure remote access to computing and data resources and the co-allocation of multiple resources.

In order to transform this vision into reality, we tried to outline a real health care scenario including all the innovations described before (See description below). Scenarios must be designed to encompass societal, economic, and technological developments and form a logical framework in which cases can be fitted. The European Commission and research organizations such as the WWRF encourage scenario-based approaches for pushing the research in the right direction. Experts have to analyze the scenarios, drawing from them consequences and future research topics. The main output of these modeling efforts will consist of the "pieces of technology" needed to provide the functions envisaged within the reference scenarios:

Mario, a 40-year-old obese subject with Type 2 diabetes was directed by his general practitioner to start a self-management education program. Before beginning the program Mario was asked to provide information that enables the clinician to target the educational contents for his age, lifestyle, risk factors, and medical history. When Mario goes to the hospital to book the class or for a 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 leaves.

When a week later Mario 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 Mario 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 the distributed computer. All the analyses are normal.

In the afternoon, Mario can choose lifestyle consultations customized to meet his health needs. The hospital endocrinologist, clinical psychologist, exercise physiologist, and registered dietitian give Mario specific indications that are recorded on the PDAs of the professionals. Should Mario 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 Mario's test results and provides a personal health action plan. Through the UMTS phone, a detailed written report and individualized directions are provided to Mario at weekly intervals. This way, Mario can follow the plan independently from his physical location.

A couple of days later, Mario starts his program. The plenary takes place in a room looking much like a hotel foyer, with comfortable furniture pleasantly arranged. As Mario enters the room and finds himself a place to work, he hears a voice asking "Hello Mario, here is the program of the course. Are you ready?" The electronic tutoring system briefly goes through its understanding of Mario's availability and preferences for the day's work. Mario is an active and advanced student so the electronic tutoring system says it might be useful if Mario spends some time today trying to pin down the problem using enhanced interactive simulation and projection facilities. It then asks whether Mario would give a brief presentation to the group. Finally, Mario agrees on the work program for the day. During the day, individuals and sub-groups gather in various spaces in the environment 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. During the day, the mentor and electronic tutoring system converse frequently, establishing where the mentor might most usefully spend his time, sometimes altering the schedule. They will also deal with requests for references/profiles of individuals. Time spent in the environment ends by negotiating a homework assignment with each individual, but only after they have been informed as to what the system expects to happen for the rest of the day and have made an appointment for their next visit.

CONCLUSIONS

The proposed scenario was constructed to provide 'something to think about' involving longer-term developments in Information and Communication Technologies (ICTs) for health care. More specifically, we wanted to explore the future technologies that are implied by the vision of Ambient Intelligence. In fact, the scenario exercise indicates that the vision of Ambient Intelligence is a strong starting point for providing research direction over the coming five years. Major opportunities to create an integrated Ambient Intelligence landscape can be built upon emerging technological strengths in areas such as mobile communications, portable devices, systems integration, embedded computing, and intelligent systems design.

However, transforming the scenario in reality is not an easy task: the more complex and costly the technology, the less the user is prone to accept it. This happens despite possibly large potential advantages, which are generally not attainable by the average user because they are not interested in spending the time and energy to acquire the underlying technology fundamentals. Therefore, the successful systems of the future will adhere to the paradigm of "disappearing technologies," valid for both communications and computing. They will provide improved ease of use at the expense of an increased, but invisible, complexity of the underlying systems and networks necessary to transport and process the information in the different multimedia forms and usage contexts. As both the physician and the patient have to be put at the "center of the universe of technologies," clearly the elaboration of a purely technical vision of future health care is not only insufficient, but also dangerous. Rather, any viable technical solution must be put into a much wider perspective.

In this sense, clinicians and health care providers that want to exploit AmI potential need to devote significant attention to project management, ergonomics, human factors, and organizational changes in the structure of the relevant health service.

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Evaluation Studies

The Construction of an Online Virtual Reality Treatment System

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Abstract: *Treating patients using virtual reality therapy to treat panic disorder and agoraphobia while still being exposed to anxiety-provoking situations in an office setting has become an asset to therapists over the past several years. The use of a system where a patient can complete his or her treatment in the virtual world on a personal computer allows for the same virtual environment exposure as when the patient physically visits the therapist's office. The structured treatment protocol allows for the treatment to be delivered online, based on the therapist's limits to how the patient is allowed to explore the virtual environment. In limiting the patient's experience, the system automatically controls the appropriate anxiety-provoking stimuli. Each patient's confidential information and the limits set by the therapist control the virtual environment and are kept in a protected database. The virtual reality treatment system has been packaged as a program that is installed on the patient's home computer, and can only run when the patient is connected to our webpage 'GOING OUT.' The navigation system designed was built to simulate the turn of the patient's head, not needing the use of a head-mounted display.*

INTRODUCTION

Virtual Reality is a technology that has proven to be useful in the treatment of several psychological disorders. However, the use of telemedicine or telepsychology systems using virtual reality have not been deeply studied due to the cost of the required equipment and the lack of adequate infrastructures.

This work presents a telepsychology system that is intended to be an additional or complementary therapy for the treatment of panic with agoraphobia. It is not a self-help system that can be utilized without any intervention from a psychologist. The patient that accesses the system must be receiving treatment in the consulting room of the therapist. At a key point in the therapy, the patient receives access to the telepsychology system that allows him/her to continue the treatment from his/her home using the same virtual environments that he/she previously visited in the psychologist office. Everything is under the control of the therapist, who determines at any moment what possibilities the system should offer the user. The main point of the system is that it offers the patient the possibility to "remember" and repeat the exposures to the virtual environments when and where he/she wants by means of the new technology.

The system is composed of: (a) an assessment protocol that, by using a short questionnaire, gives the patient a diagnosis of his/her problem; (b) a structured treatment protocol organized in separate blocks; the therapist can interact with the system in order to control which blocks should be presented to the user at each moment, and the system also controls the patient progress in order to ensure that the patient does not skip any step in the treatment; (c) an outcome protocol that assesses treatment effectiveness, both during treatment and at the end of it. The system has been prepared for a concrete trouble (for panic disorder with agoraphobia), but if it is effective it will easily be expanded to a wide range of psychological problems.

BACKGROUND

Virtual reality as a therapeutic tool in clinical psychology: One of the application areas of virtual reality in healthcare is its use as a tool for the treatment of different psychological problems. Virtual reality is able to recreate a hierarchy of real situations and one is able to experience them in a seemingly real way as all senses are involved in the experience.[1] The person constructs a series of scenarios related to the feared situation, so he/she can expose himself /herself to all possible and impossible situations. Each situation can be graded so that several levels of difficulty can be established according to the state of the person.

Virtual reality has very interesting advantages over "traditional" treatments. The typical clinical approach to the treatment of phobias is graded exposure of the patient to anxiety-producing stimuli (Systematic Desensitization).

Virtual reality is better than imagination at producing feared situations because it is more immersive, allowing several sensorial modalities to be stimulated, creating a more realistic environment.[2] VR is interactive,[2] so the patient can explore freely and experience sensations. VR can be seen as an intermediate step between the therapist's consulting room and real world[3]. VR allows the therapist to know at each moment what the patient is experiencing. Finally, the use of VR avoids the patient needing to rely in his/her capacity of imagination.[2]

VR is superior to 'in vivo' exposure in many ways. It allows those people that reject real-life exposure because they consider it too difficult a different option, as it is possible to leave the environment at any moment.[2] It offers a greater level of confidentiality and security. It allows the design of a hierarchy of exposure. The exposure to a situation can be repeated as many times as is required until the anxiety decreases. Finally, it is not necessary to wait until the feared situation occurs in the real world or to go to the place where they occur because any situation can be modeled in the virtual environment. As a result, the opportunities for training increase.

In addition, the VR system is capable of storing and measuring the behavior of the patient inside the environment. That way, it is possible to store data that would be lost using the traditional methods. It is also important to point out the flexibility of virtual environments. As they are programmable, they allow therapists to present a great range of controlled stimuli to the patient while measuring and monitoring the response.

The idea of using VR for the treatment of these problems first occurred in November 1992 in the Human-Computer Interaction Group of Clark Atlanta University, and since then, applications have been developing quickly. Their efficacy and clinical utility have been proved, the treatment of phobias being the most paradigmatic cases. We can mention the first software designed by Rothbaum and North's group for the treatment of acrophobia,[4,5,6] agoraphobia,[7,8] spider phobia,[9] and flying phobia.[10] Our group has also developed VR software for the treatment of claustrophobia and flying phobia.[11] VR has also proved its efficacy for the treatment of more complex problems such as eating disorders.[12,13] Current work in the field of virtual reality is mainly focused on trying to use "friendlier" interfaces that make systems more accessible for the patients.

Telepsychology: Another field that is changing the way medical and psychological attention is provided is Telecommunications. Up to now, telemedicine or telepsychology systems were restricted because of the cost of the equipment and the lack of adequate infrastructures or protocols regarding telecommunications. The most important technical constraints were due to limitations in the bandwidth of actual networks and the absence of technology able to compress audio/video files in real time. However, in the last few years, new high bandwidth technologies have become more present in European countries and in the United States: cable television networks, wireless technologies, HDSL, ADSL, ISDN. Most of these systems offer bidirectional capabilities, that is, they offer a high bandwidth both in the ascendant and descendent channels, and that is key for providing interactivity to networks that were previously basically unidirectional.

With this new panorama, telehealth (TH) can start to have more diffusion within the population. TH is the standard term chosen by the Standing Committee of Family and Community Affairs[14] to refer to the "remote provision of health". Telehealth may be defined as "any application that implies carrying out activities related to health (i.e., a health education and/or information service) remotely, using computers and telecommunications."[15]

However, TH is a wide term that includes several related disciplines such as Telemedicine, Telepsychiatry and Telepsychology. All these systems have in common a geographical distance between the person that provides the service and the user, and the use of telecommunication technologies to facilitate the interaction:[16] videoconferences, telephones, computers, Internet, fax, radio, and television. These systems are redefining the provision models of basic services (such as assessment and treatment) so that they include health care at home, telepsychology and telepsychiatry, practical guidelines and basic ways of proceeding, use of paraprofessionals, management of cases, harm prevention, and health promotion.[17]

Telepsychiatry or Telepsychology has been defined as: "The use of telecommunication technologies to put patients in contact with health professionals in order to accomplish tasks such as medical or psychological diagnoses, education, treatment, consultations, transmission and storage of the patients' medical stories and data, research and other activities related to the provision of health care."[18]

The telepsychiatry system in Adelaida (South Australia) has worked successfully since 1994. Digital technology has been used to provide services to chronic mental patients in isolated communities.[19] The possibility of using the phone and e-mail to diagnose and provide counseling to young psychiatric populations has been tested.[20] It has been concluded that the psychiatric assessment of a patient through videoconferencing is as reliable as face-to-face consultations.[21] It has also been proven by several studies[22,23,24,25] that this new way of providing mental health care is well accepted by the users.

However, as far as we know, most of the work that has been done up to now in this field has not taken advantage of all the possibilities that the Internet offers, and has been limited to the use of e-mail, chats, or videoconferences. E-health, the integration of TH technologies with the Internet and shared VR, is the next logical step.[26]

If we focus on the domain of online treatments, a quite frequent strategy is to provide information on particular disorders and the existing therapeutic possibilities. An example can be found at http://www.algy.com/anxiety ("The Anxiety Panic Internet Resource"). It offers the possibility of self-help for the treatment of anxiety disorders, but such help is limited to giving relevant information to the user. However, regarding the self-application of treatments, tAPIR only provides a list of general rules to follow in case of a panic attack and some exercises for stress reduction. It is simple and fragmented when compared with the self-help books dealing with this subject,[27] and it does not ensure that the person can make the correct diagnosis of his/her problem and that he/she correctly applies the treatment.

Our group has contributed with an innovative telepsychology self-help system for the treatment of fear of public speaking[28] that uses the Internet as the medium for its application. It also makes use of emerging technologies, such as XML standard for data storage and video streaming solutions, to present stimuli to the patients. At the beginning, based on a series of questionnaires, the system determines if it can be useful for the patient. During treatment, the system always controls which stimuli can be presented to the patient at each moment and stores the evolution of the patient's anxiety during his/her exposure to the different situations.

Panic disorder and agoraphobia treatment program: The treatment program presented in this work is a telepsychology system that uses the Internet as the medium for its application. The purpose is to explore the possibility of reinforcing the treatment for panic disorder with agoraphobia that occurs in the therapist's office.

In the consulting room, the psychologist exposes the patient to several situations (training room, room, bus, subway, store, and tunnel) with a different virtual environment for each one. The psychologist is present during the exposure and can generate different interoceptive stimuli in real time depending on the situation and level of anxiety of the patient inside the environment. For example, by simply pressing some function keys, the therapist can generate effects such as making the user listen to his/her cardiac rhythm (and with different accelerations), tunnel vision, blurring vision, double vision, and so on. In this case, the hardware used is a desktop PC with a head-mounted display for visualization and a mouse or joystick for navigation.

The objective of the telepsychology system is to generate an Internet-based system that allows the user to access an adapted version of the virtual environments that he/she has previously used in the consulting room. Basic requirements of the system are the following: (a) The stimuli that are shown to the patient should be controlled automatically by the system without the intervention of the psychologist. (b) The information about each patient, his/her evolution in the virtual environment and his/her responses to the different questionnaires should be stored. (c) The system should be divided into several blocks and the psychologist controls which parts each patient can access at each moment. The patient will only have access to the virtual environment, descriptions and questionnaires that the psychologist has determined, and can only move on if the system determines that the user has overcome the previous stages. (d) The required hardware should be limited as much as possible, as most patients do not have special devices at home such as head-mounted displays. (e) The bandwidth requirements should also be limited in order to be able to reach the maximum number of people (depending on different places, many people still do not have high bandwidth systems for accessing the Internet).

Psychological aspects: The system is composed of: (a) an assessment protocol that gives the person a diagnosis of his/her problem, including the interference it is causing him/her, its severity, and the degree of fear and avoidance it is producing; this part is composed of a reduced questionnaire, taking into account that the patient has previously had a diagnosis from the psychologist about his/her problem; (b) a structured treatment protocol, organized in separate blocks that are shown to the patient based on the data introduced to the system by the psychologist; (c) an outcome protocol that assesses treatment effectiveness, not only at its end, but also at every intermediate step.

Presentation of the system. When the patient connects to the web page where the system is placed, the first screen shows a drawing of Dr. Net, who welcomes him/her to the system (Figure 1). He tells the user its purpose: to be there to guide and offer help. That help will also come by means of control of the actions of the user inside the system, so the patient can be sure the he/she will not be able to go on if he/she is not prepared to do so.

Greetings. Once the patient has input his/her username and password (that the psychologist has previously given to him/her at the consulting room when he/she is prepared to access to the remote system), a greeting page appears where Dr. Net presents the application (called "GOING OUT") and gives an introduction to the features of the system and how it is going to help the patient.

Assessment. "GOING OUT" presents a short questionnaire that the user has to answer (Figure 2). Once finished, the system offers a brief psychological profile regarding panic disorder with agoraphobia. Depending on the results, the system informs the user that (a) the user suffers from panic disorder with or without agoraphobia and in that way he/she will benefit of the procedure or (b) he/she should seek another type of specialized help.

Figure 1. Application's welcome page.

"GOING OUT" will save all the information gathered through the assessment in order to, on one hand, shape the treatment program the person needs and, on the other, assess the evolution of the panic disorder with agoraphobia during the therapy process.

Treatment. "GOING OUT" informs the user that treatment will consist of a series of components: psychoeducation, exposure, attention focus and cognitive restructuring. Psychoeducation is the first part. It has been divided into five blocks that show the main aspects and the rationale for the remaining components. Previous to user access, the psychologist should have selected which part of the psychoeducation to which the patient can have access (Figure 3). In that way, the psychologist can restrict the user access only to some parts of the psychoeducation depending on the needs of the therapy.

The following stage of the treatment is the exposure to the virtual environments. "GOING OUT" presents the same virtual environments

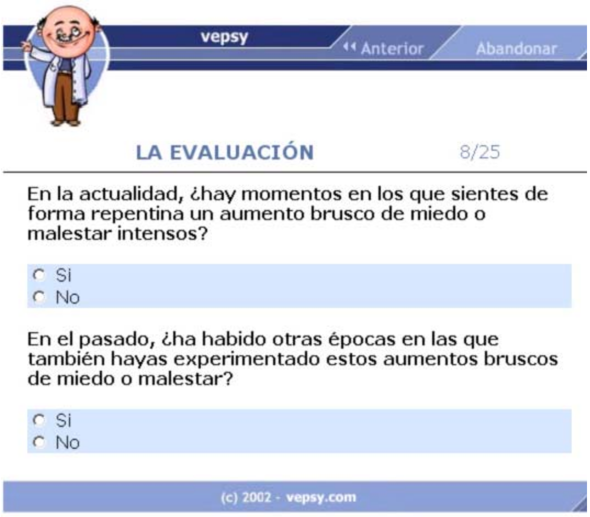

Figure 2. Assessment protocol: Initial questionnaires.

that are available in the consulting room: the training room (that is useful for the user to practice navigating inside the virtual environment), the room, the bus, the subway, the stores, and the tunnel. However, each of these environments has been divided into three levels of difficulty, so the psychologist can control which environment the user can access at each moment and with which level of difficulty. In the first level, the patient exposes himself/herself to the environment without any interoceptive (internal) stimulus. He/she only interacts with the elements of the scenario and with minimal external environments (i.e., in the case of the room, he/she can hear the answering machine, can see and hear two people talking inside the elevator, can listen to the radio, take newspapers, and similar actions). In the second level the patient exposes himself/herself to the same environment, but now the number of external stimuli increases or changes (i.e., in the case of the room, the message of the answering machine changes, and the number of people inside the elevator increases) and some internal stimuli appear gradually: the user listens to his/her slow cardiac rhythm, the vision changes to tunnel vision, blurring vision and double vision with or without cyclic form. In this level the sequence of interoceptive stimuli is always the same. Finally, in the third level the external stimuli also increase and are more aggressive than in the last level; the internal stimuli appear continually, randomly, and also more aggressively.

Before entering the virtual environment, “GOING OUT” asks the patient about his/her level of anxiety, and once inside the environment, it also asks the patient about this variable every 5 minutes or when an internal stimulus is presented. At the end of an exposure session, the system shows a graphic with the progression of his/her anxiety during the session and congratulates him/her for his/her efforts. If the level of anxiety has decreased at least three units from the highest level achieved during the session, the system considers that the user has overcome that situation and can pass to other situations or levels that have also been allowed by the psychologist for that specific user. Obviously, the psychologist can access this data so he/she can know the evolution of the user inside the system and which situations have been overcome by the user and can determine which situations the user can access as a function of his/her evolution and the observations that are made in the office.

The user can always address any additional questions to the therapist via e-mail, phone, fax or in his/her next session in the consulting room.

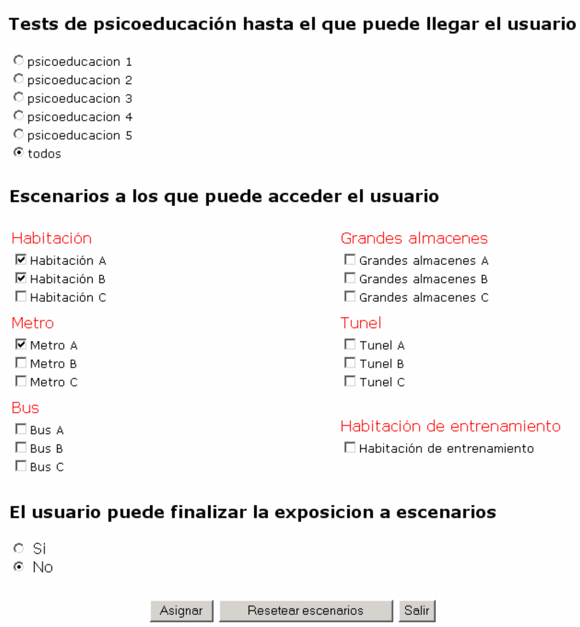

Figure 3. Assignation of virtual environments and psychoeducation pages to a patient.

Technical aspects. The adaptation of the program to the Internet requires the application of a wide range of available technologies that were determined by the psychological requirements of the system.

One requirement is that the system should be able to present stimuli to the patient. To do that, we use multimedia capabilities. The system is presented to the user as a set of stimuli related to the pathology treated: text or situation descriptions, images, sounds, and virtual environments (Figure 4).

For the presentation of many of the stimuli, we have used the XML format. XML (eXtensible Markup Language) is a standard set according to the World Wide Web Consortium. XML allows expression of the entities composing the information in a structured hierarchical way. It is extensible, since the user can define its own labels, and it is object oriented. XML is a structured data format for Internet transmission and provides the telepsychology data standardization process with a very attractive path for further progress.

The client receives the XML file from the server, along with the DTD (Document Type Definition) file, the XSL (eXtensible Style Language) file and perhaps a CSS (Cascade Style Sheet) file. An XML parser determines that the XML is valid by comparing it with the definition in the DTD. Then, the XSL interpreter interprets the valid XML by using the templates for XML elements and general page formatting that are contained in an XSL file. That generates HTML that can be formatted by a CSS interpreter using the information provided by a CSS file. The result is shown on the client's screen. In the process of generating HTML code the local processing that is made using Javascript or a similar script such as Visual Basic Script is also taken into account.

The first stimulus that has been prepared with XML is the text that is used for psychoeducation and presentation of the virtual environment prior to exposure. The texts are included in an XML file and the layout is read from an XSL template that has been created. In the XML file we can also introduce questionnaires (that would be intercalated with the text). The script is used to visualize the text in "sections" (that are different parts in which the questionnaire has been divided) by means of XMLDOM objects.

Other stimuli that are used are the different images that appear in the different web pages intercalated with the text. The information about which image to show at each moment is stored in the XML file, and interpreted by the XSL.

Finally, the most important stimuli are the different virtual environments that have been developed (Figure 5). For the development of the virtual environments, we have selected the use of the Virtools Dev 3D interactive technology. This technology offers a web player that allows the visualization of the environments from a web page. The user should install this Web Player. This installation starts automatically once the user accesses the web page and the core components are only 750 KB; any additional components are automatically installed when required. The web player is integrated as an object inside the HTML page and bidirectional communication between HTML content and Virtools content is provided by means of JavaScript or VBScript. That way, initialization data can be sent from the web page to the virtual environment, taking into account the previous data that is available from each user. At the end of the exposure, the page can store the data that the

Figure 4. Use of images and text as stimuli.

virtual environment has requested (for example, the levels of anxiety).

In order to achieve automatic control of the stimuli shown to the patient without the intervention of the psychologist, we have opted (as it has been explained in the psychological aspects) to divide each situation into three environments with growing difficulty levels. Depending on the level, the stimuli appear at predefined moments or randomly. The psychologist always has indirect control over the stimuli that can appear as long as he/she controls which levels the patient can access at each moment.

Another requirement is the storage of information about each patient and his/her evolution inside the virtual environment and the ability to control the blocks of treatment the user can access at each moment.

As we have explained, it is possible to extract information collected in the virtual environments. That information can then be stored in a database located in a remote server. We have elected to use the XML format to store that information in the database. We use this format to model the person's status, the actions carried out, and the situations to which he/she can be exposed. All the complementary data in a person's file can be transmitted from the person's computer to the database located in the remote control system so that a fast and flexible management of the information is granted.

The advantage of using this approach is that it allows local processing of the data without requiring a centralized server to provide all of the system intelligence; it provides bi-directional data flow between server and client; the data can be adapted so that compatibility with other systems is provided; and remote data access is possible (for example, the clinical history of the patient).

So, the user provides one part of the information collected by the database, but the psychologist provides the other part. The psychologist can also access the system as an administrator. The administration page extracts all the information related to the evolution of the state of the user from the XML field of the database and shows this information using the utilities of the XMLDOM object (the parser) provided by Microsoft to navigate between XML nodes. This page also allows the psychologist to select which psychoeducation pages the patient can read at each moment and which virtual environments should be available. That data is stored

Figure 5. Use of virtual environments as stimuli: The room.

in another field of the database relating to that user.

The scripts collect and store the results of the questionnaires until they are sent to the server at the end of the exposure. They also control the visualization of the different sections of the questionnaires. The server extracts data about the user state and stores it in the database. The system also determines which questionnaires can be accessed, taking into account which of them have been overcome.

As we have previously explained, the required hardware should be limited as much as possible, so that the patient does not need to use head-mounted displays in order to visualize the virtual environments. The PC monitor should be enough. The patient does not need a head-tracking device, but simulation of head rotations with the navigation system is necessary, so the appropriate modifications have been prepared.

Finally, we must also take into account that bandwidth requirements should be limited. The main problem in our system is the size of the virtual environments. We cannot simplify them to reduce their file sizes because eliminating elements from the virtual environment or reducing the quality of the textures used decrease the effectiveness of the main stimuli (that is, the virtual environments) provided to the user. We have decided that the best option would be to install the virtual environments on the patient's PC. The patient will need a CD that the psychologist will give to him/her at the right moment during the treatment. The web page will read the information related to the environment from the local hard disk of the patient. The virtual environments developed with Virtools will receive a keyword from the web page at the initialization that is required to access to the environment. This prevents the user from accessing the environment without being connected to the web page, so the exposure will be always under the system control.

The application that has been developed works with Internet Explorer 5 or higher. That navigator supports the use of XML with XSL. Besides, it also allows the use of CSS combined with Javascript to achieve dynamic effects. The server is an Internet Information Server 5.0 running over a Windows 2000 Server.

CONCLUSIONS

This work is intended to be a new step in the line of telepsychology and the possibility of using the Internet for the treatment of psychological disorders. As developed, it presents an approach for a complementary treatment for panic disorder and agoraphobia. If the application achieves the requirements of efficacy and efficiency that are needed, this could be a first step to apply the same schema to other phobias.

From the technical point of view, the most important novelty is that the virtual environments will not be downloaded from the web page, but rather installed on the patient's PC, and will only be run when the patient connects to the application's web page and enters the private part of the application by means of a user name and a password. This approach allows the size of the virtual environments to be larger, as they do not have to be downloaded. The only restriction in its size will be in the features of the patient's computer: a computer of medium characteristics and with a medium range graphics card should be able to display the environments.

It is important that this new vision transforms the patient into an active agent in the therapeutic process (of course, under the supervision of the therapist). The patient will have access to feedback from the system at any moment during the complementary treatment, so he/she will have relevant and valid data in evaluation as well as in treatment. The use of virtual reality itself allows the patient to obtain control over the feared situation, and that will generate self-efficacy prospects that will help the global efficacy of the treatment.

Another benefit of this kind of treatment is that it allows for reinforcement of the therapy without the physical presence of the therapist, so the patient will have the possibility of obtaining better results without going to the consulting room of the therapist so often. In that way, the system guarantees intimacy and confidentiality, as it can be run in one's home or in any other place chosen by the patient.

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The Creation of V-STORE

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Abstract: *The aim of the present paper is to present the application of an immersive virtual reality-based tool, V-STORE. V-STORE is currently employed as a part of a cognitive rehabilitation program based on a holistic and constructivist approach. V-STORE was designed for the rehabilitation of executive functions, and some of its features were drawn from popular neuropsychological procedures, such as the Tower of London Test and WCST. It allows patients to explore a virtual environment (an internal goods store) in which each subject has to complete a sequence of tasks, ordered in six levels of increasing complexity (i.e., putting pieces of fruit into baskets according to an imparted disposition). Tasks are designed to stimulate executive functions, problem-solving, behavioral control and programming, categorical abstraction, short-term memory, and attention. Most importantly, a series of distracting elements is added, aiming at generating time-pressure and eliciting managing strategies, which become the first goal of the rehabilitative intervention. The examiner has full control of all variables in order to enhance usability and to increase the number of sessions that a single patient will be administered. Preliminary data about the experimental and clinical use of this tool are currently been collected at "Paolo VI" Rehabilitation Centre, mostly limited to small limited trials and single case experiences. Experimental validation of this kind of instrument is needed, not only regarding its clinical efficacy, but also with regard to its usability.*

INTRODUCTION

Most experts agree that computer-based tools can be fruitfully used in the assessment and rehabilitation of cognitive deficits,[1-4] but a key issue which remains mostly unresolved is 'how' to do it and 'how to obtain better results.' Many classical neuropsychological tools like the Tower of London Test (TOL)[5] and the Wisconsin Card Sorting Test (WCST)[6-9] have been reproduced as computer-based versions. In addition every cognitive rehabilitation lab now uses software tools to create and show new integrated multimedia scenarios that are more realistic than the traditional paper and pencil (P&P) approach. Usability and motivational factors seem to be the most important reasons for the success of computer-based rehabilitation.[10-12]

Nevertheless, the key point of discussion still deals with the ecological validity of computer-based rehabilitation procedures: are these techniques useful for patients' everyday life? Is there a realistic and efficient transfer of knowledge and skills between the tasks carried out in labs and the life outside the hospital?[13,14]

Our work was focused on rehabilitation of the Dysexecutive Syndrome, usually (but not exclusively) caused by prefrontal brain injuries, which are increasingly occurring in our society due to the high rate of car accidents and other violent causes of head trauma, combined with the recent striking improvements in the chances to save patients' lives by neurological emergency intervention. Our society is facing the challenge of how to rehabilitate a growing number of persons, mostly young, that recover to good physical health, but suffer from a typical mix of important cognitive, emotional, behavioral, interpersonal, and social problems.

While many applications of P&P or computer-based rehabilitation for different areas of cognitive impairment (language, visuo-spatial cognition, memory, attention) have shown some degree of efficacy in terms of transfer to real-life situations, clinical results with dysexecutive symptoms are still very unsatisfactory.[3,4]

Damasio[15] pointed out four main reasons why assessment and rehabilitation of executive functions in the lab is mostly ineffective and misleading with respect to what the patient suffers in his real life. In a lab situation, choices and decisions are only evoked, not really performed; they lack the normal cascade of events, actions and reactions; the temporal frame is compressed rather than realistic; experimental situations are often not really presented, but only described through language.

In other words, our traditional clinical settings seem affected by intrinsic limits for an ecologically valid rehabilitation of executive functions. Thus, many clinicians in recent times are trying to find alternative ways of intervention, i.e. focusing more on psychotherapeutic approaches, social intervention, occupational therapy and so on, bringing 'the therapist into the patient's life' and not 'the patient into the therapist's lab.'

Does this mean that we should stop sitting our head-trauma patients at our desk or in front of our lab's PC? Probably not, but in the case of Dysexecutive Syndrome we feel a special need for something more, a 'third wave' after P&P and computer-based tools.[16]

IMMERSIVE VIRTUAL REALITY AS A POSSIBLE SOLUTION TO A CLINICAL QUESTION

At present, virtual reality is considered to be the most advanced evolution of the relationship between man and computers.[13,14,17,18] With the present and future development of technologies, synthetic environments will be able to re-create situations more and more similar to the ones we experience in everyday life.[19,20] VR designers typically aim to create a convincing, engaging environment in which a sense of presence has to be created. The focus for VR developers seems to be creating an improved sense of "presence." [14]

All of these features lead us to believe that VR can offer a good answer to the aforementioned problems that neuropsychology is currently facing in setting up an efficient rehabilitative environment for executive impairments in a laboratory. In our opinion, increasing the experience of presence that these patients feel within the synthetic environment means that we bring the lab much closer to real life, partly overcoming the limits that Damasio pointed out[15] and improving the clinical effectiveness and the ecological validity of our computerized tools.

This is a point that we want to stress again: immersion and presence may be not only nice features that address motivation and unfortunately bring a lot of additional technical problems, such as higher hardware and software costs and limits in usability (i.e. cybersickness), but they could be the key factors in the rehabilitation of executive functions. With regards to this issue, we were perplexed by some recent proposals for rehabilitation based on the use of similar virtual environments where subjects could interact with the synthetic world only in low naturalistic levels (with technological tools such as flatscreen computer, keyboard or joystick). We believe that immersive virtual reality (IVR) systems, based mainly on a head-mounted display and tracking devices, may offer much more in terms of presence, and thus in ecological validity.[16,21,22] The present paper will describe our first pilot study addressing this issue.

The level of presence, connected with the functional use of VEs in clinical applications, also depends on the level of interaction[23-25]. The added value of VR compared to the traditional treatment is related to its many advantages (customization based on user's needs, possibility to graduate, high level of control, ecological validity, and cost reduction).[26]

Cognitive rehabilitation has to allow head trauma patients to recover their planning, execution, and control skills by implementing sequences of actions and complex behavioral patterns that are requested in everyday life: immersive VR can be specifically indicated to reach this goal because it allows this to happen in the most naturalistic way and with the most ecologically similar environments currently available. Moreover, VR allows the construction of realistic spatial and temporal scenarios that can be easily used to increase the diagnostic sensitivity of standard paper & pencil tests.

V-STORE

The aim of the present paper is to present the application of an immersive VR-based tool, V-STORE, and to show some preliminary validation data regarding its use. V-STORE was already presented as a part of the *V.E.Ne.Re. Project* (Virtual Executive Neuropsychological Rehabilitation)[16,21,22,27] and is currently employed as a part of a cognitive rehabilitation program based on a holistic and constructivist approach.

V-STORE was designed for the rehabilitation of executive functions, and some of its features were drawn from popular neuropsychological procedures, like the aforementioned Tower of London Test and WCST. It allows patients to explore a virtual environment (an internal goods store) in which each subject has to complete a sequence of tasks, ordered in six levels of increasing complexity (i.e. putting pieces of fruit into baskets according to an imparted disposition). Tasks are designed to stimulate executive functions, problem-solving, behavioral control and programming, categorical abstraction, short-term memory, and attention. Most importantly, a series of distracting elements is added, aiming at generating time-pressure and eliciting managing strategies, which become the first goal of the rehabilitative intervention.[28] The examiner has full control of all variables in order to enhance usability and to increase the number of sessions that a single patient will be administered.

Preliminary data about the experimental and clinical use of this tool are currently been collected at "Paolo VI" Rehabilitation Centre, mostly limited to small limited trials and single case experiences. Experimental validation of this kind of instrument is needed, not only regarding its clinical efficacy, but also with regard to its usability. The theoretical background designed in the introduction of the present paper needs some empirical validation. First, we need to have some concrete feedback regarding the possibility of eliciting a more intense and engaging sense of presence through immersive VR, in comparison to traditional flatscreen tools (2-Dimensional or 3D).

In the next part of this paper, we will describe a pilot study in which data about presence (physiological, neuropsychological, and self-report indexes) will be compared with two different versions of the same V-STORE environment and tasks, one administered in immersive modality (IVR) and one with non-immersive hardware (flatscreen). For a review about different methods of evaluating a sense of presence, see Insko.[29]

PART TWO: A PILOT STUDY COMPARING THE SENSE OF PRESENCE OBTAINED THROUGH IMMERSIVE AND FLATSCREEN VERSIONS OF V-STORE

SUBJECTS

12 young normal subjects were enrolled in this pilot study. No subject reported previous neurological or psychiatric problems. No subject had previous experience with V-STORE or with IVR systems.

METHOD

V-STORE is a rehabilitative tool, built for the treatment of disorders of prefrontal executive cognitive functions. It was originally engineered to work with immersive virtual reality hardware (HMD and orientation tracking) in order to set up a virtual environment in which subjects should complete six series of ten tasks each, ordered in ascending levels of difficulty. In the original immersive version, orientation of the subject's viewpoint and the central pointing crosshair follows real-time subjects' head movements (input obtained from the three-degrees-of-freedom tracking device set on the HMD).

In order to carry out the present experiment, a parallel and perfectly equivalent version of Level Two and Level Five of V-STORE was programmed to work with a flatscreen monitor. In this version, orientation of the subject's viewpoint and the central pointing crosshair follows joystick input.

In both versions, subjects also use two buttons of a joystick, one for forward movement (no backward movement or lateral strafe is possible) and the other to take or drop objects.

Subjects were randomly assigned to two different experimental groups:

- Group A completed the tasks in a non-immersive environment (flatscreen version of V-STORE).
- Group B completed the same tasks in an immersive environment (IVR version of V-STORE).

Experimental sessions were held in the Virtual Reality Lab at "Paolo VI" Centre. The examiner tested subjects from both groups individually, asking them to complete the same tasks (Levels Two and Five of V-STORE) after some practice with the environment and the commands. The maximum duration of each "active" phase was eight minutes, after which the examiner stopped the task sequence and moved to the next phase.

Each session strictly followed the same sequence for subjects of both groups and lasted 34 minutes (see Table 1). The start and end of each session was synchronous with the broadcast of a sequence of radio songs, jingles, and commercials, which had been recorded on CD and aired through stereo equipment located in the back of the room. It was set to a fixed volume that was sufficient to ensure good perception but not loud enough to interfere with the experimental session (subjects were initially not informed that the content of the radio broadcast was relevant for the study).

Assessment of sense of presence was carried out through four independent procedures:

a) Changes in skin conductance and GSR response (physiological measure)

Starting from the "baseline" phase, skin conductance was continuously recorded through sensors applied to the first two fingertips of the dominant hand (Psycholab VD13 biofeedback equipment, by Satem Biomedical). The skin conductance value was recorded with 1 Hz frequency and data was stored in a PC. Sensors were applied during the initial introductory phase (no subject reported any problems related to the presence of the sensors during sessions).

b) Incidental memory (neuropsychological measure)

We expected that a higher level of presence and immersion in a virtual environment would result in less attention paid to stimuli coming from the real world, and this should imply a reduced possibility to remember this information.

In our experimental design, the fake radio broadcast was built in such way that, during each of the two phases in which subjects completed Level Two and Level Five of V-STORE, two songs mixed with three commercials were aired. After the end of the session, subjects were asked six questions to evaluate their memory of the content of each of the six commercials (three during Level 2 and three during Level 5). Since the subjects had not been previously asked to pay attention to the radio broadcast and remember its content, this can be considered an explicit recall test for incidental memory (not intentional). Questions were open-ended, for example: "*a commercial about a furniture shop was aired, do you remember the city it is located in?*" (expected: "*Novi Ligure*") or "*a commercial about the new*

Table 1. Schedule of experimental sequence.

TIMING	PHASE	ACTIVITIES	RADIO BROADCAST
8 minutes	General Introduction	· GSR sensor application · Configuration of joystick and/or HMD tracking · Explanation of BIP detection method	Various
8 minutes	Baseline	· Practice with V-Store environment, objects and commands (fixed scheme of exploration of the environment) · GSR recording	Various
8 minutes	Level 2	· Tasks of level 2 of V-Store · GSR recording	2 songs + 3 commercials
2 minutes	Pause	· General check · Inquiry about BIPs during level 2	Various
8 minutes	Level 5	· Tasks of level 5 of V-Store · GSR recording	2 songs + 3 commercials
Immediately after	Questions	· Removal of HMD, GSR sensors and joystick · Inquiry about BIPs during level 5 · ITC questionnaire administration	Off

record of a singer was aired, do you recall the name of the singer?" (expected: "*Adriano Celentano*"). The examiner recorded the number of correct answers.

c) BIPs (Breaks In Presence) detection

According to Slater,[30,31] a Break In Presence (BIP) is the moment of the switch between responding to signals from one environment (real or virtual) to those from an alternate environment. We followed Slater's suggestion that the number of BIPs occurring during immersion in a virtual environment could be useful as a measure of sense of presence (the fewer BIPs occurring, the higher the presence). The problem with this method is that the subject has to verbally report the occurrence of BIPs during or after immersion in the virtual environment, which implies a high liability to subjective bias. Nevertheless, we consider this to be an interesting method, especially in combination with other measures of presence.

During the introductory phase, subjects were briefly apprised regarding the nature of BIPs (with the help of some examples) and then asked to verbally report the occurrence of a BIP during the "active" phases of the session (they reported by saying the Italian word "*attenzione*"). The examiner counted the number of reported BIPs separately for each phase. After completion of Level Two and Level Five, the examiner asked the subject again if he could recall other BIPs not reported (no subject of either group ever reported any BIP after the completion of level).

d) ITC-SOPI questionnaire (self-report measure; Italian version, currently under validation)

At the end of the session, subjects completed a self-report questionnaire on sense of presence.[32,33] This Italian adaptation of the inventory consists of 44 items that the subjects rate on a 5-point Likert scale (from 1 meaning "*strongly disagree"* to 5 meaning "*strongly agree"*). The first six items relate to feelings the subjects experienced after completing the tasks in the virtual environment, while the other 38 items relate to feelings experienced during task execution. Scoring of each completed questionnaire resulted in four factor scores: spatial presence, engagement, ecological validity/naturalness, and negative effects. This Italian adaptation of the ITC-SOPI is still undergoing the validation process.

RESULTS

We performed separate analyses for each of the four different procedures used in assessing presence.

a) Changes in skin conductance and GSR response

A single mean value from recorded skin conductance potentials was calculated separately for the three "active" phases: baseline, Level Two, and Level Five.

Analyses were conducted on two indexes derived by subtracting these mean values:

- *"Task" Index*: the difference between the mean values obtained during Level Two and baseline. This index should express changes in skin conductance when the subject starts completing challenging tasks in the virtual environment, compared to free exploration of the same.
- *"Difficulty" Index*: The difference between mean values obtained during Level Five and Level Two. This index should represent changes in skin conductance when the tasks to be completed become more difficult and challenging.

Results are shown in Table 2.

Regarding the "task" index, positive means indicate that subjects of both groups showed an increase in GSR response when facing tasks and orders. Nevertheless, the increase is significantly higher for the "immersive" group.
An increase in GSR response is also evident when subjects of both groups were challenged with the more difficult tasks required to complete Level Five of V-STORE ("difficulty"

Table 2. Skin conductance data and analyses.

GSR response	*Level 2 – Baseline "task" index*	*Level 5 – Level 2 "difficulty" index*
A. "Flatscreen" Group	M = 1.20 s.d .= 3.06	M = 3.00 s.d. = 2.43
B. "Immersive" Group	M = 6.20 s.d. = 4.01	M = 4.11 s.d. = 2.83
2-tailed Student T-Test	*p < .05*	*n.s.*

index). This modification in skin conductance is not statistically different between the two groups.

b) Incidental memory

In Table 3 we report the number of questions correctly answered using incidental memory regarding the content of the commercials aired during both Level Two and Level Five. "Immersive" group subjects recalled less elements, but this difference is not significant (p=.11).

c) BIP (Breaks In Presence) detection

In Table 4 we report the number of BIPs reported by the subjects of both groups, both in total and separately during Level Two and Level Five.

d) ITC-SOPI questionnaire (Italian version, currently under validation)

In Table 5 we report the mean results for each of the four factor scores. Even if mean scores are generally higher for the "immersive" group, no statistically significant difference between the groups was found for the first three factors. Only factor four (negative effects) shows a significantly higher score for the "immersive" group.

Table 3. Incidental memory data and analyses.

Incidental Memory	Number of recalled elements
A. "Flatscreen" Group	M = 1.17 s.d .= 0.75
B. "Immersive" Group	M = 0.50 s.d. = 0.55
2-tailed Student T-Test	*n.s.*

Table 4. Breaks in presence data and analyses.

BIPs	*Level 2*	*Level 5*	*Total*
A. "Flatscreen" Group	M = 2.33 s.d .= 3.39	M = 2.17 s.d .= 2.14	M = 4.50 s.d. = 5.36
B. "Immersive" Group	M = 0.83 s.d. = 0.75	M = 0.67 s.d. = 1.03	M = 1.50 s.d. = 1.64
2-tailed Student T-Test	*n.s.*	*n.s.*	*n.s.*

DISCUSSION

The only significant differences we found between scores of the "immersive" and "flatscreen" groups were those of the "task" GSR index (changes in skin conductance related to the passage from free exploration of V-STORE to the completion of specific tasks in the same environment) and the factor "negative effects" of the ITC-SOPI questionnaire.

While this latter result is not surprising and expresses one well-known limit of current immersive VR applications, we found the first difference very interesting: GSR "task" index points out that subjects of both groups experience a rise in psychophysiological activation during the completion of tasks in a virtual environment, but this effect is significantly higher for subjects who perform tasks in an immersive VR environment.

This difference in activation may be interpreted according to two different hypotheses. First, it may reflect higher emotional participation, which can be considered a possible indicator of a higher level of presence experienced. Second, it might simply reflect a stress factor, possibly related to the fact that tasks carried out in an immersive condition could be more difficult or tiring.

We believe that if task difficulty is the cause of broader changes in skin conductance for the immersive group, we should observe a similar difference when subjects become involved in the completion of more challenging tasks (Level Five), but this does not happen. We did not observe any difference in the "difficulty" GSR index. Thus, our data about skin conductance, even if not conclusive, seem to indicate that subjects of the "immersive" group experience larger psychophysiological activation during completion of V-STORE and this might reasonably be interpreted as a sign of a higher sense of presence.

With regards to the other indexes used (neuropsychological and self-report), we observed no statistically significant difference between groups. Nevertheless, raw data show fewer BIPs and fewer incidental memory-recalled elements in the "immersive" group, and both of these indexes suggest a higher level of involvement and presence in the virtual environment. If we keep in mind that these data

Table 5. ITC-SOPI questionnaire data and analyses.

ITC-SOPI	1. Spatial Pres.	2. Engagement	3. Naturalness	4. Negative eff.
A. "Flatscreen" Group	M = 2.67 s.d .= 0.35	M = 3.32 s.d. = 0.60	M = 2.43 s.d. = 0.53	M = 1.64 s.d. = 0.39
B. "Immersive" Group	M = 3.03 s.d. = 0.95	M = 3.33 s.d. = 0.60	M = 2.77 s.d. = 1.29	M = 2.58 s.d. = 0.92
Mann-Whitney Test	*n.s.*	*n.s.*	*n.s.*	*p < .05*

are drawn from a very small pilot sample, no conclusion of any kind can be drawn at present, but we believe that these indications are enough to suggest continuing the experiment on a larger experimental sample.

Data emerging from the ITC questionnaire do show very small differences between the self-reported evaluations of presence from the subjects of the two groups. Again, no conclusion can be drawn from these partial data, but we can observe a discrepancy between this subjective measure and more objective measures (especially physiological), which, if corroborated by future research, could add a new element to the growing dissatisfaction with self-report assessment instruments.[31,34,35]

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Smoke and Mirrors: A Virtual Reality Debunking Environment

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Abstract: *Smoke and Mirrors is a virtual reality based artwork created by Sheldon Brown for the Reuben H. Fleet Science Center in San Diego. It allows two to six visitors to simultaneously enter a shared virtual environment through their own projected computer graphic media portal. The environment engages viewers in a series of activities drawn from the cultural and social history of tobacco usage.*

Participants in Smoke and Mirrors inhabit avatars comprised of 3D scans of their own faces, attached to bodies created from an isolated biological system. These avatars are navigated through a series of maze-like environments. Each participant has their own unique view of the shared world, based on their own situation and actions, which is created by an eight computer client-server architecture. Each of the six graphic clients independently generates its own particular environment state and view, with each client communicating environment event changes (such as avatar location, object triggering, etc.) to the other clients on the network and to the server. The server coordinates timed transformations such as scene changes and character construction.

The piece runs with custom software developed for the project. Custom user interfaces consist of a unique projection environment, and familiar computer game interfaces - a joystick, and a trackball and button - built into an architectural environment. To facilitate overall project development, an authoring application was created which allowed for quick changes in content and event interactions in the project.

INTRODUCTION

During the period of time from the early 1940's to our present moment, the social and cultural implications of tobacco usage, particularly cigarette smoking, have undergone a number of significant transformations. This image has been carefully constructed by the tobacco industry to create a climate where their product's usage is acceptable and desirable, and targeted towards a user base that is both susceptible to particular media strategies and to the addictive qualities of the product itself.

