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Computer-Assisted Virtual Reality Imaging in Education and Therapeutic Intervention

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Abstract: Creation of virtual environments and simulations has helped to expand student learning experiences across the medical sciences and, in health care, enhanced patient understanding of their own pathologies or even modify behavioral patterns through integrated biofeedback control methodologies. Collaborative work is underway to bring imaging science technologies from the Rochester Institute of Technology (RIT) together with scientific data generated through the Department of Psychiatry/Forensic Drug Diversion Clinic to create new, interactive computer-assisted simulations for educational and therapeutic applications. Over the past seven years, RIT faculty of the Human Visualization Project (HVP) have worked within a multidisciplinary team of graphic artists/medical illustrators, software engineers, game designers, biochemists, and anatomists to generate scientific images and animations of select organ systems from the gross to molecular level of detail. Work is underway to create virtual models of the brain and neuronal pathways known to be affected by chronic abuse of illicit drugs with particular attention paid to structural and physiological adaptations that become manifest as altered patterns of (criminal) behavior in the addict. Progress is being made to generate a library of virtual 3D models that would serve to educate health care personnel and patients about the dangerous effects of chronic drug abuse. Additionally, computer-assisted images/environments will also be created as a complement to biofeedback equipment designed to assist the drug abuser with behavior modification. This cultural shift in pedagogy will prove beneficial to students, faculty, and patients with the desire and ability to take advantage of the growing power of visualization technology.

Keywords: Virtual reality, science visualization, drug abuse, neurotransmitters, biofeedback

1.0 Introduction

Collaborative efforts are underway to develop state of the art virtual reality interactive tools and a bank of virtual images and models in support of both educational and clinical psychology intervention methodologies. When completed, fully interactive, virtual models will help medical personnel (residents, interns, fellows, allied health professionals) learn about the effects of alcohol and illicit drugs on brain, behavior and organ system function as a result of chronic abuse and adaptive physiological change. This innovative blend of technology and pedagogy will be combined with more traditional tools to create a virtual library of educational materials. Such an approach will provide a deeper learning experience for students training across diverse fields of study at Yale University School of Medicine (e.g., psychology, psychiatry, nursing, physicians), on the RIT campus (physician assistants, biomedical sciences, psychology, clinical chemistry) and ultimately adapted to support widespread dissemination to the general population at-large. In addition, a new set of models within a fully interactive virtual tool accessible through any standard desktop computer is being tailored and built into current therapeutic biofeedback technologies to teach chronic drug abuse clients about the negative effects of drugs on their health complete

with pre/post testing and options for direct feedback and reflection on their own experiences and consequences of criminal behavior.

2.0 Creation of Virtual Models

New, 3D models of select regions of the brain, corresponding neuronal pathways, and detailed neurotransmitter actions are being constructed down to the molecular level to demonstrate the structural and physiological adaptive changes known to occur during chronic drug/alcohol abuse. Correlates will also be drawn to connect dysfunctional behavioral consequences (i.e. criminal behavior) to neurotransmitter and physiological changes known to occur in the brains of chronic abusers. Initially, the focus has been to create images and educational materials that relate to the multisystem effects of alcohol abuse. From an initial set of graphite, 2D storyboards, 3D virtual models of organ and cellular structures are created using animation software, *Maya3D*, to show molecular and biochemical effects of alcohol that lead to structural changes and adaptations in the brain and liver of diseased patients. Within a standard desktop display, these 3D environments provide users demonstrations or full maneuverability to visualize and learn about disease processes above and beyond what is possible through simple 2D graphics and text. The next step is to move on to create models to show the effects illegal drugs such as opiates/morphine, benzodiazepines, cannabinoids, cocaine metabolites, and methamphetamines have on brain function at the cellular/molecular level as a means of helping users learn about underlying causes for physical and chemical addiction. In each case, molecular models of specific drugs and select neurotransmitters (derived from the Protein Data Bank) will be built into 3D brain neuronal models by the same methodology described above. In the past, we have used this same approach to create virtual environments and educational models of the heart, lung, liver, kidney, spleen, pancreas, kidney, and the entire musculoskeletal and peripheral nervous systems. In each case, special attention was paid to accurate anatomical detail based on quantitative data available in the literature and through scanning/transmission electron microscopy studies.

