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Introduction to the Special Issue

Virtual Reality and Applied Psychophysiology

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Virtual reality (VR) technology has undergone a transition in the past few years that has taken it from the realm of "expensive toy" into that of "functional technology." After a period of inflated expectations and limited delivery in the early 90s, this form of computer-based simulation technology is now beginning to emerge as a viable tool for a wide range of clinical and research applications. Continuing advances in VR technology along with concomitant system cost reductions have supported the development of more usable, useful, and accessible VR systems that can uniquely target a variety of psychological, cognitive, and physical disorders and research questions. VR integrates real-time computer graphics, body tracking sensors, audio/visual/touch displays, and sensory input devices to immerse a participant in an interactive computer-generated virtual environment (VE) that changes in a natural way with head and body motion. The rationale for VR applications designed for these purposes is fairly straightforward. By analogy, much like an aircraft simulator serves to test and train piloting ability, VEs can be developed to present simulations that assess and treat human processes and performance under a range of stimulus conditions that are not easily (or safely) deliverable using traditional methods. What makes VR applications in these areas so distinctively important is that they represent more than a simple linear extension of existing computer technology for human use. VR offers the potential to create systematic human testing, training, and treatment environments that allow for the precise control of complex, immersive, and dynamic three-dimensional (3D) stimulus presentations, within which sophisticated interaction, behavioral tracking and performance recording is possible. When combining these assets within the context of functionally relevant, ecologically enhanced VEs, a fundamental advancement could emerge in how human functioning can be addressed in many healthcare and scientific disciplines.

In this regard, there is a rather compelling rationale for the integration of VR with human physiological monitoring and brain imaging for advanced research and clinical application. There exists a rich history of research in the discipline of psychophysiology, where, the technology for recording bodily events in the least invasive fashion possible has evolved in order to capture and understand correlates of human mental and/or physical activity. Examples of such efforts would include measuring skin conductance, heart rate, and electroencephalography, etc. while a person attends to emotionally laden or cognitively

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challenging stimuli or for also integrating electromyography monitoring while a person thinks about or reaches for a target stimulus. While these monitoring technologies have existed for some time, the stimulus delivery media has remained essentially the same for many years, relying mainly on precisely delivered, fixed audio and visual content. Although sophisticated display formats have been used in psychophysiology (i.e., tachistiscopes, projection systems, flatscreen computer monitors, etc.), these systems place significant constraints on naturalistic human interaction that may be relevant for studying research questions on integrated functional behavior. The use of VR now allows for the measurement of human interaction within realistic dynamic 3D content, albeit within the constraints of the monitoring apparatus. The strength of VR for precise stimulus delivery within ecologically enhanced scenarios is well matched for this research, and it is expected that continued growth will be seen in this area. Although still a nascent field of research, VR and psychophysiology shows promise in controlled studies conducted throughout the world. Psychophysiology has allowed us to more systematically gauge the response of participants undergoing VR exposure, and, physiological feedback has been shown to improve the efficacy of VR therapy for specific phobias (Wiederhold, Gevirtz, & Spira, 2001) as well as reduce recidivism in long-term follow-up (Wiederhold & Wiederhold, 2003). In addition, during user-centered development of VR worlds, psychophysiology provides an objective measurement for assuring that appropriate cues are included in the presentation.

We are pleased and excited to introduce this special issue on Virtual Reality and Psychophysiology to the readership of *Applied Psychophysiology and Biofeedback*. It is our intent that the papers in this issue will illustrate the use of VR with integrated psychophysiological measurement across a range of clinical and research applications and stimulate further research and application.

In the first two papers, Bordnick et al. and Lee et al. report on cue exposure studies conducted in VR. Bordnick's paper presents early pilot work on human behavior and psychophysiology in a single subject exposed to smoking related "urge-inducing" stimuli. Lee et al.'s paper reports on functional magnetic resonance imaging (fMRI) from an initial set of data collected while smokers were exposed to smoking-related cues. Results indicate that the three-dimensional (3D) nature of the VR world may be superior for activating brain regions than two-dimensional (2D) cues. This area of cue exposure has now been energized by the capacity of VR to allow subjects to be exposed to such relevant stimuli in a naturalistic context that could have future implications for research and clinical directions that target the cycle of addiction.

The next article by Bullinger et al. discusses the use of cortisol as a useful indicator of the stress response during presentation of a virtual environment task designed to be stressful for the participant. This study provides a strong basis for the further application of VR environments in neuroscientific research and points to the importance of using more advanced measurement techniques in the basic research setting.

Côté and Bouchard then detail a change in psychophysiological response representing a positive change after VR exposure treatment. These findings were shown to correlate with a change in self-reported anxiety as well.

In their article, Mager et al. report on electroencephalographic (EEG) monitoring focused on event-related potentials as a means to detect attentional states in stimuli presented in VEs. Data indicate that the N100 amplitude and latency do not differ across either tasks or age groups in a VR condition, however in a non-VR condition, age-related differences are revealed.

Next, a paper by Meehan et al. summarizes four studies that examine the psychophysiology of the psychological construct of "Presence." This construct is now the topic of vigorous investigation in VR as researchers believe that it may mediate the impact of what a person may derive from their interaction in virtual worlds.

Stefani et al. explore the appropriateness of tracked interaction devices for VR navigation tasks. Based on the results from the first experiment, a second experiment was conducted and a lightweight VR interaction device was developed.

Wilhelm et al. investigate the basic research question of how VR exposure affects two different motivational systems: the behavioral inhibition system (BIS) and the behavioral activation system (BAS). It is reasoned that currently available nonstereoscopic head-mounted VR systems may be more effective at selectively activating only the BIS and not the BAS.

Even within the confines of a three Tesla magnetic imaging device with the user's head in a fixed position, humans can navigate and interact in a VR world with specialized nonferrous displays and interface devices. In fact, a significant body of research has emerged using fMRI to study brain function in normal and clinical groups operating in virtual environments and we have two articles from the Olin Neuroscience Institute at the Institute of Living (Calhoun et al. & Astur et al.) that present fMRI research on simulated driving and on wayfinding.

Finally, Morie et al. present a tool that was developed to more efficiently capture, manage, and explore the complex data that are generated in a virtual environment where unconstrained "free will" exploratory behavior is essential to research questions that involve the relationships between physiology, emotion, and memory.

We would like to publicly extend a special "thank you" to Dr. Frank Andrasik for his wisdom in asking us to pull together a sampling of the work done in this area over the past decade. As well, we would like to thank the authors for their contribution to this important body of research and for their participation in this issue. It is exciting to begin to establish VR as a useful tool for conducting controlled experimental trials where precise stimuli can be delivered to participants, and responses can be objectively recorded via psychophysiological measures. From the most basic and simplistic measures of noninvasive psychophysiology, such as skin conductance; to the most advanced physiological measures, such as fMRI, cortisol, and event-related potentials; groups around the world are finding time and again that the exactness of VR delivery of stimuli is an important adjunct for psychophysiological research.

For those interested in learning more about this area, we encourage you to review findings recently presented at the 10th Annual Cyber Therapy Conference (www.interactivemediainstitute.com) and also published regularly in the *CyberPsychology and Behavior Journal* (www.liebertpub.com).

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