As the health consequences and addictive qualities of this product became more apparent over the last 50 years, legislation has increasingly been passed to modify both modes and content of tobacco deployment, including venues and content for advertisement, methods of selling, warning labels on the product, and controls regulating usage of the product in public spaces. There have also been numerous counter-advertising campaigns launched by public health departments as well as those mandated by liability lawsuits brought against the industry. These counter-ads are generically labeled "public service announcements" and include television, radio, magazine print, brochures, billboard, and kiosk types of ads.

The results of increased legislation and aggressive counter-ads have made an impact on tobacco usage, which has steadily declined. However, the tobacco industry continues to be very savvy in the way in which it markets its products. The California Department of Health decided to try a new approach with a small part of its anti-tobacco program. They called for proposals from organizations around the state to commission artists to create artworks that would take on the issue of smoking. Implicit in this approach is awareness that art creates experiences for viewers that are somewhat different from advertising or commercial media. I will address how this applies to the particular case of this project.

The Reuben H. Fleet Science Museum in San Diego contacted me to develop a proposal for this program. They were familiar with other virtual reality based artworks that I had done that had addressed particular socio-cultural content – particularly the project *Mi Casa es Tu Casa/My House is Your House*. *Mi Casa* was a bi-national virtual reality environment between Mexico City's National Center for the Arts and The San Diego Children's Museum. The *Mi Casa* project created a simultaneous virtual reality playhouse where up to eight kids could fluidly engage in unstructured, interactive, theme-based play in the contextual environment of activities, symbols, and forms that addressed the bi-cultural situation of the environment.

For the current project, I was concerned with several factors in the design of the environment. Tobacco industry sources themselves have identified the target market as being 12 to 18 year-olds. While they maintain that their advertisements are only geared to get people to change brands and not to start smoking, they understand the tumultuous years of adolescence where issues such as sexuality, rebellion, and conformity become ripe territory for exploiting insecurity and self-image experimentation. For instance, the industry has used legislative intervention aimed at curtailing their marketing as a way of cultivating individual rebellion in usage of this product. Many adolescents do not want to be told what to do. Directly telling this population that they should not smoke because it is bad for them will only have a marginal impact on the audience.

My approach to any artwork is that I am trying to put in motion a set of materials and processes that allow a user to create revelatory interconnections between them. While I am interested in exploring particular terrains, or sets of terrains, I strive to set up a situational engagement that is open-ended – open to interpretation – and requires active cognitive involvement. My artwork is interactive on all levels – it requires bodily user participation, it often engages users' perceptual apparatus in extended ways, and it requires the user to think about, and reflect upon, their experience, asking them to complete the reading and meaning of the works – with multiple outcomes expected and hoped for on my part.

While this is not a comprehensive discourse on what art is and what it is not, I offer this brief encapsulation of my concerns as an artist to underline how I approached this project, and to provide a basis for differentiating it from public service announcements. While immediate impact on audience is of some interest, it is by no means the measure of success for an artwork. While it is customary in advertising and commercial media such as film and television to measure reception and effect, works of art are resistant to this almost by design. Historically, some of the most important artists and works of art were ignored or ridiculed during their time. Others are profoundly effective for a small part of the population, or provide extensions to the field that are followed by other professionals that gradually transform culture at large. In this case, in order for this installation to operate as a successful work of art, it has to add to the aesthetic development of the field of art and it has to provoke users of the work to have a shift in their perception of the subject – tobacco products. Part of my process as an artist is an engagement in discussion with users, both individually and in populations, to gauge user reception. These discussions occur during the process of designing the project, during early implementation, and after deployment. The first two stages of audience engagement are important in developing the project form. The latter stage primarily details how ancillary materials are developed to support the user experience.

OVERVIEW

For *Smoke and Mirrors*, the population the project was addressing has heard from the moment they were born that smoking was bad for them, but they also saw that its usage by a variety of people - both in their lives and in the media - was tolerated and legal. What I set out to create was an artwork where the user could experience the ways in which the industry has set up a shifting image of their product that responds to larger social and cultural concerns, positioning it for maximum effect. While contemporary adolescents are well-equipped with information about the deleterious effects of this product, they are ill-equipped with a historical overview of how the product came to be in the socio-cultural position that it currently occupies.

In general, the *Smoke and Mirrors* environment is set up as a series of mazes. Each of these mazes explores a particular era of tobacco consumption. Users navigate through these mazes attempting to find ways of escaping their messages; however, none of them have exits. They only lead users deeper into the trap of product usage.

The user experience begins with a person having their face scanned in three dimensions. Up to

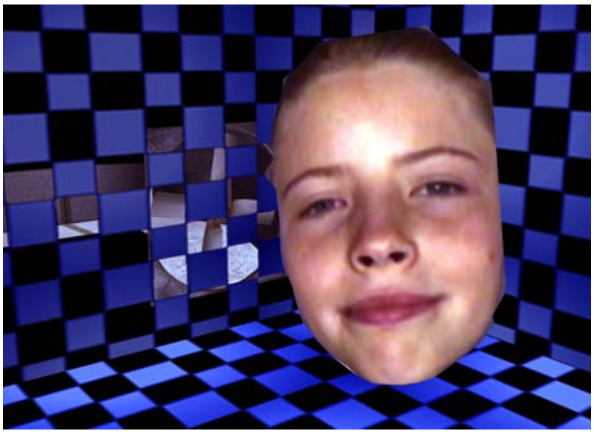

Figure 1. Participants scanned face first appears on one of six kiosk screens.

six people at a time can participate in each round. Once the users have had their faces scanned (which generally happens while a previous group of users is in the experience), they are all told at once to go and find their particular face at a particular kiosk.

The kiosks are arranged hexagonally such that all users are physically facing each other as they look into a shared architectural space, which reinforces the sense of the shared physical space that they will soon inhabit. The hexagonal form is repeated as a structure throughout the virtual world to continue to reinforce ties to their physical experience.

PROJECTION APPARATUS

Each kiosk is constructed by a 7 ft. by 5 ft. rear projection computer screen, in a portrait orientation. The image is high-resolution, 1280x1024 pixels, and comes from liquid crystal on silicon (LCOS) projects, which provide for nearly seamless pixels. The graphics are generated by GeForce 4-based cards, and are rendered with quincunx anti-aliasing. These details are important to the structure of the artwork as the user stands very close to this screen, approximately four feet away. The perspective of the environment is designed for this physical proximity to provide for increased sensory immersion to create a strong sense of embodiment while maintaining a strong connection to the physical world. In this project, as in much of my work, I create experiences for users that relish the spectacle of media, but do so by creating a self-conscious, often social and physical engagement with that media spectacle. I want people to be fully engulfed by the media experience, but I also want them to be continually aware of their physical reality and the social space of this media engagement. This set of formal arrangements and apparatus operation is crucial to reinforce the overall intent of the project. *Smoke and Mirrors* is about the translation of media spectacle into physical reality and social effect. Form and content deliver this message together.

All of these considerations made it crucial that I have the best looking pixels possible. Early experiments created projection environments with more typical LCD or DLP projectors running on 1024x768 VGA signals. Both of these projection technologies exhibited artifacts that inhibited the immersive effects of the image, and were not contributors to the self-conscious physical engagement that I had hoped for. LCD's are plagued by space between pixels where wires have to run on the transparent panel. About 20% of an LCD's surface area is committed to these wires. DLP's suffer from another disadvantage: inexpensive projectors

Figure 2. Each participant interacts at a kiosk with large rear screen display and simple interface mechanism

(below $15K) use a single chip and a rapidly spinning color wheel to create the three RGB colors. This is susceptible to color field shearing on the peripheral vision when the head is moved to look around an image, producing a significant distraction. The last two sources of undesirable image artifacts were the resolution itself – more is better; and the VGA signal, when is subject to induced noise in cabling and in its two stages of digital to analog conversions, which appears as dark waves running through the image. This is a bit of an in-depth discussion regarding some arcane details of the projection set-up, but it is important to understand how the range of technological capabilities and limitations create their resultant effect, particularly with regards to a question like immersion. In this case, paying attention to such things as pixel quality allowed me to create an environment with the right balance between the advantage of immersive media and a physically and socially shared media experience.

In front of these projection screens is a form-fitting user interface station – a molded waist-high platform that contains a joystick, trackball, and button. Each was designed to sculpturally relate to the content of the environment. The joystick was created from a 2” solid, clear acrylic rod. The upper end was scored at the tip such that a red LED in the base of the rod caused the tip to glow like the ember on the tip of cigarette. The joystick was used to control the users’ movement in the environment – essentially users are controlled by the use of this large oversized cigarette.

The glowing ember color was also used in the trackball, which controlled camera orientations; and the button, which allowed users to switch to different camera views.

The participants first enter the maze of the kiosks themselves to find their 3D graphic head floating on one of the screens. The environment they are floating in looks a bit like the booth where their face was just digitized, only the environment itself looks as if it has been transformed into a digital signal of some kind. Once all users register that they are at their station (through this process they have to negotiate the physical space with the other users and become acquainted with them), their faces are sucked through a ventilation duct, which they fly through.

The user is deposited in a body in a dark, smoke-filled room. The bodies are comprised of a biological system in a humanoid shell that looks as if it is made from a test tube. The biological systems are each ones that are affected by tobacco usage and are at a range of scales – from the sub-cellular to the large organ system. These systems are – cellular mitosis, red blood cells, the heart and circulatory system, the lungs, the brain, and a patch of skin where a tracheotomy hole has been inserted. Each of these systems is active inside the tube – the cells divide, the red blood bubbles around, the heart beats, the lungs breathe, and the skin pulses with the breath from the trachea hole fogging the test tube shell. Each person’s face is placed into the top of one of these tubes and they are told to try and move around the room.

In the room they see the other participants wandering around; the only other item is an illuminated table in the middle of the room, with chairs arrayed around it. After a brief period of instruction on the user interface, navigational control is taken away from them as they are pushed into the chairs. A video monitor emerges out of the table and a brief video is played for the users, telling them that they are part of an experiment to determine whether “instigated counter measures have been effective against a proliferation of messages.” The text and images are of ambiguous origin – it could be a tobacco organization, a scientific research lab, a media conglomerate, or the government. The style of this video is comprised of clips appropriated from government PSA films – introducing the appropriation and deconstructive strategies that will be radically employed throughout the project.

At the end of the tape the users are sucked once again through a passageway, this time through streams of videos that contain television advertising of tobacco, going back in time from the 70’s to the 60’s to the 50’s. The messages move from somewhat adult themes to tobacco sponsorship of cartoons such as the Flintstones.

This media tunnel ends in a kaleidoscopic image the turns out to be the floor of a “carousel.” This carousel is ringed by large billboard ads that begin by showing imagery of how smoking will help support our soldiers fighting in World War II. Participants are told to move to the panels

Figure 3. A participant is shown in the "Carousel" maze which consists of tobacco advertisements from the 1940's and 50's spinning around the participants, trapping them in a fabricated myth of product normalcy.

to discover a way out of these images. This environment shows people how the industry constructed a public attitude towards their product that helped ingrain it as a normative practice. Beginning with the horrific situation of soldiers at war and the assertion that a cigarette could provide a bit of comfort to our warriors, they built upon patriotic sentiment to tap into the post-war development of the suburban white middle class as the American dream. Post-war imagery was focused on the “Ozzie and Harriet” lifestyle that smoking provided. Early health concerns were refuted with testimonials from “Doctors” about the health benefits that smoking provided indigestion relief, weight control, and stress relief. Celebrity endorsements from such trusting figures as Ronald Reagan were also used.

Figure 4. A participant is in the "Trashland" maze where fragments of tobacco's post-surgeon general era are stirred up by participants attempts to find an escape - reforming themselves into the images of tobacco usage that are still part of

The carousel environment allows users to go through a variety of these images, confronting users with a very different image of how cigarettes were marketed. Each time a user encounters one ad, it seems as if it is opening up to reveal a passage but it is replaced with another. At periodic intervals, the whole environment spins around like a carousel or roulette wheel, and is reloaded with new imagery. Audio clips taken from tobacco and advertising company archives are played, with each clip talking about the advertising strategies used in their time.

At the end, the users’ control is once again taken away. The walls encircle each user, rolling them into a giant cigarette. We follow a puff of smoke out of the cigarette and when it clears, the users are standing in an environment made from mounds of garbage.

Users see that they can follow paths through these garbage mounds, and as they do so they kick pieces of it up into the air, forming fragments of tobacco advertisements from the post-Surgeon General era. Advertising strategies completely shifted after the Surgeon General’s report of the 1960’s. No longer could the product be touted as a “family value” product. It was now sold as a method by which a user could show that they were an “independent thinker,” a “non-conformer” and a “rebel.” This coincided with such larger social movements as the counter-culture movement and youth-directed product marketing. Particular segments, such as the feminist movement, were also targeted – ad campaigns mythologized a repressed past of women smokers who had now come of age, which they could show the world through their use of cigarettes.

However, unlike a substance such as marijuana, whose usage was also an indicator of these types of attributes; cigarettes had been normalized into widespread social usage. You could smoke anywhere and many people engaged in the habit – most of them far outside the represented demographic of the advertise-

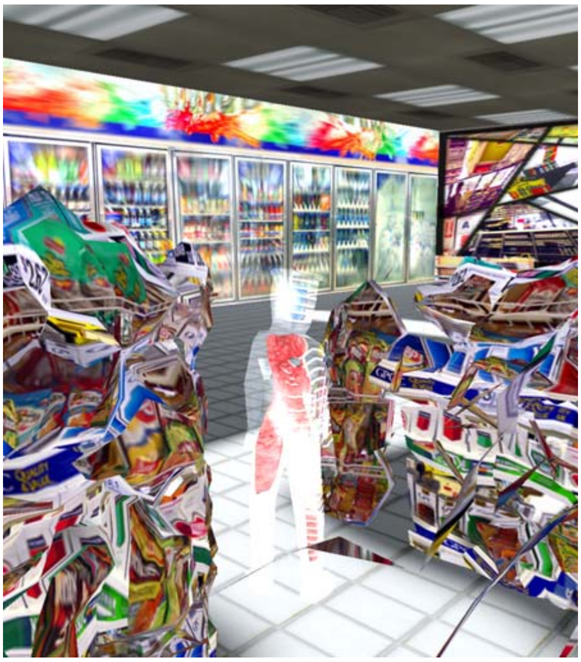

Figure 5. A participant is in the "Convenience Store" maze which uses organic growth algorithms to transform the shelves of junk food products into tobacco products.

ments. The ads were designed to create a product consumption image for new users – teens.

Tobacco companies also understood the mechanisms of addiction for their product and when it was effective for people to start using it. They also were conscious of how advertising, which appeared to target twenty-something age groups, became effective at targeting teens. We now know of this conscious understanding on their part from internal documents that the Attorneys General Master Settlement Agreement (MSA) of 1998 has forced tobacco companies to release into the public domain. This environment again uses bits and pieces of these texts as audio accompaniments to the actions.

With six people running around in this garbage land, perhaps enough refuse can be cleared to escape the confines of the dump? After a bit of time, the camera pulls back and we see that this garbage dump is the trashcan outside of a convenience store. The camera flies through the entrance of the store and zooms into a security monitor that shows our fellow avatars, scattered through the store.

Participants find their own avatar in a part of the store, and as they move, an aisle appears around them. However, this aisle is quite unusual in its appearance and operation, looking almost biological as it grows around the person moving through the store, pulsing and changing. Initially the shelves on these aisles contain the usual junk food of the convenience store – chips, soda, candy, etc. As people spend more time in the aisles, the products transform into cigarette packages.

This is the world of product placement as contemporary marketing strategy. The convenience store industry is one that was radically transformed by increasing regulations on tobacco product marketing practices of the 80's and 90's. By the accounts of this industry, tobacco sales make up anywhere from 30 to 60% of all non-gasoline sales. A high proportion of non-gasoline customers in these stores are teenagers. There have also been major corporate mergers between companies that make the snack foods sold in these stores and those that sell cigarettes (i.e. RJ Reynolds and Nabisco). The marketing strategies mix graphic strategies across snack foods and cigarettes and strategically position tobacco products and point of purchase advertising in the faces of young teens. This plants images and messages that may not be immediately acted upon, but are more likely to be acted upon with increased familiarity with the product.

Sounds in this environment come directly from convenience store owners who were interviewed by tobacco companies at a convenience store convention touting the profitability of selling cigarettes at convenience stores. A large chain owner directly states that if they did not sell cigarettes, the convenience store industry would probably disappear.

The participants try to find an exit from this environment. Of course, they cannot get to the door, as aisles appear to thwart their movements. But there is a type of an exit from this one. After a period of time, all of the users collapse, as their biological systems stop functioning.

We next cut to laboratory. On an examination table, all the innards of the test tube bodies are laid out. But all of the tissue is now diseased. The face's area is arrayed around the top of the lab table (which is the same hexagonal shape as the initial table our participants were sitting around). The test tube bodies are seen hanging upside down on a drying rack along the wall. The joysticks now operate a robotic scanner that can be used to examine each biological system, and as this occurs, users get a readout on its particular pathology. A video starts to play on the examination device, thanking each user for their participation, noting that their success at navigating the history of this product's usage has been recorded, and it will be taken into account for maximizing the relationship between the product's profit cycle and the user's life cycle.

At the end, the faces are incinerated one by one, and exhaled back out the same ductwork from which the user entered. Game over.

TECHNOLOGY

The expressive possibilities for real time graphic environments have developed rapidly in the last few years. This is due to the widespread adoption of 3D graphic gaming platforms, which provide the ubiquitous inexpensive hardware and also further develop software technologies at the level of API hardware interfaces. These developments allowed the use of inexpensive PCs with commodity graphic cards to drive this environment. The project runs with each graphic client independently generating its own scene. In this case there are six clients. They each send state information directly to the other graphic clients, which use this information to update their local scene, including such elements as the various avatar locations and their actions, and how they may have changed the environment. A central server controls large state changes in the environment such as scene transitions.

Figure 6. Providing an experience of the cultural and social history of how the industry has shifted the image of this product provides participants with the capacity to make better informed decisions about behavior choice.

This project uses a rendering engine – NetImmerse from NDL, Inc. to interface between the graphics API and the application database.

Significantly, with better implementation of such things as animation control, rendering, and scene graph management within the graphics API and the rendering engine, development was focused on higher level scene description. An application called the SceneEditor was created to create the event interactions and specify the multi-media assets in each scene. This application allowed for continued and simple changes in scene description and provided an extensible and flexible environment for creating a variety of computer graphic environments

CONCLUSION

My primary interest in developing a project such as *Smoke and Mirrors* is to further the development of interactive computer-mediated environments in the practice of art. This involves creating new types of semantic forms for these environments to engage more complex aesthetic forms as their technological structures continue to develop. This type of work engages developments across multiple cultural domains – from the technological, the social, and the artistic. In the end, I think it is this type of practice that can have the most to offer the further development of artistic practice, which goes through cycles of engagement and disenfranchisement with concerns such as the social and the technological, often finding it difficult to embrace these multiple terrains simultaneously. However, it is works that take on this type of ambition that can offer real development in the fields that they bridge. For interactive virtual environments to extend their narrative grasp beyond the simplistic realms of mega-violence or arcane escapism, taking on challenges such as this can find these new expressive modes.

As an artist, I am ultimately interested in the interrelationships between these sets of concerns and how a socially engaged, technologically innovative artwork can extend aesthetic forms into new expressive domains. Culturally, we are at a potent moment with the further development of digital technologies and the opportunities they provide for creating new social engagements and expressive forms. These expressive forms develop when they are put to particular challenges. Creating a socially engaged, aesthetically sophisticated, technologically inventive artwork is the type of challenge that can show the real potential of a media form.

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Persons and Their Artificial Partners: Robotherapy as an Alternative Non-pharmacological Treatment

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Abstract: *A discussion on the innovative conceptual framework of robotherapy, viewed as an alternative non-pharmacological treatment, is presented. Robotherapy is defined as a practical application that resulted from a newly developed theoretical and methodological field called robotic psychology. Robotic psychology is described as a study of compatibility between robots and humans on all levels – from neurological and sensory-motor to social orientation. Both methods – robotherapy and robotic psychology – underlie ongoing research on persons' and robots' co-existence that concentrates on examining person – robot communication as an example of the Complex Interactive System.*

INTRODUCTION: TWO PATHWAYS TO A HUMAN MENTAL WORLD

A great variety of therapeutic techniques and theories traditionally related to mental health can be narrowed down to a basic dichotomy, defined as "pharmacological vs. non-pharmacological" approaches to treatment. The main effects of pharmacological interventions are based upon drugs' impact on human physiology associated with certain psychological processes. The primary targets in this case are the biochemical mechanisms underlying various conditions such as mood, emotion, and many socially defined behavioral patterns (i.e., aggression, inappropriate conduct, 'abnormal' manifestations, etc.). Lately, the ideology of pharmacological treatment expanded tremendously by including in its domain traditionally psychological constructs: social anxiety, shyness, and feelings of happiness. Although the foremost productive approach uses a balanced combination of both pharmacological and non-pharmacological interventions intended to produce desirable changes in human behavior, the overuse of pharmacology-oriented methods and the underdevelopment of alternative treatments remains a phenomenological fact.

Non-pharmacological approaches for treating problems that a person experiences over the course of their life are aimed at psychological mechanisms that underlie behaviors disturbing to themselves or others. Psychological effects produced by non-pharmacological interventions also influence biochemical, neurological, and psycho-physiological patterns that form individual behaviors, states, and traits. As some authors pointed out,[1] psychological therapy achieves the same effects as pharmacological methods - from biochemistry to psychophysiology of emotions and complex social problematic behaviors. Among psychologically-oriented techniques are traditional person-to-person or group psychotherapy, sensory and mental stimulation based on color,[2] semantics of geometrical shapes and human drawings,[3] music, videotapes,[4] meditation, and physical therapy. The invention of the microchip brought new technological tools to the therapist. The unexpected rise of e-health applications[5] including telemedicine and virtual reality (VR),[6-8] rapidly formed their niche in the early 21st century non-pharmacological therapy. As of today, four major methods are distinguished in technology-mediated therapy:

- Virtual reality (VR techniques for treating anxiety, attention-deficit disorder, fear of flying, and a variety of specific phobias)
- Internet-based communication (tele-hypnosis, distant psychotherapy, therapy-related knowledge acquisition)
- Electronic games potentially ready for clinical application

- Interactions with embodied agents (social and entertainment robots with different levels of artificial intelligence and synthetic sensory feedback)

This article will concentrate on the use of robots as human companions analyzed through the newly developed concept of robotic psychology and therapy.

ROBOTIC PSYCHOLOGY

Personal Dimension of Technological Reality: Artificial partners, such as mechanical and automatic devices employed to fulfill certain human needs, were always good companions to people, playing a modest but vitally important role in their lives as tools for exploring, rebuilding or utilizing the natural environment. But only in the past decade has it clearly been realized that robots serving as humans' artificial partners are entering our lives faster than we think.

The diversity of human activities requires a variety of robotic creatures that might be involved with those activities. From the perspective of human needs, many types of interactions between people and robots deserve psychological attention. A primary classification (see Table 1) of 'smart' automats that have come into being in recent decades considers such criteria as the purpose of a robot and its relation to human activity, a robot's behavioral configuration defined by the degree of freedom, robo-IQ (complexity of artificial intelligence corresponding to both hardware and software hierarchies and degree of uncertainty in the tasks performed), and the robot's physical properties manifested in their appearance.

Robotic psychology, which can be briefly defined as the study of compatibility between robots and humans on all levels – from neurological and sensory-motor to social orientation, emphasizes three major modes of a robot's relation to human needs:

Table 1. Classification of robots with the regard to human needs.

	Human need	Behavioral configuration	Physical appearance
Industrial robots	To perform hard labor and hazardous work	Consists of basic physical movements with a few degrees of freedom	Machine-like appearance that supports mostly peripheral activities
Research robots	Extension of human sensors		
Military and rescue robots	Activity in life-threatening situations		
Medical robots	Performance of fine motor operations on the human body		
Recreational robots	Positive behaviors through entertainment	Aimed at human feelings and emotions	Animated form of existing and non-existing beings or objects
Interactive simulation robots			
Social robots	Communication	Imitates human facial expressions and complex gestures with social meaning	Anthropomorphized appearance
Robots with therapeutic potential	Therapy and treatment of negative states and behaviors	Models basic emotional states and social behaviors embodied in life-like form	Animal-like or human-like appearance

- Substitute for human activity (i.e., rescue robots)
- Extension of human activity (i.e. medical robots)
- Stimulation of human activity (i.e., social robots)

In our studies aimed at psychological and therapeutic application of robotics we used artificial creatures from the class of interactive simulation robots.[9-11]

A CONCEPT OF AN ARTIFICIAL PARTNER

The previously described class of interactive simulation robots (as seen in Table 1) is defined by two characteristics that make it potentially valuable for psychological research and practice. First, a general feature of the class of interactive simulation robots is that those creatures are designed for the purpose of communication or interaction with a human being. This is why we call this type of robot an artificial partner.[12] The concept of artificial partners places the relationships between humans and robots into a psychological, rather than technological, context. A few parameters depict an artificial partner (ART) as a good human companion:

- It imitates a real life (human or animal-like) behavior.
- It models emotional, cognitive, and motor behaviors normally experienced by humans.
- It communicates with the person on various levels such as tactile-kinesthetic, sensory, emotional, cognitive, and social–behavioral.

A second major distinction that differentiates the class of interactive and simulative artificial creatures from other groups is that it reflects a structure of the living world including:

- Anthropomorphic robots or humanoids
- Robots imitating animals
- Artificial creatures imitating living beings other than humans, animals, or fictitious creatures

As of today, numerous creatures equipped with tactile, audio, and visual sensors and different levels of robo-IQ already exist on the market and in the laboratory. The anthropomorphic robot platforms Cog and Kismet, the humanoids AMI and Asimo, the robotic dog AIBO and robot-seal Paro, and the automated dolls Amazing Amy and My Real Baby are only a few known examples. While practitioners and researchers gradually realize that an individual's special needs might require specially designed tools, theoretical and applied justification has to be developed to embrace and analyze the epistemology and phenomenology of an already diverse robo-population.

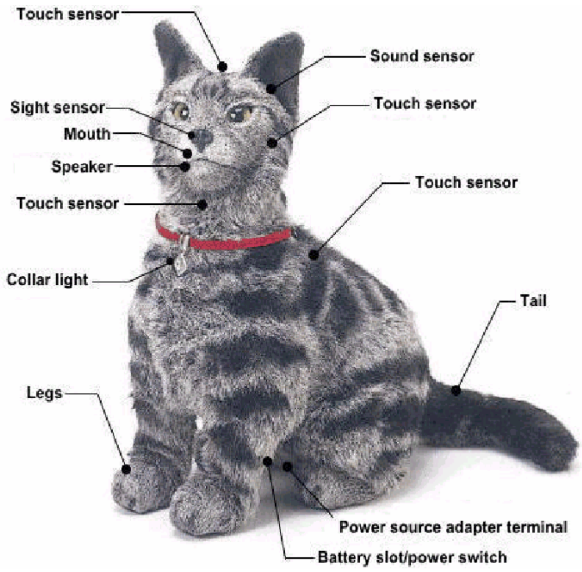

Figure 1. Robotic cat NeCoRo – a tool for robotherapy.

It is no coincidence that robots of the interactive simulation class recently became the subject of a new field of study, named robotic psychology and therapy, which emphasizes the importance of human-robot interaction analysis in psychological and social contexts.[9,10,11,13] Above is an illustration of the robotic cat NeCoRo (Figure 1), manufactured by Omron Corporation in Japan and donated for our study by Omron. The cat-type communication robot NeCoRo, which means 'companion' in Japanese, is alternatively called a mental health robot. It was designed as a pioneering emotional creature that is life-like in appearance. Besides being a sophisticated robot with an artificial intelligence system and multiple built-in sensors that provide a self-organizing behavior, the artificial cat creates playful, natural communication with humans by mimicking a real cat's reactions to stimuli.

NeCoRo stretches its body and paws, moves its tail, opens and closes its eyes, meows, and cuddles when being touched. It is worth mentioning that robots with behavioral patterns aimed toward mimicking animal or human behavior have both therapeutic and social learning value.[14]

ARTIFICIAL PARTNERS AS MEDIATORS IN ROBOTHERAPY

In the near future, the function of artificial partners might be dramatically shifted from roles in service and entertainment domains to originally exclusive human occupations, such as education and treatment. The most important change in application, although somewhat unexpected for many professionals, is that advanced artificial creatures with high robo-IQ and sophisticated synthetic sensory systems can be effectively used in different kinds of therapy playing such roles as:

- a mediator in person-to-person communication
- an interactive device for training and development of certain individual and group skills
- a tool for guided physical and mental stimulation
- a human companion in special situations and life circumstances

Norbert Wiener pointed out that a major function of sophisticated communicative machines (as well as higher living organisms) is the ability to resist entropy by modifying their behavioral configurations on the basis of past experiences and using sensitive feedback.[15] Those basic features lie at the foundation of a new theory on robotherapy, where a robot plays the role of a therapeutic agent communicating with a person in different modes and promoting physical/ sensory-motor activities, cognitive and emotional stimulation, and – most importantly – providing an individual with psychological benefits (i.e., sense of control, independence, and self-efficacy).

ROBOTIC PSYCHOLOGY AND ROBOTHERAPY IN THE CONTEXT OF A COMPLEX INTERACTIVE SYSTEMS APPROACH

The view on person-robot communication as a complex interactive system (CIS) represents it as a hierarchically organized configuration of signal exchanges mediated by the environment. We use the term 'Complex Interactive Systems'[12] with regard to the communication between human and artificial intelligence for several reasons. First of all, a robot as an embodied

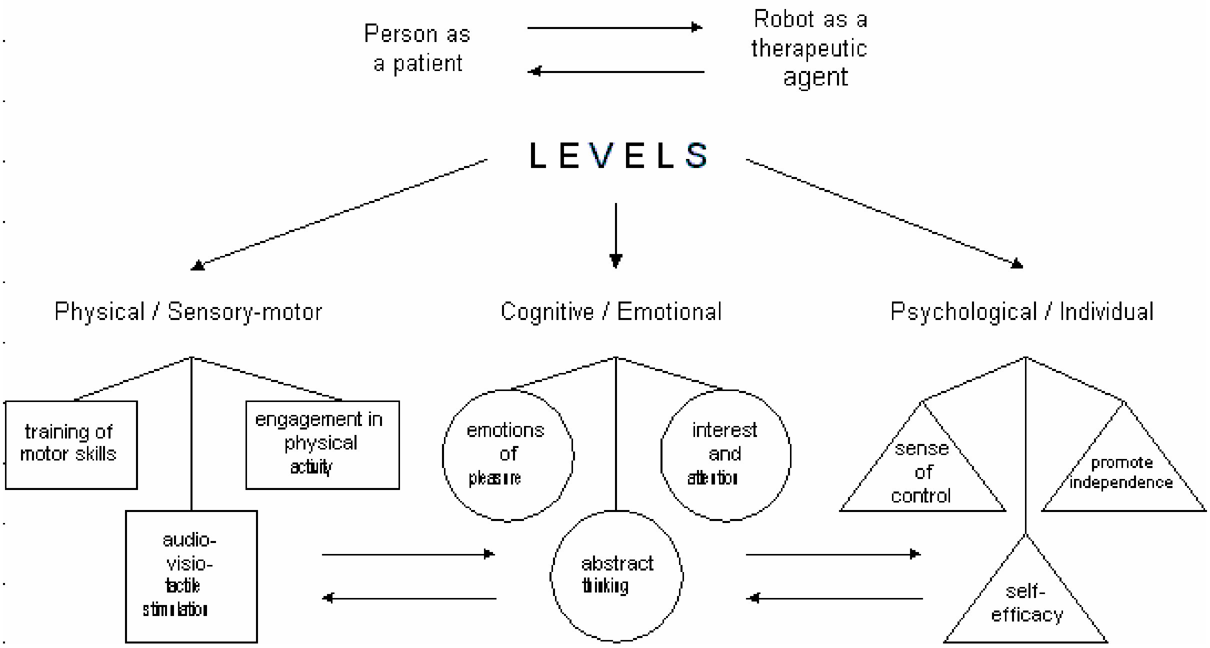

Figure 2. Communication between a person and a robot as a therapeutic agent (a Complex Interactive Systems approach).

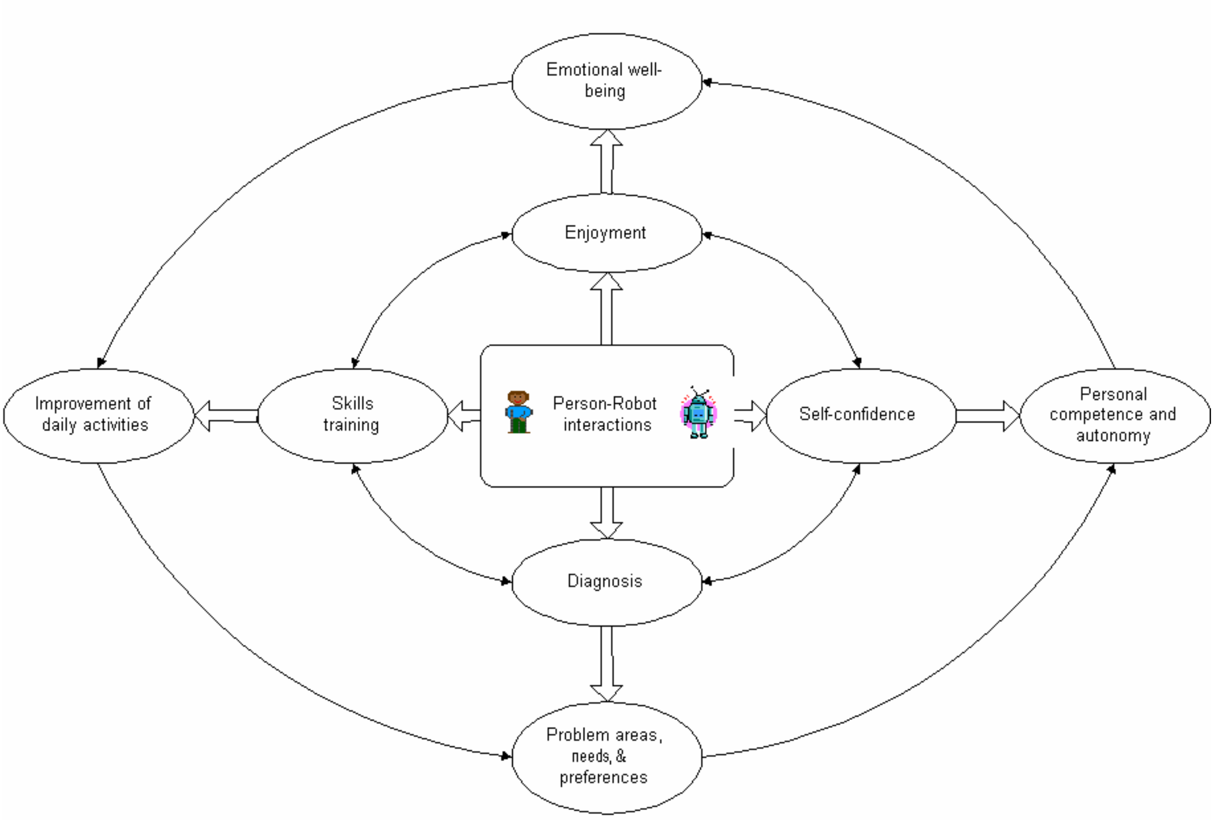

Figure 3: Multidimensional model of a person – robot communication as a complex interactive system.
Note to Figure 3. The correlation between system parameters and type of interaction
Skills training: sensory-motor stimulation, attention, and memory
Diagnosis: identification of problem areas, individual needs and preferences
Self-confidence: increasing personal competence and autonomy
Enjoyment: enhancing emotional well-being

virtual agent co-exists with the interacting person in the same given space-time continuum (GIST), becoming an interactive agent. This quality of an embodied agent is vitally important for people with limited resources, i.e., physical, cognitive or emotional impairment, or persons who strive toward further development through mastering certain skills. Secondly, because the interactive system behaves equifinally ('the same goal can be reached from different initial conditions or in different ways', von Bertalanffy, 1967, p. 74[16]), robots with different levels of artificial intelligence and types of sensory feedback can benefit people with different combinations of skills and abilities, working as an effective tool in a very broad context of individual situations. Thirdly, a systematic approach concentrates on the issue of matching a robot's behavioral configuration with individual profiles. All of the above is summarized in (Figure 3), which describes person-robot communication as an example of the complex interactive system. The model was developed with the use of available data derived from studies made on the crossroads of social robotics, computational entertainment, modern information technology, and cybertherapy. For this example we use a prototype described elsewhere.[12]

The two loops underlying person-robot communication create a complex interactive system. The internal loop is formed by the patterns that underlie skills training, diagnosis, enjoyment, and self-confidence as basic functions of the interactive robotic creature as it relates to the person's activities. The external loop embraces the results of the internal loop functioning, such as the improvement of daily or professional activities due to the sensory-motor and cognitive training, emotional well-being, personal competence and autonomy, and mental and physical profile highlights tailored to one's problem area, needs and preferences. The internal loop produces integrative system effects such as compensation and optimization, whereas the external loop yields effectiveness and adequacy.

ROBOTHERAPY AS A TECHNOLOGY-MEDIATED INNOVATIVE APPROACH FOR NON-PHARMACOLOGICAL TREATMENT OF PSYCHOLOGICAL PROBLEMS

In our approach,[9] *Robotherapy* was defined for the first time as a framework of person-robot communication aimed at the reconstruction of one's negative or lacking experiences through the development of new coping skills mediated by interactive technological tools. The effectiveness of robotherapy is influenced by both (1) one's past experiences, current needs and individual preferences, and (2) an artificial partner's non-transitive physical features and behavioral configurations defined through the intensity of simulations and responses. Our preliminary studies,[9-11,13] aimed at the psychological examination of human reactions emerging from communication with an artificial creature imitating an animal's behavior (i.e., the robotic cat NeCoRo), showed that:

- People across gender, age, and culture tend to perceive robots with life-like appearances as friendly companions.
- Regardless of physical mobility and/or cognitive status, people are able to communicate with the artificial creature at all levels: sensory–motor, cognitive-emotional, and individual-social.
- Interactive robots trigger positive behaviors and emotions such as interest, involvement, pleasure, and joy in the studied groups and individuals (people with disabilities such as multicardio infarct, sensory integration disorder, dementia, attention deficit disorder; children of 5-12 years old, elderly over 80, Americans, Japanese, and Russians).

CONCLUSION

Robotherapy might be considered the fifth major method distinguished in technology-mediated therapy with its own phenomenological and ontological status. An adequate methodology for this practical application may be best described in terms of robotic psychology as another new field of studying ethical, philosophical, and epistemological questions on the coexistence of people and robots, while at the same time examining psycho-physiological and psychological mechanisms that underlie robot-mediated behaviors.

Robotherapy as a new research area focuses on the analysis of person-robot communication, viewed as a complex interactive system, with the emphasis on psychological evaluation, diagnosis, prognosis, and principles of non-pharmacological treatment. One might expect that in the near future artificial creatures with a high robo-IQ and complicated synthetic sensory systems will be successfully used as mediators in person-to-person communication, as an interactive device for the training and development of certain individual and group skills, as a tool for guided physical and mental stimulation, and as a human companion in special situations and life circumstances. Robots with different levels of artificial intelligence and developed sensory feedback can benefit people with different combinations of skills and abilities and can be used as an effective tool in a very broad context of individual situations.

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The Importance of the Virtual Market and the Modification of Drug Scenarios.

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Abstract: *In order to develop and improve cybertherapy tools and systems for drug-related diseases, we need to have a reliable corpus of knowledge on up-to-date drug scenarios. Unfortunately, drug-related disorders are probably the most changeable issues in psychology, and have recently been strongly associated with the so-called "virtual" world. If psychological attempts in drug field remain founded on outdated information, the science of prediction and control will never rise. It has been estimated that at least a few hundred websites are dedicated to the use of recreational/ illicit drugs, as on the Web it is actually possible both to buy and synthesize these compounds. The lack of both professional attention to and scientific information on these issues is surprising indeed, since it is well-known that the computer knowledge of children and adolescents can be quite high. The main activity of European enforcement agencies has been missing the "virtual" market, and no mapping of the Web with regard to drug-related issues is available at the moment.*

The main aims of this project, financed by a grant of the European Commission, are: a) To foster collection and analysis of data; b) To start and implement an "early reaction system" for drug issues; c) To provide professionals from with a convenient and respectable evaluation and assessment of the material. As a consequence, it will be possible to identify new, emerging trends, and to provide information for prevention and immediate intervention. Methodology and results of preliminary trials are presented, and ongoing research issues are discussed.

INTRODUCTION

Every psychological intervention should be based on correct information on the "problem" and which variables are creating and maintaining the dysfunctional situation. Cybertherapy is supposed to lean on the same principles. Thus, before developing and improving cybertherapy tools and systems to apply to drug-related diseases, we need to have a reliable *corpus* of knowledge on up-to-date drug scenarios.[1] Unfortunately, drug abuse/dependency and addictive behaviors are probably the most changeable issues in psychology.[2] Because of the rapid and powerful development of Internet communication,[3] part of the drug scene has moved to the so-called "virtual" world, although its consequences are affecting many aspects of "real" society. As a result, professionals are forced to "run after" drug trends, as they cannot take preventative action, but merely try to stem damages. One foundation of scientific approach in psychology is that we can label our approaches as reliable, valid and effective, only if we are, in some way, able to predict and control an event. If psychological attempts in the drug field remain founded on outdated information, the science of prediction and control will never rise.[4] The present project was born in order to offer a more reliable source of information that will always be responsive to changes in drug trends. As it is not possible to freeze something unstable, we decided to concentrate the project on creating a method capable of remaining "tuned" to those movements.

Internet access greatly facilitates the free and easy exchange of ideas, opinions, and unedited and non-refereed information about drugs.[5] It has been estimated that a minimum of several hundred websites are dedicated to the use of recreational/illicit drugs. In fact, a significant change in drug scenarios has recently occurred. On one hand, the drug scene has revolutionized. Classical compounds (e.g. heroin) are no longer "trendy"; molecules which can be snorted, inhaled, or ingested are preferred; excitatory and psychedelic properties are a target of interest; club and rave culture has spread; and relative "awake" and "always on the edge" philosophy has broadened. On the other hand, the drug "trade" has evolved as well. We can outline this new feature in three main levels. First, we find the classic "structured hierarchy" market, where drugs are sold within a closed system and the market is kept through the threat of violence. At this level, communication is facilitated by mobile phones and the target substances are crack cocaine and heroin. At a second level we have a sort of "free" market: a fragmented system where dealers mainly work independently and target synthetic drugs. The third generation of drug diffusion, which is increasing in an exponential curve, is the "e-commerce" market, using the Internet facilities. A wide range of substances can be bought through this new market: cannabis seeds, a number of medicinal products not requiring the normal prescription, performance-enhancing hormones, ecstasy, magic mushrooms, mescaline, etc.

A rising number of sites on the World Wide Web are, in one way or another, advocating the use of drugs. Scientific literature is rich in examples of clinical cases associating drugs and the Internet: a patient who came to medical attention as the result of recreational drug-taking behavior directly influenced by her Internet browsing; a case in which the only information available about the medical effects of a new "designer" drug was found on a recreational drug Internet Web site.[5]

Precise instructions (the "recipe") to synthesize illicit products (i.e. GHB - liquid ecstasy; ecstasy, etc.) are available to everyone with an Internet connection. Moreover, the Internet is at the moment one of the major ways for the dissemination of a new class of drugs: the so-called "ecological drugs" (i.e. herb and plant derivatives ranked and sold as stimulants, sedatives, and psychedelics). In fact, consumers can easily locate advice and suggestions to enhance their drug experience. The advice offered is usually misleading at best and dangerous at worst. Potential Internet users should be made aware of these problems and ways of minimizing the risk should be found.[6] Users can also buy illicit/ recreational compounds by simply using a credit card. Below a web page is shown as an example of one of these sites (URL: http:// www.sjamaan.com).

On this site the "customer" has access to a wide number of substances. Detailed (non-scientific) information is given for each item (including chemical properties, dosage, effects, ingredients, warnings, contents, etc.). Like a normal commercial website, prices and a shopping basket are displayed. In Figure 2 liquid ecstasy is given as an example.

Recapitulating, different variables in this "drug-and-Internet" scenario can be pointed out:

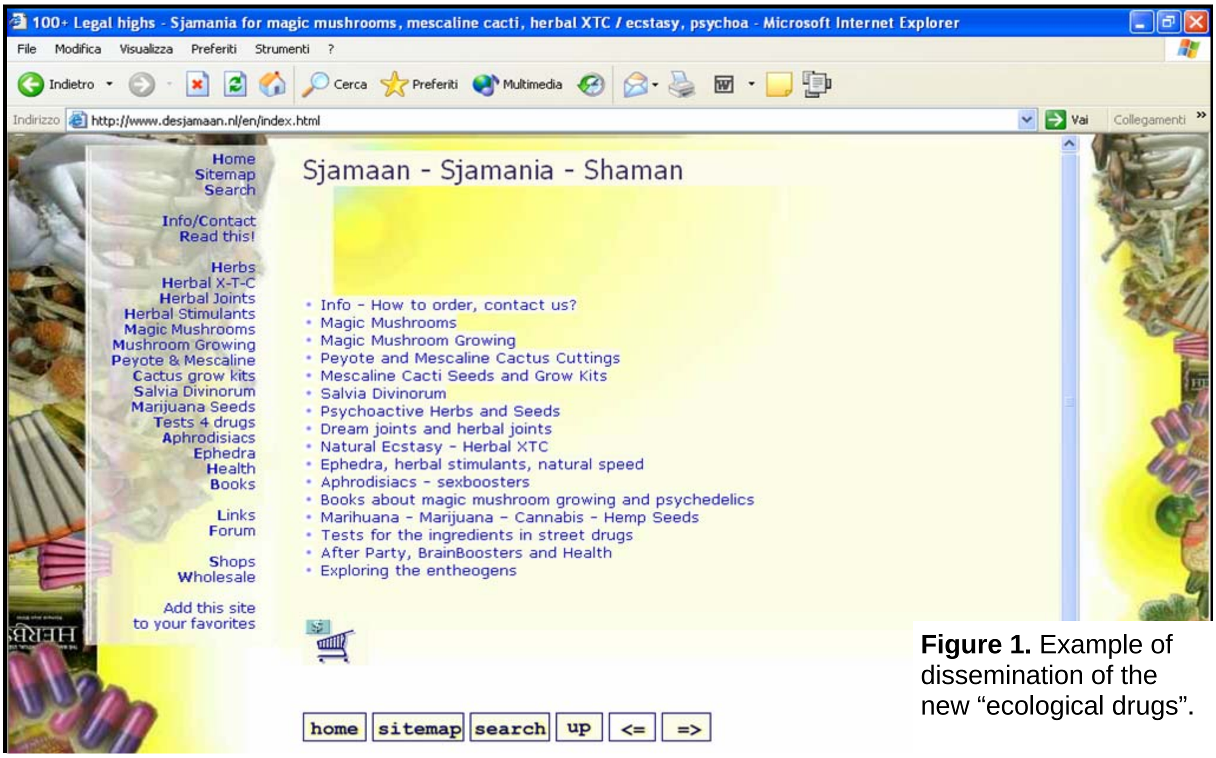

Figure 1. Example of dissemination of the new "ecological drugs".