3.0 Development of Educational Materials

Our virtual training tool will be adapted to include narrative and imaging content around effects of alcohol and drugs on neural pathways, clinical manifestations, treatment, and health policy consistent with current literature. The user will have the opportunity to observe animated demonstrations and/or to maneuver their way through a virtual environment to examine specific structural details and hyperlinked text-based explanations. A strength of the proposed protocol is that a survey will be incorporated into the tool to assess trainee attitudes, knowledge of drug abuse, and connections between structural change and behavioral patterns in the abuser as well as rating the content of the modules at pre and post interactive tool use.

4.0 Use of Simulation in Clinical Intervention

Within the scope of a psychiatric therapeutic intervention at our clinic, interactive computer technology as an integral part of biofeedback allows a patient to role-play and be immersed in a skill training exercise to support healthier communication and anger management skills. In the past, in the Forensic Drug Diversion Clinic, use of a virtual system has helped users

by guiding them through cause and effect-based interactions to provide them with personalized feedback through employment of pre & post interactive game/quiz formats. Clients are posed questions pertaining to anger management skills, communication skills, and negative consequences regarding alcohol and drug use as it pertains to healthier lifestyles. In response to simulated situations, patient physiological responses such as heart rate, visual eye tracking, phonetic indexing [e.g., pick up "I feel" statements and profanity], and loudness of voice are recorded to provide additional data. As well, video footage of clients during their interactive role-play provides feedback regarding how they looked (nonverbal communication) and sounded (content/verbal communication skills), while probing them to assess their responses to simulated situations. Interactive characters and sounds are provided to coach, give thumbs up and light positive sounds for positive feedback when a desired behavioral response occurs. All patients are counseled with new skills at the end of each role-play for each scenario they role encounter (communication skills training, anger management, conflict resolution, coping with criticisms, coping with high risk situations). Each week, patients participate in the interactive role-play and receive feedback and tested on skills acquisition for a total of 12 weeks.

To expand our capabilities, the plan is to build an interactive touch screen desktop application that allows communication between the patient and a Virtual Character (VC). The VC will be able to react to the user's input and manage the user's communication level by manipulating a pre-defined response. While being recorded, the VC will perform role-plays of typical scenarios that occur just prior to domestic violence dispute. For example, in one "real life" vignette, the client comes home late, was out drinking, and does not call and the VC is upset. The VC role-plays three unhealthy communication styles [passive, passive-aggressive, and aggressive] and eventually role-plays a healthy communication style [assertive] in response to the patient's healthy communication style. It is the intention of the collaborative research team to also incorporate anatomical and physiological neuronal models to help educate patients about the effects of chronic drug abuse particularly as pertains to behavioral changes and errors in judgment. The hope is to interface physiological signals (heart rate, skin conductance, eye-tracking) as part of a "biofeedback game" so patients can work to impact changes that would affect positive functions within the virtual neuronal models. This system is consistent with technological advances in game design i.e., in a "biofeedback game", people navigate the game by changing something about their body in a conscious or unconscious manner. Such games are often designed along a reward model, with the game rewarding the player when she or he achieves a desired change. Design of randomized clinical trials is currently underway to assess the efficacy of these virtual reality tools and role-play in effective improvement of patient health.

The mission of this project and collaboration is to discover, exploit, and build computer software and hardware solutions that will enable teachers and learners to take full advantage of the latest visualization technology. In sum, should the results of this study show favorable outcomes, it has the potential to lead to future studies that could greatly improve the overall health of men, women and their families. This innovative virtual reality tool can be easily replicated, disseminated, and sustained in real world clinical settings.

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