Mindful Technologies Research and Developments in Science and Art

Hannes Bend and **Shawn Slater**
University of Oregon
1585 E 13th Ave, Eugene, OR 97403, USA

Benjamin Knapp and **Nuo Ma**
Virginia Tech
190 Alumni Mall, Blacksburg, VA 24060, USA

Robert Alexander and **Bella Shah**
University of Michigan
500 S State St, Ann Arbor, MI 48109, USA

Ryan Jayne
Electrical Geodesics Inc.
500 East 4th Avenue, Suite 200, Eugene, OR 97401

Correspondence email: hbend@uoregon.edu

Abstract

This paper outlines three projects that lay the foundation for a trans-disciplinary approach to the creation of interactive, multi-sensory devices combining biofeedback, virtual reality, and physical/virtual human-machine interactions. We explore new possibilities for interoperability and enhancing interoception and mindfulness with potential research contributions for novel personal, professional and medical applications.

Introduction

The field of Artificial Intelligence (AI) has seen significant advances in the past decade, and the understanding of motivation, conscious awareness, comprehension, and creativity is important for continued advancement. So far only humans can consciously comprehend that probabilities do not exist (de Finetti 1974). The computational and mathematical understanding of reality has been equated with reality itself (Tegmark 2008). Cognitively experienced existence of (mathematical) dimensions as fundamentally existing seems tied to the limits of human sensory perceptions.

Recent developments of VR devices have enabled highly immersive experiences with therapeutic effects and potential medical applications. Mindfulness research has demonstrated short- and long-term health benefits of contemplative practices (Tang, Holzel and Posner 2015), and VR has been shown to support pain relief (Li et al. 2014). Increased interoceptive and proprioceptive awareness, such as attended breathing, are helpful adjuncts in trauma therapy (Payne et al. 2015).

Our goal is use computational sensory detection and processing to explore and enhance the human experience for happiness and long-term health. The intersection of these areas is currently being explored through trans-disciplinary projects at the University of Oregon (UO), Virginia Tech (VT), and the University of Michigan (UM) in three projects that merge methods from fields including computer science, neuroscience, psychology, biology, and quantum physics.

The **metaverses** project incorporates neuroscience and the subjective experience of art. The **FORMLITH** project utilizes sensory and environmental information in the construction of novel biological/virtual interfaces. The **myndful** biofeedback application augments meditative experience through the real-time sonification and visualization of users respiration and pulse. All projects focus on technology to create the immersive experience of synchronized virtual and biological environments and objects, toward the ultimate goal of better understanding and advancing human capacities.

Project 1: Metaverses, 2015

The first phase of the Metaverses project of the UO included an electroencephalography (EEG) study at the lab of Edward Vogel (now Uchicago). Despite an increase in screen-based lifestyles, work situations and environments, there is poor understanding of the association between stress and certain images and image-flows on screen. The study explored the impact of particular visual stimuli on emotional and cognitive states (e.g., stressful, stress-reduced or meditative). Results may distinguish which type of screen-based visual stimuli increase EEG activity associated with calmer and meditative brain states. The analysis of this work is intended to inform the creation of the VR project myndful. During the study, the electrophysiological activity of 44 subjects was recorded while asking them to perceive and rate their likeability of over 30,000 images on a likert-type scale from 1-5 (1-high to 5-low) twice weekly over the course of eight weeks. To the best of our knowledge, it might be one of the first comprehensive studies to examine what type of visual aesthetics are associated with positive subjective reports and EEG activity. We argue that art and aesthetics, besides their social function, have psychological, emotional, and cognitive impact and potentially induce a stress-reducing and meditative condition. Our first analysis shows an increase in frontal lobe theta rhythm power with higher

liked images averaged over all participants.

The second phase of this project involved collecting fMRI and EEG data to explore neural activation during meditation. There is no clear consensus currently about what constitutes a meditative brain state; however, research suggests that the presence of increased theta waves is associated with meditative states (Dahl, Davidson and Lutz 2015). Succeeding studies on mindfulness meditation, UO scientist and Professor Michael Posner hypothesized that frontal theta induced by meditation produces a molecular cascade that increases white matter growth and improves neural network connectivity (Posner, Tang and Lynch 2014).