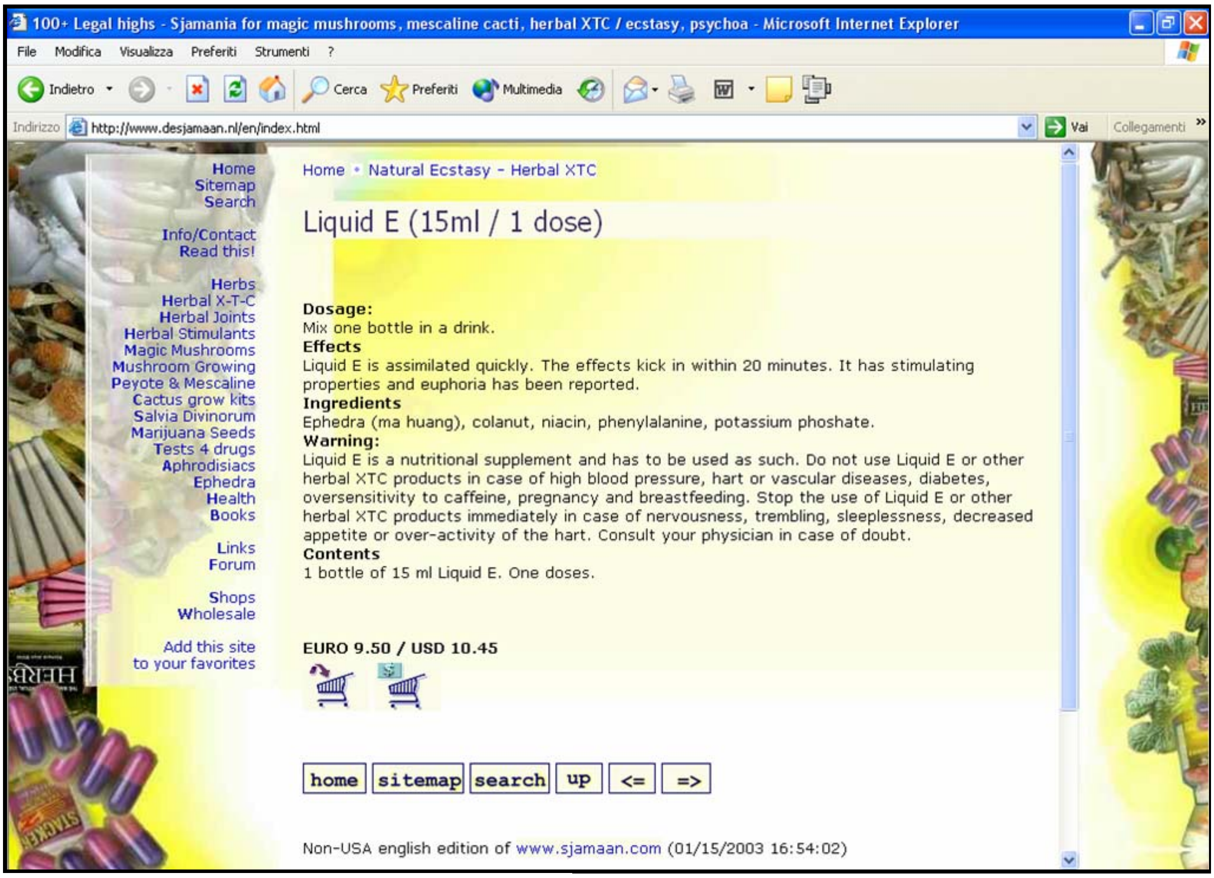

Figure 2. One of the various item offered on this site (i.e. liquid ecstasy) is described and can be purchased with a normal credit card.

a) Strong cultural transformations, which changed part of the drug business into something easier and more accessible to a broad range of people: from street sales to the convenience of home, office, school.
b) Development of a "dot-com generation" [7].
c) Easy access and enormous variety of offers (hundreds of Web sites selling and advocating; power of the Web as a media).
d) Misuse/misinformation of the scientific evidence.
e) Targeting young people (with high computer knowledge).

The lack of both professional attention and scientific information on these issues is surprising indeed, since it is well-known that the computer knowledge of children and adolescents can be quite high. For example, in the case of ecstasy, we find that 90-92% of the population of users are just experimenting this substance (they are not problem users yet). Chances are this population is influenced, directly or indirectly, by Web messages (e.g. advertisements, banners, newsgroups, etc.).

The EMCDDA (European Monitoring Center for Drugs and Drug Addiction) has implemented an "early warning system" which relies on what is actually seized in the European illicit markets. However: a) those drugs which were seized are, by definition, those drugs which will never be taken by consumers; b) the system does not take into account the possible suggestions and trends coming from emerging markets (e-commerce) [in the UK alone at least 3 million people under the age of 50 are usually accessing the Web to buy items of different natures]; c) the "early warning system" is not immediately available through the Web, nor is it automatically received by all the different Drug Treatment Units professionals of the EU; d) the role of European enforcement agencies has not been extensively focused (as far as we know), on the Web, but just on the 'real' (i.e. non virtual) market. To the best of our knowledge, no mapping of the Web with regard to drug-related issues is available at the moment.

As a result of the described situation, there is a:
a) Lack of professional attention;
b) Lack of scientific information;
c) Focus on the actual "real" market by agencies, resulting in a lack of attention to the "virtual" market; and
d) No existing map of the Web with regard to drug issues.

The present project has been designed and proposed to the European Commission, Public Health Directorate, which is financing the research.

PILOT TRIALS

This project is taking place in 11 European Countries: UK, Italy, Germany, Portugal, Spain, France, Belgium, Malta, Finland, Denmark, and Scotland (Northern Ireland and Poland are also going to be part of the research). The first part of the study included independent pilot studies in each country. As a consistent part of the final methodology has been inspired by one of the pilot studies, we are going to present some data.

This pilot study, developed by the University of Parma, tried to use an extremely naive method in order to mimic a possible approach of youngsters to finding drug-related information on the Web. In particular:

1. To use the Google search engine (http://www.google.com);
2. To make a query with the key words: DRUG ABUSE;
3. To enter in the sites indicated as result and visit them;
4. To classify the sites visited using the following categories:
   - Government site giving information or misinformation;
   - Non-government site giving information or misinformation;
   - Site giving detailed information on how synthesize different drug substances;
   - Site that enabled the user to buy drugs online;
   - Chat rooms/Newsgroups discussing on drugs.
5. To describe and comment on the site.

Pilot trial results: The results to the simple query "DRUG ABUSE" on Google gave 2,130,000 (2,140,000 if not grouped) pages. Nevertheless, the number of pages which could be opened was 1,000. Subsequently we reduced the sample, randomizing a set of pages displayed, and visiting and classifying only these pages. To do this we used an online generator of random numbers (http://www.randomizer.org). We randomized a 1,000 numbers set and used the first 50 to sample pages. After that we visited and evaluated the related sites using a data sheet created for the above categories. From an immediate analysis of results we saw that Google lists PDF and RTF documents, and pages which are part of a site. When extracted, these pages lose their meaning (and if we want understand and classify the webpage, we have to presume the original address of the site from the first part of the URL and try). In this way the percentage of pages useful for the study decreases enormously.

Pilot trail discussion: Was this bad result a matter of the search engine? In 1999[8,9] the first 10 search engines in the world were able to cover between the 2 and 16% of the estimated amount of Web pages (see Table 1).

Obviously the Web and search engines change and grow. But even nowadays it is difficult to affirm that a search engine can cover more than 35% of the world's web pages. The latter consideration can be decisive if we think of the method we use like a "vehicle:" we can use it however we want, but the range of options available has been pre-selected.

After that we wondered if other approaches would have been possible, i.e.: what else beyond Google and other search engines? A possible

SEARCH ENGINE	% WEB COVERING
Northern light	16
Snap	15.5
AltaVista	15.5
HotBot	11.3
Microsoft	8.5
Infoseek	8
Google	7.8
Yahoo	7.4
Excite	5.6
Lycos	2.5

Table 1. How the 10 most important Web search engines were covering the number of pages on the Internet in 1999 [9].

way to avoid the limits of search engines and indexes (different criteria on selecting and search information, resulting in restricted and arbitrary covering of Web) is to use "METACRAWLERS." This software enables one to search the archives of many search engines and create a single list removing duplicates. Examples are: "ALL 4 ONE SEARCH ENGINE," "ALL IN ONE," "ASK JEEVES," "METACRAWLER," etc.[10] Search engines can provide only a partial response to customers requests,[8,9] in terms of instruments of information management. The time spent trying to find sites we are looking for could be used in "higher" functions. A few software houses have caught this request and created specific software for "information retrieval" (analysis of contents), built with algorithms of artificial intelligence: the so-called SEARCH AGENTS. They operate following specific instructions and they "learn" and improve through feedback. An interesting example of these SEARCHBOTS is given in a project of Dartmouth University (USA). It would be also possible to use a free server database (in SQL language) to collect information produced by different Collaborators in the UE Countries. Basically it works like a page (opened when the researcher explores the Web) where it is easy to provide estimates about the pages examined. A database engine on local PC (e.g. Microsoft Access) can be also used, even if it becomes more difficult to assemble all data. Otherwise we could create a specific software using *Phyton* or *Perl* languages, once we have set our keywords (on the basis of the analysis of 1,000 pages, for instance). A subsequent statistical analysis of data could be done with software like SPSS, for instance, if the categories have been created with a numerical base.

What is then the most suitable way to proceed? Which is more reliable: men or machines? Apparently machines cannot substitute for men, at least with an adequate cost/benefit ratio. This means that we could spend our human efforts in doing something "higher." If we delegate trained software to Web scanning, we could concentrate on the analysis of "underground" drug-related communications. In the conclusion of this pilot trial we stated that the main matter concerns the method. By using a bottom-up approach, we can draw a centered, methodological structure goal. For these reasons the suggestion of the pilot investigation was to split the operation in two parallel works: a quantitative approach (technology) and a qualitative one (human intelligence).

PART TWO: THE PSYCHONAUT 2003 RESEARCH, STATE OF THE ART

OBJECTIVES

Main aims of the "Psychonaut 2002" project are:

a) To foster collection and analysis of data from web pages related to recreational/illicit psychopharmacological substances;

b) To start/implement an *"early reaction system"* (through the data/information collected from the web-virtual market) in relation to public health threats linked to drugs (especially new/synthetic drugs) at a European, national and regional level;

c) To provide the professionals from the different European countries involved in the project with an easily accessible and reliable evaluation of the material. As a consequence, it will be possible to identify new, emerging trends, and to provide information for prevention and immediate intervention.

METHOD

In a preliminary meeting with researchers from all 11 European Countries of the project, researchers examined all the pilot trials and evaluated different possibilities. Below is a summary of the final methodology agreed. Main research guidelines involve:

1. Access random number on Google.
2. Visit the first 100 sites and analyze them.
3. Select at random according to set plan.
4. Follow links on these websites that are going to be thoroughly researched.
5. Set criteria for core accountabilities.
6. Allow the research to be developmental.

(Chat rooms as well as websites should be evaluated in each country's home language; technical tasks will be carried out in English.)

Each country is now evaluating and assessing websites according to set criteria (e.g. based on: scientific soundness of the information presented, level of legality/illicitness of substances described, commercial/non-commercial nature of the site, etc.). The Uniform Resource Locators (URLs) of these pages will be collected by automatic (i.e. metasearch

Table 2. Mandatory tasks given to core members

DRUG	COUNTRY
Ecstasy	London
Precursors	France
Heroin, Opiates	Italy
Other stimulants, inha-	Italy
Herbs, plants	Finland
Prescription drugs, to-	Scotland
Cannabis	Denmark
Amphetamines	Germany
"Dance" drugs	Spain
"Ecological drugs"	Portugal

software) and manual means. An e-mail discussion list to facilitate communication between collaborators has been organized. The collected URLs and the review of their contents will be published in both conventional and electronic peer-reviewed journals. All of the statutory and non-statutory Addiction Services professionals of the 11 European countries involved will be regularly provided with reviews of the examined material. A protected website, with encrypted and restricted access available only to the registered professionals, is also going to open.

EXPECTED RESULTS AND DISCUSSION

Below is the timetable for the project:
Start: 1st October 2002. Organization of the first meeting (London, UK): discussion of the technical organization of the work for web mapping; agreement/consensus on the technical aspects of the search and of the metasearch; discussion about the organization of the e-mail list and of the webpage.

December 2002: Completion of the web mapping at the International, European and national level. Evaluation of the material on the webpages, according to set criteria. Building an e-mail discussion list to facilitate communications between collaborators.

May 2003 – October 2004: Six reviews a year of the web (plus evaluation of the material) for the European professionals. Publication of web-page contents and reviews in peer-reviewed conventional and electronic scientific journals and magazines. Building a webpage of the Psychonaut project.

October 2003: Second meeting (Rovigo, Italy): discussion of the findings of the web mapping at the international, European and national level; discussion of the findings with regard to the periodical review of the web mapping; discussion about misinformation of illicit drugs on the web; evaluation of the level of interest shown by the different professionals of the different countries.

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Original Research

A Pilot Study of a Thought/Facial-Controlled Robotic Arm for Brain-Injured and Quadriplegic Persons

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Abstract: *An interface that allows a robotic arm to be manipulated by the Cyberlink 'mental' interface has been developed using C++. The system has been evaluated by ten non-disabled volunteers with no previous experience of the interface or with the use of the Cyberlink. A quadriplegic man, and a brain-injured man, both of whom had experience with the use of the Cyberlink also tested the system. It was found that all twelve participants were able to control the robotic arm successfully. Non-disabled participants were able to achieve this in significantly shorter times than the two participants who had a disability. One hour or less of training and practice was required.*

In a second study pilot study the quadriplegic participant used a Don Johnston sensor switch to operate a batch file command for the robotic arm. The batch file command was executed from a single button on the computer and allowed the participant to use the robotic arm, from a specified location on the table, to successfully eat two cookies, provided they were put in a cookie shoot in a marked location.

INTRODUCTION

Approximately five million Americans have a brain injury that may inhibit their ability to communicate and/or use their limbs. The Rehabilitation Research and Training Center on Aging with Spinal Chord Injury (RRTC) has stated that many of the millions of spinal chord injured persons are experiencing longevity into their 70's, 80's, and beyond. The RRTC has been concerned about the quality of life for many such people and has worked with family members of the disabled persons, scientists, educators, community service providers, and a variety of engineers of other disciplines to improve the quality of life of such individuals.[1]

Dr. Doherty and students at Fairleigh Dickinson University have been working with Bruce Davis of Cheshire Home in Florham Park, N.J. and members of other nearby institutions to develop and test computer-controlled robotic arms to improve the quality of life for persons unable to use their upper limbs. The work reported here is part of that program.

THE PILOT STUDY

The participants consisted of four adult males and six adult females without a disability, and two adult males, one of whom was paraplegic, the other having a brain injury. It would have been desirable to have more disabled persons but only these two returned their permission slips and the research was approved to be performed until May 31, 2002. The pilot study was conducted at two long-term care facilities and at Fairleigh Dickinson University after all permissions were obtained.

The experimental task was to use the Cyberlink to control the robotic arm in order to pick up a paper ball and move it to a defined location. Picking up an object of any kind and moving it to another location simulated an activity of daily living that the disabled participants wished to perform but cannot presently do. Control of the Cyberlink was achieved by means of contact electrodes located on a headband. The experiment started on March 30, 2002 and ended April 17, 2002.

HARDWARE

The robotic arm was obtained in kit form (OWI-007 Robotic Arm and Interface kit, Images SI, Incorporated) and assembled by the investigators. Details of the Cyberlink, and its use with persons having a disability, have been given in detail elsewhere.[2]

Figure 1. Bruce Davis using the thought/facial-controlled robotic arm system.

SOFTWARE

The graphical user interface (GUI) was developed using Visual C++ version 6.0. This GUI is an intermediary between the Cyberlink mental interface and robotic arm. It works by scanning a series of buttons with associated robotic functions. In order to select a function the user performs a left click with the Cyberlink. That function is then operational until a second click is performed. The selected function then ceases and scanning is resumed. The software operates via the laptop parallel port (See Figure 2).

PARTICIPANTS

The twelve participants were adult males and females from 22 to 56 years of age and came from 5 continents. Some took medications that

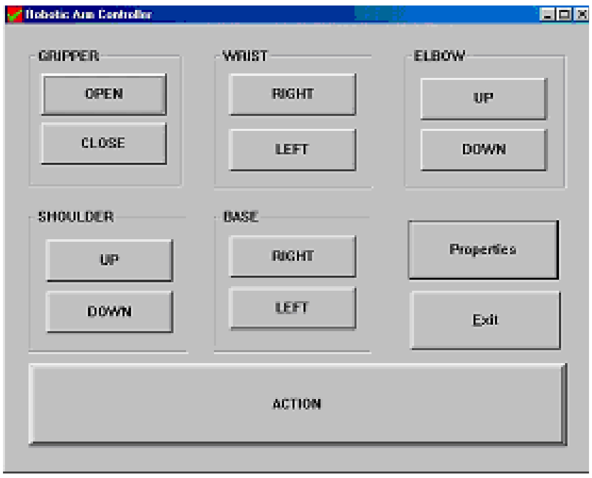

Figure 2. Robotic Arm Controller Program

may or may not have affected the operation of the robotic system. Only two participants lived in long-term care facilities.

METHODOLOGY

The two available institutionalized participants were visited to give an hour-long training demonstration on the use of the robotic arm and mental interface. This training preceded the actual experimental task. This special consideration

Table 1. Participant Profile Table

Part. #	Profile	Prescribed Medications Used By Participant	Gender	Institution-alized (long term care facilities)
1	Quadriplegic, Verbal, C5 spinal chord injury	Dantrium	Male	Yes
2	Brain Injured	Anti-Parkinson	Male	Yes
3			Female	
4			Female	
5			Female	
6		Anti-Inflamma-tory	Female	
7			Male	
8			Male	
9			Male	
10			Male	
11			Female	
12			Female	

was given to the disabled persons in the study because of the recommendation of Miller,[3] who states that many special needs people need extra encouragement and time to learn or do tasks. The participants were then visited on April 13th or 17th, depending on their schedule and availability due to daily medical regimes in the facilities. The electrodes and equipment were sanitized before the participant was put in contact with the equipment.

Each participant was fitted with the electrode embedded in a headband and fastened to the forehead. The computer-aided tracking program

(C.A.T.)[4] used to operate the mental interface control of the cursor, was then started. A second interface program to control the robotic arm (Figure 2) was started. The C.A.T. only allowed the user to perform a click while the program built by the students (See Figure 2) allowed the user's click to control the robotic arm. The participants were told to move the base of the robot 90 degrees counter clockwise, lower the arm, and open the gripper to obtain a ball of paper. The participant was then instructed to use the system to close the gripper on the ball and move the arm approximately 135 degrees. The final step was to put the ball on a designated spot. The task was considered done when the gripper was opened, releasing the ball in the new location. The researcher was always present because of the safety implications of using a robot.

RESULTS

The participants were all successful in using the robotic arm system to do the task after an hour or less of training. The non-disabled persons received ten minutes or less of training that consisted of a demonstration explaining how to perform a click and control the robotic arm. However, the disabled people took much longer to perform the task in spite of the increased training. Table 2 describes the results for each of the participants.

On occasion it was found that participants had difficulty implementing a click with the Cyberlink. On these occasions the researcher had to intervene and manually restart the C.A.T. program so that the Cyberlink could perform clicks to use with the robotic arm program. It was apparent to the researcher that performance could be greatly improved by having a mental interface whose control software was more stable. The two disabled participants gave permission to have their results filmed.

EVALUATION BY PARTICIPANT ONE

Participant One, who is a co-author of this paper, was asked to give his own evaluation of the interface. This is reproduced below:

I have not been able to use any prosthetic limbs since my accident and I feel more should be done to enable others and me to work. The results took me thirty minutes but would have taken much less time had the Cyberlink been more robust. I think the students' use of contextual inquiry design and prototyping was good because my particular condition and situation was the primary design factor. The interface was fine but the problem was being able to click. I then often had to wait a minute before the robotic function I wanted to perform was available again.

I also think the buttons and fonts should be bigger because many disabled persons also have vision problems. The buttons should also change color as they are highlighted so I don't have to squint which often caused an unwanted click. The interface was a good start and did enable me to pick up two objects and move them to a new location. That is something I could not do in the last 15 years without asking someone to do it for me. I think that research and development of this kind is essential to the future of independently controlled enabling devices for severely disabled people and should be greatly encouraged.

EVALUATION BY PSYCHOLOGIST

One can see by using the name "robotic arm" that we are trying to humanize the use of technology for the disabled persons as we try to give them the ability to be more independent.

Table 2. Results of participants using robotic system to perform task

Part. #	Time to Successfully Perform Task	Previous Cyberlink Mental Interface	Comments
1	Approx. 30 minutes	YES	He did the task twice at his own request without intervention
2	Approx 20 minutes	YES	
3	8 minutes		
4	5 minutes		
5	7.5 minutes		
6	Approx 15 minutes		
7	7 minutes		
8	9 minutes		
9	3 minutes		
10	3 minutes		
11	9 minutes		
12	2 minutes		

There may be a difference in the perception of the value of the robotic arm outside the USA. The American disabled users in our study were more interested in using the arm for giving them independence for social and recreational purposes while some people with fewer resources outside the USA may be interested in using the robotic for more practical purposes such as vocational rehabilitation. People in America often think that a feeble body means a feeble mind and there is often a tendency by non-disabled Americans to underestimate the value of the disabled person. A person's value is often related to their physical and mental capability. A robotic arm may be a method of increasing that disabled person's capability and perceived value.

GENERAL DISCUSSION

It was very evident from observing the test subjects that the disabled people have a slower reaction time when selecting highlighted buttons on the screen. Spending one second on each button as it scans through the list of functions may be acceptable for people without a disability but severely motor-impaired persons will generally require a longer 'dwell' time in order to perform a click on the correct button. Everyone cannot use the same scan setting for selecting buttons to control the robot. Our system therefore allows the user to set the dwell time.

The robotic interface also connected through the parallel port of the user's computer. These ports can be one of three common addresses. We therefore created an option in properties that allowed the user to perform a click and change to one of the common three port addresses. This selection of the port address then allowed the user to directly use the student program to operate the robotic arm. The disabled users indicated they were happy that they could independently select a port without relying on a health care worker or engineer to configure this for them.

A simple linear scanning system was used, and participants did report some frustration with the cycle time between options. The quadriplegic user was initially happy that the interface worked and he could independently use the system to move objects on his hospital table. However, as he improved at operating the robotic system, he then wished to perform the tasks faster or at least more efficiently. He said, for example, that if he missed the open gripper function, he must then wait 44 seconds until the other buttons were scanned and this function became available again. It may be that a more sophisticated scanning system, based on an analysis of the task required and the possible options open at any one time, would improve this. The student designers also speculated that this time could be improved by scanning each major object such as gripper, wrist, shoulder, base, and elbow, then the functions associated with that object. For example, a user might select the wrist object, then a specific function such as wrist open, or wrist close. Our next experiment and software revisions will incorporate these new features.

However, this simple experiment has demonstrated that it is possible to use the Cyberlink interface to control a robotic arm, albeit with a limited sample in terms of numbers of participants and the range of disabilities.

A more interesting problem is how participants with significant disabilities are able to relate between the positioning of the robotic arm and control from a computer screen. Previous work with the Cyberlink[5-7] has shown that users with profound disabilities such as traumatic brain injury or spinal chord injury have most to gain from the use of this technology. Such users have little control over their own body movement and so have a limited view of the robotic arm and its field of operation. Spatial awareness of the position of the arm in relation to other objects then becomes a significant issue.

THE COOKIE DISPENSER

Participant One verbalized a desire to be able to independently eat some processed food, such as a cookie, using the robotic arm. He then asked if the students could improve the previous system to allow him to eat by selecting only one button. He also wanted to use a Don Johnston sensor switch as the input device.

HARDWARE

The Don Johnston sensor switch is a device that uses EMG collected from an electrode placed on the user's forehead to create events such as clicking on the desktop.

SOFTWARE

The students used the same Visual C++ program to develop an interface with four buttons. One button said EAT and it executed a function that had a batch of commands consisting of small timed movements that operated the robotic arm and moved it from a "home" location to pick up the cookie from a dispenser and then take it to the mouth of the user. The second button said FEED and released the food in the participant's mouth. The third button said RETURN and executed a batch function that returned the arm to the original "home" location. The fourth button said STOP. Its use is obvious. The buttons were scanned at a speed of two seconds each. The speed was optimized for comfort at the request of the participant.

RESULTS

The participant was able to successfully use the software to control the robot arm and feed himself a cookie. However, in this prototype version of the hardware there were problems (such as gear slippage) that prevented repeated use of the system. The time taken for the successful run was approximately one minute.

DISCUSSION

Large buttons that perform a series of small movements in a predefined task is a definite improvement in "time to do a task" as compared to manual control. However, slippage of plastic gears and vibration of the servomotors cause the robotic arm to move to unwanted locations, and thus the batch commands could not be used to reliably perform repetitive tasks like eating. Eating a cookie once is not acceptable to the user. It seems a robotic arm with positional feedback is needed so that the arm can be placed in a predictable "home" or "goal" location. There are also safety implications with a system such as this. It is vital that any system failure results in a safe state.

CONCLUSION

Spinal chord injured users with a vertebrate five rating, such as User One, cannot presently use any artificial limb or any device to operate a computer to control a mechanical device to move objects and perform activities of daily living. These two pilot studies show that a diverse group of people with and without a disability may easily and quickly learn to operate and use a Cyberlink, a visual interface that incorporates scanning, and a robotic arm to move objects on a table to do some activities of daily living. This is a first for User One, and has helped his self esteem and given him some hope that he can perform some activities of daily living with a robotic arm and mental interface. The second study shows the same paralyzed user feeding himself for the first time in years, even if it is in a limited capacity.

Figure 3. Participant 1 Eating Cookies with Robotic Arm

FUTURE WORK

We are discussing our needs with Images Co. of Staten Island, New York. They are adding digital positional feedback so timed loop programming can be discontinued and a home or goal location can be named regardless of the present position of the robotic arm.

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Tactile Illusion in a Real Hand Evoked by a Synchronous Visual Stimulus on a Virtual Hand

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Abstract: *Virtual Reality (VR) technology can provide various stimuli (including visual and auditory stimuli) simultaneously in the virtual environment, and this encourages user interaction. Virtual reality is a set of computer technologies, which when combined, provides an interactive interface to a computer-generated world. In this world, the subject can see, hear, and navigate in a dynamically changing environment in which he participates as an active player by modifying the environment according to his will. Moreover, the subject can get a feeling for the virtual environment in much the same way as one experiences real life situations. In the real world, a plethora of information from various modalities may be in conflict and modulate each other to form an illusion. In this study, we investigated whether a tactile illusion on a real hand could be evoked by a virtual stimulus, the time required to generate this illusion, and its duration. This study shows that the illusion occurred and was correlated with the presence score in the virtual environment.*

INTRODUCTION

Many events in everyday life are registered by more than one sense organ, for example by both the eyes and the ears. Consequently, the coordination and integration of information derived from different sensory systems is essential for providing a unified perception of our environment, and for directing attention and controlling movement within the environment. The capacity of the central nervous system to combine inputs across the senses can lead to marked improvements in the detection, localization, and discrimination of external stimuli, and to faster reactions to those stimuli. In addition, many stimuli from various modalities might conflict, modulating each other or creating an illusion.

A number of studies have reported that a visual illusion can be induced by sound; for example, a single flash of light is accompanied by multiple auditory beeps, or the single flash is perceived as multiple flashes.[1,2] In addition, strong cross-modal integration can also occur as an emergent attribute of dynamic arrays, specifically the direction of apparent motion.[4]

Investigators have used the Event-Related Potential (ERP) in order to determine the modulation of somatosensory cortex activity by a non-informative view of the stimulated body site with concomitant enhancement of tactile acuity in normal subjects,[5] and accordingly, to answer whether the cross-modal influence on visual perception occurs at the level of the modality specific visual pathway or later.[3] A tactile illusion could be referred to as an alien limb.[6] The illusion has been explained by the spurious reconciliation of visual and tactile inputs reflecting functional connectivity. It was also investigated in schizophrenia.[7] However, all these studies were base on real-life illusions.

Virtual reality (VR) technology can provide various stimuli simultaneously in a virtual environment, which causes the user to interact, providing visual and auditory stimuli.[8] Virtual reality is a set of computer technologies, which when combined, provides an interactive interface to a computer-generated world. VR technology combines real-time computer graphics, body-tracking devices, visual displays, and other sensory input devices, which immerse a participant in a computer-generated virtual environment. The subject can then see, hear, and navigate in a dynamically changing scenario in which he participates as an active player, modifying the environment according to his interventions. However, because of technological constraints, little research has been conducted on whether this kind of illusion could be evoked in the virtual environment (except for a study on haptic perception[9]).

Therefore, we investigated whether a tactile illusion on a virtual hand could be evoked by virtual stimulus, how long it takes to create such an illusion, and its duration.

MATERIALS AND METHODS

Subjects: 24 undergraduate volunteers participated in this experiment. They were right-handed males, with an average age of 22.12 years (SD = 2.57).

Instrument: The virtual reality system for providing stimulus consisted of a Pentium IV PC, DirectX 3D Accelerator VGA Card, Head Mount Display (HMD , i-visor DH- 4400VPD), and a 3DOF Position sensor (Intertrax2). The PC with a 3D Accelerator VGA Card generates real-time virtual images for the subject to navigate. A position sensor transferred a subject's head orientation data to the computer.

The virtual environment consisted of a virtual human in a room with a gimlet near the virtual hand. The gimlet moved forwards and backwards at the same time as a real tactile stimulus (an air-puff) was produced and controlled by a computer (See Figure 2).

PROCEDURE

Subjects were individually seated at a desk wearing virtual reality (VR) equipment (HMD with a position tracker). Subjects were asked to place their left arm on the desk in a position similar to that of the virtual arm. They could not actually see their own left arm, and could only see the virtual arm, as the HMD covered their eyes completely. Subjects were instructed to immerse themselves in the virtual environment and to respond when they did not feel a tactile

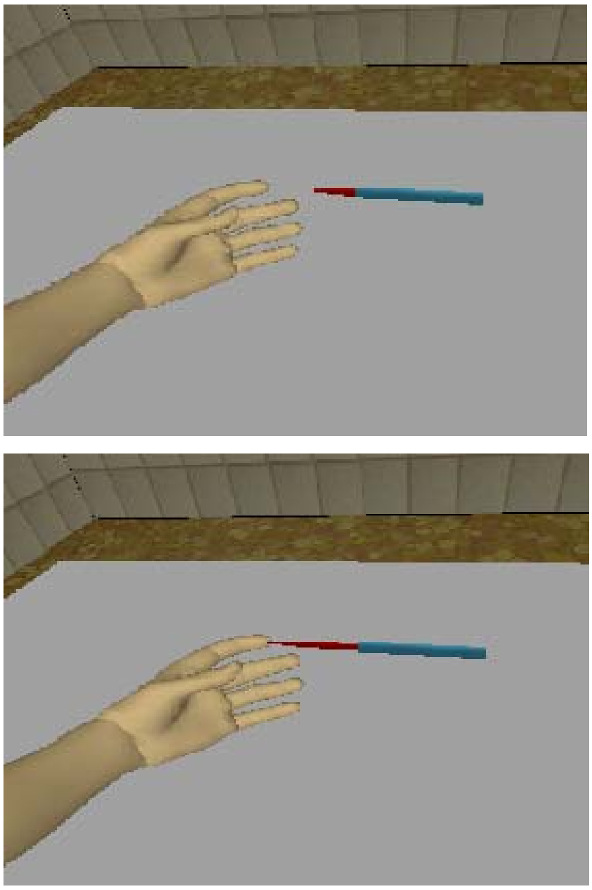

Figure 1. The virtual arm and gimlet.

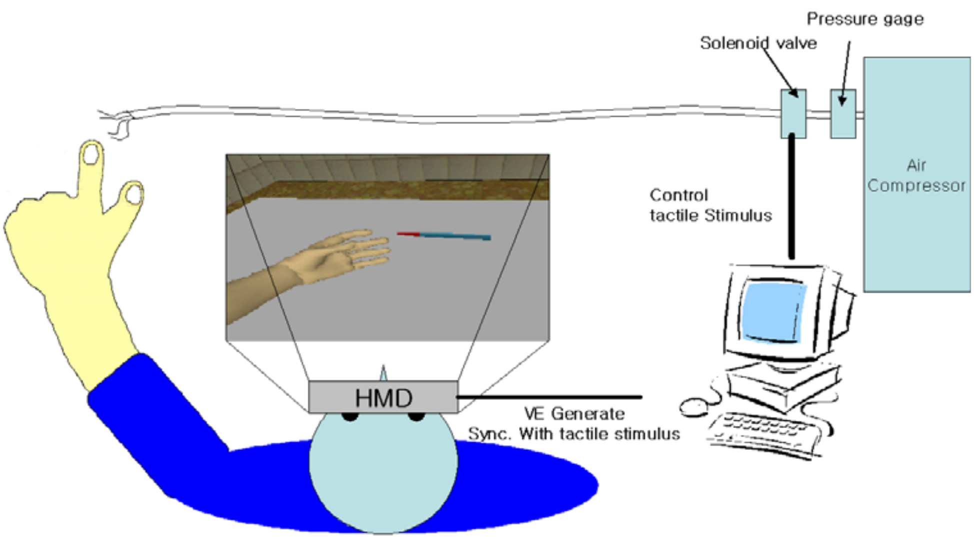

Figure 2. Diagram of the experimental setting.

stimulus. In each session of 5 sessions, a tactile stimulus was provided 60, 50, 40, 30, and 10 times in combination with a visual stimulus, (V+T), and a visual only stimuli was intermittently applied until the subject responded affirmatively. When he responded to the visual only stimulus, the next session was started (See Figure 3). Based on the subject's behavior, the following were noted, 'time to evoke the tactile illusion', 'the lasting period' and 'the correlation between the duration and the period'. After the testing experience, subjects completed a questionnaire that requested: a description of the subjects experience, and an affirmation or denial of the occurrence of nine specific perceptual effects as noted by a survey that was modified to fit this experimental setting (See Table 1).[6] Subjects were also asked to complete a VR questionnaire that requested details of their VR experience and the compatibility of VR, Witmer's Presence Questionnaire (PQ) and the Immersive Tendency Questionnaire (ITQ).[10]

DATA ANALYSIS

Scoring for each of the nine perceptual effects was high for affirmation of the illusion and low for the denial of the illusion. Scoring was established as follows: 1, ---; 2, --; 3, -; 4, 0; 5, +; 6, ++; 7, +++. In addition, we defined an illusion index as the mean score for all perceptual effects. Presence scores were average PQ scores, and the score of negative questions were reversed. In addition, the correlation between the subscales of PQ and the illusion index was investigated.

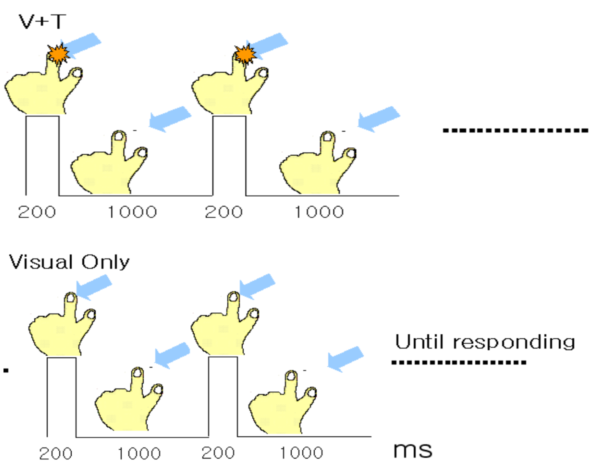

Figure 3. Stimulus provided in the experiment

Table 1. Illusion questionnaire for the virtual hand experiment range from 'agree strongly'(+++) to 'disagree strongly'(---)

1. It seemed as if I were feeling the gimlet's touch in the location where I saw the virtual hand touched.
2. It seemed as though the touch I felt was caused by the gimlet touching the virtual hand.
3. I felt as if the virtual hand was my hand.
4. It felt as if my (real) hand was drifting towards the right (towards the virtual hand).
5. It seemed as if I might have more than one left hand or arm.
6. It seemed as if the touch I was feeling came from somewhere between my own hand and the virtual hand.
7. It felt as if my (real) hand was becoming 'virtual.'
8. It appeared (visually) as if the virtual hand were drifting towards the left (toward my hand).
9. The virtual hand began to resemble my own (real) hand, in terms of shape, skin tone, freckles or some other visual feature.

RESULTS

No significant behavioral characteristics were observed because most of the subjects responded as soon as the air-puff stimulus disappeared, though a few subjects showed a delay between the air-puff stimulus disappearing and tactile-stimulus feeling disappearing.

However, from the perceptual effect report made by the subjects, it was evident that an illusion had occurred (See Table 2).

The presence score was 159.13 (SD=35) and the immersive tendency score was 118.25 (SD= 16.42). The scores of the PQ and ITQ subscales are shown in Table 3.

A correlation was found between the illusion index and the presence score ($r=0.539$, $p<0.01$), but the immersive tendency score was not significantly correlated to the illusion index. In particular, the control factor and sensory factor in PQ were correlated ($r=0.483, p<0.05$; and

Table 2. The Perceptual Effects of Virtual Hand Illusion (n=24)

Modified Cohen's questions from Table 1	Mean	SD
Question 1	3.8333	2.0990
Question 2	3.8333	1.8572
Question 3	3.2917	1.6806
Question 4	3.0833	1.6396
Question 5	3.0833	1.7173
Question 6	3.9167	1.8863
Question 7	2.9167	1.6129
Question 8	2.6250	1.2790
Question 9	2.3750	1.3126
Index	3.43	1.16

Table 3. The subscale scores of PQ and ITQ (n=24)

		Mean	SD
	Control factor	61.08	16.26
	Sensory factor	51.25	11.89
PQ	Distraction factor	14.25	4.65
	Realism factor	26.21	7.88
	Nothing	6.33	1.69
PQ total (240)		159.13	35
	Involvement factor	43.67	8.48
ITQ	Focus factor	42.79	6.21
	Game factor	10.63	3.85
	Nothing	21.17	4.12
ITQ total (100)		118.25	16.42

r=0.543,p<0.01, resp.). Question 1 in the illusion questionnaire was significantly correlated with prior experience (r=-.0414, p<0.05), and Questions 5 and 6 were significantly correlated with control factor and sensory factor in the PQ and with the PQ score. Question 5 was correlated with involvement factor in the ITQ. Question 8 was correlated with the sensory factor in the PQ.

Table 4. The correlations among the perceptual effect, PQ and ITQ

perceptual effect questions	Experience, PQ and ITQ	r
Question 1	Experience	-0.414*
Question 3	Control factor in PQ	0.397
Question 5	Control factor in PQ	0.054**
	Sensory factor in PQ	0.425*
	PQ total score	0.464*
	Involvement factor in ITQ	0.414*
Question 6	Sensory factor in PQ	0.526**
	Realism factor in PQ	0.413*
	PQ total score	0.425*
Question 8	Sensory factor in PQ	0.435*
illusion index	Control factor in PQ	0.483*
	Sensory factor in PQ	0.543**
	PQ total score	0.500*

DISCUSSION

In this study, an illusion caused by a virtual hand was investigated. However, no behavioral characteristics were observed. The reason for this might be due to differences between real and virtual, the period of stimulus provided and the instruction to respond when the subject did not feel the touch. However, the fact that the illusion occurred was supported by the illusion index, which was high, and the subject's verbal report.

Though there were no behavioral characteristics, this study shows that illusions can be created by a virtual environment, and most of all that the majority of participants felt that the virtual hand appeared to be their hand. This result is coincident with the result of Matthew Botvinick and Jonathan Cohen's Rubber Hand Illusion experiment and with Avi Peled's experiment with schizophrenic patients. In particular, the correlation between presence score and the illusion index shows that presence in virtual reality serves a very important role in evoking the illusion. The result of this study that an illusion can occur supports the notion that virtual reality can induce real feelings.

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Visual Stimulation: Non-pharmacological Pain Relief

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Abstract: *A three-phase study has been organized covering stages from experimental laboratory study to clinical application in order to examine the therapeutic effect of visual stimulation on pain management. The gate control theory[1-3] of pain proposes the use of cognitive processes, such as distraction, to alter pain perception. The results of this study support the theory.*

INTRODUCTION

The efficacy and effectiveness of visual stimulation as a potential analgesic has been examined on healthy volunteers. The design of the study was randomized, controlled, and contained crossover. Pain was produced through the use of a modified tourniquet technique. Visual stimulation was generated through the watching of soundless videotapes from a 29-inch television in the first phase (N=46)[4] and wearing a lightweight eyeglass (Figure 1& 2) in the second phase (N=72).[5] The lightweight eyeglass display would project a feeling of watching a 52-inch television screen from six and a half feet away. Subjects alternated between having visual stimulation (Figure 3) and a static blank screen (Figure 4). The content of the visual stimulation was a nature scene of mountains, waterfalls, flowers, and trees.

Figure 2. Wearing the eyeglasses.

There was a significant increase in pain threshold (*P* <0.001) and pain tolerance (*P* <0.001) with visual stimulation in both phase studies. The degree of immersion was positively correlated with improvement in pain threshold, whereas the anxiety level was negatively correlated with improvement in pain threshold.

Figure 1. Eyeglasses were connected to a VCD.

The impact of visual stimulation on pain perception was examined. It was found that when subjects watched videotapes via the 29-inch television, which generated the visual stimuli, the result was a 33% increase in pain threshold and 27% increase in pain tolerance as compared to the control group. When an eyeglass display generated visual stimulation, there was a 52% increase in pain threshold and 40% increase in pain tolerance as compared to the control group. It was found that the use of visual stimuli might be more effective if the eyeglass display was used.

The eyeglass display is considered to be more effective in blocking off unpleasant sights of the immediate environment and creating a pleasing environment in the video world. Furthermore, only 4 out of 72 participants reported having a

Figure 3. Visual stimulation with natural scenery.

slight degree motion sickness. In this connection, visual stimuli provided via the eyeglass display are unlikely to create many undesirable effects such as motion sickness or other discomforts.

The findings of these experimental studies have implications for the use of visual stimulation as a positive adjunct to other methods of pain relief. They also have applications for the treatment of different pain conditions in clinical areas. These findings have also laid the groundwork for the clinical application of this technology.

Chronic ulceration of the leg is a condition more prevalent in the elderly population.[6-7] Patients with leg ulcers tend to experience constant pain and feelings of frustration, and are more likely to become inactive and socially isolated.[8-9] Leg ulcer pain is considered to be continuous and difficult to control. Pain relief for dressing change in leg ulcer patient has been found to be inadequate.[9-10] In addition, elderly patients are more vulnerable to the adverse effects of analgesics, making physicians cautious in prescribing adequate analgesic for ulcer pain.[11-12]

The third phase of the study was conducted with 33 patients (age range from 53-102) having a mean age of 75.8 (±9.8). All of them had leg ulcers and needed wound dressing and superficial debridement (Figure 5). 17 subjects were male and 16 were female. Among these patients, 67% were living in nursing home and 33% were staying in their own houses. In terms of medical illness, 33% of them did not have any health problems besides leg ulcers that needed wound dressing and superficial debridement, whereas 46% had history of old cerebral vascular accidents and 21% had diabetic mellitus in addition to the leg ulcers.

Figure 4. Watching a static blank screen.

It was a randomized, controlled, crossover clinical trial. Patients alternated between wearing the eyeglass display with soundless videotapes broadcasting (V session) and a static blank screen (B session) while experiencing superficial debridement and wound dressing for the leg ulcers. There was a significant difference ($P < 0.001$) in pain scores from V session to B session. The mean pain scores decreased from 67.7 to 25.6 with visual stimulation (Figure 6). Age was positively correlated with the net improvement in pain scores (Table 1).

There was no significant difference in relation to gender, residency and the underlying medical

Figure 5. Leg ulcers on one of the participants.

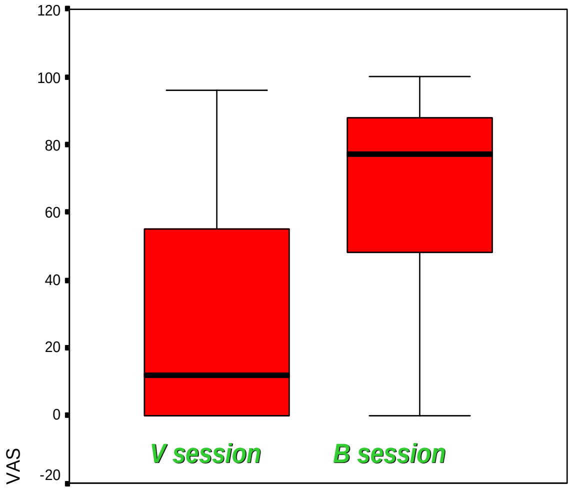
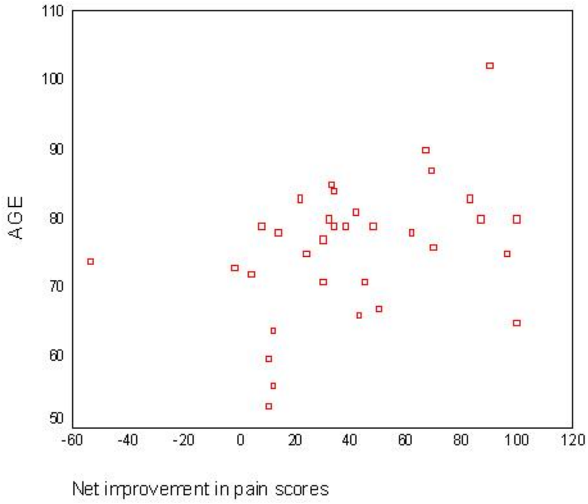


Figure 6: A comparison of the mean perceived pain intensity between the V-session and the B-session (N=33).

Table 1. Age and net improvement in pain scores.



	Net improvement in pain scores	P-value
	Mean (±S.D.)	
Gender		
Female (N=16)	43 (±33)	
Male (N=17)	38 (±38)	0.696
Location of residency		
Own Home (N=11)	25 (±33)	
Nursing Home (N=22)	49 (±33)	0.057
Underlying medical conditions		
Nil (N=11)	54 (±31)	
Old CVA (N=15)	33 (±35)	0.271
DM (N=7)	36 (±36)	

Table 2. The effect of gender, location of residency and underlying medical condition on improvement in VAS.

Note:

Independent samples t test. A P-value <0.05 was considered statistically significant.

One way ANOVA was used. A P-value <0.05 was considered statistically significant.

conditions with the net improvement in pain perception (Table 2).

CONCLUSION

The findings of our studies suggest the use of visual stimuli as an adjunct to pain relief to be beneficial, especially due to its non-pharmacological, robust, portable, inexpensive, easy to use properties, and the fact that it requires no prescription by the physician. Indeed, the use of the eyeglass display has been highly acceptable to patients. Nurses and other health-care professionals are strongly encouraged to use this intervention when performing painful procedures on patients. These studies represent the pioneering use of visual stimulation as a non-pharmacological means of pain management among the local Chinese population. They will certainly add to the existing knowledge of pain relief methods.

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Virtual Reality as a Psychosocial Coping Environment

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Abstract: *In this paper we report on an in-progress research project that is comparing a first-person immersion, multi-user virtual environment with an environment in which the user interacts through an emotionally realistic avatar. Both environments were designed to evaluate stress coping techniques in a situation similar to one that might be encountered in real-life. So far, over 100 normal adults between 25-40 years of age have been randomly assigned to one of two groups. We have ensured that there are the same number of participants across groups, and gender balance within groups. Both groups will go through two phases. In Phase I, each participant is being individually assessed using a three stage assessment inspired by the transactional stress theory of Lazarus[1] and the stress inoculation theory of Meichenbaum[2]. Each participant's coping skills are being evaluated by asking them to propose solutions to various hypothetical stressful encounters within a set time period. There are two different test conditions and a control group. Condition A participants are given a virtual stress assessment scenario from a first-person perspective. Condition B participants undergo a virtual stress assessment scenario using a behaviorally realistic virtual-self avatar. Condition C consists of an interview without a treatment condition. In Phase II, all three groups will be mixed together and perform the same tasks, acting in pairs. Preliminary results show that in Phase I the Condition B group is performing notably better in terms of cognitive appraisals, emotions, and attributions than the other two groups.*

INTRODUCTION

The use of virtual reality (VR) to develop new diagnostic tools for psychology and neuropsychology has been proposed and discussed by many research groups[3-6] since the early 1990's. Basically, VR is suggested as a means of assessing aspects of behavior that are normally inaccessible during traditional formal psychometric testing. In fact, VR-based tests are thought to be more representative of everyday situations than paper-and-pencil (P&P) tests, while potentially as precise and reliable as the latter. A primary necessity is, therefore, the demonstration that VR adds value to already existing neuropsychometric tools. This would imply, for example, that new tools are better in terms of sensitivity to specific cognitive deficits than older ones. To some extent, therefore, new products need to be compared with older, but reliable and validated, tools. A straightforward approach would be to test the same subjects on both traditional and VR-based tools and compare the results. This, however, is complicated by the fact that VR - and especially immersive VR - substantially changes the cognitive requests of a given test. For example, the amplification of spatial, motor, and time-related aspects of a task that unavoidably takes place in virtual reality may change the response values and their distribution in an unpredictable way, even though the strategic aspects are kept constant. It has been therefore anticipated that VR-based tests will evolve as a new class of diagnostic tool[7] with psychometric characteristics substantially different from their P&P analogs.

Our two groups in this experiment are involved in a research project dealing with the development of new VR-based tools and methodologies to assess and retrain acquired coping strategies. We are focusing particularly on coping skills that arise as a consequence of stress and psychosocial/work related disorders. This paper summarizes the work that has been carried out so far to assess situation-specific psychosocial coping skills. Using a Distributed Cognition theoretical framework, we tried to map interpersonal interactions and assess whether the coping behaviors in a collaborative virtual environment are self-directed or environment-directed strategies.

THE VIRTUAL ENVIRONMENT

The VR work-related stress scenario was developed using a custom VR system at Aristotle University of Thessalonica, Department of Psychology. The system was a Pentium III-based immersive VR system (700Mhz, 128Mb RAM, graphic engine: Matrox G400 Dual Head, 32Mb WRam) including two CRT display subsystems (Kaiser Proview XL35/50) and some EEG sensors. The visual immersion is created through the rear projection and active stereo. The trainee wears lightweight (compared to HMD) shutter glasses and faces the screen of ~3.0x2.8m size. Due to the rear projection, the subject is able to approach the screen very closely without any shadow being cast on the screen. Compared to HMD, this solution is less cumbersome and we avoid problems of very limited field of view, cyber sickness (related to the lack of peripheral vision), and claustrophobic effects in the case of more sensitive trainees.

The navigation paradigm is based on a single magnetic tracker attached to the trainee's head. Ascensions PC Bird is used for this purpose. In order to "walk around" the virtual environment, the trainee needs to step into the navigation ring, which in effect triggers camera motion in the desired direction. The trainee can still move inside the central area of the ring without causing any camera motion. In order to "look around" the trainee needs to look at the margins of the projection screen. This analogously triggers horizontal and vertical camera rotation. The paradigm is lightweight and intuitive to understand. Moreover, following the requirement of the modularity and scalability, a wireless hand-held mouse or a normal mouse could replace the magnetic tracker in case of a scale-down.

The virtual coping skills scenario is a virtual collaborative environment developed using the VRScape Immersive Cluster from VRCO. The main scene is the interior of a work office within a large virtual organization. The possible variations include different work roles, a highly motivated director and some special hostile environment situations that are extremely stressful. The therapist constantly monitors the session using a Multidimensional Health Profile – Psychosocial (MHP-P) Score Report,[8] modeling the emotional and behavioral responses of the subjects. In particular the therapist can define the length of the virtual experience, its end and the cues that the scenario is going to propose according to the phase of the session.

METHODOLOGY

We have then developed a VR analog based on the Stress and Coping Process Questionnaire (SCPQ), one of the most commonly used "coping skills assessment" tests.[9] The writer has described the project in detail in previous papers and its application to a clinical case has been recently discussed.[10] Here we are presenting results concerning psychometric aspects of the performance of healthy coping strategies and the strategies of coping impaired individuals (work-related stress disorder), and the relationships between the two test versions.

Methods:

The virtual environment features only two very simple architectural modules: rooms and connecting corridors that resemble a real-life work environment. While in a room, subjects are asked to move about by opening one of several doors that contain some stress scenes from the three categories of the transactional Stress and Coping Process Questionnaire (SCPQ). The subjects' task is to proceed by trial and error until they find the doors that lead outside of the work offices building. Each subject is expected to develop a strategy to avoid the frustration of frequent failure. Subjects face a commercial high-resolution stereoscopic CRT display and stand inside a virtual ring that serves to navigate through the virtual environment and interact with the doors. They are given a maximum of 45 minutes to complete their journey through 32 virtual rooms. The software keeps a record of a number of events and their time of occurrence.

Subjects:

60 healthy subjects and 60 patients with work-related stress disorders volunteered for this study. In the patients' group there were 25 subjects with aggressive behavior, 19 with neurological sequelae of cerebrovascular accidents, one with traumatic brain injury, and one with normal pressure hydrocephalus. Controls and patients did not differ in mean age and years of formal education. Subjects were tested in a counterbalanced order on the VRA and on the VRFP. An external experimenter (A.M.), who was unaware of the subjects' clinical diagnosis, performed the scoring.[11] Errors were not further classified because of the difficulty to equate perseverative events that occurred in a VR setting. The square root of the

ratio between all of the correct responses and errors was taken to compute summary indexes of performance on the two tests.

Results:
Controls had higher summary index values than patients on both the VRFP test and its VRA analog. Within each group, however, there was a difference between those who were given first the VRA analog and those who got the VRFP test first (Table 1). On average, patients attained fewer categories, gave more responses of the "correct" type and made more errors than healthy subjects on the VRFP; on the VRA analog, they also attained fewer categories and made more errors. The way subjects learned the strategy was, however, markedly different between the two tests. On the VRFP, the average number of errors to attain successive stress and coping process categories increased almost linearly up to the fourth or the fifth set for the controls and patients, respectively. On the VRA test, it decreased steeply going from the first to the second and third categories. Within each test, patients differed from controls on the number of trials to attain a given category, but not on the overall pattern of response. Summary index values were used for this analysis. The strength of the linear correlation computed over the whole sample (n. 64) was modest (Pearson's r=.44) but statistically significant (p. = .001); patients' values were less scattered around the regression line than controls' values, but the two groups had identical slopes. Finally, the number of attained criteria, the total correct and error responses for each test were used as input for discriminant analyses aimed at assessing the potential to distinguish coping skills in intact subjects from work-related stress coping skills in impaired subjects. Two discriminant functions were extracted from each analysis. Overall hit rates for the VRFP and the VRA tests were 60.1% and 71.4%, respectively. In particular, more patients were correctly classified by the VRA than by the P&P test (95% vs. 85%). These results should be interpreted as a very preliminary and empirical application, since we have made no attempts to optimize the equations or to confirm their performance on new cases.

Study II. The previous study could not separate the influence of a group from individual participation in a VR-based task, nor could it control for possible transfer of learning from one SCPQ task to the other. Particularly, the first issue is a relevant one since the interaction with a virtual environment is never intuitive nor fully natural - except maybe when stress crisis situations are simulated as in the first experiment. For a number of other situations, however, the user must learn how to operate an uncommon input device such as the navigation ring. This may have a limited yet considerable cost in terms of cognitive demands and resources available to carry out the primary task. This concern may be even more justified when TBI subjects are tested. Our group at Aristotle University of Thessaloniki has carried out a second experiment to show the differential effect on group-team or individual participant.

Method:
The same 120 subjects as in the first study participated again in mixed groups (mean age 36 sd 11.5 yrs). The study utilized a virtual environment comprised of four rooms in a large virtual organization. Twenty-five decision-making tasks were situated in these rooms.

Table 1. Demographic data and distribution of summary indexes* according to diagnostic group and order of test administration

** Summary index: the square root of the ratio between total correct responses and total errors.*

	Controls (n.60)	Patients (n.60)	2 x ANOVA F. p.
	mean sd	mean sd	
age (yrs.)	32.6 8.4	36.4 11.5	
education (yrs.)	12 2.8	12.1 3.2	
ALONE			
VRFP first	3.45 1.10	2.73 1.32	
VRA first	3.48 1.42	2.96 1.30	4.2 .04
TEAM			
VRFP first	1.73 1.01	1.20 0.48	
VRA first	1.86 0.75	1.36 0.82	5.4 .02

Subjects were asked to explore the rooms in search of a specific task which, in fact, was not there. They could move inside the virtual organization in a CAVE setting (immersive VR setup). This VR setting was again a VRFP and a VRA but with a more collaborative design. The SCPQ test was adjusted for this study and a factor analysis was carried out in order to match the transactional stress theory of Lazarus in a collaborative design. Participants were randomly allocated to the group or individual condition and tested in "yoked" pairs without actually knowing it. Immediately after completion of the route through the virtual house, both members of a pair were asked to complete the SCPQ analog of the collaborative coping skills VR setting.

Results:
Contrary to expectations, healthy subjects who were exploring the VE in pairs did not score worse than their "individual" VR test (mean probability .51 SD .12 vs. .51 sd .15). Group participants performed better than individual members of yoked pairs in all the tasks of the VRFP categories analogous to this virtual setting (mean probability .58 SD .17 Vs .45 SD .15). A 2x2 ANOVA for repeated measures confirmed a significant effect of healthy coping skills versus work-related stress (df 1,24 F. 80,4 p.<.001). The interaction between role and type of coping task fell short of significance (F. 3.72 p.=.06).

Comment:
This study confirms that the group VR test we have developed has psychometric properties comparable to those of the individual scenarios from which they are derived. Thus, it can distinguish patients from healthy subjects at least as well as the latter, though there are hints that it can do better. The fact that there is no transfer of implicit knowledge from one test to the other supports the hypothesis that VR-based tests have specific characteristics. Accordingly, we have found only weak correlation between summary scores obtained by using the two variants. Also relevant to this issue is the demonstration that the learning process that underlies the acquisition of a correct strategy takes a different course in the two tests. We suggest that this finding depends on the more complex (and complete) cognitive demands of the VR setting at the beginning of the test when perceptuomotor, visuospatial (orientation), memory, and conceptual aspects of the task need to be fully integrated into an efficient routine. We have previously provided ancillary evidence that a successful performance on the VR test depends on such an integration.[12] On the VRFP, instead, the initial conceptualization is attained relatively easily and little additional difficulty is met until an anger management event occurs, when a rather counterintuitive "restart" at the point of view has to be made. Of course, these conclusions are pertinent to the study groups we have examined and cannot - at the present time - be generalized. Finally, this study provides further evidence that an immersive VR system can be safely used with groups of individuals with a variety of mild to moderately severe neurological and cognitive impairments.

Figure 1. Mean number of errors made to attain the categories on the SCPQ and results of between groups statistical comparisons (T-test).

SUMMARY AND FUTURE PLANS

VR technology could potentially improve the reliability of neuropsychological assessment by allowing for more consistent presentation and manipulation of complex test stimuli along with more precise measurement of participant responses. The reliability and validity of measurement of the component cognitive domains of attention could potentially be enhanced by the capacity of VR technology to present both test and distraction stimuli along with better quantification of discrete response. In this manner, VR has the potential for cognitive assessment and rehabilitation within simulated "real-world" functional testing and training environments with an aim towards improving ecological validity. A more precise form of measuring attention performance within a standard theoretical framework, like distributed cognition, using VEs modeled after real life settings should, in theory,[13] provide better predictions of performance in the real world. Distributed cognition is a theoretical framework that differs from mainstream cognitive science by not privileging the individual human actor as the unit of analysis. Distributed cognition acknowledges that in a vast majority of cases, cognitive work is not being done in isolation inside our heads but is distributed among people, between persons and artifacts, and across time. What makes a system cognitive is the presence of processes applied to representational states that result in cognitive work. Tracking the representational states using a behaviorally realistic virtual-self avatar (agent) can uncover the specific cognitive processes being employed. Our collaborative virtual environments, though designed to assess coping behaviors directed to work-related disorders, could potentially act as preventive optimism training (CBT) for improved health behaviors, service utilization, and depression.[14] Following empirical testing of the parameters outlined above, our plan is to develop an inexpensive system that would be used in clinics, schools, and research settings. While we are currently using high-end equipment, we hope that by the time we have empirically developed a reliable and valid set of VR tasks, and conducted basic clinical trials to develop normative data, the technology will have advanced concurrently to the point where our scenario could be delivered on less expensive and readily available equipment. This view reflects the current thrust of our work.

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Combining Virtual Reality Experiments with Functional Magnetic Resonance Imaging: Initial Work Assessing Human Spatial Navigation

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Abstract: *A testing platform that enables behavioral assessments in virtual reality (VR) to be probed with functional magnetic resonance imaging (fMRI) provides rich opportunity to investigate the brain activity generated by ecologically valid tasks. By integrating and modifying commercially available hardware, as well as developing new devices in our laboratory, we have created such a platform and demonstrated its use in experiments assessing human spatial navigation. Young subjects (n=9, 26 +/- 6 years) and older subjects (n=8, 62 +/- 10 years), and two patients with probable Alzheimer's disease (prAD) learned to navigate through "Sunnybrook City," a virtual town consisting of two city blocks. Compared to young adults, older adults took longer to navigate a specific route through the city and to reach a plateau in their performance, and made more wrong turns. One prAD patient who exhibited mostly verbal deficits performed as well as the older subjects, whereas another patient exhibiting mostly visuospatial impairment performed markedly worse than the older subjects. In addition, fMRI of a single young adult during the task illustrated activation patterns consistent with the current understanding of the functional neuroanatomy associated with spatial navigation. In particular, temporal variations in activity within the prefrontal cortex, the medial temporal lobe, and the parietal lobe highlight the utility of fMRI in understanding how learning and memory evolve during the task. Collectively, the results suggest that the Sunnybrook City task may potentially facilitate the early detection of AD in patients suffering mostly from spatial deficits. Future research directions for combined use of VR and fMRI are also discussed.*

INTRODUCTION

Virtual reality (VR) is being increasingly recognized as a beneficial psychological tool. Current VR applications include exposure treatment of various phobias and alleviation of acute pain, while numerous applications for neuropsychological assessment and cognitive and physical rehabilitation are being developed.[1] Despite this progress, how the brain functions during exposure to virtual environments (VEs) is not known in detail. With the availability of functional neuroimaging methods to provide maps of brain activity, we should be able to reach a better understanding of this issue. For example, it is important to delineate the brain activity that underlies participant behavioral responses during VR exposure. Does this brain activity mirror what is produced by actions in the real world? How does this brain activity relate to that produced by conventional behavioral assessment tools, such as pencil and paper tests? How does the brain reorganize in response to VR therapy? What are the consequences of simulating reality instead of replicating it? By attempting to answer such questions using functional imaging, new knowledge with the potential to improve VR applications may be acquired.

Of the functional experimental neuroimaging methods available, the three most widespread are electroencephalography (EEG), positron emission tomography (PET), and functional magnetic resonance imaging (fMRI). The EEG signal indirectly measures the flow of electrical information resulting from neural activity, with high temporal resolution (approximately ms) but low spatial resolution (approximately 1 cm restricted to cortical regions). In the case of PET, which can measure the spatial distribution of neurotransmitters, cerebral metabolism, or localized hemodynamic effects associated with neural activity, spatial resolution is several millimeters throughout the brain volume but with low temporal resolution (approximately minutes). Also based on hemodynamic signals, fMRI exhibits spatial resolution that is equivalent or better than PET over the entire brain volume, with a temporal resolution of approximately seconds.[2,3] Considering the fact that fMRI is now fairly widely available, and that subjects can be scanned repetitively without the use of ionizing radiation, fMRI is a particularly attractive option for probing brain function during VR experiments.

Combining fMRI and VR experiments is not simple, however. First, a testing platform must be developed that allows fMRI during VR exposure, without significantly compromising either technology. Peripheral devices must be capable of operating at high magnetic fields with minimal electromagnetic interference during fMRI. Furthermore, immersive VR experiments must be implemented within a confined magnet, with the subject in supine position, and with minimal head motion. VR experiments during fMRI must also be modified and optimized so that brain activity can be determined effectively. In addition, efficient interplay between researchers in multiple disciplines is required to make such experiments feasible and relevant.

Despite these challenges, initial progress is being made in our laboratory to develop a broad program of research aimed at combining VR with fMRI. We describe here the initial development of a testing platform for this purpose, including newly-developed fMRI-compatible devices. Use of this platform is best demonstrated through an example - our current work-to-date to develop new tools to probe human spatial navigation. The neuropsychological motivation for this research direction follows immediately below.

Neuropsychological Rationale for Assessing Spatial Navigation using VR: Assessing spatial orientation, which is defined as the ability to relate position, direction, or movements of objects in space,[4] is particularly important for characterizing and understanding the aging brain. For example, despite the fact that older adults are slower or have a shorter memory span than younger adults across a spectrum of tasks, the largest age differences relate to visuospatial ability.[5]

Age-related deficits are also particularly present in route learning or topographical memory, a subcomponent of spatial orientation. The elderly acquire spatial information in a new environment at a slower rate than young adults.[6] Contributing factors include a poorer ability to a) select a proper and sufficient number of landmarks to assist in navigation; b) to recall landmarks accurately and in the correct order (temporally and spatially); and c) to use maps as aids (particularly in elderly women).[6-9]

From a clinical perspective, “getting lost” is one of the early symptoms of Alzheimer's Disease (AD).[10] In the early stages, AD pathology tends to be lateralized,[11-13] primarily affecting parieto-temporal regions involved in spatial navigation, particularly in the right hemisphere.[14-16] Individuals without clinically detectable verbal impairment might have pathological processes predominantly lateralized to the right parietotemporal region.[17,18] As this type of patient would be particularly likely to exhibit deficits on spatial tasks, the development of appropriate sensitive and specific tests of spatial navigation is an important clinical goal.

Numerous traditional neuropsychological assessment tools, such as the Topographical Localization Test,[19] the Test of Geographic Orientation,[20] the Fargo Map Test,[21] and the Extrapersonal Orientation Test,[22] have been developed to evaluate route learning or topographical memory. Despite the utility of these pencil and paper assessment tools, they lack two important aspects of real-world navigation. The absence of translocation, or at least the illusion of movement, of the body in space[23] excludes the contribution of important sensorimotor, vestibular, and proprioceptive information to spatial learning.[7, 24, 25] Furthermore, these tests probe participants' “survey knowledge,” or their ability to learn and remember routes or locations from an allocentric perspective (a bird's eye view of the world). However, people typically gain a great deal of real-life navigational information in the form of “route knowledge,” formed by physically traveling from landmark to landmark in a large-scale space, inherently using an egocentric, or body-centered, perspective. Importantly, having route knowledge of an environment does not guarantee survey knowledge, although repeated exposure to a given locale will probably insure such development over time as different routes are traversed[26]. Consequently, allocentric and egocentric navigational skills are distinct.[27-29] Contrived table-top tests do not provide an adequate evaluation of memory for routes, but are widely used for a lack of better alternatives in clinical evaluations.

The key to increasing ecological validity is to test cognitive-functional performances in an environment closer to the real world.[30] Although real-life settings can be used to assess navigational learning and memory (locations such as in a supermarket[6,31] or a hospital[7]), they are impractical due to the complexity of conducting experiments in large environments and the difficulty in maintaining experimental control of the surroundings.[6,30] Consequently, VR is a particularly useful tool to "bring reality to the laboratory" while allowing extremely flexible control of the environment.[32] Participants can be immersed in VEs, something that is impossible to do with table-top tests and that enhances the realism of the task.[33] For example, an immersive VR simulation has been shown to be a more efficient type of training for landmark and route learning of a real building than the analogous, combined use of verbal directions and photographs.[34]

Study Goals. Given this background motivation, our current effort has been focused on achieving the following objectives:

- designing and implementing an immersive VE and behavioral task for assessing spatial navigation;
- applying these tools to assess and compare navigational performance between healthy young and elderly subjects, and selected patients with early probable AD;
- characterizing the neuroanatomical correlates of the behavioral task by performing fMRI of young healthy subjects.

MATERIALS AND METHODS:

Testing Platform: The testing platform (Figure 1, numbered items) is under continuing development, but three requirements appear in all versions: 1) the capability to deliver high-performance 3D graphics and provide human-computer interactions at acceptable computer video frame rates; 2) scalability to integrate new software and hardware with modest incremental effort; and 3) flexibility to enable behavioral testing of subjects both inside and outside an MRI scanner. At present, the primary component is (1) a personal computer (PC) workstation (ZX-10, Intergraph Inc., 733 MHz Intel Pentium III processor, 1 GB SDRAM, 21-inch SVGA monitor) containing an advanced graphics card with stereoscopic capability (Wildcat 4210, 3Dlabs Inc.) that was close to state-of-the-art when purchased (mid-2001) and that provides good performance for the cost.

Creation and presentation of VEs on the PC is achieved using (2) a real-time development environment with a graphical user interface (GUI) allowing rapid object-oriented design and implementation through built-in support for many peripheral devices and industry standards such as OpenGL, C and Visual Basic (WorldUp Release 5.0, Engineering Animation Inc.).

Three different modes have been implemented in the presentation of visual stimuli. The standard display mode presents VEs monoscopically on the workstation monitor, and is used during software development. Stereoscopic presentation is achieved outside the MRI scanner using (3)

Figure 1. Components of the testing platform. See text for description of numbered items.

an LCD-based, head-mounted display (HMD) with wide visual angle (Proview XL-50, Kaiser Electro-Optics Inc.; 1024 by 768 screen resolution, 60 Hz refresh rate, 40° horizontal by 30° vertical visual angle) in conjunction with (4) an electromagnetic position tracking system (MiniBird 800, Ascension Technologies Inc.) to update the viewpoint within the VE based on head motion. To prevent neck strain, overhead support of the HMD is provided using an adjustable bungee cord. Inside the scanner, (5) a goggle-based fMRI-compatible system provides stereoscopic display (SV-4021 Silent Vision System, Avotec Inc.; 832 horizontal x 624 vertical screen resolution, 60 Hz refresh rate, 30° horizontal x 23° vertical visual angle) when connected to the workstation. The goggles are mounted immediately above the subject's eyes and include corrective lenses, an important practical consideration.

The capability to present auditory stimuli is provided by (6) a set of "sound-pipe" headphones (Silent Scan, Avotec Inc.) with stereophonic capability, acoustic padding to block scanner noise, and graphic equalization to extend the range of acoustic frequencies transmitted into the magnet. The ability to create sounds at different virtual locations using these headphones has been key to previous work in our laboratory to identify which neural Pathways were part of the auditory system, and where they are located.[35]

Motor responses within VEs are implemented using either of two devices. (7) Response pads (Lumitouch, Lightwave Technologies Inc.) enable subjects to make key-press responses using two fingers on each hand, from which reaction times or choices can be recorded. (8) Navigation in two dimensions is implemented using a simple eight-way gameport joystick (PC Gamepad, Gravis Inc.), modified in-house for MRI-compatibility.

The testing platform also includes (9) a scan converter (DSC-10224G, Sony Corp.) connected to (10) a VCR (HS-U650, Mitsubishi) and (11) a television monitor (KV-13TR10, Sony Corp.). These devices allow experiences within the VE, taken as the viewpoint of the left video channel, to be videotaped. Behavioral assessments based on human observation are therefore easily recorded offline after experiments are conducted. The entire testing platform is housed on (12) a wheeled computer desk that is easily transported to and from the area adjacent to the MRI console. Work is also ongoing to integrate additional novel peripheral devices into the testing platform. For example, Shape Tape (Measurand Inc.) contains an array of fiber optic bend and twist sensors enabling tape geometry to be 3D rendered in real time. The tape is normally fabricated with a spring steel skeleton but is available with a mylar substrate that provides fMRI-compatibility. We have extensively characterized the tape's fMRI compatibility and suitability for behavioral tasks during fMRI (see Table 1), and considered its advantages in two configurations.

A "virtual stylus" has been implemented by recording the position of the distal tip of the tape when attached either to a plastic stylus or the tip of the subject's finger, and then projecting this po-

Table 1. Shape Tape Performance Summary.

Attributes of Shape TapeTM (Model S1280CS)	Number of Sensors 32 (16 pairs) Sensor Spacing 6 cm Sensing Length 96 cm Unsensorized Lead Length 6 m Tape Thickness x Width: 1.3 mm x (13-19) mm PC Interface Serial Port Output Data Format Cartesian (x, y, z, rotx, roty, rotz), or bend and twist
Physical	Acquisition Rate > 90 Hz Simulation Frame Rate 30-40 frames/sec MRI Compatibility Excellent Thermal Drift at Endpoint (60 minutes from start-up) No calibration: Ä rMAX = 24 mm, ó MAX = 7.5 mm Periodic recalibration: Ä rMAX = 4 mm, ó MAX = 2 mm Endpoint Spatial Resolution 0.3 mm rms, x, y, or z; 0.5 deg, roll, pitch, or yaw Endpoint Spatial Accuracy ~5 mm near tape centerline, simple bend Ideal Working Volume 30 cm x 20 cm x 10 cm (1 to 3 cm accuracy, can be improved with additional calibration) Induced Head Motion <1 mm in compliant subjects
Performance	fMRI Modalities: Data glove, virtual stylus, joint motion capture

sition on a two-dimensional viewing surface that is visually presented to the subject (Figure 2a). Stylus location is indicated by a cursor. By writing or tracing on a plastic pallet, the virtual stylus enables fMRI of many conventional behavioral assessments, potentially for comparison with fMRI of their VE counterparts. The virtual stylus is also a highly intuitive interface and should facilitate fMRI of patients that have difficulty in learning or performing the appropriate response selection with joysticks and button boxes.

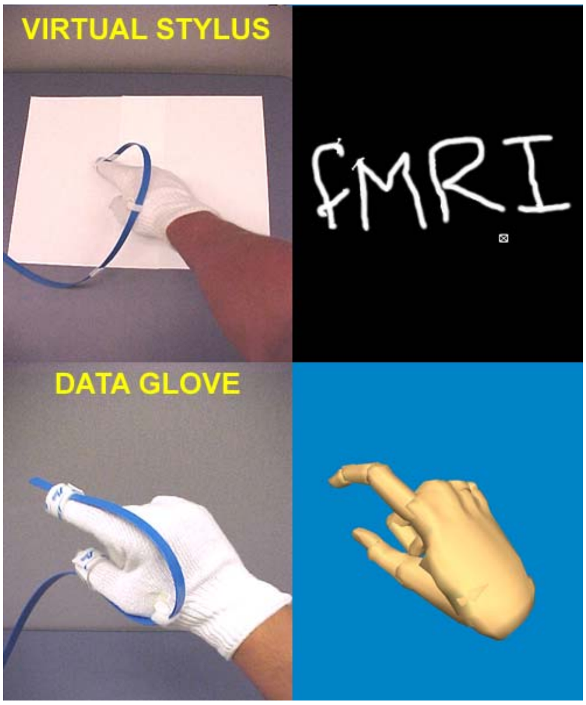
Secondly, Shape Tape™ has been configured as a "pinch" data glove by looping the tape around the index finger and thumb (Figure 2a). By using Shape Tape™ to control a virtual hand, pinching, pointing, and reaching tasks are readily achievable during fMRI.

We have also developed magnetomechanical vibrotactile devices (MVDs) that use the MRI scanner's large magnetic field to produce somatosensory stimuli. When small (approximately milliamperes) of alternating current flow through a loop of wire placed in the scanner, oscillatory torque is produced that is easily converted into a vibrotactile stimulus.

Different MVD applications provide flexible, controlled, and robust activation of primary and secondary somatosensory cortices during fMRI.[36] In the case of combined VR and fMRI, MVDs are easily adapted to present tactile stimuli on most skin surfaces and particularly to enable haptic stimuli at the fingertip for interaction with virtual objects, potentially in conjunction with the pinch glove.

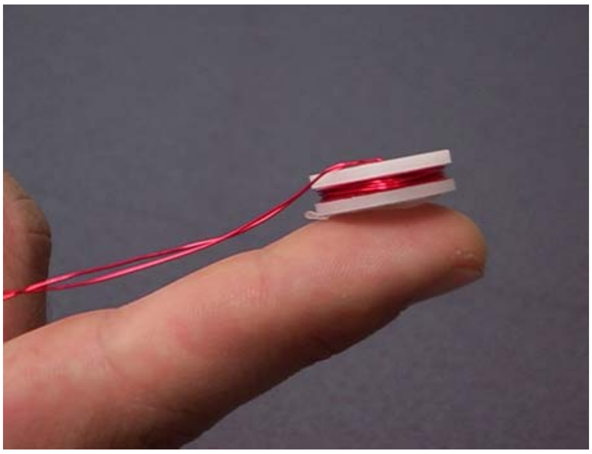
SUBJECTS

We recruited 9 young adults (mean age 26 +/- 6 years) and 7 older adults (mean age 62 +/- 10 years) through an available research pool at the University of Toronto at Scarborough. Eight of the young adults and all the older adults were tested without fMRI. In this preliminary study, representative functional MRI results are reported for a single young male adult only (age 31). Both groups had similar years of education. Older participants were screened for psychiatric or neurological disorders, history of moderate to severe head injury, and cerebrovascular disease (e.g., stroke) through the administration of a questionnaire and various neuropsychological tests. Two male patients with a clinical diagnosis of probable Alzheimer's disease (PrAD) as defined by NINCDS-ADRA 37 were also included in the study.



Figures 2a (above) and 2b (below). Additional fMRI-compatible peripheral devices developed in-house.

a) Configurations of Shape Tape for combined VR and fMRI experiments. Actual and virtual representations of the tape as a virtual stylus and as a data glove are shown.
b) Magnetomechanical vibrotactile device (MVD) for presentation of somatosensory stimuli.



Both patients were under the care of a neurologist from Sunnybrook and Women's College Health Sciences Centre (S&W). Patient J.H. was 73 years old, and possessed 17 years of education. He had been suffering from PrAD for about 5 years. Patient S.D. was 68 years of age and had been suffering from PrAD for 4 years. He had 21 years of education.

Both patients had no experience with videogames but had used computers in the workplace. All participants, except for two men in the younger group, were right-handed. Experimentation was conducted with the informed consent of the participants and with approval from the S&W Research Ethics Board.

NAVIGATION TASK IN VR

Participants learned to navigate within "Sunnybrook City," a realistic virtual town consisting of five streets laid out in the shape of a figure eight (Figure 3a) containing numerous distinctive landmarks. The streets of the city also included sidewalks, standard road signs, and parked and moving cars. Representative views are shown in Figure 3b. The frame rate was nominally 25 frames/sec. Outside the MRI scanner, navigation was achieved using the joystick to provide forward and reverse motion at constant velocity (approximately 3 virtual m/s). Left and right turns were controlled by head movement using the HMD and position tracking system, and subjects were encouraged to rotate their entire body on a swivel chair. Spatial orientation within the city was videotaped throughout.

The details of the behavioral task were modeled after the California Verbal Learning Test (CVLT),[38] a widely used neuropsychological test. The CVLT assesses learning of verbal material and the amount of material retained at various intervals.[4] It has been shown to be the most sensitive way to measure to AD in a recent meta-analysis of neuropsychological test findings.[39] Our own task aimed at measuring spatial learning and memory over many trials and delay periods. Subjects first had to learn a given route, which we called Path A, over four trials (Figure 3a).

For each of the four learning trials, participants were shown the entire path from an egocentric viewpoint, using computer playback of the same pre-recorded route. Each time Path A was shown, subjects were then to navigate Path A as they would in real life, which included walking on the sidewalks, and crossing the street at intersections. After the four learning trials, a second route, Path B, was presented as a single learning trial to document proactive interference effects. This latter route was made to overlap as little as possible with Path A (Figure 3a). Subsequently, participants were asked to recall and re-navigate Path A without being shown the route (thus exercising their short delay recall).

Figures 3a (left), 3b (center), and 3c (right).
Virtual environments for navigation. a) Top view of "Sunnybrook City" indicating Paths A and B. b) Representative screen shots showing some of the landmarks within the virtual city. c) Additional featureless maze used in fMRI experiments.

After a 20-minute delay, subjects were again asked to recall Path A (exercising long delay recall). The time to completion and the distance traveled, as well as navigation errors in the form of wrong turns, were tabulated for all trials. In addition, navigational accuracy was characterized by counting the number of times people bumped into buildings or wandered off the sidewalk.

A cybersickness questionnaire (M. Boulos & K. K. Zakzanis, unpublished) was administered during the 20-minute delay between the short-delay and long-delay recall trials. Participants were asked to rate the intensity of various cybersickness symptoms as felt while in the VE, as well as immediate after-effects experienced after coming out of the VE. Possible scores for each respective subtest ranged from 19 to 95 and 7 to 35.

Several standard neuropsychological tests were also performed to characterize the cognitive status of the elderly subjects, which was found to lie in the normal range in all cases.

The battery of tests included the Mattis Dementia Rating Scale (DRS)[40,41] which is typically used to stage dementia severity as it provides an index of cognitive functioning in several domains. The Controlled Oral Word Association Test,[42,43] the Boston Naming Test (BNT).[44] the Rey-Osterrieth Complex Figure (ROCF).[45] and the CVLT[38] were also included. The entire testing session lasted approximately two and a half hours. The two patients suffering from PrAD were administered these tests by a trained psychometrist at their yearly neuropsychological assessment.

MODIFYING THE TEST FOR fMRI

To infer neural activity on the basis of fMRI data, the principle of "cognitive subtraction" is usually adopted. In this case, the principle was used to generate activation images depicting the contrast between two behavioral tasks: navigation of Sunnybrook City, and traversal of a random maze with simple feature content (Figure 3c). The maze was traversed several times initially to gain familiarity with operating the joystick. (A similar procedure was conducted for assessments outside the MRI scanner.) Subsequently, the maze was traversed between successive learning trials and recall trials. The maze configuration was randomized at each traversal, with the total distance and number of turns held constant. This procedure stopped the subject from forming a "cognitive" map of the maze, and ensured that the resulting activation maps primarily contained information associated with spatial navigation rather than the sensorimotor activation associated with controlling the joystick.

In addition, because even small head motions (approximately millimeters) can confound fMRI data, navigation was performed with the subject maintaining his head still throughout the assessment procedure, while looking through the Avotec goggles. The joystick controls were also modified such that "up" and "down" controlled forward and reverse motion, and "left" and "right" controlled counterclockwise and clockwise rotation, respectively. In the interests of brevity, only three learning trials for Path A were completed, which were adequate to show a significant learning effect, particularly in young adults (see results).

FUNCTIONAL MRI PROCEDURE

Imaging was performed with a 1.5T MRI system (Signa, LX 8.5 software, CV/i hardware; GE Medical Systems, Waukesha, WI) using the standard quadrature transmit/receive birdcage head coil (Figure 1) padded with high-density foam to minimize head motion. Brain activity was measured using a T2*-weighted pulse sequence with single-shot spiral k-space readout (theta/TE/TR = 80°/40 ms/2000 ms, 20 cm field-of-view (FOV), 5 mm thick), offline gridding and reconstruction.[46] Multislice, axial images were acquired to cover the entire brain volume.

Subsequent data processing was performed using the boxcar correlation technique in the analysis of functional neuroimages (AFNI) software, including use of a co-registration algorithm to reduce the effects of head motion.[47,48] Each component of active navigation (during both the learning and recall Trials) was contrasted with the maze traversal that immediately followed. Anatomical MRI was performed using 3D fast spoiled gradient echo imaging (FOV = 22 by 18 cm, flip angle/TE/TR = 35°/6 ms/15 ms, 256 x 192, 128 slices 1.5 mm thick). These images served to localize regions of brain activation with respect to brain anatomy.

RESULTS

Of the behavioral metrics investigated, e.g. the time to completion and the number of wrong turns showed consistent, there were highly statistically significant differences in the findings between young and older adults (Figure 4). Healthy older adults took more time on average to navigate Path A. Young participants' performance reached plateau by the second trial, whereas older adults needed three trials to complete navigation in less than 130 seconds. Very few mistakes could be made if one were to complete the task in 130 seconds or less. The average time to completion for Trial 4 in older adults was artificially inflated by the performance of one participant who became disoriented towards the end of the trial and took 325 seconds (>2 standard deviations away from the mean) to complete navigation. Excluding this outlier, older participants completed the fourth trial in an average of 130.16 seconds, consistent with the improvement shown throughout the first three learning Trials.

Interestingly, the both the older and the younger participants completed Path B in a comparable amount of time. It is important to note that Path B contained the same number of turns as Path A but was a slightly shorter in length. Hence it could be completed in a shorter amount of time than Path A. The result on this trial might be explained by the fact that this shorter trial did not leave enough room for variability. Furthermore, age-related differences may not be present between navigation of Path B compared to the first trial of Path A. The performance of the older adults on Path B might have been improved by the familiarity with the environment. Conversely, this performance might also indicate that young participants' performance was more affected by proactive interference and rendered equal to that of older adults.

Younger adults also outperformed older adults when re-navigating Path A from memory after both a short and long delay. It is interesting to note that the group of older participants showed great variability in performance on the long delay trial. In addition, older adults made consistently more wrong turns than young participants, demonstrating increasing intrusion of incorrect spatial information (Figure 4). Younger adults seem to complete the navigation staying "on-path" whereas older adults committed

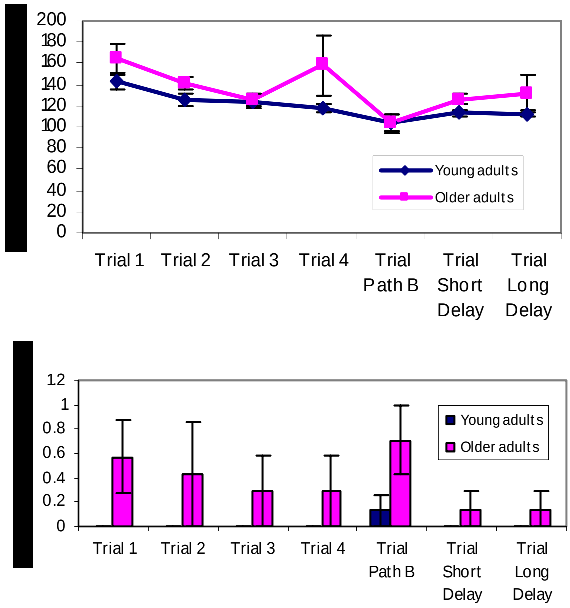


Figure 4a (top) and 4b (bottom).
Behavioral metrics distinguishing young and older healthy adults that navigated Sunnybrook City.

a) Time to Completion and
b) Number of Wrong Turns across all trials.

one wrong turn on average. This effect was most striking on the first learning trial for both Paths A and B, but was observed consistently over all trials.

Both groups did not differ on the levels of cybersickness experienced during immersion in the environment (young adults: 31 +/- 3; older adults: 36 +/- 6) or after stepping out of it (young adults: 12 +/- 2; older adults: 11 +/- 2). As expected, reports of cybersickness during and after immersion were highly correlated (r= 0.65, p=0.01).

The performance of the two patients suffering from PrAD was interesting in comparison with the data from healthy young and older adults. Both were able to complete the VR task without significant cybersickness. J.H.'s most striking deficits were on naming tasks. His performance on the BNT was 14 out of 30, placing him below the tenth percentile, taking into account his age and schooling. He was clearly shown to be anomic on the Western Aphasia Battery (WAB), and demonstrated learning difficulties on the CVLT, where he was only able to retain four words on the fifth learning trial. The patient's performance on non-verbal tasks was slightly impaired but clearly superior to his verbal skills. He did not copy the ROCF perfectly (31/36), but was within the normal range considering his age and schooling. He also performed well on the Judgment of Line Orientation task (30/30) and scored above the 95th percentile on Raven Progressive Matrices. Within Sunnybrook City, at his worst J.H. performed only slightly beyond the first standard deviation as compared to healthy older participants on almost all measures. Exceptions were observed on a few trials when he bumped into buildings or objects more than would be expected from healthy adults. Thus, he demonstrated fairly preserved spatial learning and memory despite a severe naming impairment.

In contrast, S.D. did not show pronounced deficits in naming as his score on the BNT was 29/30, and he was classified as having normal speech on the WAB. His performance on the CVLT, however, was clearly impaired. Even though he was able to learn seven items by the fifth learning trial, he only remembered one item on free recall after a short delay. His performance at copying the ROCF was perfect but he did show slight deficits at non-verbal tasks such as the Raven Progressive Matrices (28/36, 75-90 percentile).

These slight non-verbal and memory deficits became quite apparent in S.D.'s performance in Sunnybrook City. It took him more than two or three standard deviations from the average performance in healthy older adults to complete many learning trials. This also applied to the distance he needed to travel to reach his goal. This deficit was particularly apparent on the first three learning trials as well as in the short-delay recall. Overall, S.D. experienced more difficulty than J.H. on all variables except collision.

Brain Activity: Representative images of brain activation are shown in Fig. 5 for one young healthy adult subject. Bilateral prefrontal activity was observed when learning to navigate Path A, which subsequently decreased over Trials 1 to 3, particularly on the left side. Over these trials, time to completion decreased from 153 to 143 s, and distance traveled decreased from 373 to 358 virtual meters (vm) as the subject learned to navigate the path. No navigational errors (wrong turns, collisions, falling off sidewalk) were observed throughout the imaging examination. Brain activity for Trial 1 of Path A and Path B was very similar, indicating consistency of results (data not shown). Short and long delay recall showed activation of the right parahippocampus, although it was less so in the latter trial. Activation of left parietal cortex was additionally observed on the long delay recall. Time to completion and distance traveled were very similar on both recall trials (short delay: 142 s, 342 vm; long delay: 138 s, 337 vm).

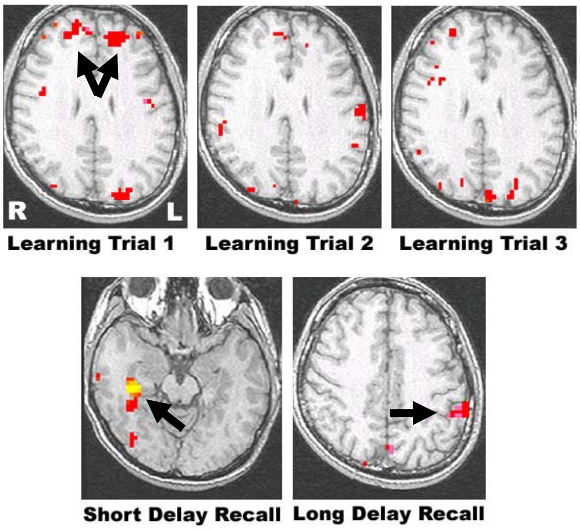


Figure 5. Images of brain activity during learning and recall trials of Path A for a young healthy adult. Activation in bilateral prefrontal cortex, right medial temporal lobe, and left parietal cortex are of particular interest (arrows).

DISCUSSION

Use of a testing platform for combining VR and fMRI experiments, as developed and described here, clearly has strong potential for conducting research to further the applications of VR in psychology. It also has the probable ability to improve the understanding of the relationship between brain activity and behavior. Such work is in an early phase, but the initial results are promising. The following section briefly discusses the results obtained from using the platform to probe spatial navigation, as well as some directions for future research. The navigational performance of both the young and older healthy groups improved over successive trials in Sunnybrook City, particularly in the first two trials for younger subjects and in the initial three trials for healthy older participants. Despite the improvement shown by both groups, age-related differences were observed throughout all trials, which is consistent with previous studies.[7,49]

The most stable age-related differences observed were increased time to complete Path A, and increased wrong turns made by the older group. Given that both young and healthy older participants had an equal number of years of computer familiarity and were thoroughly trained to use the joystick prior to testing, it was extremely unlikely that these factors had a significant confounding effect on time to completion.[49]

The increased number of wrong turns in older adults was clearly a contributing factor in their elevated time to completion, which is also consistent with previous studies.[7,49] Wilkniss and her colleagues[7] mentioned that older adults experience difficulty in selecting relevant features that would help them maintain their path. These same adults also had difficulty with ordering these features spatiotemporally, leading to navigational errors. Evidently, cues that are sufficient for young adults to navigate flawlessly are not processed as effectively by older adults.

It is highly likely that there were additional differences in the performance between the young and older subjects that were not captured in the behavioral metrics adopted to characterize navigation in Sunnybrook City. For example, it was noticed anecdotally that healthy older participants tended to scan the environment to try to find their way without physically moving. Thus, they didn't travel substantially far from the path even if they were lost or made a wrong turn.

Quantifying the amount of scanning should be possible in a future study. This type of behavior has been observed more frequently in elderly participants than in younger subjects, particularly in an unfamiliar environment.[6] Kirasic[6] hypothesized that older participants tend to minimize movement to conserve energy in a real-life setting. Our qualitative observations seem to hint that the virtual environment can mimic such a real-life effect but this remains to be verified.

One of the goals of this study was to investigate whether this route learning and memory test in Sunnybrook City could be a useful diagnostic tool in clinical populations, such as patients with AD. Only preliminary comments can be made on the issue, as only two patients, J.H. and S.D., have been tested to date. Nevertheless, the differing performance of these patients in Sunnybrook City does suggest that the task could quantify what conventional neuropsychological tasks have hinted, namely the presence of asymmetry in their cognitive performance in relation to one another.

J.H.'s neuropsychological assessment showed that he was mostly affected on verbal tasks. Indeed, his performance was fairly similar to healthy older adults in Sunnybrook City, mostly within one standard deviation from the average performance of healthy older adults. S.D., on the other hand, committed many wrong turns, especially on Path B. It also took him more time and distance to travel the paths as compared to most healthy older adults. Thus, he was experiencing spatial problems while his verbal domain appeared much more intact.

These differences in cognitive performance seem to point to the fact that J.H. has incurred AD-type neuropathological changes predominantly lateralized to the left hemisphere, whereas S.D.'s impairment is likely to be more prominent in the right hemisphere. Thus, if this test can show such a clear difference of performance only between two patients suffering from mild AD, it may potentially help in the early detection of AD in patients suffering mostly from spatial deficits. It would be interesting to test this task longitudinally in patients suffering from mild cognitive impairment (MCI) to see if there was a significant correlation between scores on this test and later conversion to a diagnosis of PrAD. Initial VR testing of MCI patients is already underway in our laboratory. Other pertinent patient populations include individuals recovering from stroke or traumatic brain injury.

The initial fMRI results observed for navigation of Sunnybrook City are consistent with current neuroanatomical theory of spatial memory.[28] Decreasing prefrontal activation in Path A during the learning trials may reflect decreasing executive control over navigation as the path is learned, as well as less demanding encoding of an increasingly familiar route. The role of these regions is further supported by their activation during the interference trial (Path B), which required the subject to learn a new navigational strategy. The decrease in prefrontal activation could also be due to a shift from short-term frontally-based spatial memory to a consolidated memory, which relies more on the parahippocampal cortex.[50] Parahippocampal activation was additionally observed with both short and long delay recall, and this region has previously been associated with topographical orientation.[16,51] Activation in the parietal regions was observed primarily for the long delay recall and may reflect consolidation of navigational memory from the egocentric perspective, with very little change in time to completion or distance traveled.

Prior functional neuroimaging literature has concentrated on the role of hippocampal and parahippocampal regions in human navigation. In particular, there is converging evidence that the right hippocampus contains an internalized map of the route of interest in allocentric (world-centered) coordinates.[27] Hippocampal activations were not observed with statistical significance for the subject investigated here. This is not necessarily surprising, as hippocampal activations are difficult to observe reliably with fMRI at 1.5 T and typically require group analyses.