Based on current research, we recorded experienced meditation practitioners with EEG and also observed a higher frontal theta power during EEG recordings specifically with open awareness and body-scan meditation techniques. Subsequently, in collaboration with Michael Posner, we conducted an fMRI- based study to compare meditation techniques within subjects. First results show a high activation of multiple neural networks during the body-scan meditation. Bringing the body or specific body regions into mental focus may be linked to a recent rediscovery of a human ability to the voluntary activate the autonomic nervous system (Kox et al. 2014). Attended breathing and meditation tasks are integral parts of the Wim Hof training program to voluntarily activate the autonomic nervous system and consciously suppress inflammatory responses of the immune system. The research and studied techniques inspired the myndful project.

Project 2: FORMLITH

The Mirror Worlds project of the Institute for Creativity, Arts, and Technology (ICAT) at VT explores a fusion of real and virtual realities by converging Building Information Modeling, multiple sensory information including thermal imaging and persistent, online, multi-user virtual environments. The aim is to analyze the effects of virtual environments on performance in physical environments and to enable new possibilities for situational experience and telepresence. As an infrastructure targeting the support of diverse research based on multiple sensory information, it provides measurement of motion includes Kinects, blob tracking cameras, and localization microphones. The raw and processed data is also exposed to 3D virtual worlds clients. This dedicated physical sensor-drenched spaces is located in Virginia Tech Moss Arts Center building.

Our team of VT and UO researchers started to develop a motion and thermal wavelength detecting program and interface in this infrastructure to create a shared space with interactions between the physical biological response and virtual representation. Wavelengths of the electromagnetic spectrum perceivable to the human sensory perception are essential for human cognition and interpretation of reality, and the focus is to access, sonify and visualize wavelengths and realms of reality only accessible through technology. The findings of the neuroaesthetics studies at the UO about which type of images (fractals, CGI etc.) are perceived as calming will be combined with the methods employed at VT. The interactive human/machine hybrid interface will provide potentially new emerging perspectives about reality through the virtual and digital sensory processing of exogenous signals for enhanced comprehension with potential machine learning applications.

Project 3: myndful

Researchers from the UO and UM are developing software incorporating real-time biofeedback of endogenous signals (respiration, pulse, and heart rate variability (HRV). The sonification and visualization of the user's physiology is realized through custom parameter-mapping algorithms. This biofeedback is intended to enable user mindfulness, fitness and breath control. The UM team is finalizing the sound and visual-based application titled Breath of Life. The UO team is creating a VR visualization program with biofeedback (HRV) and possible neurofeedback via EEG. Based on our current program design, the user will be immersed in visualizations and audio in-sync with the heart rate with the intention to reduce stress and anxiety.

Heart rate and HRV provide a window to the autonomic nervous system (Lehrer and Gevirtz 2014). The alteration of the autonomic nervous system has been linked with a correlation between theta oscillations and high-frequency HRV in short-term meditation practices (Tang et al. 2009), and an increase in theta with wider brain network of body-schema, somatosensory and motor-related areas (Wang et al. 2016), power of frontal theta with the perception of 3D VR experiences with a higher sense of presence (Slobounov et al. 2015). Conscious breathing tasks are also an integral component of many ancient meditation practices and somatic contemplative practices enabling the practitioners to raise their core body temperature (CBT) consciously (Kozhevnikov et al. 2013). We are currently developing a study investigating subjective states, EEG, CBT, HRV, and oxygen consumption in an attended breathing task of virtual reality users. We investigate how to access and enhance new neuroimmunological abilities through technology, especially in the light of the discovery of the connection of the brain to the immune system (Louveau et al. 2015). The research insights will influence and update the computational and creative developments of the myndful app.

Conclusions

The **metaverses**, **FORMLITH** and **myndful** projects offer new insights into the reality of nature through human/machine interaction, and the possibility to self-modulate ones autonomic nervous system. The project myndful could have positive implications with improved cognitive activity, immune system responses, adaptation to cold environments and differing circadian cycles, stress- and anxiety-reduction, heightened sense of presence, integration and degree of happiness. This work could provide short-term and long-term health benefits and be used in private and professional environments, clinical research and for educational purposes. The new immersive mindful technology interfaces offer access to untapped potential and benefits of ancient and contemporary mindfulness practices to rediscover and/or enhance human capacities.

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