Additional experiments are underway in our laboratory to extend our findings to a group of young healthy subjects. Current results from six individuals are qualitatively consistent with Figure 5. This preliminary fMRI data will provide the basis for conducting further studies in the elderly, who are harder to image from a methodological standpoint. From a broader perspective, designing behavioral tasks to be performed in VR that robustly generate an fMRI signal is challenging. As mentioned previously, the simplest procedure utilizes the principal of cognitive subtraction to contrast a specific state of brain activation, with a baseline state in an alternating blocked design. Each block typically lasts 20 seconds or longer. In conventional fMRI procedures, the behavioral task is typically very focused to ensure that the two states differ primarily by specific neural activation of interest, although the validity of this assumption has been questioned.[52] Multiple control experiments may also be performed to account for activations associated with the tasks that are not of specific interest, or that distinguish different cognitive components of the behavioral task. This procedure is widely accepted in functional neuroimaging, but has disadvantages.[53] Variations in performance (such as learning effects, or response errors) cannot be distinguished within a block. Furthermore, the behavior elicited in VR experiments is likely to involve a complex interplay of multimodal sensory integration, multiple cognitive domains, and motor responses. Multiple control experiments may be impractical due to time considerations, necessitating activation maps based on comparatively simple baseline conditions. The interpretation of such activation maps is, therefore, likely to be quite complex.

Alternatively, “event-related” experimental designs result in activation maps of brief behaviors typically lasting a few seconds or less. This approach does not address the need for control experiments, but is more sensitive to learning effects and can separate successful responses from unsuccessful ones. Because fMRI signals are weak (typically 1-4% signal change from baseline at 1.5 T[54]), multiple repetitions of blocks or events must be averaged to map brain activation reliably. Although event-related VR-fMRI studies are likely possible in particular applications, VR-fMRI tasks must be inherently repetitive and should not normally hinge on highly specific, isolated events. Thus, there will inevitably be tradeoffs between the realistic behavior that can be elicited in VR and the behavior required to optimize fMRI experimental design.

Irrespective of whether a blocked, event-related, or hybrid design is employed, conventional fMRI analysis involves correlation, or linear fitting of the task pattern (e.g. navigation vs. rest) to fMRI time series data at each voxel. More relevant is a correlation of fMRI signals to behavioral data such as navigational accuracy, or physiological data such as that obtained by electroencephalography, electromyography, eye tracking, heart rate, respiration rate, and galvanic skin response.[55] This is technologically and computationally possible using alternative approaches for fMRI data post-processing, such as independent component analysis (ICA)[56] or partial least squares (PLS).[57] Given the complexity of the tasks involved, integrated physiological monitoring and multivariate analyses will be essential to future VR-fMRI studies.[58]

Other fMRI research that we plan to undertake in the near future involves assessing the ecological validity of the Sunnybrook City task. This will involve fMRI during navigation in VR, and during conventional paper and pencil tests. These comparisons are readily achievable using our testing platform, particularly with the use of ShapeTape in its virtual stylus mode. Moreover, such comparisons are essential - they facilitate assessing the validity of generalizations that can be made from traditional neuropsychological measures, which are often contrived.

Furthermore, combining VR with fMRI technology can potentially demonstrate how brain reorganization and recovery are produced through the use of VR rehabilitation procedures (e.g. treatment of phobias). A new focus of interest in our laboratory is the use of VR for cognitive and physical rehabilitation procedures to promote stroke recovery. We are currently conducting fMRI experiments designed to track the natural course of brain reorganization during stroke recovery.[59] We are also using it to enhance recovery through a combined used of physical therapy and amphetamine administration to enhance neuroplasticity.[60] We anticipate that the use of VEs will increase the motivation of stroke patients to participate in rehabilitation and, through use of targeted and graded training regimens, enhance recovery outcome by improving patient self-esteem and quality of life. Functional MRI will be important for comparing such new therapies with conventional procedures and to gauge the generalizability of functional recovery.

Lastly, it is important to mention that most participants experienced a certain amount of cybersickness while navigating the VE. This is not unexpected, given the inherent conflict between visual sense of movement with proprioceptive and vestibular information.[24] It has been observed that as many as 80% to 95% of people exposed to a VE suffer from cybersickness to some degree,[61] and that 5% to 30% of participants have severe symptoms that necessitate discontinuing testing.[62,63] In our navigation study, the types of symptoms experienced varied greatly across individuals, but most exhibited some sort of minor discomfort. No participant, however, discontinued testing. Subjects usually tend to experience a steady increase in cybersickness symptoms as the immersion period progresses.[64] Still, participants' self-rating of symptoms were fairly low when they were assessed at the end of the immersion period.

As previously noted, participants' performance improved across learning trials despite this discomfort. We can thus speculate that the impact of cybersickness was probably not overwhelming but it is obviously a limitation of this kind of technology. The control and flexibility offered by this VE are still, however, advantages that potentially outweigh this side effect.

Final Note: There is much scope for improving and expanding the use of Virtual Reality and fMRI in psychological research. In the illustrative example reported here, the results of spatial navigation in a VE indicate a difference between the ability of young and old adults to exercise route learning and memorization. Older participants were neither as fast nor as accurate as young participants during navigation. For the two PrAD patients, J.H.'s performance was comparable to healthy older adults whereas S.D.'s was clearly inferior. It would be pertinent to pursue testing in patients with AD to confirm the promissory results obtained in this study. The fMRI results in a young healthy adult are consistent with existing functional neuroanatomic theory, and provide an intriguing window as to how brain activity evolves over the course of the Sunnybrook City task. Continued fMRI testing on a larger number of subjects promises to be even more revealing.

Since we started assembling the platform in our laboratory, additional companies have developed robust fMRI-compatible stimulus presentation equipment applicable to VR testing. Turnkey solutions for fMRI-compatible VR are also emerging. These advancements, together with the continued rapid increase in computing power and graphical rendering performance, ensure that it will be possible to make significant headway in charting the brain activity associated with VEs of sophisticated complexity, performance, and application.

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Three Studies Using an fMRI Compatible Virtual Reality System

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Psychology Software Tools

ABSTRACT: *Functional MRI studies present a host of problems for neurobehavioral researchers whose subjects need to use electronic devices. In particular, most virtual reality studies require the use of a joystick and/or mouse. The MRI scanner is a hostile environment for electronic equipment, requiring the development of specialized virtual reality equipment that is compatible with the scanner. MRI compatible versions of some conventional computer equipment and are available for the joystick, dataglove and motion tracker, and touchpad (which replaces the mouse). In our first study we investigated the ability of various cigarette-smoking stimuli embedded within the simulation to elicit a craving-to-smoke in smokers who had been deprived of a cigarette for at least 12 hours. They were tested in two different runs, each lasting about 15-20 minutes. In the first run they go through the apartment, urban streets, and restaurant without any smoking stimuli placed in the environments. In the second run the stimuli are embedded in the scenes. Nearly all smokers rated the bar scene as the strongest stimulus for evoking their craving to smoke. The VR/fMRI system has been used to acquire data from subjects participating in two tasks – one for spatial navigation memory and another for executive function. For the spatial navigation memory task the experimental paradigm consisted of three separate runs, each of which lasted seven minutes. Echo planar imaging was used to acquire 37 axial slices covering the entire brain every three seconds for a total of 140 volume acquisitions during each seven-minute run. We observed a decrease in activation during the passive period and the increase in activation during the active navigation period. For the executive function task the subjects were placed in the apartment environment and given a sequence of five progressively more difficult tasks to perform in blocks of two minutes each. Echo planar imaging was used to acquire 37 axial slices covering the entire brain every three seconds for a total of 40 volume acquisitions during each two-minute run. For the executive-function loading task, the five separate runs were arranged for inter-run comparison. The result is a highly significant activation bilaterally in the anterior frontal lobes, an area associated with executive function. Most of the activation persists even when the most difficult run is compared to a run of medium difficulty.*

INTRODUCTION

Advances in computer hardware in the form of faster processors, more memory and better graphics cards allow desktop PCs running Windows to be configured to run virtual reality applications, and the popular gaming industry has driven the market to provide software development engines that are quite affordable for scientific laboratories. These engines are able to provide fast frame-rates for applications that can display tens of thousands of polygons at one time with richly textured, realistic-looking scenes and characters. The technology is available and affordable for neurobehavioral research, and some investigators, including our own group, have made strides to incorporate the technology into neurobehavioral and neuroimaging paradigms.

VR has been used to study a variety of basic research questions involving perception,[20,22] attention,[16] memory,[13] spatial navigation,[1,17,18,23] and memory deficits in neurosurgical patients.[25] Applications are being used in areas as diverse as desensitization therapy for the treatment of phobias,[6,8,21,24,27-29] rehabilitation of brain-injured children,[9] pain control,[12] drug abuse treatment[15] and to combat teen smoking.[30]

We are developing a user-friendly VR system of integrated hardware and software for scientific research and clinical application that is sufficiently general in scope that it should have broad appeal to a variety of researchers, yet be flexible enough to allow investigators or clinicians to tailor the system to their particular interests. It allows simultaneous monitoring of physiological signals, and it enables researchers to perform a variety of neurobehavioral studies in the laboratory or within neuroimaging scanners.

In an effort to study isolated segments of the brain, neuroimaging studies are often quite simplistic. More sophisticated analysis techniques now make possible the use of more complex, realistic, and socially relevant experimental paradigms. However, outside of a few university research laboratories, an integrated virtual reality (VR) system for neuroimaging studies using functional magnetic resonance imaging (fMRI), positron emission tomography (PET) or magnetoencephalography (MEG) is not available.

Functional MRI has become the primary neuroimaging tool for neurobehavioral research, yet experiments designed for use in fMRI studies are often abstract, contrived and devoid of real-life context. Visual tasks may utilize a flashing checkerboard, memory tasks might use a sequence of letters and limbic activation might be studied with emotionally provocative but static pictures of angry faces. Such basic designs are useful for mapping the primary functional areas of the brain, but they provide mere glimpses of the networked brain activity that must occur during real-life situations when multiple functional areas are called upon to guide one's behavior. More relevant and meaningful studies require more sophisticated designs that better mimic reality, especially for studies of social behavior.

Virtual reality (VR) offers the potential of simulating real-life, everyday experiences. Consequently, it can provide the appropriate context for a variety of neurobehavioral studies. Acrophobia might be studied by having patients climb a set of stairs in a multi-story building and look out a window at each level while their physiology is monitored. Autism might be studied by having a subject wander around an urban street scene, encountering realistic-looking characters who look directly at the subject while their eye movements are monitored. Attention deficit hyperactivity disorder (ADHD) might be studied by simulating a school classroom with periodic distracters vying for the attention of a child trying to read an age-appropriate passage from a book.

Functional MRI is a relatively new imaging technique for mapping the working brain that was developed in the last decade and has grown exponentially in its use since then.[14,19] The blood oxygenation level dependent (BOLD) effect is the basis for most the fMRI studies done today and is most pronounced on gradient echo (GRE) images. (Buxton[4] has an excellent review of the physiology and physics underlying BOLD fMRI.) As brain activation increases in the cortex, there is a localized increase in blood flow and oxygenation of the blood. The combination of increased oxygenation and blood flow results in higher localized ratios of oxygenated hemoglobin relative to paramagnetic deoxyhemoglobin in areas of active tissue. This results in an increase in the apparent transverse relaxation time (T_2*), producing a higher MRI return signal for the more activated tissue. fMRI monitors changes in brain blood oxygenation and flow without the need to inject contrast or radioactive agents, as is necessary in PET studies.

Functional MRI has the potential to provide information about cortical function and organization with near-millimeter precision. The spatial resolution of fMRI is on the order of 1-3 mm and is generally considered superior to that of PET (~ 5 mm). The temporal resolution is on the order of 1 second per whole brain volume, far better than PET (~ 1 minute), but still several orders of magnitude greater than EEG and MEG. Functional MRI is widely used as one of the primary means of studying cognition,[5] and increasingly is being used in surgical planning.[2,11] Furthermore, because fMRI is nontoxic, individuals can be scanned repeatedly, which permits multiple, within-subject contrasts that support in-depth studies of cognitive function and cortical activity.

As fMRI equipment, experimental design, and analysis techniques have improved, investigators have moved from basic experiments that activate only single neural pathways to more sophisticated designs that involve multimodal stimuli (such as VR) and analytic techniques that focus on networks of activation within multiple regions. Functional MRI groups have employed VR to investigate navigation[1,10,17,23,26] and spatial memory.[3] These studies often are the result of several man-years of effort from multi-disciplinary teams of university researchers with highly specialized expertise and a wealth of institutional resources to draw upon. To make this technology more widespread and available to a larger array of investigators, an affordable, user-friendly system is necessary, and we plan to provide such a commercial system within the current year.

DESCRIPTION OF THE VR/fMRI SYSTEM

The software application consists of a virtual world of 13 interconnected environments: an urban area, an apartment in a complex, a restaurant with a bar, a bank, a cinema complex, a subway system containing three stations, two airports, a suburban village, a doctor's office, and a house. Some of the environments are shown in Figure 1. Additional environments can be built and easily added, and two more – a casino/nightclub and a grocery store – are under construction. Since all of the environments are interconnected, the subject is free to wander throughout the world and explore its contents. Navigation is performed with a joystick, and object manipulation can be accomplished with a mouse, touchpad, or dataglove. Interactivity is provided for many typical objects such as doors, cabinets, drawers, clothes, chairs, light switches, lamps, bathroom fixtures, kitchen appliances, groceries, drinks, and money.

There are more than 50 characters in the world, most of them animated or capable of interacting with the subject; each public environment contains at least one character capable of interacting with the subject. The emphasis

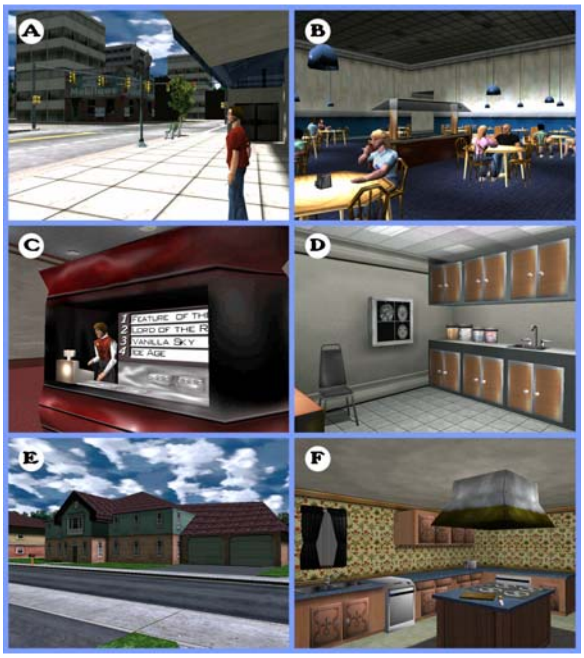

Figure 1. A) Urban street; B) restaurant; C) movie theater lobby; D) doctor's office; E) house in suburban village; F) kitchen inside house.

throughout the application is on realism, so motion-capture software is used for realistic facial expressions and lip-synching with the audio stream. Three levels of detail enable switching from low to high-resolution features as the subject draws near interactive characters.

A startup interface provides a means of initializing the simulation to the experimenter's or clinician's specifications. Demographic data can be recorded, optional hardware can be configured, and multiple menus are available for selecting characters and objects that a researcher might want to place at specific locations within the simulation. For instance a researcher studying craving in smoking-addicted subjects might want to place cues such as cigarette advertisements or smoking characters at various places throughout the world (see Figures 2 & 3) for the subject to encounter while physiology is monitored; or therapists working with patients who have animal phobias might want to place spiders or dogs in various behavioral postures (benign to aggressive) at defined places for the subject to encounter as part of desensitization therapy.

Navigation throughout this large application is aided by the use of semi-transparent maps that overlay the local environment (Figure 4). These can be left in place while the subject navigates, and a small icon representing the subject moves on the map to show the subject's relative location with respect to the surrounding area. The map is a useful tool for studies of memory and spatial navigation.

All movements and actions of the subject within the world can be tracked and recorded to an Excel spreadsheet for data analysis (see Figure 6). Each environment is divided into small regions of interest (ROI), and the spreadsheet provides a timestamp when the subject enters each ROI, what action they perform there (e.g. opening a door, turning on a light), which characters they interacted with and what their response was to any questions posed by the character. In addition the entire simulation can be recorded on videotape for archiving and analysis.

A variety of other features are available to improve the sense of realism and immersion. Four theaters in the cinema complex actually show movies. A television in the bar plays

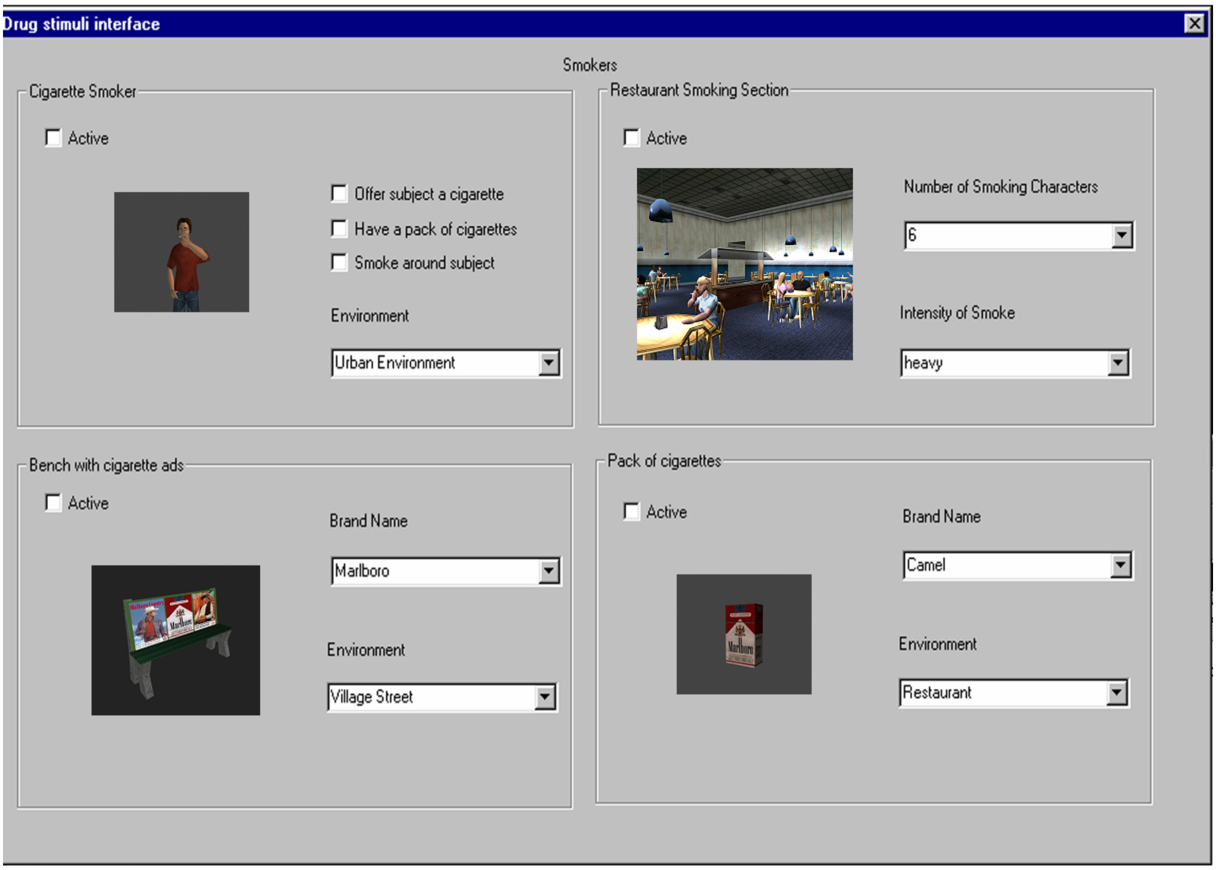

Figure 2. Menu for selecting various smoking stimuli for placement within the simulation.

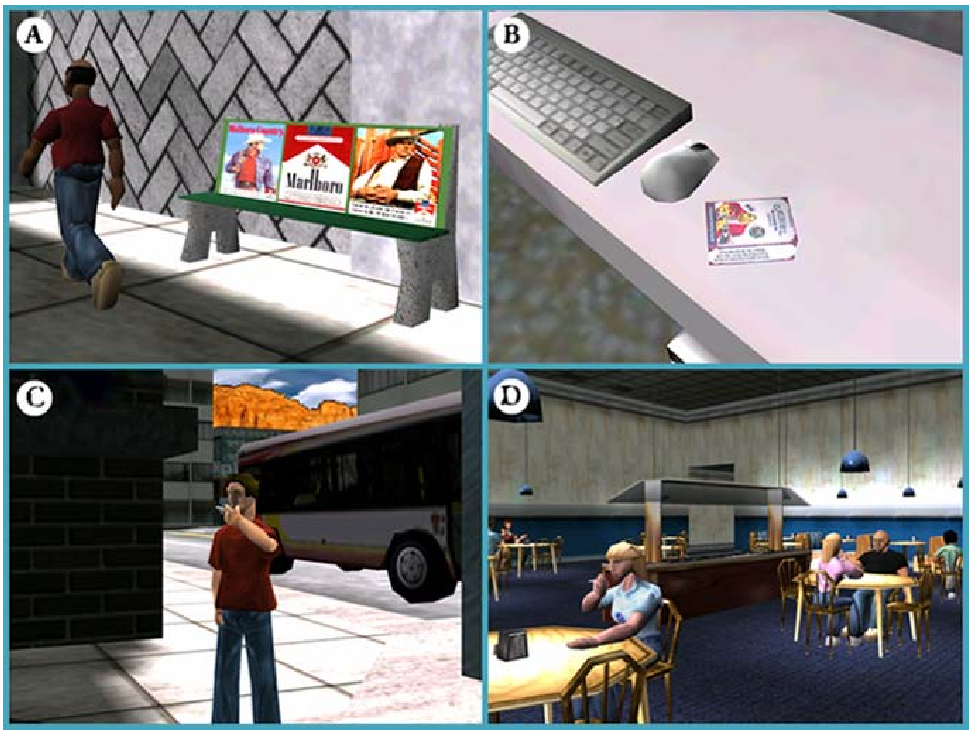

Figure 3. Placement of various smoking stimuli within the simulation.

Figure 4. Semi-transparent map overlaid upon urban street scene showing location of avatar (small square at intersection below theater) with respect to major landmarks.

sports programs. Stereo sound is supported. Video output can be fed to head-mounted displays or PC monitors with up to 1600 x 1200 resolution. Communication between the subject and the experimenter uses a microphone and stereo headphones, but can be supplemented by allowing the experimenter to type text on a portion of the screen to silently direct the subject to perform a task.

The application runs on a Windows-based PC (98, 2000, XP, ME) with at least a 1 GHz Pentium III, Direct X 8.1 or greater and a good graphics card such as the nVidia GeForce3 containing 64 Mbytes of RAM. Faster machines and even better graphics cards enable faster frame-rates and level switching between the environments. We currently run the application on 1.7 GHz machines or faster containing graphics cards (ATI 9700 or nVidia GeForce4) with 128 Mbytes of RAM. As the application develops more characters and interactions, faster machines will be essential to maintain adequate frame rates, so that the simulation does not slow down or become jerky.

Functional MRI studies present a host of problems for neurobehavioral researchers whose subjects need to use electronic devices. In particular, most VR studies require the use of a joystick and/or mouse. The MRI scanner is a hostile environment for electronic equipment, because it produces pulses of radio-frequency (RF) electromagnetic radiation and a large standing magnet field (approximately 30,000-60,000 times the earth's magnetic field for 1.5 or 3.0 Tesla magnets) that can disrupt normal function of the electronic equipment. Indeed it can be dangerous to bring objects containing ferromagnetic material close to the bore of the scanner, because the object can be drawn into the bore and become a dangerous projectile with life-threatening consequences for the subject. In addition, the very process that enables the scanner to produce the remarkable images of internal human anatomy also makes it exquisitely sensitive to the presence of stray electromagnetic fields, and all active electronic equipment, unless it is properly shielded and filtered, can produce electromagnetic noise that may contaminate the MR images.

Our VR system for non-MRI studies normally includes a joystick for navigation, a touchpad or mouse and an optional dataglove with an attached motion tracker. The video output on the PC can be used to display the application on a head-mounted display (HMD) or a computer monitor. MRI compatible versions of some of this equipment have been developed and are available for the joystick, dataglove + motion tracker and touchpad (which replaces the mouse).

Concurrent physiological data can be acquired for up to 16 channels single-ended or 8 channels differentially with 200 KHz sampling rates and 12-bit resolution. Respiration, heart rate, blood volume pulsatility, and skin conductance response can be recorded in the MR scanner, and the system provides synchronization of the VR simulation with the physiological recordings and the functional MR images.

DATA FROM A NEUROBEHAVIORAL STUDY OF SMOKING CUES

We are studying the ability of various cigarette-smoking stimuli embedded within the simulation to elicit a craving-to-smoke in smokers who have been deprived of a cigarette for at least 12 hours. Previous studies have looked at the ability of pictures to elicit a craving in smokers,[7] but VR allows stimuli to be evaluated within a more naturalistic and immersive context. A startup interface enables an experimenter to place stimuli at various locations within several of the environments. The stimuli consist of opened cigarette packages, ashtrays, cigarette vending machines, cigarettes for sale at a news-stand, cigarette ads, cigarette butts, individual smokers, groups of smokers, and a bar scene with smokers and beer.

Smokers participating in the study are given a CO test to confirm that they have not had a cigarette for at least 12 hours. Then they are seated in front of a large 21” computer monitor and given instructions for navigating through the world. They are allowed to practice in another part of the simulation that will not be involved in the testing until they feel comfortable, usually about 20-30 minutes. Then they are tested in two different runs, each lasting about 15-20 minutes. In the first run they go through the apartment, urban streets, and restaurant without any smoking stimuli placed in the environments. In the second run the stimuli are embedded in the scenes.

The subjects are instructed to explore some of the environments and occasionally asked to navigate in certain directions or to go to a certain place. Periodically, the experimenter, who is at the keyboard and watching from behind the subject, brings up a rating scale which overlays the scene. The subject must rate their craving to smoke on a scale of 0 – 100, with 0 being absolutely no craving and 100 being absolutely the strongest craving to smoke. Most subjects begin the simulation with a rating of 40-60, even before they have seen any smoking stimuli. However, they often become so immersed in the game and distracted from their smoking craving that they do not have any conscious urge to smoke until they see the smoking stimuli or the rating scale. At the end of the simulation, each subject is asked to rank order the stimuli from strongest to weakest. Nearly all smokers rate the bar scene as the strongest stimulus for evoking their craving to smoke (see Figure 5). This is the most social of the stimuli with a wide variety of stimuli for smokers that includes groups of smokers sitting at tables or standing at a bar, smoke coming from the cigarettes, ashtrays and cigarette butts, opened alcoholic beverages and sports highlights on a TV. The logfile records all of the locations and ratings during the simulation (Table 1), and enables the experimenter to evaluate the relative strength and success of the various stimuli in evoking the urge to smoke in the subjects.

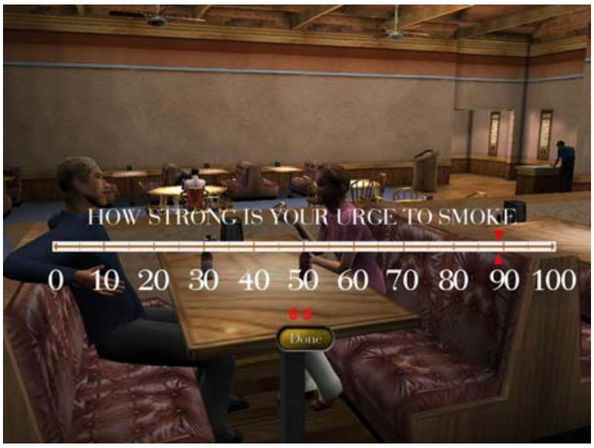

Figure 5. Rating scale for smokers that is triggered by a command from the experimenter. Subject’s rating is sent to the logfile displayed in Table 1 with the corresponding line that logged this data highlighted towards the end of the file.

DATA FROM TWO VR/FMRI PILOT STUDIES

The VR/fMRI system has been used to acquire data from subjects participating in two tasks – one for spatial navigation memory and another for executive function. Informed consent was obtained for each subject. Subjects were shown how to use the joystick and touchpad to move through the virtual world (see Figure 6), and were allowed to practice navigating in an area that would not be used in subsequent sessions until they felt comfortable maneuvering through the simulation. Then they were asked to sit passively and observe carefully to form a mental map of the urban area as they were taken on a guided tour that lasted about 5 minutes.

The following day they participated in a functional MRI study using a GE Signa 1.5 Tesla scanner. For the spatial navigation memory task the experimental paradigm consisted of three separate runs, each of which lasted seven min-

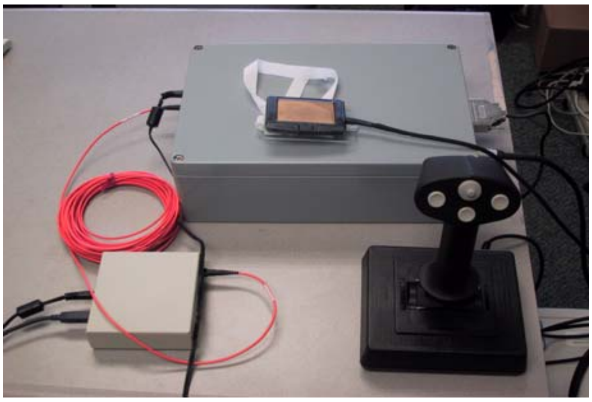

Figure 6. MRI compatible joystick and touchpad for navigating in the scanner during fMRI studies. Interface (larger) box communicates with computer via fiber optic cable and USB connector.

Table 1. Logfile showing behavioral data collected in smoking study from subject exposed to increasingly strong smoking cues placed within the simulation. Data is time compressed through deletion around blank lines. Note how rating increases.

Name Pilot Subject for smoking study					
Age: 22	*Gender: Male*				
Starting Point: Apartment					
Time	**Region**	**Action**	**Object**	**Question**	**Rating (0-100)**
17:47:05	APT_ENTRYWAY	Entered			
17:47:22	APT_ENTRYWAY	Experimenter's Question		Rate Stimuli	62.613
17:47:24	APT_LR_COMPARE	Entered			
17:47:56	APT_LR_COMPARE	Experimenter's Question		Rate Stimuli	68.897
17:48:01	APT_LR_DINIGARE	Entered			
17:48:02	APT_LR_TVAREA	Entered			
17:48:09	APT_BEDROOM	Entered			
17:48:20	APT_BEDROOM	Manipulated	Light Switch		
17:48:35	APT_BEDROOM	Experimenter's Question		Rate Stimuli	72.211
17:48:55	APT_BEDROOM	Manipulated	Door		
17:51:49	ART_SIDEWALK	Experimenter's Question		Rate Stimuli	79.066
17:52:12	U_ROAD	Entered			
17:52:29	U_ROAD	Experimenter's Question		Rate Stimuli	76.096
17:52:45	U_ROAD	Entered			
17:52:52	U_ROADPLAIN	Entered			
17:53:12	U_ROADPLAIN	Experimenter's Question		Rate Stimuli	69.126
17:53:14	U_ROAD	Entered			
17:54:07	U_ROADPLAIN	Entered			
17:54:08	U_ROADPLAIN	Experimenter's Question		Rate Stimuli	87.521
17:54:10	SIDEWALKCOR-	Entered			
17:55:18	SIDEWALKTILES	Entered			
17:55:32	SIDEWALKTILES	Experimenter's Question		Rate Stimuli	70.383
17:55:33	SIDEWALKTILES	Manipulated	Door		
17:55:35	H_HALLFLOOR	Entered			
17:56:01	H_HALLFLOOR	Experimenter's Question		Rate Stimuli	88.55
17:56:12	RT_CARPET	Entered			
17:56:19	H_HALLFLOOR	Entered			
17:56:50	H_HALLFLOOR	Experimenter's Question		Rate Stimuli	99.976
17:57:04	RT_CARPET	Entered			
17:57:25	RT_CARPET	Experimenter's Question		Rate Stimuli	100

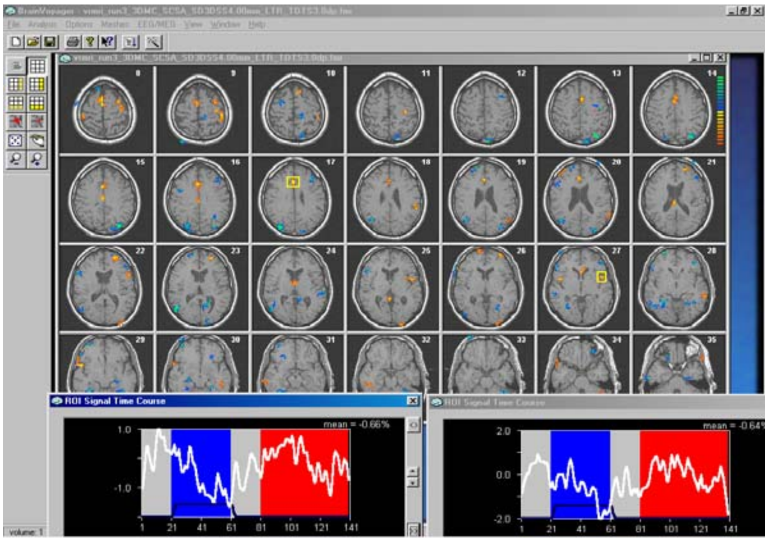

Figure 7. Axial slices from a subject engaged in a spatial navigation memory task.

utes and required the subject to watch a static image from the simulation for one minute, then follow a passive guided tour of an area for two minutes, and then a static image for another minute. Finally, they were required to navigate to an area of the urban environment within three minutes based on their recollection of a mental map from the previous day. Echo planar imaging was used to acquire 37 axial slices covering the entire brain every three seconds for a total of 140 volume acquisitions during each seven-minute run.

For the executive function task the subjects were placed in the apartment environment and given a sequence of five progressively more difficult tasks to perform in blocks of two minutes each. The first task was simply to explore the apartment using the joystick; the second task was to explore the apartment and to activate as many objects as possible using the touchpad; the third task was to find and change the state of all the light switches in the apartment; the fourth task was to check the functionality of all the plumbing, chairs, and drawers in the kitchen and dining room; and the last task was to go to each closet (four) and count and categorize all of the objects (18 objects in five categories). Echo planar imaging was used to acquire 37 axial slices covering the entire brain every three seconds for a total of 40 volume acquisitions during each two-minute run.

As can be seen in Figure 7, multiple cortical areas show activation when an active navigation task is compared to a passive guided tour. Two areas are highlighted with yellow boxes – the cingulate cortex (image 17 in second row), which is involved in attention, and the prefrontal cortex (image 27 in third row), which is involved in short-term memory. Plots of the time-course of activation for each region are shown at the bottom of the figure. Light grey denotes two one-minute time periods when a static image was shown, black denotes a two-minute time period when the subject was given a passive guided tour and dark grey denotes a three-minute time period when the subject actively navigated a route based on his memory of the route from a passive tour given the previous day. We observed a decrease in activation during the passive period and the increase in activation during the active navigation period.

The fMRI data was analyzed using Brain Voyager software (Brain Innovations, The Netherlands). All data was preprocessed for linear trend removal and filtered for smoothing. A General Linear Model was used to compare the period blocks.

For the spatial navigation memory task, active navigation periods were compared to the passive guided tour periods for all three runs combined, using the static image periods as a baseline. Data from a single subject is shown in Figure 7. After a correction for the number of voxels analyzed, the results were highly significant ($p<0.10^{-6}$).

A number of relevant cortical areas are shown to be active during the task including motor areas (bilateral sensorimotor, supplementary motor, and cerebellum from using the hands for navigation), attention areas (cingulate and parietal cortex), memory areas (frontal, dorsolateral prefrontal and parietal), and visual areas (occipital and calcarine). The result is a robust display of multiple areas of activation appropriate to the task.

For the executive-function loading task, the five separate runs were arranged for inter-run comparison. Since T1 saturation effects predominate in the first few volumes of each run, these volumes were not used in the analysis, but appear as spikes in the graphical display of the region of interest (ROI) data. (Subsequently, we have developed a memo pad for subject display that allows the experimenter to communicate instructions clearly to the subject to change tasks during the course of a long run that can be divided into contiguous blocks of different tasks.) The result is a highly significant ($p < 9.5 \times 10^{-12}$) activation bilaterally in the anterior frontal lobes, an area associated with executive function (see Figure 8). Most of the activation persists even when the most difficult run is compared to a run of medium difficulty (Figure 9).

FUTURE PLANS

A number of additional environments and characters are being added to the world - including a casino, a grocery store, a hotel and an airplane – each with interactive characters

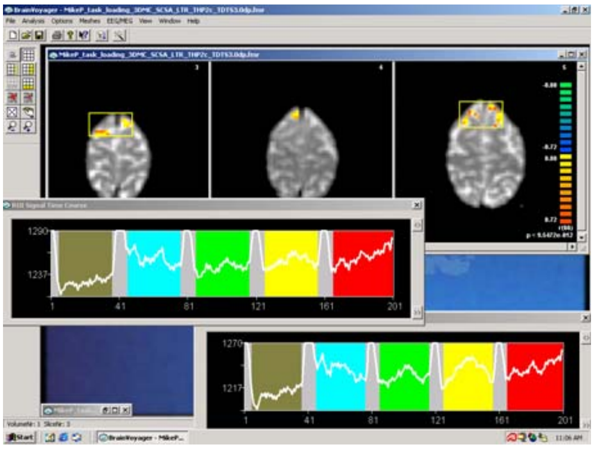

Figure 8. Activation of anterior frontal cortex is displayed on two axial images from a single subject engaged in the task-loading experiment. Activation time courses are displayed below each slice. T1 saturation effects (spikes) predominate between each two-minute run in this pilot data. Note the highly significant bilateral frontal lobe activation when the last run (far right) is compared to the first run (far left).

that will allow the subject to perform appropriate social and goal-driven tasks in the environments. Particular effort is being made to make the facial features and expressions on the characters more realistic.

An integrated, fMRI-compatible dataglove is being developed that will include motion tracking for the fingers and arm, as well as tactile feedback for the fingertips. The ability to use

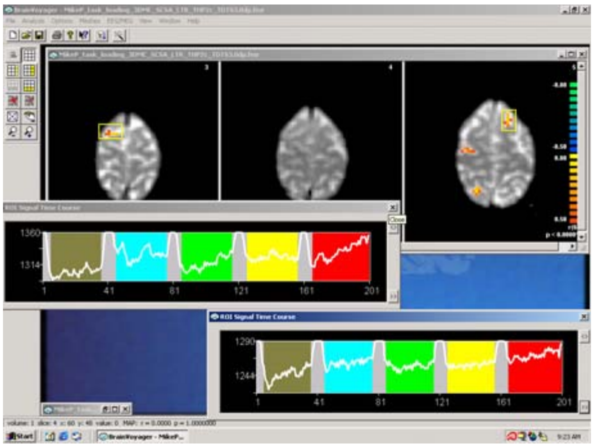

Figure 9. The task-loading effect persists when the last run is compared to the middle run, although the activation is not as widespread.

money or credit cards in the world is being developed. We intend to extend the startup interface to allow more flexibility for researchers to include or exclude certain objects and characters, as well as to allow biofeedback to control the exposure of the subject to certain features for the use of desensitization therapy in the treatment of anxiety and phobic disorders.

CONCLUSION

A virtual reality system of integrated software and hardware has been developed for neurobehavioral and clinical studies in the laboratory or in neuroimaging scanners, particularly for fMRI studies. The system has a variety of features to provide flexibility and generalizability for researchers or clinicians across a broad spectrum of interests. Pilot data from fMRI studies of memory for spatial navigation and executive function for task loading shows robust activation in multiple cortical regions expected to be involved in these tasks. To our knowledge this is the first virtual reality system for fMRI studies to be made commercially available.

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Clinical Observations

Designing Virtual Worlds to Treat Social Phobia

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Abstract: *Social phobia is an anxiety disorder that affects between two and four percent of the adult population. Certain anti-depressants and cognitive behavioral therapies (CBT) have both proven effective in the treatment of social phobia. A core component of CBT is exposing the patient to the feared situations in order the patient to learn to recognize the cognitions associated with the phobia and how to effectively deal with them. However, conducting such exposure in real life can be difficult to control and may limit patient confidentiality. Virtual reality exposure therapy is thus being explored as a possible alternative therapeutic method. The goal of this project was to assess the efficacy of virtual reality exposure therapy vs. traditional CBT.*

Before beginning a small clinical trial, a social phobia module was constructed to serve as a place for the patients to be exposed to phobic stimuli and learn new behaviors. Each environment within the module represents a situation that has been recognized as a specialized faucet of social phobia. The methods used to design the virtual worlds and the hardware requirements of our system are described. As patients began to progress through the program, we were able to reaffirm the observation that an exact representation of reality is not necessary as long as the anxiety-provoking stimuli are as close to accurate as possible. An improvement in the social phobia symptoms has been noticed among the patients who followed the complete course of virtual reality exposure therapy and confirmed by psychometric evaluations. A treatment attendance higher than is usually seen in clinical practice was also observed. The patients remarked upon the "playful" aspect of therapy, which may explain the elevated attendance rate.

INTRODUCTION

According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV), social phobia, like other phobias, is defined by "a persistent and irrational fear, anxiety and avoidance." Social phobics experience significant emotional distress when facing situations where they are introduced to other people, the center of attention, being teased or criticized, meeting people with some sort of authority, and so on. Several physiological symptoms may occur together with social phobia: intense fear, racing heart, blushing, excessive sweating, dry throat and mouth, or trembling.

Social phobia affects between two and four percent of the adult population. This disease is one of the most frequent mental diseases and generally first appears between the ages of fifteen and twenty. Though this disorder has long been neglected, its most common example, the fear of public speaking, is now the object of an intensive study.

Social phobia is accessible to two forms of treatment: drugs such as certain anti-depressants (inhibitors of serotonin recapture) and Cognitive Behavioral Therapies (CBT). CBT combines three different components, listed below:

- Exposure therapy: A regular and prolonged confrontation of the subject to anxiety-producing social situations.
- Cognitive therapy: A modification of the subject's thoughts and assessments of social situations.
- Assertiveness therapy: The learning of more efficient relational behaviors.

The exposure to feared social situations is essential to obtain an improvement of the anxiety symptoms. Traditionally, exposure therapies are done either *in vivo*, where the subject is confronted by real social situations, or by imagining them. However, *in vivo* exposure has some drawbacks and this technique is faintness, it may be difficult, even impossible, to stop the phobic stimulus. In addition, since the exposure is in real conditions, the patient may be exhibited to public eyes and the indispensable confidentiality cannot be assured. Some phobic patients also find it impossible to imagine the anxious stimuli described by the therapist. The clinician is furthermore unable to know what the patient imagines in actuality.

Virtual reality seems to bring significant advantages by allowing exposure to numerous, varied, and well-mastered situations. Moreover, it has been shown that human subjects respond appropriately to negative or positive audiences, even when completely virtual. We can therefore assume that socially phobic patients will feel anxiety and physiological disorders when they are confronted by virtual environments related to their illness.

We used virtual reality techniques in cognitive behavioral therapy to treat social phobia. This work is part of the VEPSY Updated project, whose goal is to understand and exploit the potential of virtual reality to treat psychological disorders.

The social phobia module consists of four virtual environments where the patients are exposed to the phobic stimuli and learn new behaviors. These environments are used according to a clinical protocol that is defined in Nugues et al.[16] The clinical protocol specifies the patients' assessment and allocation, as well as the therapy's structure. Also described are the required equipment, the virtual worlds, the scenarios, and the techniques we designed for the therapy. The efficiency of virtual reality therapy was assessed, as was the comfort and convenience of the designed technology within the framework of a small-scale clinical trial. Finally, a report on the results obtained is included.

The final purpose of this project is to assess the efficiency of virtual reality therapy (VRT) compared to validated CBT, and to evaluate the absence of treatment for social phobia patients.

THE CLINICAL PROTOCOL

The target population was comprised of patients showing a social phobia according to the diagnostic criteria of the DSM-IV. They must comply with:

- Inclusion criteria: men and women, at least 18 years old and at most 65 years old, ambulatory social phobics, and
- Non-inclusion criteria: in terms of population (pregnant women), of pathology (severe organic disease, mental disorder of an organic origin, depression), and of treatment (with active medicinal treatment against social phobia that is not stabilized, other kind of psychotherapy).

After the clinical assessment, the patients were subjected to psychometric assessments. They had to fill out self-report questionnaires that included the Hospital Anxiety Depression Scale (HAD), the Social Anxiety Scale (SAS), the short Beck Depression Inventory (BDI-13), and the Rathus Assertiveness Schedule (RAS).

We selected four exposure situations dealing with anxiety tied to assertiveness, performance, intimacy, and scrutiny. Each situation corresponds to a specially recognized case of social anxiety, with the purpose being the reduction of the patient's unease in the corresponding real situations. The objective was to teach the patient new behaviors such as protecting one's interests, fostering respect, speaking in public, facing "important" people, dealing informal contacts,

Table 1. Structure of the therapy groups.

Virtual Reality Therapy	**Cognitive Behavioral Therapy**
Individual session	Session in small group (8 -10 patients)
Directed by a CB Therapist	Directed by a CB Therapist
Duration: 45 minutes (exposure < 20 min.)	Duration: 2 hours
12 weekly sessions spread over 3 to 4 months	12 weekly sessions spread over 3 to 4 months
Prescription of tasks	Prescription of tasks

having small talks with friends, moving or speaking in the presence of others, and being observed.

We defined the structure of the Virtual Reality Therapy (VRT), which includes patients' assessment and the contents of the VR sessions.
Each patient attended twelve sessions of VRT. Each session was individual and directed by a cognitive behavioral psychotherapist. During these weekly sessions of forty-five minutes, the patient was exposed to virtual worlds for the purpose of assessment or therapy. The duration of each exposure should be less than twenty minutes (Table 1).

During the first session the therapist introduced and presented the therapy to the patient. Then the patient familiarized him or herself with the virtual training world and the tools. The next ten virtual sessions constituted the core of the therapy. During session twelve a final conclusion was given to the patient.

At the end of each session the therapist prescribed tasks for the patient to carry out in order to apply what was been learned.

Virtual reality sessions were conducted according to three phases:

The assessment phase contains questions to explore:

Cognitions – *What thoughts do you have?*
Emotions – *What do you feel?*
Behaviors – *What do you do?*

Therapeutic phases mix

Spontaneous phase: The patient moves about freely in the world and decides for him or herself which attitudes to adopt;

Instructed phase: The therapist instructs the patient which attitudes are relevant to the situation. The therapist helps the patient to learn adapted reactions in relation to cognitions, emotions, and behaviors.

During the small-scale clinical trial, each patient carried out an assessment of the virtual technology for the four virtual environments. In order to evaluate the reality of judgment of the patient and the sense of presence in the environment, the subject had to fill in the Reality Judgment and Presence Questionnaire.

EQUIPMENT AND SOFTWARE

The use of low-cost PCs in virtual reality is one of the requirements of the VEPSY Updated project. The system minimum configuration is a Pentium III or IV PC with 64 MB of RAM, an Internet browser (Explorer and Navigator), and

Figure 1. Cyberpuck.

a plug-in to visualize the virtual worlds. Some features are recommended. They include a Direct3D or OpenGL compatible 3D accelerator graphics card with at least 8 MB of RAM, DirectX, a monitor color display set to 16/32 bits, and a sound card.

The virtual world images are displayed on a large screen monitor. The patient navigates in the world and interacts with his or her environment using either with a mouse and a keyboard or a Cyberpuck pad (Figure 1). The Cyberpuck

Figure 2. VFX3D Head-Mounted Display.

Table 2. Types of virtual situations

Type of Anxiety	Virtual World	Goal
Assertiveness	Lift – Hall – Shoe store	Protecting one's interests, viewpoints, being respected
Intimacy	Apartment	Informal contacts, small talk, next-door neighbors, friends
Scrutiny	Outside of a coffee shop	Crossing a crowded coffee shop, being observed
Performance	Meeting room	Speaking in public, interviews

Figure 3. Assertiveness environment.

is a hand controller resembling a hockey puck, which allows the patient to turn by pivoting the hand. It has three buttons to interact with the environment. Two of them are used to go forward and backward, while the third is used to click on interactive objects.

We also conducted experiments with a VFX3D head-mounted display (HMD) that ensures a complete immersion. The VFX3D consists of a tracker with three degrees of freedom for roll, pitch and yaw positioning, a standard VGA interface, audio inputs and 360,000 pixel color displays (Figure 2). It gives the real-time position of the patient's head.

We used two main software tools to create the 3D virtual exposure environments in the treatment of social phobia. We designed the objects, the visual effects, and the virtual worlds with Discreet 3D Studio Max 4. We also created animated characters with Character Studio 3, an extension of 3DS Max. The 3D design was then integrated in a behavior-based interactive 3D development tool, Virtools Dev.

The environments run on a PC and can be viewed with the Virtools Web Player (www.virtools.com).

THE VIRTUAL ENVIRONMENTS

We sketched four scenarios fitting the CBT and then created four virtual environments with corresponding characters and sounds (Table 2). A fifth virtual environment was designed without characters. In this environment the patient learns how to use the tools and how to navigate in a virtual world.

In the assertiveness environment (Figure 3), the patient learns to protect her/his interests, viewpoints, and be respected. Three main rooms were created: an upstairs, with an elevator containing two people who can criticize the patient, downstairs contains a hall with three people who block the exit, and a shoe store with

Figure 4. Intimacy environment.

a director and two assistants who will try, repeatedly, to sell shoes to the patient. Between the hall and the shoe store, the patient can also navigate in a street where people are standing or sitting on benches.

In the intimacy environment (Figure 4), the patient learns to establish contact with neighbors, friends, and have small conversations. The storyboard takes place in an apartment, showing a table set for dinner, a lounge, a kitchen, and decorative objects such as lamps, shelves, and pictures. A friend invites the patient over, along with four other people. The patient should introduce her or himself, remark on the decor, and answer questions when all the guests are around the table.

Figure 5. Scrutiny environment.

In the scrutiny environment (Figure 5), the patient learns to move and to speak while under observation. The patient walks from a street lined with trees to a square and the exterior of a coffee shop. Many people who are sitting on benches, at tables, or standing up are looking at the patient. He or she must enter the coffee shop, look for a friend, and then go out and reach a free chair next to his or her friend who has just arrived, and engage in conversation with him. The waiter will come to take the order, then to collect the bill. There will be a mistake in the sum. In all the situations, the patient will feel as if he or she is under scrutiny.

In the performance environment (Figure 6), the patient learns to speak in public. The storyboard takes place in a meeting room where the patient joins seven other participants who are already sitting and speaking around a big table. First he

Figure 6. Performance environment.

or she should reach a free chair at the table. After the arrival of the director he or she should introduce him or herself, then stand up and walk to a paperboard to expose a subject while everybody is looking on (possibly attentively, possibly not).

OBJECT AND MEDIA TYPES IN VIRTUAL WORLDS

The Virtools rendering tool imposes constraints on the object models to synthesize images in real time and to allow an interactive navigation.

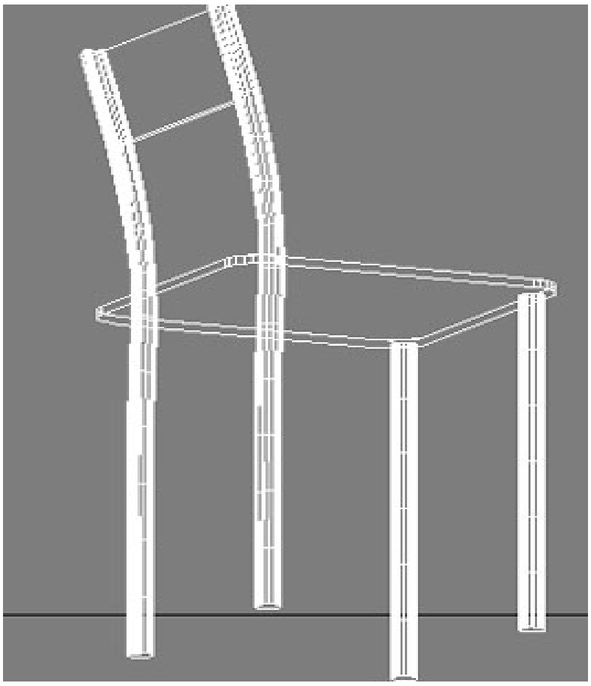

Figure 7. Mesh representation of an object.

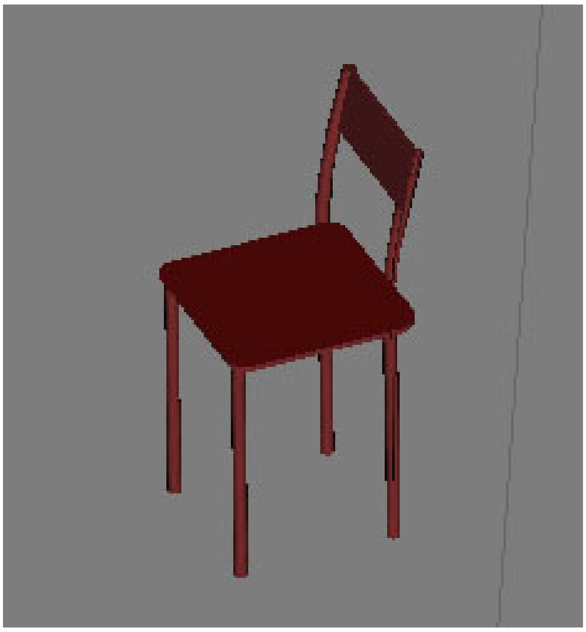

Figure 8. A simple rendered object.

These constraints include the axis orientation, the texture size, the number of vertices and facets, and so forth. Here we describe the design process and the decisions we made to comply with these constraints.

We designed the 3D Objects models from polygon meshes using 3DS Max (Figure 7) and then we exported them to a Virtools readable format (Figure 8). Attention was paid to the orientation, the size, and the scale of all the designed objects in order to respect the Virtools constraints. We optimized the design to render the virtual world faster. Most of the objects have a simple shape, with a limited number of vertices and faces. Non-visible faces were eliminated. Repeated objects were duplicated in Virtools. In this case, there are two object entities but only one mesh. The new objects always refer to the original mesh so the rendering is faster and spares disk space. We used invisible objects to detect collisions. When it was not necessary to design 3D objects, we used texture-mapping techniques (Figure 9).

Figure 9. An example of mapping.

Figure 10. A 3D Sprite.

The characters in our environment are 3D Sprites, which are simple plain surfaces used to simulate single quad objects with textures (Figure 10). Real people were filmed in simple everyday situations via a digital video camera. The photos were edited in Photoshop and exported to a Virtools readable format. A 3D Sprite can be constrained on one or more axes to always face the camera. This choice was a good trade-off between realism and the number of avatars. The design and the implementation of such a number of biped characters with Character Studio would have been time-consuming.

The textures are images used to give an element a certain appearance. Realistic textures increase the quality aspect of the environments. However, a trade-off was constantly looked for between the degree of realism and the size of the textures.

The sounds designed in the storyboards were recorded in real situations. We decided to use wav files in order to preserve the quality of the sounds.

INTERACTIVITY

Virtools Dev was used to integrate the objects and media – textures, sounds – and to add the interactive element to the environments. This has been created using behaviors that can be applied to almost any element in Virtools. Each behavior, when executed, can activate other behaviors through links, characterized by a link delay measured in frames. The propagation of the activation depends on this link delay.

We let the patient experience the environments from a first person perspective without the intermediary of an avatar, which would hinder the identification and the involvement of the patient. The patient is represented by a 3D Frame (a reference point) bound to a camera. Both move together because of a hierarchy link, the camera being a child of the frame. The collision tests between the patient and objects of the environments are managed by the 3D Frame, which is also bound to floor.

The patient navigates through the environments using the mouse and the cursor movement keys or a Cyberpuck pad. The mouse and pad allow rotation movements, while the cursor movement keys and the pad allow translation movements.

We also conducted these experiments with complete immersion. In this case the patient wears a VFX3D head-mounted display (HMD) that determines the patient's head position and moves forward or backward with the Cyberpuck pad. The images that the patient sees in the HMD also appear on the screen of the computer for the therapist.

The interaction with some objects in the virtual environments, such as doors, is possible when using the mouse or the pad. Tests of collisions with walls, objects, and characters of the environments were introduced. We also developed some effects such as the "sitting down effect." When the patient has to sit down on an indicated chair, he moves towards the chair and, in the proximity of it, the computer takes charge of the installation of the patient.

The virtual session always unfolds under the control of the therapist who can introduce virtual characters or ambient sounds and manage the progress of the session.

RESULTS AND DISCUSSION

We carried out a small-scale clinical trial in the Unité de Thérapie Comportementale et Cognitive (Behavioral Cognitive Therapy Unit under the direction of Doctor Patrick Légeron) of the Sainte Anne University Hospital (Professors Henri Loo and Jean-Pierre Olié), Paris. Ten socially phobic patients were included and followed a virtual therapy treatment. Two patients experienced a complete session, and the eight others experienced part of one of the two virtual sessions. A complete case report is described in Roy et al.[23]

We report here some results of this trial. Using the interfaces we described and assisted by the therapist, the patients navigated with ease in the virtual environments. In the Reality Judgment and Presence Questionnaire the patients were asked about the realism of the worlds, the interactivity, and their attention while navigating. They reported an average adhesion in all these fields.

We experimented with navigation using the VFX3D head-mounted display. Though the HMD definitely brings a better sense of immersion, it is not without drawbacks such as its weight, the small size of the image seen on the screen, and shortcomings in the rendering of the stereoscopic vision. These shortcomings are certainly due to the VFX3D equipment, which is a very sensitive device. Its calibration or adjustment is a relatively difficult task and it needs a refreshment rate of 60Hz for stereoscopy. We think that a new approach to solve these vision and immersion issues would be to use a large screen and a video projector.

Though an exact replication of reality is not necessary to generate a reaction from the patients, it is essential to bring all possible accuracy into the stimuli design. The work of adapting the technical possibilities to the clinical requirements was the result of close collaboration between all the members of our team.

The patients' reaction to the virtual environments is similar to that of the corresponding *in vivo* experiments. The patients are sensitive to the environments and react consistently with their disorder. When they are facing the feared situation, they feel discomfort, anxiety, or shame. Blushing and other physical symptoms of feelings may occur. These results are consistent with those of Rothbaum et al.[13] and North et al.[6] in demonstrating the effectiveness of VR exposure.

An improvement in the symptoms has been noticed among the patients who followed a complete course of VRT. This improvement was confirmed by psychometric evaluation, clinical observation, and by the statements of the patients.

We found a good observance of the treatment. The ten included patients came to all of the prescribed sessions. Our clinical experience shows that when participating in regular sessions of therapy, patients often miss some sessions, which was not the case here. The patients underlined the "playful" aspect of the therapy, which may explain their consistent attendance.

During this trial, we noticed that the reactions of the patients facing the environments differed according to their problem (assertiveness, scrutiny, intimacy, or performance). To our knowledge, this is the first study of social phobia in which a complete VRT was carried out.

According to the same clinical protocol, we are currently carrying out a large-scale clinical trial to compare virtual reality group therapy (36 patients) with cognitive-behavioral group therapy (18 patients) and a no-treatment group (18 patients).

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Virtual Reality for Psycho-Neurological Assessment and Rehabilitation

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Abstract: *Previous work has shown that even relatively unsophisticated virtual reality tools can prove a valuable tool in psycho-neurological assessment and rehabilitation. The aim of the "Telemedicine and Portable Virtual Environment in Clinical Psychology" - VEPSY UPDATED – a European Community funded research project (IST-2000-25323, http://www.cybertherapy.info) is to comprehend the potential of virtual reality applications in this area and utilize virtual reality in treatment protocols. We are particularly interested in developing various virtual reality applications to be used in clinical assessment and treatment of both neurological and psychological disorders. In this work we describe both the clinical and technical rationale behind the various clinical applications that have been developed by members of VEPSY UPDATED. This work also serves as an analysis of the possible roles of virtual reality in the fields of clinical psychology and neurological rehabilitation.*

INTRODUCTION

Even if many clinicians have the naive assumption that couches and conversation are the best therapeutic tools to be used in mental health care, the tools for supporting psychotherapy are evolving in a much more complex environment than a designer chaise-lounge. In particular, the use of virtual reality (VR) offers many new possibilities to therapists.

Previous work has shown that even relatively unsophisticated virtual reality tools can prove a valuable tool in psycho-neurological assessment and rehabilitation.[1,2] 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, and steep reductions in the cost of hardware and software, make it possible to bring distributed VR environments directly to clients' homes – thereby offering improved access for users who are inadequately served by current services. 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.[3]

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 the psychologist. 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 provides an "empowering environment" in which patients can undergo therapy.[1] As noted by Botella and colleagues,[4] 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. Thus, VR becomes a very useful intermediate step between the therapist 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 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, both 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-bones VR simulation. A 2.5 Ghz Pentium III/Athlon with 256 Mb of RAM can provide a convincing virtual environment and a dual 3 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.[2]

Immersion 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 costly. An HMD with VGA quality and 3D video produced by a Korean manufacturer is now about $2,500. However, this price will probably decrease during the next five years.

Presently, input devices for desktop VR systems 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.

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

- *Pentium IV/Athlon XP desktop VR system:*
  -2000 mhz or better,
  -256 mega RAM or better,
  -minimum specification for the graphics engine: ATI Radeon 9000 64MB Vram or Nvidia GeForce 4 440MX 640Mb 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 9000 16Mb VRam or Nvidia GeForce 4 Go 32Mb VRam

The hardware also includes:

- a head-mounted display (HMD) subsystem

The HMDs used are:

- 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 is enough "eye relief" (distance from the eye to the nearest lens) that it is 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).
- 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. An accelerometer based serial tracker (Pitch & Roll Sensitivity +/- 70 degrees +/- ~0.1 degrees; Yaw Sensitivity 360 degrees +/- 0.1 degrees) is also included.
- A two-button joystick-type input device to provide an easy way of navigating: by pressing the upper button, the operator moves forward. Pressing the lower button moves the operator backwards. The direction of the movement is given by the rotation of operator's head.

To ensure the broadest user base, all of the VR modules have been developed as shared telemedicine tools available through the Internet 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, mainly faster processors and enhanced multimedia support. Both solutions allow the support of end-users in their living environment.

The software

Each module was created by 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). It then combines this information 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.

THE CLINICAL RATIONALE

Up to now, the most common application of VR in clinical psychology is the treatment of phobias. The VEPSY Updated project also addressed phobias. The Spanish group headed by Cristina Botella focused on the treatment of panic disorder and agoraphobia, while 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 controlled and cost-effective than *in vivo* exposure. Another advantage of VR is the possibility of carrying out exposure to bodily sensations (interoceptive exposure) and situational exposure simultaneously. Traditionally, exposure for panic disorder involves exposure to agoraphobic situations and interoceptive exposure that is 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,[5,6] spider phobia,[7] and fear of flying.[8-11]

The second clinical focus of the VEPSY Updated project was the treatment of male sexual disturbances. In particular, Optale and his team[12,13] used immersive virtual reality to improve the efficacy of a psychodynamic approach in treating male erectile disorders.

In the proposed virtual environment (VE), four different expandable pathways open up through a forest, bringing the patients back into their childhood, adolescence, and teens, when they started to get interested in the opposite sex. Different situations are presented with obstacles that the patient had to overcome to continue. VR environments are here used as a form of controlled “dreams,” allowing the patient to express transference reactions and free associations related to the ontogenetic development of male sexual identity in a nonverbal way. General principles of psychological dynamism, 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 partial or complete positive response after 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.[14] 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.[13]

The third part of the project focuses on obesity and eating disorders. Particularly, Riva and his clinical group lead by Bacchetta and Molinari,[15,16] are using Experiential Cognitive Therapy (ECT), 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.[17,18] The essence of this cognitive perspective is that the central psychopathological concerns of an individual bias 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 of the person's awareness unless the person consciously reflects upon his or her thought processes (as in cognitive therapy).

According to Williamson and colleagues,[17] body size overestimation can be considered a complex judgment bias, strictly linked to attentional 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, biased information processing occurs automatically and 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 to convince them 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.[19,20]

Given these difficulties, there are only two different approaches to the treatment of body image disturbances:[18]

- *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.[21,22,23]
- -*Feminist approach*: Feminist therapists usually use experiential techniques, such as guided imagery, movement exercises, and art and dance therapy.[24,25] Other experiential techniques include free-associative writing regarding a problematic body part, stage performance, or psychodrama.[25,26]

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 different 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 a cursor, which moves in accordance with the movement of our own hand), as a part of or an extension of our own hands.[27] As noted by Iriki and colleagues,[28] "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[29] and can be modified more easily.

In a case study, a 22-year old female university student diagnosed with Anorexia Nervosa underwent ECT treatment.[30] At the end of the inpatient treatment, the subject increased her bodily awareness, and experienced 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:[31-34] 25 patients suffering from binge-eating disorders were in the first study, 20 were in the second, and 18 obese subjects were in the third. At the end of the inpatient treatments, the patients of all 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 a specific psychotherapeutic approach, change generally comes through an intense focus on a particular instance or experience.[35] 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, or the enhancement of experience awareness in experiential therapies.

What are the differences between them? According to Safran and Greenberg,[36] behind the specific therapeutic approaches 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 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 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.[37] 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.[35] 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 both of it and related behaviors. Finally, different patients who initially engage the therapeutic work only through top-down processing may able later in the therapy to make use of bottom-up emotional processing. In this situation, a critical advantage can be provided by VR.

VR can be considered a sophisticated communication interface.[38] Even if the three applications developed by the VEPSY Updated project have very different rationale, all use VR as a communication interface, able to collect and integrate different inputs and data sets in a single realistic experience. Using 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 of 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, and 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[39-41] that can be used to help the patient differentiate between perception and cognition. As noted by Glantz and colleagues:[42] "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" (p. 96). Using the sense of presence induced by VR, the therapist can actually demonstrate to the patient that what looks like a perception does not really exist. Once this has been understood, individual maladaptive assumptions can be challenged more easily.

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 therapists will continue to investigate applying these tools in their day-to-day clinical practice.[43] 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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Chat-On-Play-Experiences (COPE) by VR Achieves New Pattern of Capacities in Child and Adolescent Rehabilitation

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Children and adolescents with disabilities and special needs experience self-capacities in cyberspace that they do not sense otherwise. They walk, run, play, and move without hindrance even if they are actually seated in a wheelchair. They play together and chat with unknown others, in spite of signs of agoraphobia. This presentation involves an innovative part of an EU project aimed at developing new socio-pedagogical therapy built on Chat-On-Play-Experiences (COPE), grounded in the concepts of 'plasticity of man' as well as learning at the intersubjective level. The 'reverse' rehabilitation processes aim to be 'igniting-sparks' to wake up functions, with a starting-point in the immediate experience and the a-modal perception. The experiments are captured through an observation and evaluation method (Multiple-Events-Screen Design) involving four levels of analysis. So far, the results show increased courage, interpreted as the power behind a minimized sense of 'losing face' in front of others. Also, subjects experience an awakening of being able to do things. Time-sharing seems to be very important, and manipulation of the speed of transfer is therefore crucial for the immediate experience of a sense of continuing to be increasingly competent.

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Self-help system for treating small animal phobia with 3D virtual environments via the Internet

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Effective treatment of psychological disorders using virtual reality environments is now a reality. However, it is still necessary to generate systems that allow patients to remotely access self-help virtual reality (VR) treatment, without the direct intervention of a therapist. There have been some steps towards this objective, one of which is the work described in this abstract.

The intent of the project is to design and test a self-help treatment program for small animal phobia (spiders, cockroaches, and rats) by means of virtual reality environments via the Internet.

Three treatment conditions are going to be compared:

- Traditional *in vivo* exposure.
- Tele-exposure using Internet.
- Tele-exposure using Internet and VR projected by a head-mounted device.

For the tele-exposure system, patients must follow a defined process that is controlled by the system. To initiate the treatment, the patient has to access a web page in which, initially, an evaluation of the problem is made. Immediately after, the treatment begins. A set of stimuli related to the detected problems are presented to the patient, including images, sounds, and exposure to virtual environments. There is a unique environment in which several tasks of growing difficulty levels should be completed. A realistic simulation of small animals is achieved through animation, textures, and sounds. However, we consider the realism of the environment to be less important, as it is not as related to the phobia being treated. This helps minimize the size of the file and makes it easier to download. The patient will be asked about his/her level of anxiety from time to time or when certain events occur. The possible emotional states are defined and the system establishes restrictions to some situations if the patient has not overcome the preceding one. The patient's state at each moment and their responses to questionnaires are stored in XML format in a database located in a web server.

The patient can leave the exposure at any time, and when he/she accesses again, he/she will continue from the last level not overcome.

It is interesting to attempt to minimize the required hardware infrastructure, because it is not often that the patient has specific devices such as a head-mounted device or a head-tracker.

However, we will analyze the use of the head-mounted device in the tele-exposure via Internet, in order to see the possible advantages that it can have compared with direct visualization of the monitor.

We have decided not to use the tracker. This decision implies the development of a navigation system that allows the mouse to perform changes in the direction of view of the patient.

As results of the study, we expect to obtain the minimal bandwidth and hardware configuration required for the treatment to be effective.

The system will provide a self-help treatment via the Internet, similar to 'Talk to me,' but with the novelty of using virtual environments instead of videos. With respect to traditional VR therapy, the system allows the automation tasks that are usually performed by the therapist.

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Internet-based telehealth system for the treatment of agoraphobia

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Psychological treatments with virtual reality are usually carried out exclusively in the psychologist's consulting room because special virtual reality hardware is necessary. Moreover, in this way, the psychologist controls the therapy and the patient will only use the appropriate virtual environment for his/her treatment.

In this work, which is being validated within the European VEPSY project, we demonstrate a system that permits the patient to continue the treatment from his/her home using the same virtual environments of the psychologist's consulting room, but now they will be installed on his/her own PC. This system will permit the psychologist to continue controlling the clinical treatment thanks to Internet. Therefore, this system will be an additional, or complementary, form of therapy.

In the office, the psychologist exposes the patient to several situations (room, bus, subway, store, tunnel) with a different virtual environment for each one. Moreover, the psychologist can select the special conditions that the patient will "live" in the virtual environment; the physiological answers, simulations, etc.

For therapy using the patient's PC, each virtual environment is divided into several sub environments, each one distinguished by some special conditions that limit its difficulty level. The stimuli shown to the patient are controlled automatically by the system without the intervention of the psychologist.

The information of every patient is stored in a database that is placed on a web server. The psychologist can modify the virtual environment assigned to each patient according to his or her evolution in the sessions in the psychologist's office.

In order to install the virtual environments on his/her PC, the patient will need a CD that the psychologist will give to him/her at the right moment. In order to run any virtual environment from home, the patient must connect to a web page and introduce his/her user name and password. Nevertheless, the patient will only run the virtual environments that the psychologist has selected. The patient will always have the possibility of reviewing stages overcome in previous sessions.

The virtual environments can request the anxiety degree of the patient automatically, when a certain amount of time has lapsed or when a specific event has taken place. All this information is stored in a database using XML format. Thus, the psychologist can always know the evolution of the patient in the virtual environments and control the treatment.

In the treatment via Internet, the patient does not need head-mounted displays in order to view the virtual environments. The PC monitor will be enough. The patient does not need a tracking device either, but it is necessary that the simulation incorporate head rotations with the navigation system. This is why some modifications have been made in this system.

From the technical point of view, the most important novelties are the following:

The virtual environments will not be downloaded from the web page, but rather they will be installed on the PC of the patient, and they will only be run when the patient connects to the web and introduces the username and password. Therefore, the size of the virtual environments does not have to be small to facilitate an easy download. This allows for certain freedom to include textures, sounds, etc., to create more realistic virtual environments.

The tasks that are typically carried out by the psychologist are now automated in the virtual environments.

From the psychological point of view, the most important novelty of this system is the possibility of using a complementary treatment to that carried out in the psychologist's office by using virtual reality via the Internet.

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Experiential-cognitive therapy: An innovative approach for the treatment of eating disorders and obesity

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Experiential-Cognitive Therapy, currently carried out at the Applied Technology for Neuro-Psychology Laboratory of the Istituto Auxologico Italiano, Ospedale S. Giuseppe, Piancavallo (VB), European Project VEPSY UPDATED (IST – 2000 - 25323), proposes a new integrated approach to the treatment of eating disorders and obesity. This integrated approach is the result of years of research and clinical experience on eating disorders. Cognitive-Behavioral Therapy integrates effective features of different therapeutic approaches with an innovative methodology for the assessment and treatment of eating disorders and obesity. In this approach, cognitive, behavioral and visuo-motorial techniques are integrated for the treatment of different critical areas of these pathologies. In order to face denial attitude and resistance of the users the Socratic method is used because at the very beginning of the treatment, patients suffering from eating disorders often do not realize the nature of their difficulties. Virtual reality is an innovative tool in psychotherapy. The Psychology Laboratory of our Institute has experimented to determine its efficacy in the assessment and treatment of eating disorders and obesity. Telemedicine is another promising tool for psychotherapy, and it is particularly suited for monitoring patients at home in the follow-up phase of the therapy.

Experiential-Cognitive Therapy may be subdivided in two successive phases: the in-patient phase corresponds to the period of permanence at the Istituto Auxologico Italiano (almost four weeks) while the out-patient phase continues almost six months after discharge. This methodology represents a complete therapeutic approach for the assessment and treatment of eating disorders and obesity.

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A virtual reality system for neurobehavioral and functional MRI studies

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Background/Problem:
In an effort to study isolated segments of the brain, neuroimaging studies are often quite simple and contrived. More sophisticated analysis techniques now make possible the use of more complex, realistic, and socially relevant experimental paradigms. However, outside of a few university research laboratories, a virtual reality (VR) system for neuroimaging studies is not readily available.

Method/Tools:
We are developing a flexible, broad-based, and user-friendly VR system of integrated hardware and software for scientific research and eventual clinical application. It allows simultaneous physiological monitoring, and it will enable researchers to perform a variety of neurobehavioral studies in the laboratory or within magnetic resonance imaging (MRI) scanners. Currently, the software consists of a world of 10 interconnected environments – an urban area, an apartment, a restaurant, a cinema complex, a subway, an airport, a village, a doctor's office, a grocery store, and a house. Additional environments can be built and easily added, and four more are under construction. There are more than 50 characters in the world, and nearly half of them are animated. The emphasis throughout the application is on a realistic simulation, so motion capture software is used for realistic facial expressions, and interactivity is provided for many typical objects such as doors, bathroom fixtures, kitchen appliances and other household items.

A startup interface provides menus for selecting specific characters and objects that a researcher might want to put at specific location within the simulation. Pull-down maps are available as navigational aids. All movements and actions of the subject within the world are tracked and recorded to an Excel spreadsheet for data analysis. Input/output devices include a dataglove with motion tracker, a touchpad, and a joystick, all of which have been tested for MRI compatibility. Presently, concurrent physiological data can be acquired for up to 16 channels, with respiration and heartbeat data available in the MR scanner, and skin conductance response soon to be added. The VR hardware and software is being integrated with an existing functional MRI (fMRI) experiment-presentation system for performing brain imaging studies. The integrated system will provide synchronization of the VR simulation with the physiological recordings and the functional MR images.

Results:
The VR software will be shown via a tour of several of the environments with associated character interactions. Special features for scientific applications, such as data logging and synchronization, will be demonstrated. Some pilot fMRI data with concurrent physiology recorded during use of this integrated VR/fMRI system will be presented.

Conclusion:
An integrated VR system for functional MRI studies is under development. It will be flexible and sufficiently broad-based in appeal that neurobehavioral researchers from a variety of disciplines might be interested in its use for basic research and clinical studies.

Novelty:
This will be the first commercially available VR system specifically developed for fMRI studies.

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The use of virtual reality for the treatment of panic disorder and agoraphobia

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We can state that, soon, virtual reality (VR) will have a place in the usual tasks that psychologists perform. VR provides support to clinical psychologists in order to carry out basic tasks more easily. Because of this, clinical psychology is paying increasing attention to this technology. Pioneer works were published with the first applications of VR to different fears: acrophobia, spider phobia, claustrophobia, flying phobia, etc. The findings show that VR is becoming an important therapeutic tool that can be used to teach the patient to gradually become familiar and interact with the situation he/she considers threatening while maintaining a high degree of control.

Regarding the treatment of panic disorder and agoraphobia, important advances have taken place in the last decade, and we have data that support that the most effective procedures to treat this problem are cognitive-behavioral programs. These programs include several components: educational, relaxation techniques, cognitive therapy, and interoceptive and situational exposure. However, one limitation of these treatments is that exposure did not benefit all panic sufferers. This is because some patients find exposure very aversive as it requires confrontation of the feared situation. Therefore, some patients reject or drop out of the treatment. VR can help to overcome this limitation. VR can be an intermediate step between the consultation room (a totally safe place) and the feared situation (totally threatening). VR allows some of the limitations of *in vivo* exposure for agoraphobia to be overcome, such as the wide range of situations involved (with VR we can expose the patient to several situations without leaving the consultation room). Another advantage of VR exposure for panic disorder is the possibility of carrying out interoceptive exposure and situational exposure at the same time. Traditionally, exposure for panic disorder involves exposure to agoraphobic situations and exposure to bodily sensations (interoceptive) that are performed in different sessions. VR allows the exposure of the patient to an agoraphobic situation (i.e. a train), and at the same time, can elicit bodily sensations by means of visual or sound effects (blurry vision, pounding heart).

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Effectiveness of VR for the treatment of panic disorder and agoraphobia: preliminary data

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The aim of the present work is to offer preliminary data about the effectiveness of VR exposure versus in vivo exposure in the treatment of panic disorder and agoraphobia. The participants were ten people who met DSM-IV criteria for panic disorder (with or without agoraphobia) or agoraphobia without history of panic disorder. They were randomly assigned to one of two experimental conditions: in vivo exposure and VR exposure.

The results of this work constitute a small clinical trial belonging to the VEPSY project, funded by the European Fifth Framework program. The results from this pilot trial will be use to fine tune the clinical protocols and the VR scenarios in order to conduct a larger trial with a bigger sample.

Our results showed that VR was as effective as in vivo exposure in important outcome measures: avoidance, fear, degree of belief in catastrophic thoughts associated to the target behaviors; the Panic Disorder Severity Scale (PDSS, Shear, Sholomskas & Cloitre, 1992), the Anxiety Sensitivity Index (ASI, Reiss, Peterson, Gursky & McNally, 1986) and the Mobility Inventory (MI, Chambless, Caputo, Jasin, Gracely & Williams, 1985). Participants showed also a high degree of satisfaction with the treatment in both conditions. These findings showed that VR exposure could be an effective and efficient tool for the treatment of panic disorder and agoraphobia.

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An update on the first 18 months of clinical studies on anxiety disorders at the UQO Cyberpsychology Lab

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Background:
The high cost of virtual reality (VR) equipment and environments is a significant deterrent to the widespread dissemination of this technology from the research labs to the clinicians office. Prospective users of VR can either develop their own environments or buy the few already available, but these options are both very expensive. Moreover, developing environments is hardly an option for the average clinical psychologist because it involves the use of very complex programs. An alternative solution is to adapt 3D games.

Our research team used 3D game editors to develop VR environments to treat acrophobia, arachnophobia, and claustrophobia. Three studies will be presented: (a) a comparison between adult phobics and adult non-phobics immersed in our VR environments; (b) an outcome study with children suffering from arachnophobia; and (c) a psychometric study on the Presence Questionnaire, the Immersive Tendency Questionnaire, and the Cybersickness Questionnaire.

Method:
A total of 130 participants were immersed in our VR environments. All participants were selected on the basis of a structured diagnostic interview using DSM-IV's criteria to assess the presence or absence of specific phobias. Phobic participants in each clinical sample received a principal diagnosis of: acrophobia, arachnophobia, or claustrophobia. Non-phobic participants were selected on the basis of not suffering from any anxiety disorder.

Pre and post-immersion assessment tools were different for the participants in the three studies, but all consist of: (a) anxiety questionnaires, (b) questionnaires specific to the target problem of each sample, and (c) measures specific to VR such as Witmer and Singer's *Presence Questionnaire* (*PQ*) and *Immersive Tendency Questionnaire* (*ITQ*) as well as Kennedy's *Cybersickness Questionnaire*. For the children, the treatment consisted of one introductory session and three 90-minute VR exposure sessions. Immersions were generated with a Pentium III computer, an ATI Radeon 64 graphics card, an Eye-Glass HMD and an Intertrax2 tracker.

The analyses consist of ANOVAs for Study 1 (N = 30), visual analyses for a multiple baseline across subjects design in Study 2 (N = 10), and principal component factor analyses with varimax rotations in Study 3 (N = 130).

Results:
In all studies, presence ratings were very high, as were participants comments on the graphic qualities and the flexibility of the programs. The comparisons between phobics and non-phobics showed that anxiety has a significant and positive impact on presence and that fearful stimuli can generate a significantly higher level of anxiety among phobics. Results of the clinical trial with children supported the effectiveness of VR exposure for spider phobia. The factors analyses of the *PQ* and the *ITQ* suggested that the factor structures proposed by Witmer and Singer may not be adequate and new factors were proposed.

Novelty / Conclusion:
Our results show that is possible to use and adapt 3D games to create powerful virtual environments. Our clinical trial is the first suggesting that VR exposure may be effective for children. New factor structures are proposed for two very popular instruments in VR research and this later study warrants replication by other research teams.

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Smoke and Mirrors: a virtual reality debunking environment

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Smoke and Mirrors is an artwork created by Sheldon Brown that is now on exhibit at Reuben H. Fleet Science Center in San Diego. Smoke and Mirrors allows two to six visitors at a time to enter into a shared virtual environment through their own projected computer graphic media portal. The environment engages viewers in a series of activities drawn from the cultural and social history of tobacco usage.

Participants in *Smoke and Mirrors* first have their faces three-dimensionally scanned. They then have to find which of the kiosks their scanned face has been sent to. The first stage of the narrative attaches their face to an avatar, created out of an isolated biological system. The user now navigates this avatar through a series of maze-like environments.

While in the shared virtual world, users can see the actions that all of the other participants are undertaking. Each environment responds to people's movements through them, further revealing the ways in which an image of this particular product has been constructed over the years, using both overt and covert strategies.

The project operates on an eight computer client-server architecture to create the shared virtual environment, where each person has his or her own avatar based experience. Each of the 6 graphic clients independently generate their own particular environment state and view, with each client communicating environment event changes (such as avatar location, object triggering, etc.) to the other clients on the network and to the server. The server coordinates timed transformations such as scene changes and character construction.

The piece runs with custom software developed for the project, written with a game engine, NetImmerse from NDL, Inc. Face scan data is taken from each scan and translated into the appropriate file formats, assigned by the server to particular characters and distributed to each client computer. Each client computer uses Nvidia GeForce 4 cards for display. And the displays are created specifically for the physical installation, consisting of Hitachi LCOS projectors, projected sideways to create a 7' x 5' portrait orientation screen for each kiosk.

The project software and content developed over a year. To facilitate creative development, an application called the SceneEditor was created which allowed for quick changes in project content and in scripting interactions in the project. In particular, one area of interest is the way in which the project uses viewpoint choreography that is a further development of montage strategies that Sheldon Brown has been developing which combine cinematic and gaming vocabularies.

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The ISLANDS Project: Integrated system for long distance psychiatric assistance and non-conventional distributed health services

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Background:
There are some regions in the European Union with particular characteristics that account for their being behind the average socio-economic development in Europe. They have an economic as well as medical logistic disadvantage. They are, literally speaking, in the middle of nowhere with a lack of access to modern health care facilities, especially psychiatric and cognitive-behavioral therapies. Sometimes they are even remote from main traffic lines. Their economic achievement is behind that of other European areas. We can estimate that from all European citizens 5-10% live in such an environment (about 15 to 30 million people).

Method:
The overall aim of the project is to develop services to provide modular, non-conventional, remote psychiatric and psychotherapeutic assistance for these areas. The project will reduce inequalities in mental health services and status among European regions.

There will be intermediate objectives, among them:

- To gather epidemiological data concerning the mental disorders addressed
- To identify specific needs of patients, their informal careers and professionals in remote areas
- To extend state of the art remote psychological counseling to a broader spectrum of users and disorders
- To develop remote services in diagnosing,

counseling and even treating psychological disorders; establishing appropriate content and service provision media
- To develop innovative computerized tools (i.e. assessment and training tools, a relevant cases database, a service application expert tool) with multimedia and multilingual user interfaces, to offer these services in an optimal way
- To develop a modular, distributed telepsychiatry platform, which will allow transfer of critical parameters in a secure medical telecare network between patients, their family members and/or stationary centers, equipped with medical staff, enabling virtual telepresence, remote monitoring and teleconsultation with medical experts, irrespective of location limitations
- To evaluate the feasibility, effectiveness and costs-efficiency of the new service.
- To develop recommendations and guidelines for public mental health services, in providing the new services
- To enhance information about mental health problems and how to solve them in remote European regions
- To propose cost-effective policies to improve the mental disorders addressed

Nine specific categories will address the needs of possible users in the psychiatric and/or psychotherapeutic field. According to different mental health problems (anxiety, depression, substance use, psycho-somatic) each category will comprise modules to help users suffering from or concerned with this problem. All kinds of prevention – primary, secondary, tertiary – will be supported in order to lower actual or forthcoming costs of mental health disorders. As pilot application fields, four typical case studies of psychological problems have been selected that can be found quite often in normal populations and are of specific interest to each pilot site.

They are:

- post-traumatic stress disorder,
- agoraphobia and other phobias,
- depression, and
- problems of alcohol abuse and concurrent violence in families.

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VEPSY Web Site: An example of health services provided through the web

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The main goal of this paper is to show the state of the work done by ELSAG, an Italian business enterprise, to develop the VEPSY website, an Internet-based health services provider. This website is one of the final products of the EU funded VEPSY Updated project and it aims at managing and delivering applications and software packages that have been developed inside the project. The structure of the website allows possible users to find VEPSY project clinical results and to interact with psychotherapists and other professionals in order to receive qualified health care. In practice, patients can download information, documents (such as clinical protocols), and tools. They can also communicate with their psychotherapists using hypermedia tools. In addition, the website is focused on providing specific software and relevant information to psychologists and other health-care professionals. In particular, this website is able to provide virtual reality tools (protocols, environments, documents, plug-ins) to both therapists and patients in order to provide through the Internet the virtual reality enhanced psychotherapies that have been developed in the VEPSY project for different mental disorders (agoraphobia, panic disorder, social phobia, eating disorders, sexual dysfunctions).

ELSAG implemented an on-line evaluation tool to allow VEPSY partners to give their opinion on some graphical proposals in order to improve the web site. Moreover, ELSAG web developers began to face possible technical and security problems in strict cooperation with the web designers' team. This team also dedicated great attention in layout structure, usability, and accessibility. In order to strengthen the web identity, ELSAG chose blue as a representative color. Flash animation also reinforced the identity of the site, drawing the user's attention for some seconds.

From a functional point of view, the VEPSY website has been divided into four main publishing areas:

The institutional area gives an overview of the VEPSY Project and its partners, and provides several types of information about the related activities.

The private area has been split up into two sections, one for patients and one for therapists. Access is achieved through input of a user ID and password. The stored information is protected from any external intrusion and the data integrity is assured.

The news area is totally dynamic and is the most unique and important part of the site. It allows the web administrator to publish documents and news easily and in real time.

The search-contact area contains tools that help user to surf through the VEPSY web site.

The VEPSY web site also represents one of the main tools to disseminate the results of the VEPSY Project. The site is an on-line reference for health-care professionals who use it to obtain scientific publications and articles, train themselves, and establish connections with other therapists and the scientific community.

At present, a first release of the site is on-line at http://vepsy.elsag.it.

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Biorobotic research for neurological rehabilitation: A new device (DAPHNE) for finger control

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This paper concerns a biorobotic system based on fuzzy logic to diagnose and monitor the neuro-psychophysical conditions of an individual. The system, called DAPHNE, is characterized by a small dimension design; user-friendly hardware and software mean that even non-experts will be able to use this device. Furthermore, thanks to its design concept, the system can be used not only for medical applications, but also in the fields of daily health-care and sports. DAPHNE is a portable system, involving multiple parameters such as reaction time, speed, strength, and tremor that are processed by means of fuzzy logic; additionally, the device is characterized by a voice detection system.

The system, called DAPHNE, is a biorobotic device. It facilitates the diagnosis of a neuro psychophysical condition, whether the subject is healthy or is affected by nervous system pathologies such as Parkinson's disease, etc.

The system measures the reaction time of the finger in front of the visual-audio signal of "touch," the velocity of the finger during the contact and the pressing, the force which the finger exerts on the button, and the tremor of the hand before an during the touch action.

The DAPHNE system is compact and can be easily held either with the right or left hand. It is light and portable; these features, combined with user-friendly software and simple mechanics ensure autonomous, easy-to-manage testing. This instrument offers two types of tests, both characterized by well-defined test performance protocols.

Following a visual-sound stimulus, the first type of test (*Button push*) is performed by placing the forefinger on the button and pushing it down lightly. In this way four kinetic-dynamic parameters, *reaction time, speed, strength, and tremor*, are detected.

This test is divided into two protocols:

Fast protocol – The user starts by placing his finger on the button. After receiving a visual-sound stimulus, he either pushes the button quickly or realizes it once the target has been reached.

Virtual protocol – The user should perform the same movement, but unlike the above-mentioned protocol, this time he should follow the diagram illustrating finger movement on the instrument's display. In this way the individual's attention is focused on movement thus activating what neurologists call "working memory." Performance of this movement is very important when working with people affected by Parkinson's disease, owing to the fact that, due to akinesia, the patients tend to perform fast movements with very high reaction times at very low speeds; however, when compelled to concentrate (in this case on the finger movement diagram), patient performance improves considerably. Studies conducted by neurologists demonstrate that this answer is generally given sooner than that obtained during *fast reading*; the fact that this takes less time is connected not only to the preparatory performance of perceptive processes and motor-verbal visual transfer, but also to optimum performance of the program connecting mechanism already acquired during final neuro-motor processes.

A first cycle of experimental tests performed using the DAPHNE system on healthy individuals led to results confirming neurologists' findings on that subject.

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An Interactive Multimedia System for Psychosocial Support on Long-Duration Space Flights

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On long-duration space flights, the evacuation of astronauts due to psychological or social problems can be dangerous, costly, and sometimes impossible. We are developing a prototype of a computer-based system to assist astronauts in preventing, diagnosing, and managing psychological and social problems that can arise on long-duration space missions. This project merges the fields of psychotherapy with multimedia by producing prototypes of self-help training programs for prevention, assessment, and self-treatment. The two areas that we are addressing in the prototype are conflict resolution and self-treatment of depression. The project involves three phases: (1) Consultation interviews with former long-duration flyers from the International Space Station, Mir, and Skylab; (2) Interactive multimedia production and formative evaluation and; (3) Evaluation with astronauts at NASA-Johnson Space Center. The system will be modular and expandable, to accommodate additional content in the future. Earth benefits include developing similar systems for other isolated living and work environments (military and commercial ships, polar research bases, oil rigs, etc.), as well as for use by the general public in schools, mental health centers, primary care practices, public health centers, social service agencies, HMO's, prisons, and other settings.

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Using technological tools in psychotherapy: Possible integration between traditional techniques and new shared hypermedia in the clinical setting

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As we transition from the industrial era to an information era, it is imperative that we remain knowledgeable of how changes will impact psychotherapy, psychologists and our patients, as Norcross et al. noted in 2002. Technology is also influencing psychological fields: in particular, *computer-mediated communication* is allowing the experimentation of new tools that can be fruitfully applied in psychotherapy.

These new technologies do not substitute traditional techniques and approaches but they could be integrated into the clinical setting, enhancing or making particular steps easier. For example, one of most critical phases of psychotherapy where technology can find a role is the follow-up: using CMC, the relationship between therapist and patient could be preserved, allowing more contacts and exchange of experiences, emotions, etc.

In the information era new kinds of possibilities regarding the mental health field are growing: Nickelson in 1998 defined "telehealth" as the use of telecommunications and technology "to provide access to health assessment, diagnosis, intervention, consultation, supervision, education and information, across distance."

This paper examines the possible scemarios for using new tools in traditional clinical settings and shows the pros and cons of the use of technology. In particular, the paper focuses on the concept of *e-therapy* and the relative technology that is necessary to develop these new technology-enhanced treatments. E-therapy "is a new modality of helping people resolve life and relationship issues. As Grohol said in 1999, it utilizes the power and convenience of the Internet to allow simultaneous (synchronous) and time-delayed (asynchronous) communication between an individual and a professional. It is important to underline that e-therapy is not an alternative treatment, but a resource that can be added to traditional psychotherapy.

The paper focuses also on the analysis of the most functional tools and software now available with particular attention to shared hypermedia, consisting of new Internet tools in which different users, who are simultaneously browsing the Web, can communicate and surf together.

Starting from the results of this analysis, the paper finally discusses how *shared hypermedia* could be fruitfully applied in psychology and psychotherapy, evaluating their effectiveness in clinical practice.

It is necessary to create multidisciplinary teams with know-how from different areas in order to share ideas and carry on studies. To enhance the diffusion of e-therapy, further research is needed evaluating all the pros and cons.

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The use of experiential cognitive therapy in the treatment of obesity: A controlled study

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The main goal of this work is to verify the efficacy of a new VR and telemedicine-based approach for the treatment of obesity. Experiential-Cognitive Therapy for eating disorders and obesity is a relatively short-term, integrated, patient-oriented approach that focuses on individual discovery. The treatment lasts about 28 weeks: 4-week inpatient/outpatient treatment and 24-week telemedicine (Internet-based) treatment. It is administered by therapists who have a cognitive-behavioral orientation and who work in conjunction with a psychiatrist as far as the pharmacological component is concerned.

The subjects are 68 obese women, aged 18-50 years (Mean age: 33.07 ±8.08 yrs; Mean weight: 105.44 ±17.73 Kg.; Mean height: 1.62 ±0.06 cm; Mean B.M.I.: 39.80 ±6.10). Subjects were then randomly assigned to the experimental group and to the three control groups as following: Experimental group (Experiential-Cognitive Therapy), Control Group I (Cognitive-Behavioral Therapy), Control Group II (Nutritional Group) and Control Group III (Waiting List).

Subjects were assessed by one of three independent assessment clinicians who were not involved in the direct clinical care of any subject. They were two MA-level chartered psychologists and a PhD-level chartered psychotherapist. All subjects were assessed at pre-treatment, after three and six months, and upon completion of the clinical trial. Patients were administered a battery of outcome measures assessing eating disorders symptoms, attitudes toward food, body dissatisfaction, level of anxiety, motivation for change, level of assertiveness, and general psychiatric symptoms.

For the obese sample involved in the Experimental Cognitive Therapy, a pre-post treatment comparison revealed relevant changes both at the psychological and physiological levels. The results indicate that Depression (BDI) and Anxiety (STAI) levels significantly decrease in ECT condition ($p<0.001$ and $p<0.038$) and that the improvement of Self-Esteem (RSE) is significant only in the ECT group ($p<0.003$). Moreover, positive changes in Assertive Behaviors (RAS) are pronounced in ECT ($p<0.004$), confirming the assumption that virtual simulation of real situations improves a patient's social skills. ECT is more effective in improving body image ($p<0.001$), body awareness ($p<0.029$), body satisfaction ($p<0.001$), and physical acceptance ($p<0.053$).

In summary, results show that the virtual simulation of demanding "real-life" situations is useful for improving a patient's awareness, body satisfaction, eating control, social skills, self-esteem, and motivation to change. In particular, pre-treatment/post-treatment comparisons seem to indicate that Experiential Cognitive Therapy was more effective than traditional approaches in the treatment of obesity (Cognitive-Behavioral Therapy and Nutritional Course). These results will be checked in the six-month follow-up that will be presented in the conference.

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Virtual reality in the treatment of binge-eating disorders

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Binge eating disorder is probably the most common eating disorder. People with binge eating disorder, whether or not they want to lose weight, should get help from a health professional such as a psychiatrist, psychologist, or clinical social worker for their eating behavior. There are several different ways to treat binge eating disorder: cognitive-behavioral therapy, interpersonal psychotherapy, and drug therapy *(*such as antidepressants). In this study we propose a new treatment of binge eating disorder, the main characteristic of which is the use of virtual reality. The individuals included were 36 women diagnosed as Binge Eaters, aged 18-50 years (Mean age: 33.07 ±8.08 yrs; Mean weight: 105.44 ±17.73 Kg.; Mean height: 1.62 ±0.06 cm; Mean B.M.I.: 39.80 ±6.10). Subjects were then randomly assigned to the experimental group and to the three control groups which were: Experimental Group (Experiential-Cognitive Therapy), Control Group I (Cognitive-Behavioral Therapy), Control Group II (Nutritional Group) and Control Group III (Waiting List). For all groups the treatment is divided in two successive phases: a 4-week in-patient phase and a 6-month outpatient phase. Subjects were assessed with a battery of psychometric tests (behavioral, cognitive, and emotional) at the start of the in-patient phase, at the end, after three months, after six months and after one year.

The results at the end of the in-patient phase show a significant decrease in the depression levels (BDI) in both ECT (Main before: 22.23; Main after: 8.11; *p*: 0.008) and CBT (Main before: 20.55; Main after: 12.11; *p*: 0.050); however, complete remission of depressive symptoms is observed only in the ECT group. Positive changes in Assertive Behaviors (RAS) are observed in ECT only (*p*: 0.015). This confirms the assumption that virtual simulation of real situations allows for improvement of the patient's social skills. Also, ECT is more effective than CBT in improving body image (BIAQ – BSS – CDRS): in particular, ECT increases body awareness (*p*: 0.012), body satisfaction and physical acceptance (*p*: 0.018), and makes patients confident about the possibility of further progress (*p*: 0.017). These data show two interesting results.

Only ECT produced a significant change in body image, usually associated with a reduction in problematic eating and social behaviors. The possibility of inducing a significant change in body image and its associated behaviors using short-term therapy can be useful to improve the efficacy of the existing approaches. Second, using ECT, therapists were able to improve the motivation for change in the clinical sample.

In conclusion, these results support the hypothesis that Experiential Cognitive Therapy was more effective than traditional approaches in the treatment of binge-eating disorders. A three-month and six-month follow up phase is currently running and these results will be presented during the conference presentation.

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VEPSY Business Model: Strategies to market VEPSY virtual reality tools

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The main goal of this paper is to show the business strategies to market the services based on the virtual reality clinical protocols, developed in the EU-funded VEPSY Updated Project for different mental disorders.

The VEPSY Project has investigated the technical and clinical viability of using portable and shared virtual reality (VR) systems in clinical psychology. After a phase of clinical trials, the project has developed innovative VR-based tools for psychotherapists and clinicians, and we are also carrying out action plans for the dissemination of VEPSY results. The disorders investigated in the project are: panic disorder and agoraphobia, social phobia, obesity, bulimia, anorexia and binge-eating disorders, male impotence, and premature ejaculation.

ELSAG, an Italian IT Services Company, is carrying out the Business Model starting from the Market Analysis developed in cooperation with some of the other partners involved in the VEPSY Project; the Market Analysis has been organized using the SWOT analysis technique (Strength, Weakness, Opportunities, and Threats).

At first ELSAG defined products and services related to Project results. With regards to the developed products, the first one is a modular VR/telemedicine clinical platform for the treatment of mental disorders. It works on low price hardware platforms with low bandwidth Internet connections.

The second product is a set of services that allow therapists to use the VEPSY products and to employ VR therapy with patients.

Preliminary evaluations of market size and type of investments made in this sector suggest that the most appropriate solution to market the VR tools (developed and tested within VEPSY) is the creation of Service and Training Centers (STC) in which VR tools will be installed and maintained, clinical tests in different specialist areas will be performed and training courses will be held using both traditional and innovative tools.

The main services the STC will provide are clinical and technical training, maintenance and updates of hardware and software tools, forums, and workshops. In order to support the service delivery, a web site has also been developed by ELSAG. Its main functions are to distribute developed modules with downloading technique and to keep “professional users” updated; it will also put them in contact either through a chat line or with more shared hypermedia tools.

The last step of the Business Model implementation concerns the analysis of the potential market both in Europe and in USA, evaluating possible criticisms such as localization and cultural aspects. Rough economical evaluation ends with the work of identifying the main sources of revenues and costs.

The business model so implemented represents the input used to prepare the Business Plan that has delineated all the economical and financial aspects and will identify investments expected and possible sales.

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A virtual reality system for the training of volunteers involved in emergency healthcare situations

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In order to guarantee an effective and punctual medical intervention to injured people involved in emergency healthcare situations, a fast and accurate treatment has to be carried out. In emergency healthcare interventions, both professional and non-professional health operators are involved. In the case of catastrophic or very sudden situations, non-professional operators who did not receive proper training (volunteers among them) could be affected by psychological inhibitions that slow down their performance, thus affecting the quality of the treatment. Negative effects can be severe and can turn, in some cases, into permanent disabilities. Both *direct* social costs for medical treatments, rehabilitation, and assistance as well as social *indirect* costs such as absence from the workplace may become higher and higher. Proper training of non-professional operators is therefore a very critical issue in most European countries and new training techniques for this purpose have to be investigated. The system presented is based on a virtual reality technology that provides advanced support for the continuous education and training of non-professional operators. This virtual reality system has been designed and developed in order to: 1) check emergency healthcare operators' capabilities to adopt correct decision-making procedures and to make optimal use of new technological equipment and 2) overcome psychological barriers.

In the article we present the virtual reality system for the training of volunteers in use at the emergency healthcare centre of San Martino Hospital, Italy. The system is composed of:

1) a hi-end PC with two Pentium IV processors and a hi-end graphics card. Its main functions are: execution of the main software module of VR simulation developed in C++, receipt of simulation control data from the simulation control PC, rendering of 3D scenes in sequential stereo mode, rendering of VR simulation sound, control of data transmission from shutter glasses, receiving input from the magnetic tracking system and from the glove and control of the instrumented glove tactile actuators;

2) a low-end control PC. It controls the VR simulation running on the simulation PC, manages medical emergency simulation scenarios, introduces unexpected events to the simulation and controls the simulation difficulty level, and triggers the activities chosen by the trainee's voice;

3) a magnetic-based motion-tracking device (Flock of Birds from Ascension Technology Corporation) used for head and hand tracking;

4) a Cyber Touch instrumented glove from Virtual Technologies with eighteen sensors measuring flexion of fingers and six vibrating tactile stimulators. The glove points at the elements of the VR scene and selects them;

5) a wireless pair of shutter glasses from Stereographics, Inc. based on an IR emitter connected to the simulation PC graphics card used to enable the trainee's perception of the sequential stereoscopic images of the VR simulation;

6) a cathode ray tube (CRT) wall projector with high refresh rate, resolution of at least 1280x1024 pixel and a rear projection option;

7) a wall projection screen with a rear projection screen. Its size is approximately 3.0m wide and 2.5m high. It has to present the sequential stereoscopic images of the VR simulation;

8) a high-end surround sound system.

The expected benefits have been verified through the design and implementation of controlled clinical trials. Preliminary results will be presented in the article.

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Virtual reality exposure therapy for World Trade Center post traumatic stress disorder: A case report

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Done properly by experienced therapists, re-exposure to memories of traumatic events via imaginal exposure therapy can lead to a reduction of PTSD symptoms. Exposure helps the patient process and habituate to the memories and strong emotions associated with the traumatic event, memories and emotions they have been carefully avoiding. But many patients are unwilling or unable to self-generate and re-experience painful emotional images. The present case study describes the treatment of a survivor of the World Trade Center (WTC) attack of September 11, 2001 who had developed acute Post-Traumatic Stress Disorder (PTSD). After she failed to improve with traditional imaginal exposure therapy, we sought to increase emotional engagement and treatment success using VR exposure therapy.

Over the course of six one-hour VR exposure therapy sessions, we gradually and systematically exposed the PTSD patient to virtual planes flying over the World Trade Center, jets crashing into the World Trade Center with animated explosions and sound effects, virtual people jumping to their deaths from the burning buildings, towers collapsing, and dust clouds. VR graded exposure therapy was successful for reducing her acute PTSD symptoms. Depression and PTSD symptoms as measured by the Beck Depression Inventory and the clinician-administered PTSD Scale indicated a large (83%) reduction in depression, and large (90%) reduction in PTSD symptoms after completing VR exposure therapy. Although case reports are scientifically inconclusive by nature, these strong preliminary results suggest that VR exposure therapy is a promising new medium for treating acute PTSD. This study may be examined in more detail at www.vrpain.com.

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Creating a system using a robotic arm and mental / EMG interface to help the quadriplegic person eat independently

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There are over five million Americans that have suffered a traumatic brain injury of some sort, and another million that are living with spinal chord injury. Statistics are not clear as to what mobility has been left intact for these people, but many cannot independently feed themselves. Many also feel a loss of self-esteem. Recent advances in mechanical devices allow people to eat independently but many of these devices require residual abilities left intact after the trauma. However, recent advances in assistive technologies, military avionics, and hobbyist robotics allow scientists and students on limited budgets to develop proof-of-concept systems to demonstrate that quadriplegic persons can now feed themselves for the first time. This paper describes the system built by twelve students and their professor using hobbyist robotics kits, a military aviation interface, and a Visual C++ compiler that has allowed Bruce Davis, a quadriplegic person, the opportunity to feed himself. We describe the constraints, goals, methodology, and results, and draw some conclusions for preliminary work in independent feeding systems.

Background/Problem:
The problem was to develop a system using a robotic arm, mental/EMG interface, and a Visual C++ compiler that allowed quadriplegic and brain-injured users an opportunity to feed

him/herself. The cost of the robotic arm was limited to $125.00, which was the maximum the students could afford. Low budget robotic arms like ours use timed loops instead of digital positional feedback, which posed a greater programming challenge to the students.

Method/Tools:
The methodology was to have each student build their own OWI-007 robotic arm trainer and build an electronic interface to connect the robot to the laptop. The students then used transcripts of discussions from disabled persons, their families, and care staff to create a prototype of an interface for independent feeding. A Don Johnston Sensor Switch (EMG switch) and non-invasive Cyberlink mental interface were used as the input devices to take signals collected at the user's forehead and operate a computer cursor on the screen. The students then tried their systems on each other. The students then went to a nursing home to test their systems after being indoctrinated on basic brain anatomy, institutional rules, and hygiene. One disabled person wore a Cyberlink and used the student program to pick up and eat a cookie with the arm. He later did the same task with a Sensor Switch instead of a Cyberlink.

Results:
The results show that the system needs to be started by a care assistant but that a user can independently use the system to eat a snack within one hour of being introduced to the system.

Conclusion:
The conclusion is that it is possible to use off-the-shelf budget assistive technology such as the sensor switch, Cyberlink, and OWI-Robotic trainer to make "low cost" systems to allow quadriplegic persons to eat solid processed food on a limited basis.

Novelty:
Most feeding systems use mechanically controlled arms and rotating plates that require some remaining residual ability after the trauma. Other systems use expensive robotic arms and require numerous commands to simply eat noodles. These systems are considered awkward and not an option for many disabled persons such as our test subject, author Bruce Davis. Our work is unique in that it requires only slight impulses collected at the forehead to control a robotic arm system to feed oneself.

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Affective imaging: A concept for image-based therapeutic procedures

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Lang, Bradley, and colleagues have demonstrated that emotional reactions to pictorial stimuli can be reliably measured based on physiological reactions or using scaling techniques. It is also known that imaging-based techniques such as virtual reality worlds can be successfully used to treat various emotional disorders.

Based on this information, one can hypothesize that it is possible to predictably change the emotional state of a person by designing a sequence of pictorial or multimedia stimuli that can be used for therapeutic purposes. The second hypothesis is that the effectiveness of such a sequence can be significantly enhanced if the images are chosen based on an individual's "pictorial" profile. It can be further enhanced if a proper (individualized) means of active interaction with the images is provided. These hypotheses have been tested within the Affective Imaging research project carried out at Eastman Kodak Company. Affective Imaging (as we currently define it) attempts to integrate the knowledge in several areas such as psychology, psychophysiology, imaging, computer science, and human factors.

As a first step in this direction, several pilot experiments were conducted where observers' cognitive and psychophysiological responses to pictorial stimuli were evaluated. In the first experiment, subjects viewed a set of randomly presented images while physiological monitoring was performed. After each image presentation, the subjects rated every image on a number of cognitive scales. In the second experiment, images producing certain physiological effects (deactivating, neutral, or activating) were individually selected based on the results of the first experiment and shown to the subjects again.

Psychophysiological measurements included electrocardiogram, hand temperature, muscle tension, eye movements, blood oxygen, respiration, and galvanic skin response. The subjects also rated their emotional state before and after groups of images were presented.

Results of these experiments indicate that individual "pictorial" profiles were different for different subjects. This finding supports the necessity of an individual image selection for image-based therapeutic procedures. We also observed that individually chosen groups of images produced predicted emotional changes, which were dependent on the order of presentation for each image group.

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VR for psychotherapists: What is hot?

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There is growing recognition that VR can play an important role in clinical psychology. In a recent study, a panel of 62 psychotherapy experts using Delphi methodology predicted that the use of virtual reality would be a major psychotherapy trend in the next decade. Applications of VR technology to psychotherapy and rehabilitation have addressed a variety of pathologies such as phobias, anxiety disorders, eating disorders, sexual disorders, and neurological damages. Virtual environments represent an effective assessment tool as well. In fact, this technology offers mental health professionals the opportunity to manipulate complex test stimuli along with the more precise measurement of participant responses.

One major challenge faced by clinicians interested in VR-aided psychotherapy is to improve the efficacy of this innovative methodology. However, there is no consensus among the experts on the most suitable hardware (i.e. head-mounted displays, monitors, CAVE etc.) and software equipment to use in the clinical practice.

The objective of this paper is to analyze the trends of some of the more significant developments in the virtual environment (VE) technology over the last few years. Its aim is to cover not only the technological developments in virtual reality (VR), but to also provide information about the equipment and its clinical use. A particular focus is given to the analysis of visualization hardware, discussing the particular pros and cons of different devices. The study concludes with suggestions for evaluating the value of different VR tools to existing clinical applications.

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3D virtual environments for cybertherapy: a psychosocial approach to effective usability

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Background:
The present study is to be considered a framework of the VEPSY UPDATED project, whose main objective is to prove the technical and clinical viability of using virtual reality therapy (VRT) in clinical psychology by means of portable and shared VR systems. The project will provide innovative tools (telemedicine and portable tools) for the treatment of patients, clinical trials to verify their viability, and action plans for dissemination of its results to an extended audience. In order to achieve these goals, it will first be necessary to overcome a number of clinical, ergonomic, technological, and organizational challenges. The main goal of the research is the identification of a usability evaluation method allowing general definitions in the context of the project by considering areas of VR not yet completely explored from the usability point of view. For instance, the concepts of spatiality,

telepresence, representation (construction of meaning), and the transfer of the results on the basis of a user-centered approach strongly applied to the real context.

Method
The analysis takes into consideration two of the three VEPSY modules: anxiety disorders and eating disorders. Different methods have been integrated: the functional analysis and the user-based tests. Guidelines for the observation and analysis of usability tests prepared by the research unit represent a reference tool for usability evaluation during the different phases of the modules' implementation and tuning as well as a support tool for identifying intervention priorities.

Anxiety Disorders' Modules
Status: Completed
Method applied: User-based tests
The usability tests were conducted on 33 subjects (16 immersive modality, 17 non-immersive modality) belonging to both sexes, aged between 20 and 26. Observation methods: thinking aloud (16 subjects) and aided interaction (17 subjects). A focus group (5 participants) was conducted after the tests.

Eating Disorders' Modules
Status: In progress
Method applied: Functional Desk Analysis + User-based tests
The Functional Desk Analysis was conducted both in immersive and non-immersive modalities. The user tests will be conducted on 16 subjects (four immersive modality and four non-immersive modality) belonging to both sexes aged between 18 and 40 and over 40. The user sample will consist of psychologists and non-psychologists.

Novelty
The approach of the study refers, in particular, to the new definition of presence proposed by Mantovani and Riva that (a) recognizes the mediated character of every possible experience of presence; (b) always conceives of experience as immersed in a social context; (c) stresses the component of ambiguity inherent in everyday situations; and (d) highlights the function of confirmation which culture plays. The results of previous EU-funded projects conducted by the research unit and the analysis of specific literature lead to the conclusion that the most significant goals of the study are:

- The evaluation of the suitability of Nielsen's heuristics on VR environment usability tests and possible adaptations or integrations;
- The comparison of usability problems found by expert evaluation and user-based tests carried out in a real-use context.

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Artifact-based trust in on-line interactions

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Background
The work presented is part of a more complex study on trust construction in on-line interactions, aimed at the definition of an effective model to be applied in different situations: first of all, on-line therapy and on-line psychological counseling. This part of the study takes into consideration the e-commerce context for two main reasons:

- the difficulty level of the interaction is low
- the recruitment of users for the testing phase does not present particular problems

Method
One of the main problems of on-line interactions consists in winning over the users' resistance in order to gain trust. As trust is not based only on previous experiences, but also on feelings and impressions emerging in the course of the interaction, the study aims at finding out what elements make a website trust-worthy.

In order to obtain basic information about the web interaction processes an on-line shopping situation has been considered in this first phase.

User sample: 46 couples

The methods applied were traditional usability methods considered suitable for the test performed:

- Direct observation during the interaction
- Screen recording for post-test analysis

- Voice recording of users' comments during the interaction
- Interviews
- Questionnaire

Novelty
Interaction had a common structure based on different tasks: in general, users first search for elements to understand the website structure, then look for a specific item to buy, and finally build their own confidence to start the buying process. The interview and the analysis of voice-recorded comments show that each element of the website influences the shopping process and the seller's representation. Screen-recorded interaction (including mouse movement analysis) showed the importance of navigation bars and menu structure in selecting paths.

On the basis of the collected data, a model was prepared to represent web-based trust. In this model, interface elements are the starting point to perceive information on the website and catalogue structure and to get information on items included. Information collected allows the user to create a mental model of the whole interaction process, not just of 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 seller, on any other interlocutor and on the interaction itself. This information is then evaluated, according to different criteria (based on previous experience in order to express a judgment). These criteria are:

- "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 (by leaving the site); it's based on the motivation that, as far as e-commerce is concerned, consists in price convenience. "Satisfaction about the interaction" underlines the importance of usability and accessibility of the site. "Perceived competence" is an element pertaining to the users' mental model of the seller as well as the "Perceived transparency."

During this process, users continue the interaction task (understanding the site and the catalogue structure, searching for specific items and buying them) only when the mental model is sufficiently clear and the different criteria are fulfilled. Interaction tasks are not to be considered independent and separated but, on the contrary, complementary in order to reach the goal of generating confidence and trust.

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 buying process.

The next step of the research is to obtain quantitative data in order to validate the model and to use it in other contexts, especially in telemedicine, including on-line psychological counseling and therapy.

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A platform for combining virtual reality experiments with functional magnetic resonance imaging

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Background:
Virtual reality (VR) applications in areas such as cognitive neuroscience, neuropsychology, and cognitive and physical rehabilitation are typically assessed using behavioral performance measures. However, there is growing interest to investigate how VR applications are characterized in terms of specific regional brain activity and how VR will improve the ecological validity of traditional "paper and pencil" neuropsychological measures. Combining VR with functional neuroimaging technology can help answer these questions. In particular, functional magnetic resonance imaging (fMRI) exhibits attractive characteristics: non-invasiveness, full-brain coverage,

and spatial and temporal resolution on the order of millimeters and seconds, respectively, for measuring brain activation. However, combining VR and fMRI is technically challenging.

As an initial step toward combined VR-fMRI studies, we developed a dedicated testing platform for efficient design and implementation of virtual environments (VEs), both with and without fMRI. Here we describe the platform and report preliminary results from VR-fMRI experiments involving navigation through a virtual city to support the feasibility of our approach.

Method and Tools:
The VR platform consists of a PC workstation (ZX-10, Intergraph Inc.) featuring an advanced graphics card (Wildcat 4210, 3Dlabs Inc.). Development and presentation of VEs involves two related software packages (WorldUp and WorldToolKit, Engineering Animation Inc.). Graphics are routed to a ProView XL-50 (Kaiser Electro-Optics Inc.) head-mounted display (HMD) or the MR-compatible Silent Vision System (Avotec Inc.). Attached to the HMD is a miniBird 800 electromagnetic tracker (Ascension Technologies Inc.). The platform also includes a scan converter, television, and VCR for data recording, and an fMRI-compatible joystick.

The first VE developed for the platform involved human navigation through a virtual city, ultimately designed to study early effects of Alzheimer's disease on spatial memory. The task consisted of several phases: trials involving path memorization, path recollection, and object recognition. The principal behavioral metrics were time to completion and distance traveled. Two young healthy adults were tested during fMRI, and eight adults were tested outside the magnet.

Results:
Presentation of interactive and complex stereoscopic graphics at close to 30 frames per second was feasible during fMRI. Initial fMRI of spatial navigation demonstrated a decrease in bilateral prefrontal activity over the course of the learning trials, correlating with decreased time to completion (performance improved analogously for subjects tested outside the scanner). Short and long delay recall produced activity in the right parahippocampus and left parietal lobe.

Conclusions:
An integrated, flexible testing platform has been developed for conducting behavioral assessment in rich, immersive VEs, with the additional capability to use fMRI as a probe. Initial VR-fMRI results are consistent with purported neuro-anatomic mechanisms of human navigation.

Novelty:
Such a testing platform is clearly an important tool for investigating VR applications using fMRI. Future work will include further VR-fMRI tests of spatial navigation in young adult volunteers and other subject populations, extending VR-fMRI to tasks other than spatial navigation, and the integration of other fMRI-compatible devices for interacting with VEs.

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Integrating Shape Tape™ with experiments involving virtual reality and fMRI

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Background:
In the quest to design virtual reality (VR) applications that evoke real-life sensations and actions, a new peripheral device of particular interest is Shape Tape™ (Measurand Inc.), a lightweight, wearable, flexible ribbon that provides contour data in real-time. The purpose of this study was to integrate the Shape Tape into an existing VR testing platform and to develop tasks in which subjects could more realistically interact with virtual environments (VEs) during functional magnetic resonance imaging (fMRI). Combined with fMRI, Shape Tape offers

a unique opportunity to assess both VR and conventional behavioral assessments involving reaching, pointing, or drawing.

Method and Tools:
The Shape Tape's array of bend and twist sensors track position (X, Y, Z, roll, pitch, yaw) along its length. Consisting of Mylar and optical fiber, the tape's active region is completely fMRI-compatible. Proprietary software included with the tape enables communication with our VE development package (WorldUp, Engineering Animation Inc.).

Three experiments were performed to characterize using the Shape Tape in VR-fMRI studies. We measured 1) drift due to temperature fluctuations; 2) positional accuracy and reliability; and 3) head motion produced by representative tasks (important for fMRI data quality). The latter experiment involved two volunteers performing repetitive pointing in an fMRI simulator system.

To demonstrate its use during fMRI, the tape was configured as a "pinch" data glove to perform right-handed finger-tapping tasks. Two young, healthy adults performed self-paced finger-tapping 1) without watching their hand; 2) watching their real hand; 3) watching their virtual hand, and 4) watching their virtual hand with a variable delay between their movement and the display.

The Shape Tape was also configured as an fMRI-compatible stylus, and its preliminary use was assessed in tasks involving tracing and writing: the Porteus Maze Test and the Sunnybrook Neglect Assessment Procedure (SNAP).

Results:
With periodic recalibration every 5 minutes, the tape exhibited negligible thermal drift. Position accuracy varied inversely with the amount of twist in the tape, with highest accuracy displayed along the tape's centerline. Head motion was correlated with task motion, but was < 1mm, indicating the feasibility of fMRI with a data glove in compliant subjects. Finger tapping experiments showed reproducible increased engagement of a network of sensorimotor brain regions when subjects tapped while viewing their virtual hand. Use of the tape in writing and tracing tasks was found to be practical under fMRI conditions.

Conclusions:
The Shape Tape provides more intuitive and realistic interaction within VEs and can be used effectively in conjunction with fMRI to measure brain-behavior correlations.

Novelty:
The ability to record, playback, and manipulate Shape Tape motion data can potentially augment conventional assessment and rehabilitation techniques. Future work will include fMRI studies of hemispatial neglect, and augmented biofeedback to be used with specific physical therapies on selected stroke patients.

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Water-friendly virtual reality pain control during wound care in the hydrotank: a case report

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To date, most studies on virtual reality burn pain control have been conducted during physical therapy, when patients' wounds remain bandaged. The most painful burn wound care (e.g., bandage changes, cleaning of the open burn wound, inspecting, and re-bandaging the wound) is typically performed with the patient sitting up to their waist in a tub of water, precluding the use of conventional miniature LCD screen based VR helmets.

The goal of the present project is to explore the clinical use of virtual reality for pain control during burn wound care/dressing changes in the hydro tank, using our new optic fiber "photonic" virtual reality image delivery system for the first time. The virtual images are converted to light, so that only visible light is transmitted to the patient via non-conductive glass optic fiber image guides with plastic sheathing. Data from our first burn patient to try water-friendly VR will be presented.

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Funding opportunities available at NIDA

Jackie Kaftarian, PhD

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The National Institute on Drug Abuse (NIDA) at the National Institutes of Health (NIH) supports over 85 percent of the world's research on the health aspects of drug abuse and addiction. NIDA-supported science addresses the most fundamental and essential questions about drug abuse, which range from the molecular to managed care, and from DNA research to community outreach. The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) funding mechanisms focus on bridging the gap between research and commercialization of resulting innovations. This presentation will provide information on the general features of the SBIR and STTR funding mechanisms, and explain how they can be utilized for feasibility studies, research and development purposes, as well as commercialization of innovative products.

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Human magnetoreception: Does it exist?

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Background:
During the past 40 years, there have been many studies on the nature of the vertebrate magnetic sensory system, including studies based in behavior, anatomy, and biophysics. Behavioral studies confirm magnetoreception in all major groups of vertebrates, including fish, amphibians, reptiles, birds, and mammals. Anatomically, the ophthalmic branch of the trigeminal nerve in birds and fish is the main conduit of magnetic field information to the brain, implying that this ability predates their last common ancestor. In brown trout, specialized cells containing single-domain crystals of biogenic magnetite (Fe_3O_4) are found near the distal termini of the trigeminal system; these structures are probably the long sought-after magnetoreceptors. Biophysical experiments demonstrate that a ferromagnetic receptor is indeed present in honeybees, newts, and birds. A simple model of a linear magnetism chain in a viscously-damped fluid is able to account for virtually all of the known biophysical constraints on animal behavior, including sensitivity and frequency response.

Application to Humans:
Humans also have the biochemical ability to precipitate magnetite. However, attempts to demonstrate the existence of human magnetoreception through behavioral experiments have been difficult to replicate. M.E. Bitterman therefore suggested an alternate approach involving variations on the 'classical' conditioning experiment, in which humans respond subconsciously to a variety of sensory stimuli prior to shock, with skin conductance used to monitor the progress. Although our initial experiments at Caltech with his simplest of paradigms yielded negative results, Bitterman suggested that we try pairing the magnetic stimulus (a weak 2 hertz oscillating magnetic field of constant direction) with that of a clearly audible tone, which was gradually faded away. This procedure did elicit an apparently significant magnetic conditioning.

Another preliminary set of experiments with a two-alternative, forced-choice conditioning paradigm produced essentially random results, except for several occasions when subjects produced incredibly improbable, extraordinarily significant strings of correct answers (including one session containing only three errors out of 50, or a chance probability $p < 10^{-7}$). However, it is proven difficult so far to find subjects who can do this reliably.

Future Possibilities:
If magnetoreception is present in the human subconscious, it may be possible to develop a psy-

chological training paradigm to bring this "sixth sense" into conscious awareness. This could have immediate application to the problem of spatial disorientation in airplane pilots, as perception of the geomagnetic field could provide additional warning cues of situations like the "Graveyard Spiral." For this, however, it will be necessary to devise training paradigms in which shifts in the direction of the magnetic field are used as the conditioning stimulus, rather than the fluctuations in intensity used so far. Approaches to this problem will be discussed at the meeting, including the possibility that conscious perception might not be strictly necessary for an effective pilot warning response.

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Virtual reality provides leisure time opportunities for individuals with physical and intellectual disabilities

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Problem:
Due to limitations in their physical abilities, individuals with cerebral palsy (CP) have relatively few opportunities to engage in independent leisure activities. The pastimes that are available to them tend to involve sedentary activities such as viewing movies and playing games on a computer that has been adapted to provide greater accessibility. A wider range of leisure activities such as "strolling" in the park or eating out in a restaurant may be made possible with the cooperation of a companion. Nevertheless, individuals with CP, and especially those who also have an intellectual disability, have few options for vocational pastimes. This pervasive lack of opportunity often leads to the development of dependent behavioral patterns and learned helplessness. The objective of this study was to explore ways in which virtual reality can provide positive and enjoyable leisure experiences during physical interactions with different game-like virtual environments. We suggest that independent leisure experiences such as these will improve self-esteem and lead to an increased sense of self-empowerment.

Method/Tools:
We have commenced a study using VividGroup's Gesture Xtreme video capture virtual reality system (www.vividgroup.com), originally developed as an entertainment system designed to demonstrate VR in science museums. When using the Gesture Xtreme VR system, users stand or sit in a demarcated area viewing a large monitor that displays one of a series of simulated functional tasks, such as catching virtual balls or playing goalie in a virtual soccer game. The participant's video-captured image is processed on the same plane as screen graphical animations that react in real time in response to his or her movements. We have adapted the system in accordance with principles based on rehabilitation intervention such that the level of difficulty can be graded and performance documented. The study sample consists of young adults with cerebral palsy and moderate intellectual disabilities who are non-speaking and who use wheelchairs for mobility. Each participant experiences three game-like virtual scenarios (Birds & Balls, Soccer, Snowboard). Outcome measures include the participants' responses to a task-specific questionnaire (based on Witmer & Singer's (1998) presence questionnaire) and a checklist recording behaviors such as initiative, communication, and motivation.

Results and Initial Conclusions:
To date we have tested the responses of five individuals who have experienced the three different virtual scenarios. Their responses to the questionnaire, graded on a 5 point scale, show a high level of presence in all three scenarios (Birds & Balls, 3.94 ± .43; Snowboard, 3.5 ± .71) and especially in Soccer (4.45 ± .57). These participants demonstrated an exceptional degree of enthusiasm during each VR experience, reacting to the various stimuli via appropriate and goal-oriented responses.

Novelty:
This is one of the first studies that focuses on using an immersive VR system for people with intellectual disabilities in order to enable them to

participate in leisure activities that would otherwise be inaccessible to them. Documentation of their behaviors during and following the VR experiences will provide insight into the important role that VR may play in nurturing their self-esteem and sense of empowerment.

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Tactile illusion in a real hand evoked by a synchronous visual stimulus on a virtual hand

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Virtual reality (VR) technology can provide various stimuli (including visual and auditory stimuli, simultaneously in the virtual environment) which encourages the user to interact with it. Virtual reality is a set of computer technologies, which when combined, provides an interactive interface to a computer-generated world. In this world the subject can see, hear, and navigate in a dynamic environment in which he or she participates as an active player by modifying the environment according to his or her will. Moreover, the subject can get a feeling for the virtual environment in much the same way as one gains familiarity with real life situations. In the real world, a plethora of information from various modalities may be in conflict, and modulate each other to form an illusion. In this study, we investigated whether a tactile illusion on a real hand could be evoked by a virtual stimulus, the time required to generate this illusion, and its duration. This study shows that the illusion occurred, and that it was correlated with presence score in the virtual environment.

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A virtual reality system for the cognitive assessment of schizophrenia

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Patients with schizophrenia have thinking disorders such as delusions or hallucinations, because they have a deficit in the ability to systematize and integrate information. Therefore, they cannot integrate or systematize visual, auditory and tactile stimuli. The multimodal integration model of the brain can provide a theoretical background from which one can approach multimodal stimulus integration. In this study, we suggest a virtual reality system for the assessment of the cognitive ability of schizophrenia patients, based on the brain multimodal integration model. The virtual reality system provides multimodal stimuli, such as visual and auditory stimuli, to the patient, and can evaluate the patient's multimodal integration and working memory integration abilities by making the patient interpret and react to multimodal stimuli, which must be remembered for a given period of time. The clinical study showed that the virtual reality program developed is comparable to the Wisconsin Card Sorting Test (WCST) and the Standard Progressive Matrices (SPM).

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Designing virtual environments for the treatment of social phobia

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Background/Problem:
Social phobia is an anxiety disorder that is now the object of intensive research. It has been shown that social phobia is associated with two forms of treatment yielding scientifically validated results: drugs and cognitive-behavioral psychotherapies. Exposure to feared social situations is fundamental to obtain an improvement of the anxious symptoms. Traditionally, exposure therapies are done either *in vivo* or by imagining them.

Virtual reality (VR) seems to bring significant advantages. It allows exposures to numerous situations and creates a strong feeling of presence in the situation. Studies have shown that human subjects are appropriately sensitive to virtual environments.

Method/tools:
This paper reports a protocol, which specifies patients' assessment and allocation, the therapy's structure, and a study to treat social phobia using virtual reality techniques. It describes the virtual environment consisting of four three-dimensional worlds reproducing four situations that social phobics feel to be the most threatening. It explains the steps of the worlds' design, the hardware requirements, and the software tools. It also describes some specific constraints we add to take into account in the world model and to improve the therapeutic usability.

It finally assesses the efficiency of the virtual reality therapy and the comfort and handiness of the designed technology within the framework of a small-scale clinical trial.

Conclusion:
The patients reacted to the virtual environments in a manner similar to that of their *in vivo* experiments. We noticed an improvement of their symptomatology and a good observance of the treatment. The patients showed an average adhesion to the virtual environments in which they navigated with ease.

Novelty/Discussion:
Several studies have been conducted using virtual reality in the treatment of the fear of public speaking. However, most of the social phobic patients suffer from a set of associated troubles and in consequence, these studies address only one of their troubles. The novelty of our work is that it addresses a group of situations that the phobic patient is most likely to experience, and it treats patients according to a very precise protocol.

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Exposure therapy of acrophobia in a virtual environment: comparing a data helmet and a three-segmented power-wall

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Background:
Specific phobias are one of the most frequent mental health problems and can lead to years of personal suffering. The most effective treatment is exposure therapy. But it is very hard to evaluate therapeutic effects in an objective manner because exposure conditions and measurements are variable. Therefore, there is little known about biochemical, physiological, and psychological interactions. Virtual environments can provide standardized stimuli and – at the same

time – the possibility to measure physiological reactions.

Method:
Our aim was to prove feasibility and efficacy of virtual environments as well as to compare two different presentation technologies (a data helmet and three-segmented power-wall) in treating acrophobia patients using a manual-guided exposure therapy. Our study was designed as a randomized intervention with an *in vivo* condition as a control group. Cortisol levels, respiratory and cardiac parameters, skin conductance, and other physiological reactions were measured during exposure.

Results and Conclusion:
103 patients have been included in this study so far. They were randomly assigned to three different therapeutic settings (data helmet, three-segmented power-wall, *in vivo*). The results show that exposure in virtual environments is a feasible technique. Both presentation technologies can reliably provoke anxiety and lead to desirable levels of habituation if coupled with behavioral therapy. The complete set of (neuro-) physiological data as well as the treatment results will be presented.

Novelty/Discussion:
There are still a lot of differing definitions concerning virtual reality as a treatment tool in behavioral therapy. Also, with regards to the equipment considered useful and effective, there are no usage standards, nor is there a scientifically sound basis for any assumptions regarding which hardware and software configurations could or even should be used for a specific purpose. At COAT-Basel we have begun a whole series of comparison studies in which virtual environments are presented via different system configurations and compared to each other using an *in vivo* control group as a gold standard of sorts. Among these sets of investigations the acrophobia study is the one that is closest to completion and was therefore chosen for presentation.

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Development of a system for assessing driving ability and training in brain injury patients

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In our modern, fast-paced society, great value is placed on an individual's ability to function independently. Individuals who sustain brain injuries are often faced with physical and cognitive impairments that inhibit their ability to function independently with respect to everyday living or their ability to maintain a job.

We will identify the driving ability of brain injury patients from pre-driving assessment tests. The driving simulator includes standard vehicles and those equipped with adaptive hand and foot controls to create a simulated real-time driving experience.

The latest in visual display technology and a high-fidelity audio system will complete the driving experience. The subject will be immersed in sight, sound and movement so real that 5 scenarios can be convincingly presented with no danger to the subject.

The simulator recreates both visual experience and the feel of driving an automobile. It also includes a module to analyze the subject's cognitive, physical, and behavioral disabilities.

For assessment, driving skills were measured (average speed, steering stability, centerline violation, traffic signal violation, time taken, and so on) in various road states such as on a straight road, curved road, etc.

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The application of the virtual reality system for the activities of daily living

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Successful rehabilitation with respect to the activities of daily living (ADL) requires accurate and effective assessment and training. A number of studies have emphasized the requirement for rehabilitation methods that are both relevant to the patient's real world environment, and that can also be transferred to other daily living tasks. Virtual reality (VR) has many advantages over other ADL rehabilitation techniques, and offers the potential to develop a human performance testing and training environment. Therefore, in this study, the virtual supermarket was developed and the possibility of using a VR system to assess and train cognitive ability in ADL was investigated. This study demonstrates that VR technology offers great promise in the field of ADL training.

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Cue exposure system using virtual reality for nicotine craving

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Research has shown that many smokers experience an increase in the desire to smoke when exposed to smoking-related cues. Cue exposure treatment (CET) refers to the manual, repeated exposure to smoking-related cues, aimed at reducing cue reactivity by extinction. In this study, we constructed a virtual reality system of smoking-related cues based on the results of a Questionnaire of Nicotine Craving. We compared the virtual reality system with a classical device (pictures). As a result, we reached the conclusion that virtual reality does well at eliciting craving symptoms as compared to classical devices.

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Psychonaut 2002: The role of cyberspace in assessing and modifying drug scenarios

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It has been estimated that at least a few hundred websites are already dedicated to the use of recreational/illicit drugs. Most of these sites advocate the use of drugs and give advice to consumers to enhance their drug experience. Moreover, it is possible online both to buy illicit/recreational compounds and to find precise instructions on how to synthesize most of the licit and illicit psychoactive compounds. Finally, the Internet is one of the major methods for the dissemination of a new class of drugs: the so-called 'ecological drugs.' The lack of both professional attention and scientific information on these issues is surprising indeed, since it is well known that the computer literacy of children and adolescents can be quite high. The main activity of the European enforcement agencies has been focused just on the actual 'real' (i.e. non-virtual) market, and no mapping of the web with regards to drug-related issues is currently available.

The main aims of the "Psychonaut 2002" project, financed by a grant of the European Commission, Public Health Directorate, are:

- To foster collection and analysis of data from web pages related to recreational/illicit psychopharmacological substances;

- To start/implement an *'early reaction system'* in relation to public health threats linked to drugs (especially new/synthetic drugs) at a European, national, and regional level;
- To provide the professionals from the different European countries involved in the project with easily accessible and reliable evaluation and assessment of the material. Therefore, it will be possible to identify new, emerging trends, and to provide information for prevention and immediate intervention.

The material from the webpages is being evaluated and assessed according to set criteria (based on scientific soundness of the information presented, level of legality/illicitness of substances described, commercial/ noncommercial nature of the site, etc). The Uniform Resource Locators (URLs) of these pages will be collected by automatic (metasearch software) and manual means. An e-mail discussion list to facilitate communication between collaborators has been organized. The Collected URLs and the review of their contents will be published in both conventional and electronic peer reviewed journals.

All the statutory and non-statutory Addiction Services professionals of the 11 European countries involved will be regularly provided with reviews of the examined material. In fact, a protected website, with encrypted and restricted access available only to the registered professionals, is going to exist. Recently, three different pilot trials have already been completed and the first Psychonaut 2002 European meeting was held in London at the beginning of December 2002. The methodology of the project has been discussed and agreed upon between the participants, so the formal collection of the information will start in the next few weeks.

Methodology and results of preliminary trials will be presented, and ongoing research issues will be discussed.

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Persons and their artificial partners: Robotherapy as an alternative non-pharmacological approach in therapy

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This presentation discusses an innovative conceptual framework that is the basis of in-progress research on robotherapy.

Two types of therapies traditionally related to mental health are based upon unfortunately contradictory pharmacological and non-pharmacological approaches. Whereas the former method uses drugs' impact on human physiology associated with psychological processes, the latter achieves the same psychophysiological effects by using such methods as psychotherapy, stimulation (i.e., color or basic geometrical shapes), physical therapy, and meditation. The most unexpected rise of e-health as a new technology, including telemedicine and VR applications, rapidly formed a niche in the late 20th century non-pharmacological therapy. However, the use of interactive, non-virtual techniques (robots or artificial creatures with sensory feedback and electronically-based intelligence) almost escaped researchers' and practitioners' attention. Robots as humans' artificial partners are entering our lives faster than we think. In the nearest future, their functions might be dramatically shifted from the entertainment domain – which is still distant for many of us who are too busy to play – to the professional, (i.e., industrial, military, exploratory, and medical areas). The most important concept – although somewhat unexpected for many people – is that advanced robots can be effectively used in different kinds of therapy playing roles as 1) a mediator in person-to-person communication; 2) an interactive device for training and development of certain individual and group skills; and 3) a human companion in special situations and life circumstances. Numerous creatures equipped with touch, audio, and visual sensors and different levels of Robo-IQ (hence artificial intelligence) already exist on the market and in the laboratory (AIBO, PINO, the cat NeCoRo, the seal Parro, the dolls Amazing Amy and My Real Baby, humanoid AMI etc.). While practitioners and researchers gradually realize that an individual's special needs might require specially designed tools, theoretical and applied justification has to be developed to embrace and analyze the epistemology and phenomenology of the already diverse robo-population. In our approach for the first time Robotherapy is defined as a framework of person-robot communication aimed at the reconstruction of one's negative or lacking experiences through the development of new coping skills mediated by interactive technological tools. Robotherapy, as a new research area, focuses on the analysis of the person - robot communication, viewed as a complex interactive system, with emphasis on psychological evaluation, diagnosis, prognosis, and principles of non-pharmacological treatment. The effectiveness of robotherapy is influenced by both (1) one's past experiences, current needs, and individual preferences, and (2) an artificial partner's non-transitive physical features and behavioral configurations defined through the intensity of simulations and responses. Our preliminary study was aimed at the psychological examination of human reactions emerging from communication with an artificial creature imitating an animal's behavior (robotic cat NeCoRo). A special scale was developed for assessing numerous effects of a person-robotic creature interaction. Certain individual and group differences influenced by biological, psychological, and ergonomic factors are discussed in the context of human-robot coexistence.

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The use of interactive artificial creatures in psychological practice: a case of robotherapy

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This presentation will discuss a pioneering study on robotherapy currently in progress.

The long-predicted merge of the artificial and human worlds is happening before our very eyes. We see different, but mostly positive, consequences of human beings interacting with their artificial partners. From the therapeutic point of view, interactions between a person and a robot have diagnostic power. Generally speaking, individual manners of establishing relationships with the robot reflect both styles of self-expression and individual coping styles. In particular, an artificial creature serves as the mediator between a person's behavior and a situation with a high degree of uncertainty. The analysis of this interplay allows us to draw conclusions on specific features of the participating person and of some psychological problems, including difficulties in self-expression. Here the technological tool becomes a mediator between individual life experiences and a private 'inner' world. Robotherapy is especially important for studying a child's exteriorization-related problems. It is well-known that children and adults with certain mental health difficulties have an especially hard time trying to communicate their internal thoughts, feelings, and emotions to others. However, this difficulty may be overcome by interactions with toys, pets, or in our study, robotic pets. Robotic cat NeCoRo, created by Dr. Shibata and manufactured by Omron Corporation, was the primary subject in our pilot study on robotherapy. NeCoRo belongs to a class of interactive simulation robots, and it has three distinctive characteristics which allow it to be considered a human companion or artificial partner, as well as a new therapeutic tool:

1. The Cat NeCoRo simulates a real animal-like behavior.
2. It is based on modeling emotional, cognitive, motor and other mental traits and states normally experienced by humans.
3. It gives a person an opportunity to communicate on various levels such as tactile-kinesthetic, sensory, emotional, cognitive, and socially – behavioral.

The general principals of human-robotic creature interactions were modified for the purpose of our study with the cat NeCoRo through the analysis of a person's experiences with a real pet. Pet-therapy is a well-known non-pharmacological approach to the treatment of mood disorders, negative emotional condition, loneliness, and depression. In our study, a person's interactions with the robotic pet were evaluated via the newly developed Person-Robot Complex Interactions Scale (PR-CIS). 16 participants of both genders and different ages were engaged in 15-minute session with a robot. The structure of a new scale includes 10 an assessment of a person's individual style of communication with the artificial creature (in our case the robotic cat NeCoRo); 2) participant's evaluation of his/her experiences with the robotic cat; 3) a person's experiences with live pets and modern technology; and 4) A participant's evaluation of the robotic cat's features, and its advantages and disadvantages. PR-CIS was developed with the purpose of investigating diagnostic and therapeutic potentials of person–robot interactions. Our preliminary data show that robotherapy might be a useful tool for both research and clinical practice.

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Is 'presence' a key factor for the effectiveness of cognitive rehabilitation of executive functions? Experience with V-STORE, a new immersive virtual reality-based tool

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Many agree that computer-based tools can be useful in the assessment and rehabilitation of cognitive deficits, but a key issue mostly unresolved is 'how' to do it and obtain better results. The key point deals with the ecological validity of computer-based rehabilitation procedures: are these useful for patient's everyday life? Is there an efficient transfer of knowledge and skills between the tasks carried out in labs and life outside the hospital?

We focused on Dysexecutive Syndrome, usually depending on prefrontal brain area injuries. While many applications of P&P or computer-based rehabilitation for different cognitive impairments have proven some degree of efficacy in terms of transfer to real-life situations, clinical results with dysexecutive symptoms are mostly unsatisfactory. Damasio in 1994 pointed out that our traditional 'experimental' settings seem to bear intrinsic limits to obtaining clinical improvements of dysexecutive syndrome.

Our opinion is that virtual reality (VR) can offer a good method of setting up an efficient rehabilitative environment, even for executive symptoms. By increasing the sense of presence that these patients feel within the synthetic environment we build for them, we bring the lab much closer to real life, partly overcoming the limits that Damasio identified. Immersive VR systems, based mainly on a head-mounted display and some tracking device, may offer enough in terms of presence and thus ecological validity.

Rehabilitation has to allow head trauma patients to recover their planning, execution and control skills by implementing sequences of actions and complex behavioral patterns that are requested in everyday life: immersive VR can be specifically designed to reach this goal because it does it in the most naturalistic way.

A new VR-based rehabilitation tool for executive functions, V-STORE, will be presented. It allows patients to explore a virtual environment (an internal goods store) in which they solve a series of tasks ordered in six levels of complexity, designed to stress executive functions, behavioral control and programming, categorical abstraction, short-term memory, and attention. Distracting stimuli are present to generate time-pressure and to elicit managing strategies.

Preliminary impressions about the clinical use of this tool will be provided: a single-case analysis show good compliance and motivation, but also some usability concerns.

Furthermore, we compared the sense of presence experienced by 12 unskilled normal subjects who had to complete two levels of V-STORE and were randomly assigned to two different versions: immersive and non-immersive (a similar flat-screen version in which movements are commanded by joystick). Experimental assessment of presence was conducted with different indexes: self-report (ITC presence questionnaire), psycho-physiological (GSR response), neuropsychological (incidental recall memory test related to audio information provided during tasks from the 'real' environment), and behavioral (breaks in presence, BIP). Preliminary results show the immersive group had a significantly higher GSR activation during tasks and higher levels of self-reported presence. Neuropsychological and behavioral data only show a congruent but non-significant tendency in favor of the immersive condition (they had recalled fewer elements from 'reality' and less BIPs); a larger experimental group is currently under examination to evaluate significance of these data.

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Neurophysiological age differences during task-performance in a stereoscopic VE

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Status:
Experiments in 36 subjects were completed; experiments in an additional group have been started.

Background and Purpose:
In society today there are an increasing number of workplaces in virtual environments (VE). But there are only a few reports dealing with occupational health issues. The question arises as to how VR generally interferes with cognitive processes. This interference might have relevant implications for workability and work-efficiency in virtual environments. Event-related potentials are known to reflect different stages of stimulus reception, evaluation, and response.

We have established electroencephalographic (EEG) monitoring focusing on event-related potentials to obtain access to pre-attentive and attention-dependent processing of sensory impulses applied in VE.

The aim of the present study was to investigate cognitive responses to auditory and visual stimuli in different age groups in VR and to describe characteristic response patterns.

Methods:
ERP's were recorded in a group of 36 shift-workers with a similar level of education. Two different age groups were formed: Group 1: Mean age 24.7 years and Group 2: Mean age 46.0 years.

Mismatch-negativity (MMN), N100, P200 and P300 were chosen as parameters. A central working task was performed in a stereoscopic VE such as a modified Stroop task. Two additional reading sessions were implemented as controls. At the end of the experiment sleep pressure was measured collecting power spectral EEG data. A passive auditory oddball paradigm was employed during all sessions except the final sleep pressure trial. A segmental power wall (3 segments) subserved as experimental platform.
A 32-channel EEG was installed, fitting persons with an electrode cap, and data were acquired during the complete VE exposure. Electrodes were referenced to the connected ear lobes. Two different tones were applied: a standard tone (500Hz) and a deviant rare tone (550Hz). Stimulation frequency was 0.5 Hz during the Stroop task and 1 Hz during all other conditions. Tones were given in the Stroop task 300 ms preceding the visual stimulus to distract subjects by a task irrelevant stimulus.

Data analysis was performed offline. ERP's amplitudes and latencies were calculated for the different age groups. MMN and P200 during the working task in VE were compared with the other task conditions. Performance measurements were evaluated: reaction time, error rate, strategy, and error classification.

Results:
In the present study definite age differences could be demonstrated in VR performance as given by objective work-performance parameters. The performance deficit in the older group was closely correlated to the ERP latencies. Both age groups could also be segregated in respect to different responses to distracting task irrelevant stimuli. The database will serve to improve VE design and to increase workability and work efficiency in VE's.

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Virtual training in health-care: Enhancing skills acquisition and transfer of knowledge through learning experience in virtual environments

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Recent advances in educational and training technology are offering an increasing number of innovative and promising learning tools. These include three-dimensional and two-dimensional virtual worlds as well as computer simulations, which can provide an opportunity to enhance the training of health-care professionals through experience in virtual environments.

As is well-known by teachers, performing a task enhances the learning process; within this perspective, virtual reality (VR) can provide a rich, interactive, and engaging educational context, thus supporting experiential learning-by-doing. In fact, VR can raise interest and motivation in trainees and effectively support skills acquisition and transfer, since the learning process can be settled within an experiential framework. Moreover, virtual environments are highly flexible and adaptable, so that trainees can be presented many different scenarios, and the training process can be tailored to individuals.

However, understanding how to use VR to support training and learning activities in health-care presents a substantial challenge for the designers and researchers in this field. No matter the skill taught or the technology employed, the learning potential of virtual training relies on the possibility of learners making a number of significant first-person experiences and failing in a safe/protected environment. In effective virtual learning-by-doing, the experience seems real and engaging to participants, as "if they were there." The participant should feel (emotionally and cognitively) present in the situation. The sense of presence experienced by learners in virtual training is thus a key feature to ensure the transfer of knowledge from the training context to real life.

Current virtual training applications for health-care differ a lot in both their technological/ multimedia sophistication and the types of skills trained, varying for example, from telesurgical applications to interactive simulations of the human body and brain (for the acquisition of physio-anatomical knowledge), to virtual worlds for emergency training (to empower coping skills in critical situations). Other interesting applications include the development of immersive 3D environments for training psychiatrists and psychologists in the treatment of schizophrenia (presentation of visual and auditory hallucinations to deepen therapists' understanding of the disease).

The main aim of this presentation is discussing the rationale and main benefits of using virtual reality in health-care education and training. A number of key attributes of VR environments will be described and discussed in relationship to educational theory and pedagogical practice. Significant research and projects carried out in this field will also be presented, together with suggestions and guidelines for future development of VR learning systems. However, further research is required, both on the technological side and on key issues such as transfer of learning, appropriate curriculum implementation, elements of effective VR design, and the psychological and social impact of technology usage.

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The use of technology-supported mental imagery in neurological rehabilitation: A research protocol

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It's a largely shared opinion that the human brain can simulate motor actions without physically executing them, and that there is a neuro-psychological relationship between imaging and performing a movement. In fact, there is scientific evidence showing that the mental simulation of an action is correlated to a subliminal activation of the motor system. There is also evidence that virtual stimulation can enhance the acquisition of simple motor sequences. Virtual training, for example, has been found to be as beneficial as real training and more beneficial than a work-book and a no training condition in teaching complex motor skills to people with learning disabilities. Moreover, studies of brain-injured, hemiplegic patients suggest that these patients retain the ability to generate accurate motor images even when they cannot perform the actions.

Combined with evidence indicating that motor imagery and motor planning share common neural mechanisms, these observations suggest that supporting mental imagery through non-immersive, low-cost virtual reality applications may be a potentially effective intervention in the rehabilitation of brain-injured patients. Starting from this background, our goal is to design and develop a radically new technique for the acquisition of new motor abilities - "imagery enhanced learning" (or I-learning) - to be used in neuro-psychological rehabilitation. A key feature of I-learning is the use of potentially low-cost, Virtual Reality technology to create a compelling sense of presence, facilitating motor imagery.

This presentation will discuss the rationale and a rehabilitation protocol for investigating mental imagery as a means of promoting motor recovery in patients with a neurological disorder. The treatment strategy aims at evoking powerful imaginative responses using an innovative technique that makes no attempt to simulate the real-world motor behavior, but draws the patient's attention to its underlying dynamic structure. This is done by displaying highly stylized sketches of the motor behavior on a computer screen and gradually increasing the perceptual realism of the visualization. This strategy assumes that optimal learning will be achieved when the patient is allowed to elaborate his own schema and sequences of movements, thereby constructing his own personal image of the motor behavior to be trained.

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Male sexual dysfunctions and multimedia immersion therapy

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Introduction:
This work follows our earlier research using psycho-dynamic psychotherapy accompanied by pre-recorded sound (music) which integrated the use of virtual reality (VR) for the treatment of erectile dysfunction (ED) and premature ejaculation (PE). This study grouped together 150 heterosexual males affected by sexual dysfunctions undergoing a treatment including VR to demonstrate that this new method, which uses a repeatable therapeutic protocol, can speed up the psychodynamic process leading to the regression of the problem in a high proportion of cases. The efficiency of this method was also verified after one year.

Materials & Methods:
The plan for therapy using the Virtual Reality-Optale Method consisting of 12 sessions (15 if there was any sexual partner) over a 25-week period. The methods involved the use of a VR helmet, joystick, and miniature television screens that projected specially designed CD-ROM programs on the ontogenetic development of male sexual identity. This study considered 40 cases (average age 38 years) with ED due to presumably purely psychological origin, 60 cases (average age 49 years) due to mixed causes

(organic and psychogenic but no major organic component or psychiatric disorder), and 50 (average age 33 years) suffering from primary PE who had undergone no prior sexual therapy and given their informed consent, with follow-up 12 months after treatment.

Results:
After a 25-week period of treatment, the overall partial (2 times out of 3) and complete positive response rate was 69%, excluding dropouts (18%) before the 7th session (drop-outs after session 7 are counted as negative results). Two patients reported an undesirable physical reaction (nausea) during the first 15-minute VR experience. After one year, the global partial and complete positive response rate was 71%, excluding patients who dropped out during the treatment cycle and patients who did not show up for follow-up (19%).

Conclusions:
Considering the particular way that full-immersion VR involves the subject who experiences it, we hypothesized that this methodological approach could speed up the process of the cure for sexual dysfunctions. While we are aware that the positive results obtained are in part connected with the non-inclusion of drop-outs, we concluded that the positive effects of this therapy were durable, suggesting that this method accelerates the healing process by re-opening old brain pathways or consolidating them. This implies that new and rarely-used inter-synaptic connections, characterized by a particular magnitude of activation, may be established so that new mnemonic associations favoring satisfaction of natural drives can flow. We are going to make available both innovative tools (Telemedicine and Portable tools) for the treatment of patients with ED and PE.

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The integrated virtual reality profile: A VR-based assessment tool for cognitive impairments

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Centro Sistemi Virtual Reality (CSVR)

During the last two years, the clinical staff at Centro Sistemi Virtual Reality (CSVR) has assessed over 150 patients suffering from mild/severe cognitive and neuro-psychological impairments. The innovative assessment protocol developed by CSVR is useful in describing preserved neuro-psychological skills, as well as in defining and planing the most appropriate therapeutic/training intervention. The main assessment tool used was the Integrated Virtual Reality Profile (IVRP). Results of the clinical evaluation showed that patients who participated in the program were able to develop a positive attitude toward the VR setting. This trend was confirmed with patients who had been previously treated with standard therapeutic approaches. The program was also effective in helping patients develop relational, sensorial, and emotional responses, as well as in improving their motivation to cooperate with the clinical staff. Finally, diagnostic indications of IVRP were found particularly useful in setting up effective neuro-psychological rehabilitative treatment.

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Spatial navigation of an immersive virtual environment: differences related to age and Alzheimer's disease

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Status:
Complete

Background & Significance of the Problem:
Immersive virtual reality (VR) is an innovative tool that can allow study of human spatial navigation in a more realistic but controlled environment. The purpose of this study was to examine differences relating to age and Alzheimer's disease (AD) in route learning and memory using VR. Visuospatial cognition, more than verbal cognition, has been shown to be particularly susceptible to the effects of aging. Furthermore, spatial disorientation is one of the early symptoms of Alzheimer's disease. Yet we found that there was a dearth of adequate, ecologically valid clinical tests to assess severity of spatial deficits in either of these groups. A VR platform seemed the ideal tool to use to develop a spatial learning and memory test.

Methods/Tools:
We tested 8 young subjects, 7 older subjects, and 2 patients suffering from AD. Participants were immersed in a virtual city, using a Proview XL-50 (Kaiser Electro-Optics Inc.) head-mounted display, and shown a path through this environment. Afterwards, they were asked to navigate the path as quickly and accurately as possible. They were granted four learning trials on this route. An interference trial involving another path was conducted before participants were asked to re-navigate the first route at short and long delays. Time to completion, distance traveled, and navigation errors in the form of wrong turns were tabulated for each trial. In addition, the accuracy in navigation was calculated by counting the number of times people bumped into buildings or wandered off the sidewalk. As a final task, participants were tested for their recognition of the city's buildings and objects

Results:
Young adults were consistently quicker and more accurate in their path navigation. A patient exhibiting mostly verbal deficits in AD performed as well as healthy older adults. The performance of another patient suffering from AD, mostly with visuospatial impairment, was clearly impaired. Older participants, whether healthy or suffering from AD, made more mistakes on the recognition task, being more likely to affirm having seen an element in the city when it was in fact a foil.

Conclusion:
The results of this study indicate a difference between young and old adults in route learning and memory. The next logical step will be to combine this VR task with imaging technology in order to investigate the neurological basis of such differences. We are interested both in testing further patients with AD to confirm the promissory results obtained in this study as well as assessing other clinical populations such as patients suffering from hemispatial neglect following a stroke.

Novelty:
This study was innovative in its design of a VR test of spatial memory and learning that can be applicable to clinical populations.

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Ambient intelligence in health care

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Since the development of methods of electronic communication, clinicians have been using information and communication technologies for the exchange of health-related information. However, the evolution and increased availability of new shared media, such as the Internet and virtual reality are changing the ways in which patients and clinicians relate and communicate.

To date, some e-health applications have improved the quality of health care, and later they will lead to substantial cost savings. For instance, physicians can review radiological films and pathology slides in remote sites or assist and perform surgery via remote robotics. However, most of these applications are used for discrete clinical activities, such as scripting, lab-testing, patient monitoring, and condition-specific diagnostics and treatment. The next challenge is to integrate them within a common clinical framework able to change our experience of health care.

Ambient Intelligence (AmI), 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, is the next logical step of this process. 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.

How does the emergence of the AmI paradigm influence the future of health care? Using a scenario-based approach, the presentation will outline the possible role of AmI in health care by focusing on both its technological and relational nature. In this sense, clinicians and health care providers that want to exploit AmI potential need to pay significant attention to technology, ergonomics, project management, human factors and organizational changes in the structure of the relevant health service.

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Data, development issues and future visions from the USC Integrated Media Systems Center Virtual Environments Laboratory

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Introduction:
The Virtual Environments (VE) Laboratory at the University of Southern California (USC) continues to evolve its research program aimed at developing virtual reality (VR) applications for the study, assessment, and rehabilitation of cognitive and functional processes and pain distraction in children. Our development work has expanded with the creation of 360 degree panoramic video environments designed to address anger management and social phobia. We will review the status and results from studies using graphics-based VR (virtual classroom, virtual office, virtual pain distraction scenario) and our panoramic work.

Highlights to be presented include:

- Virtual Classroom: Development of a package of 11 cognitive tests, a head-tracked performance record visualization tool, and issues surrounding commercial development.
- Virtual Office: Preliminary data from a study currently in progress at the Kessler Medical Rehabilitation Research Center comparing traumatic brain injured subjects with normal controls on an ecologically valid measure of everyday memory performance.
- Virtual Home: Demonstration of an environment created with advanced gaming development toolkits to be applied in a study with Alzheimer's patients and normal healthy elderly subjects.
- Pain Distraction Scenario: Preliminary data of an "art-based" VR scenario being tested with children who are fearful of venipuncture procedures.
- 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.
- Commercial Trials and Tribulations: This part of the talk will cover some of the issues we have encountered in our efforts to develop commercial applications.

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Definition of a VR-based protocol for the treatment of social phobia

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Social phobia is an anxiety disorder that imposes persistent functional impairment and interferes with the person's social activities or relationships. Social phobia is the most prevalent anxiety disorder and is accessible to two forms of treatment yielding scientifically validated results: medication and cognitive-behavioral therapies (CBT). Graded exposure to feared social situations is fundamental to obtain an improvement of the anxious symptoms. Traditionally, exposure therapies are done either *in vivo* or by imagining them.

In vivo exposure is sometimes difficult to control. Research reviews demonstrate that many patients have some difficulties in using imaginative techniques. Virtual reality (VR) techniques enable the recreation three-dimensional worlds and the production of realistic situations where a user can move and interact with artifacts. Virtual Reality has the advantage of allowing exposures to numerous and varied situations.

Several controlled studies have already confirmed the efficiency of VR-based therapies for certain phobic disorders, such as acrophobia and fear of flying. It also seems relevant to estimate the efficiency of such a therapeutic approach in the treatment of social phobia, which has not been studied yet.

This paper reports the definition of a clinical protocol whose purpose is to assess the efficiency of VR therapy compared to CBT and to the absence of treatment for socially phobic patients. It explains the illness' diagnosis and its usual treatments. It describes the target population and it exposes the architecture of the study. It presents all the assessment tools and the patients' allocation to one of the three groups of treatment. It describes the structure and the content of the therapy sessions and the unfolding of VR and CB therapies. The virtual environments used in the treatment reproduce four situations that social phobics feel are the most threatening: exposure to performance, intimacy, scrutiny and assertiveness anxiety. With the help of the therapist, the patient learns to speak in public, to establish informal contacts, to be under scrutiny, and to protect her or his interests with the aim of reducing her or his anxiety in the corresponding real situations.

The therapy is currently being evaluated at the Sainte-Anne Hospital in Paris.

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Balancing the needs and objectives of research and service delivery in the quest for subjects

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In a Spring 1999 publication describing the state of research studies in the United States, the Association of Clinical Research Professionals noted that difficulties encountered in subject recruitment accounted for as many as 80 percent of clinical trial delays. Delays in a project put it at risk for failure. A trend toward delay in subject recruitment is echoed in the experience of researchers at Sister Kenny Institute in their work to implement a community-based protocol to explore the value of telehealth technologies for delivering vocational rehabilitation services to persons with disabilities living in rural Minnesota.

This paper provides a case study of subject recruitment successes and failures in a multi-center, National Institute on Disability and Rehabilitation Research (NIDRR) funded research project to evaluate disabled individuals' success in goal attainment when therapy is delivered from a distance via videotelephone. The protocol, "Effects of Videotelephone Use on Vocational Rehabilitation and Independent Living Outcomes," (R2) was designed to be carried out in collaboration with community practitioners.

As defined in the research protocol, the role of academic and clinical researchers was to support the formulation of individual client-specific goals, to provide technical support and training for program development, and to evaluate study outcomes. The role of the community practitioner partner, a center for independent living therapist, was to provide client service, and to track and monitor client progress toward established goals.

While it is easy for researchers and community rehabilitation professionals to find common ground in the care and treatment of individuals with disabilities, the process by which that is achieved is more challenging. This case study explores conflicts and concerns that have been of issue in R2 thus far. Among these challenges are: balancing research protocol constraints with the primary therapy needs of the subjects; providing training and collaboration opportunities at a distance; establishing a platform of assessments and measures that address the needs of both the research and service provision; and addressing the financial concerns (compensation for therapist time conducting research) of the collaborating agencies.

R2 was undertaken within the context of a five-year grant from NIDRR to establish a Rehabilitation Engineering Research Center (RERC) on Telerehabilitation. The primary focus in Minnesota has been to increase rehabilitation service access for clients in rural areas by bringing programs into local clinics, hospitals, and clients' homes.

Some grant initiatives have been enacted in formal research projects and others have been formulated as demonstration projects with less rigid protocols. Common across all of the initiatives is the need for subjects.

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Virtual reality intervention for older women with breast cancer

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Background /Specific Aims:
The goal of this study is to examine the effects of a virtual reality distraction intervention on chemotherapy-related symptom distress levels in 20 women aged 50 and older who are receiving chemotherapy for breast cancer. A crossover design will be used to answer the following research questions: 1) Is virtual reality an effective distraction intervention for reducing chemotherapy -related symptom distress levels in women with breast cancer? and 2) Does virtual reality have a lasting effect?

Each year, approximately 180,000 women are newly diagnosed with invasive breast cancer. Seventy-seven percent of new cases and 84% of breast cancer deaths occur in women aged 50 and older. The incidence of breast cancer is highest among the 75-79 year old age group. Chemotherapy is frequently prescribed for these women, either prior to or after surgery, in an attempt to diminish tumor mass, eradicate occult micrometastatic disease, and increase disease-free survival. The chances for survival are enhanced if women can receive all of the recommended chemotherapy treatments. However, because of chemotherapy-related distress symptoms, women often have difficulty adhering to the prescribed schedule. Thus, helping women to tolerate the needed treatments is critical to their survival.

Methods/Instruments:
This study uses Lazarus and Folkman's Stress and coping model to explore the feasibility of using virtual reality as a distraction intervention with older women who are receiving outpatient chemotherapy at a Duke University Comprehensive Cancer Center. For this study, a head mounted display (Sony PC Glasstron PLM – S700) was used to display encompassing images and block competing stimuli in the chemotherapy treatment room. Participants chose one of three possible CD-ROM-based scenarios (Oceans Below®, A World of Art®, or Titanic: Adventure Out of Time®).

The Symptom Distress Scale (SDS) was used to measure the global construct of symptom distress. Specific measures of symptom distress included the Revised Piper Fatigue Scale, and the State Anxiety Inventory. For two matched chemotherapy treatments, one pre-test and two post-test measures were employed. Participants received the virtual reality distraction intervention during one chemotherapy treatment and received no distraction intervention (control condition) during an alternate chemotherapy treatment. The order of the treatment and control conditions was determined by random assignment.

Results:
Paired t-tests will be used to test for differences in levels of symptom distress: 1) immediately following chemotherapy treatments and 2) 48 hours following the completion of chemotherapy treatments. An open-ended questionnaire was used to elicit the subject's evaluation of the ease of equipment use, length of time used, scenario choices, effectiveness of VR as a distracter, and desire to use VR during future treatments. Data collection will be completed Sept. 2002. Final Results will be presented. This study is funded by NINR (1-P20-NR07795-01).

Novelty:
To date, the majority of research exploring VR as distraction has utilized samples of adolescents, young adults, and male subjects. This study examines the effectiveness of VR using a sample of older women. Implications regarding use of VR with this age group will be presented.

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Effect of Virtual Reality on fatigue in breast cancer patients

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Background /Specific Aims:
Each year, 180,000 women are diagnosed with breast cancer. Fatigue is the most commonly reported side effect of chemotherapy. This study examined the effects of a virtual reality (VR) distraction intervention on chemotherapy-related fatigue in 20 women, ages 18-55 with breast cancer. Distraction interventions are effective because the individual concentrates on interesting stimuli rather than unpleasant symptoms. In this study, women wore a Sony Glasstron® head-mounted display during an outpatient intravenous chemotherapy treatment. Participants chose one of three CD ROM-based scenarios: Oceans Below®, Titanic: Adventure Out of Time®, and World of Art®. Lazarus and Folkman's stress and coping framework was used to guide the study.

Methods:
A crossover design was used to answer the following questions: Is VR an effective distraction intervention for reducing chemotherapy-related fatigue and does VR have a lasting effect? For two matched chemotherapy treatments, one pre-test and two post-test measures were employed. Subjects were randomly assigned to receive the VR distraction intervention during one chemotherapy treatment and receive no distraction intervention (control condition) during an alternate treatment.

Results:
Paired t-tests were used to determine the mean differences in fatigue immediately after and 48 hours following treatments. Significant improvement in fatigue ($p < .05$), as measured by The Revised Piper Fatigue Scale was found immediately following the chemotherapy treatment during which the women used VR (effect size =.31). Analysis revealed significant differences in the sensory ($p = .01$) and cognitive/mood ($p=.05$) subscales. No significant changes were noted 48 hours following the use of VR, but there was a trend toward less fatigue. The intervention was well received and has potential as an adjunct to standard treatment for the management of fatigue. The study was funded by an American Cancer Society institutional grant.

Novelty:
While the effectiveness of virtual reality as a distraction intervention has frequently been tested for pain management, this is the first study which examines the effects of virtual reality on the symptom of fatigue.

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Social anxiety in virtual environments: A pilot study

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An experiment was carried out to assess the extent to which social anxiety can be triggered within a virtual environment in the context of human interaction with programmed avatars. Subjects were exposed to two environments, a relatively socially neutral journey on a London underground train, and a relatively socially charged experience in a bar. The purpose was to assess whether social anxiety would occur at all in these circumstances, and if so, whether there was a greater tendency towards this in the bar compared to the train.

Methods:
Ten subjects were recruited by advertisement from amongst graduate students in the Computer Science Department at UCL. Half of the subjects experienced the train ride first followed by the wine bar experience, and others experienced the opposite order. Each exposure was for about 2 minutes, and was carried out in UCL's 4-walled immersive stereo projection CAVE-like system, the Trimension ReaCTor.

The 'tube' train simulates a ride in Central London. The subject is in a carriage of the train, which is populated by several avatars that pay some attention to the subject (one avatar looks at the subject, another will ask the subject for directions). There were seven avatars within the bar environment – females and males. The people in the bar were designed to behave in a relatively negative manner toward the subject (e.g., shrugging, walking away).

A questionnaire that gathered background information was administered prior to the VR experiences and also included the standard Social Avoidance and Distress (SAD) questionnaire. This provides 27 yes/no questions assessing social anxiety in everyday life. The higher the subject scored on these tests, the greater the social anxiety. After each of the two VR experiences another questionnaire was administered. The most important data collected was again a SAD questionnaire, but this time the questions were adjusted so that they clearly referred to the previous experience rather than to the typical responses in everyday life. The point was to try to assess the degree of social anxiety generated by that particular experience. A second response variable elicited from this questionnaire was concerned with self-reported physiological responses. There were 9 physiological responses (e.g., sweating, heart palpitations) and the questionnaire required a Yes/No answer to each of these possible conditions in response to the last experience (train or wine bar).

Results:
A regression analysis was carried out with post-SAD as the dependent variable, with independent variables being type of scene, order of presentation, and explanatory variable pre-SAD. Each of these was significant at the 5% level, indicating that the bar experience produced significantly more social anxiety than the train journey, independently of order of presentation, and taking into account pre-SAD. The same result was obtained for subjective physiological response as the dependent variable.

Conclusions:
The results suggest that social anxiety can be generated within a virtual social setting -– in spite of the relative paucity of these environments compared to real-life social settings. This generalizes our earlier findings in relation to the specific context of fear of public speaking.

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New dimensions of "system usability:" Performing an ergonomic evaluation of virtual environments designed for clinical use

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Our research team, working as a part of the VEPSY Updated Project, completed in 2002 a series of ergonomic trials of two VR systems designed for clinical use. The problem that the team had to face was that of finding a sound methodological approach for the analysis of systems that - due to their clinical destination - seemed to elude standard ergonomic evaluations. While ordinary research in ergonomics aims to identify and remove obstacles and confusions possibly hindering the flow of the interaction between computer systems and human actors, our task had to face the very fact that in the VR clinical systems under analysis, designers had purposefully introduced obstacles and bewildering elements into the environments for clinical purposes. The object of the evaluation was not to assess the "easiness" of use, but to measure how much the system was understood and navigated by its users according to the goals of its clinical designers.

To solve this problem two tools have been developed. The first was a conceptual approach focused on the "alignment" of the understanding that clients actually produced reactions to the intentions and goals set by the clinical designers. The theoretical framework for the analysis of the alignment was provided by the Situated Action Theory. The situated use, which was the target of our analysis, was inscribed within the clinical setting and the specific goals of the therapist were described in the protocols prepared for the VEPSY Updated Project. The second tool was a methodological approach combining experimental tests on users' navigation and qualitative analyses of users' verbal and non-verbal actions. This approach was designed and successfully applied in order to perform a socio-cognitive evaluation. Four methods concurred in the exploration of different levels of the interaction taking place within the clinical VR systems under analysis: pluralistic cognitive walkthrough, expert evaluation, interaction analysis, and semantic analysis.

The analysis performed provided evidence of a good "alignment" between the understanding of the systems attained by participants in our trials with the goals fixed for the VEs by their designers. It is necessary to note that for ethical and methodological reasons our trials did not involve people suffering from known psychological or psychophysical illnesses; as a consequence, the final evaluation of the clinical VE systems under analysis will emerge in their "real" clinical use.

This research developed an innovative socio-cognitive perspective on ergonomic evaluation which is consistent with the position of the International Standard Organization (ISO) which defines "usability" as "the effectiveness, efficiency, and satisfaction with which a certain user may achieve a specific objective in a particular environment." This implies that the usability of a system is not a fixed, general, all-purpose quality of the system itself, but a relational quality that depends on the overall quality of the interaction taking place between the system and its users-in-context.

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Experimental studies of virtual reality delivered exercise programs compared to conventional exercise programs for rehabilitation

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Background/Problem:
The use of alternative approaches for the rehabilitation of joint range-of-motion limitations and/or balance may effectively increase exercise participation by patients, increase patient adherence to exercise regimes, and decrease the cost of rehabilitation service provision. Limitations of virtual reality (VR) delivered exercise programs include cost of equipment and carry-over of treatment effect to real-world tasks. We will present data from two experimental studies comparing a virtual reality exercise modality to conventional exercise in distinct populations with different disabilities.

Study 1: Shoulder joint range-of-motion limitations significantly compromise functional capacity and are progressive unless vigorous intervention is used. Basic movements such as combing hair or reaching into one's back pocket become limited, resulting in a loss of independence and ability to participate in work and leisure activities. The purpose of this study was to compare VR and conventional approaches for rehabilitation of chronic shoulder joint range-of-motion limitations.

Study 2: Balance dysfunction is one of the most difficult deficits to treat in brain-injured patients, due in part to the multiple structures involved in maintaining balance as well as the inadequacy of current treatment techniques. Residual balance deficits post-rehabilitation therapy often lead to loss of independence as well as the inability to participate in work and leisure activities. The purpose of this study was to compare VR and conventional approaches for retraining balance in patients with traumatic brain injury.

Method/Tools:
The studies to be presented use similar experimental methodologies. Subjects were quasi-randomly assigned to either a VR or a conventional exercise group matched as closely as possible for age and sex. Study 2 subjects were also matched on initial Berg balance scores. Patients completed 18 (Study 1) or 24 (Study 2) 45-minute sessions of physical therapist led exercise. Study-specific outcomes were measured by physical therapists blinded to the group assignment. Outcome measures were obtained prior to exercise participation, immediately post-exercise completion, and three months post-exercise completion. Primary outcome measures are the Disabilities of the Arm, Shoulder and Hand (Study 1) and the Community Balance and Mobility Scale (Study 2).

Different applications of the same virtual reality system were used in both studies. Patients face a camera that captures their image, which is isolated and combined with an exercise 'scenario'. Patients see their image as part of the scenario on the large monitor where they are able to interact through gestures, movement, and motion within the virtual environment.

Results:
Data will be presented from experimental studies on the effectiveness of VR exercise programs versus conventional exercise programs for rehabilitation of chronic shoulder joint range-of-motion limitations (Study 1) and balance retraining post-traumatic brain injury (Study 2).

Conclusion:
Analysis of the effectiveness of the VR and conventional exercise programs will be presented and implications for rehabilitation will be discussed.

Novelty:
Experimental testing of a VR application to two different client populations for two distinct disabilities demonstrates the generalizability of VR as a therapeutic exercise modality. The use of functional outcome measures addresses the question of treatment carryover.

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Virtual reality as psychosocial coping environment

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This paper reports on the results of an in progress research project evaluating virtual collaborative environments as psychosocial coping environments and as measurements of daily coping in real-life situations. Recent developments in coping research are proposing a shift from a trait-oriented approach of coping to a more situation-specific treatment. We defined as a real-life situation a target-oriented situation that demands a complex coping skills inventory of high self-efficacy and internal or external "locus of control" strategies.

The participants were 48 normal adults 25-30 years of age, randomly spread across 3 groups. There were the same number of participants across groups and gender balance within groups. All three groups went through two phases. In Phase I, Solo, each participant was assessed using a three-stage assessment inspired by the transactional stress theory of Lazarus. Each participant was then given a coping skills measurement within the time course of various hypothetical stressful encounters performed in two different conditions and a control group. In Condition A, the participant was assessed using the Stress and Coping Process Questionnaire (SCPQ). In Condition B, the participant was given a virtual stress assessment scenario relative to the three stages of SCPQ (VSA). Condition C consisted of no treatment condition; it was just an interview (NTC). In Phase II, Groups, all three groups were mixed together and conducted the same tasks in pairs.

The results showed that the VSA group performed notably better in terms of cognitive appraisals, emotions, and attributions than the other two groups in Phase I (VSA: 95%, SCPQ: 75%, NTC: 62%). In Phase II the difference was larger as the VSA group performed notably better than the other two. These results indicate that a virtual collaborative environment seems to be a consistent psychosocial environment, tapping two classes of stress: (a) aversive or ambiguous situations, and (b) loss or failure situations in relation to the SCPQ. In terms of coping behaviors, a distinction is made between self-directed and environment-directed strategies. A great advantage of the virtual collaborative environment is the ability to consider team coping intentions in different stages. Even if the aim of a project is to tap transactional processes in real-life situations, it might be better to conduct research using a virtual collaborative environment than a virtual scenario containing just one user. The VE consisted of a dual processor PC system, a video splitter, a digital camera, and two head-mounted displays. The system was programmed in C++ and it created an artificial environment that encodes the user's motion and can translate it in real time.

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Immersive virtual reality for reducing pain during physical therapy in a cerebral palsy patient: A case study

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The pain experienced by cerebral palsy patients during physical therapy range-of-motion exercises while recovering from surgery can be extreme, and can discourage patients from complying with their physical therapy. We explored the novel use of immersive virtual reality (VR) to distract a cerebral palsy patient from pain while he participated in rehabilitation physical therapy/ stretching exercises after Single Event Multilevel Surgeries to increase mobility. This case report provides the first evidence that entering an immersive virtual environment can serve as a powerful adjunctive, nonpharmacologic analgesic for cerebral palsy.

The patient was a 16-year-old male with a history of right-sided hemiplegia. His operation included a femoral de-rotation osteotomy, quadriceps tendon trans-location, and releases of the Achilles and hamstrings tendons. On six separate days (all using traditional opioids in both conditions), the patient spent some of his physical therapy in VR, and spent an equal amount of his physical therapy with traditional pain control (no VR), order counterbalanced.

On a zero to five FACES subjective rating scale, on days 1-6 the patient's pain ratings in VR dropped 50%, 33%, 0%, 33%, 33% and 75% respectively compared to no VR. We contend that virtual reality is a uniquely attention-capturing technology that is ideal for drawing attention away from the "real world," allowing patients to tolerate painful procedures. These preliminary results suggest that immersive VR merits more attention as a potentially viable form of treatment for procedural pain.

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Progress and opportunities in virtual reality research at the National Institute on Drug Abuse

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The National Institute on Drug Abuse (NIDA) is the largest funder of drug abuse research in the world. NIDA is concerned with basic research on drug abuse, drug abuse prevention, and drug abuse treatment. With an annual budget of nearly a billion dollars, NIDA employs an array of approaches and techniques to help understand, prevent and treat drug abuse. Given that drug abuse is highly dependent on environmental cues, virtual reality (VR) technologies offer a novel and powerful tool for the field of drug abuse treatment and research. Over the past year, NIDA has begun funding numerous VR studies, using grants, contracts, and supplements. This talk will highlight some of the progress made over the past year and identify further funding opportunities as NIDA continues to increase its commitment to VR research.

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Design and evaluation of a virtual environment for teaching nonverbal communication

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Background:
Severe social impairment is the primary deficit of autism spectrum disorders. Accumulating evidence points to a failure to extract information from nonverbal communication, the presence of face-processing impairment, the differences in face gaze, and neurophysiological correlates of face-processing differences. At the same time, findings of significant gains from intensive behavioral therapy for some young children with autism provide grounds for optimism in regard to early teaching interventions.

Method:
This is an iterative design project with evaluation by consumers and consumer-proxies who will review or try out each stage of the prototype. The objective is a virtual environment in which children aged two to four who have received a diagnosis of autism can be engaged in a structured training interaction to acquire the basic, non-verbal social communicative skills that typically-developing children display during their first year of life.

Among the key specifications are that the environment be sufficiently enticing and enjoyable enough that the child will voluntarily enter and sit in it for several minutes at a time; that the child is able to enter and exit at will and in safety when the ‘pod’ is stationary; that the vestibular reward (the ride) can be stopped immediately if the child rises from the seat; and that eye tracking be accurate, calibration rapid and near-automatic, and that it remain constant or is able to be readily corrected.

The first version of the system, incorporating eye tracking, contingent output, and data acquisition, is about to begin trials with children in the target age group, 24-54 months, including children with autism and children who are developing typically. Older, verbal children with autism and siblings of children with autism will also try the system, provided that they are small enough to use it comfortably. The children’s parents, and when available, their teachers and therapists, will be invited to observe the trials. Questionnaires will be used to rate the appeal of the VE to the target population.

Novelty:
This represents the first attempt to address the core social deficit of autism using a virtual or mixed environment. Other aspects of novelty include the use of vestibular stimulation in the VR, the integration with gaze tracking such that display, including rewards, are contingent on the child’s gaze behavior, the implementation in a VE of a structured, branching training procedure to

teach attention to and interpretation of face-borne communication, and the fact that it must appeal to very young children. The project is also unique in its theoretical foundation, the hypothesis that failure of early face-processing experiences undermines development of typical nonverbal communication, language, and higher-level cognitive functions.

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Visual stimulation as pain relief for Hong Kong Chinese patients with leg ulcers

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Background:
Chronic ulceration of the leg is a condition most prevalent in the elderly population. Patients with leg ulcers tend to feel pain, frustration, and are more likely to become inactive and socially isolated. Leg ulcer pain is considered to be continuous and difficult to control. Pain relief for dressing change in leg ulcer has been found to be inadequate. Elderly patients are also more vulnerable to the adverse effects of analgesics, making physicians cautious in prescribing adequate analgesic for ulcer pain.

Method:
The present study attempts to demonstrate the analgesic potential of visual stimulation in 33 patients with leg ulcers in a randomized, controlled, crossover clinical trial. Patients alternated between wearing the eyeglass display with soundless videotapes (V sessions) and a static blank screen (B sessions) while receiving superficial debridement and wound dressing for their leg ulcers.

The eyeglass display was only 120g in weight, and could easily slip onto the user's face as a pair of spectacles. The eyeglass was connected to a VCD to broadcast videotapes. The content of the videotapes was chosen in accordance with the preference of the patient. Pain intensity was measured by using the visual analogue scale immediately after the dressing procedures. Also, the degree of enjoyment and memory of the content of the videotapes were measured.

Results:
There were 33 patients (age range from 53-102) with the mean age of 75.8 (±9.8) in this study. 17 were male and 16 were female. Among these patients, 67% were living in a nursing home and 33% were staying in their own houses. In terms of medical illness, 33% of them did not have any health problems besides a leg ulcer that needed wound dressing and superficial debridement, 46% had history of old cerebral vascular accident, and 21% had diabetic mellitus on top of the leg ulcers.

A significant (P<0.001) reduction in pain scores was found during V sessions, with the VAS decreases from 67.7 ± 29 to 25.6 ± 30 when V sessions were compared with B sessions. Age was positively correlated with an improvement in VAS. Gender, residency, the underlying medical conditions, degree of enjoyment, and memory of the content of the visual stimuli were not correlated with the improvement in pain score.

Novelty/Discussion:
The present study studied the use of visual stimulation via the eyeglass display as an adjunct to pain relief. Indeed, the use of visual stimulation might be beneficial to both genders in an older age group regardless of the medical status. In light of its properties of being non-pharmacological, simple, robust, safe, inexpensive, convenient to use, and requiring no prescription by the physician, it was highly acceptable to patients in this study. All these make the use of visual stimulation highly appealing especially to the elderly.

Conclusion:
This is the pioneering use of visual stimulation as a non-pharmacological means of pain management among the Hong Kong Chinese population during a wound dressing procedure. This study will certainly add knowledge to the existing pain relief methods.

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Experiential Cognitive Therapy (ECT) for the treatment of panic disorder with agoraphobia: A preliminary controlled trial

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Since 1998 our multicentric research group has been working on a short-term clinical protocol based on virtual reality (VR) to be used for the treatment of panic disorder and agoraphobia. The preliminary treatment protocol, named Experiential-Cognitive Therapy (ECT), was developed in Fall 1998 at the Applied Technology for Neuro-Psychology Lab of Istituto Auxologico Italiano, Verbania, Italy, in cooperation with the Psychology Department of the Catholic University of Milan, Italy. The actual version includes the efforts of researchers from the Virtual Reality Medical Center, San Diego, CA, USA; Seoul Paik Hospital, Inje University, Seoul, Korea; and the Department of Psychology, Universite du Quebec a Hull, Canada.

The Protocol:
The goal of ECT is to recondition fear reactions to modify misinterpreted cognition related to panic symptoms and to reduce anxiety symptoms. We decided to focus on the techniques included in the cognitive-behavioral approach because they showed high levels of efficacy. Further, using virtual environments we can gradually expose the patient to the feared situation, using virtual reality content to re-create in our clinical office a real experiential world. The patient faces the feared stimuli in a context that is nearer to reality than imagination.

For ECT we developed the Virtual Environments for Panic Disorders with Agoraphobia (VEPDA) system. VEPDA was developed using a Thunder 2000/C virtual reality system by VRHealth of San Diego, CA, USA. The Thunder 2000/C is a Pentium IV based immersive VR system (2000 mhz, 256 Mb RAM, graphic engine: Radeon 9700, 128 Mb VRam) including an HMD subsystem and a two-button joystick-type motion input device.

VEPDA is a 4-zone (elevator, supermarket, subway, and plaza) virtual environment developed using the Virtools 2.1 development toolkit. The four zones reproduce different potentially fearful situations. In each zone the therapist, through a set-up menu, defines the characteristics of the anxiety-related experience. In particular, the therapist can define the length of the virtual experience, its end point, and the number of virtual subjects (from none to a crowd) to be included in the zone.

Method:
The subjects included in the study are 15 patients, aged 18-55, seeking treatment in one of the institutions involved in the study. All the subjects met DSM-IV criteria for panic disorders and agoraphobia for a minimum of six months as determined by an independent clinician on clinical interview, according to the SCID model. Before starting the trial, the nature of the treatment was explained to the patients and their written informed consent was obtained.

The selected subjects were randomly divided in three groups: the ECT group which experienced the cognitive behavioral therapy virtual reality assisted treatment (8 sessions); the CBT group which experienced the traditional cognitive behavioral approach (12 sessions) and a waiting list control group. People on medication were not allowed to modify the prescribed dosage during the treatment.

Results:
The statistical analysis showed significant differences between the ECT group and the waiting list control group (BDI: Chi-square = 7.63; $p < 0.05$; STAI-Trait: Chi-square = 7.04; $p < 0.05$; STAI-State: Chi-square = 6.33; $p < 0.05$; Panic attack frequency: Chi-square = 10.67; $p < 0.05$). No significant differences were found between CBT and ECT.

Conclusions:
The data showed that both CBT and ECT were able to significantly reduce the number of panic attacks, the level of depression, and both state and trait anxiety. However, ECT obtained these results using 33% fewer sessions than CBT. This

preliminary result supports the use of VR as a boosting technique able to reduce the time required by the therapy.

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Virtual reality and computer games in the treatment of driving phobia induced by a motor vehicle accident

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Travel phobia induced by an accident (accident phobia) occurs in 18 – 38% of those involved in a vehicular accident of sufficient severity to warrant referral to the Emergency departments of a general hospital. Phobic victims experience anxiety when driving and /or when traveling as a passenger resulting in a reduction or cessation of car travel. At MMVR 02/10 preliminary results were presented of an ongoing study of 14 subjects who met DSM-IV criteria for simple phobia/ accident phobia who were exposed to a virtual driving environment (Hanyang University's Driving Phobia Environment) and computer driving games (London Racer/Midtown Madness 2).

Program:
Patients who experienced heightened anxiety in one of the driving simulations (operationally defined as an increase in SUD ratings of 3 and/or an increase of heart rate > 15 BPM) were exposed to a cognitive behavioral program with up to 12 one-hour sessions involving graded driving simulation tasks with self monitoring, physiological feedback, diaphragmatic breathing, and cognitive reappraisal.

Measurements:
Subjects were monitored throughout sessions with physiological recordings (heart rate) and subjective ratings of distress (SUD) levels. Subjects were assessed at the beginning and end of therapy with the Fear of Driving Inventory, physiological responsivity in simulated traumatic driving situations (speeding, crashing), achievement of target behaviors, and ratings of severity of co-morbid diagnoses including PTSD and depression.

Results:
Results will be presented and discussed at the conference with suggestions for developing this therapy.

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Adding personality characteristics to an existing framework for VR therapy

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Over the past six years, the value of including objective physiological measures as part of the virtual reality treatment process has been demonstrated by several independent research groups. These measures help determine the patient's progression through therapy, and in some studies have proven a much more reliable indicator of treatment outcomes than the traditional self-report and subjective scales. The patient who scores high on social desirability may want to please the therapist and originally report high scores on subjective scales, significantly lowering scores on self-report and subjective scales as therapy progresses. He knows this is the norm, and does his best to say what is "expected." In addition, another group of patients may find it difficult to admit that a computer simulation results in anxiety conditions, and may report no arousal when asked by the therapist for a subjective rating. By using an objective measurement not prone to manipulation by patient self-report or clinician expectations, the patient's progression can be more clearly identified, and changes that may need to be made along the way to allow for a more effective and efficient therapy may be noted sooner.

It is evident that patients' self-report scales are influenced by individual personality characteristics. It is also clear that certain personality characteristics may be initially well-suited for the successful completion of virtual reality therapy or training applications. By understanding and exploring the personality aspects of participants in simulations, it may be that we can begin to develop an even more clearly defined predictive model of who will need more, or less, sessions in the virtual world; who may be a "dropout;" and who may need a more traditional type of training approach. To work within the individual's own framework, by expanding our existing framework, we may begin to develop more successful and refined treatment protocols.

We have begun to administer the NEO-PI-R personality inventory to persons seeking both simulation training and treatment at The Virtual Reality Medical Center. The NEO-PI-R includes scores for the "big five" personality factors—Neuroticism, Extroversion, Openness to Experience, Agreeableness, and Conscientiousness—as well as scores on 18 facet scales which present important distinctions among individual personality types. These characteristics are being correlated with phobia type to determine if those seeking treatment for various phobias are more prone to exhibit certain personality characteristics. In addition, personality is being correlated with treatment outcome, physiological response, and self-report scores during treatment. In our training studies, we are also seeking to determine the physiological and self-report indices indicative of various personality dimensions. Initial results of these analyses will be presented.

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Similarities between training and therapy: Lessons Learned from TADMUS and VRMC

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The Virtual Reality Medical Center

Uses of virtual environments and simulations for training, although pioneered by the military, are finding increased applications in clinical psychology and executive training in the private sector. Studies have shown that training of skills in a non-stress condition does not transfer to improved task performance when those same skills are then performed in a stressful situation. Therefore, it would be advantageous to employ more real-world stress simulations which should allow for more generalizability of skill sets. In 1988, a National Research Council study on enhancing military performance found that when a person is given knowledge of future events, stress surrounding those events is then reduced. In general, this occurs because stress is viewed as a new, novel task. Stress training therefore renders the task less novel and improves the trainee's self-efficacy, which in turn improves performance.

At the Virtual Reality Medical Center (VRMC), we have used a combination of cognitive-behavioral therapy (CBT) and physiological monitoring for the treatment of a variety of psychological disorders. We have evaluated over 3,000 sessions in virtual environments and have noted that successful treatment of stress and anxiety-related disorders requires gradual exposure to more and more stressful situations, which allows the patient to overlearn coping skills and renders the task less novel, which allows for a sense of mastery and an increase in self-efficacy.

Similarities between tactical decision making under stress (TADMUS) stress exposure training and cognitive behavioral therapy will be discussed. Objective physiological results as well as self-report measures differentiating training responders and non-responders will be presented.

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