How Calming is My Technology? Using Physiological Measures to Assess whether Augmented Reality Systems Can Enhance Psychological Functioning in Workplace Settings

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ABSTRACT

In our laboratory, we are currently collecting physiological data (to complement our behavioral and cognitive data) that seeks to address the following question: What are the psychological effects when computational technology mediates the human experience of the natural world? We believe our research supports the workshop goals quite nicely. Namely, we will be able to contribute to discussions about physiological sensing technologies, physiology as a usability metric, and healthcare applications. We also look forward to learning more about (a) what other laboratories are doing in these regards, and (b) interactive applications and affective computing. Batya Friedman will attend the workshop.

Keywords

Affective computing, calming technology, environmental psychology, healthcare applications, nature, physiological computing, plasma displays, usability metrics, value sensitive design, windows, workplace

INTRODUCTION

A large body of diverse research shows that direct experiences with nature have beneficial effects on people's physical, cognitive, and emotional well-being (Kahn, 1999; Kellert & Wilson, 1993). For example, Ulrich (1993) found that post-operative recovery improved when hospital patients were assigned to a room with a view of a natural setting (a small stand of deciduous trees) versus a view of a brown brick wall. Other studies have shown that looking at a natural landscape can reduce immediate and long-term stress, reduce sickness of prisoners, and calm patients before and during surgery.

In recent years, technological augmentations of the natural world have begun to be inserted into human/nature interactions. For example, currently it is possible to go on-line to garden "remotely" by controlling a robot in a distant garden (Goldberg, 2000; http://telegarden.aec.at/html/login.html). In this situation, the technology acts as an intermediary to facilitate a human/nature interaction. Nature films are another example wherein the film mediates a "real" nature experience.

As technological augmentations become increasingly sophisticated and pervasive in human lives, important questions need to be answered. Is it the case, for example, that through augmented interactions with the natural world we can achieve similar psychological effects to their non-augmented natural counterparts? If so, then technology will provide a powerful and pervasive means to foster human well-being. Or is it the case that in some ways – perhaps many ways – augmented reality of the natural world falls short?

We are currently investigating these questions in a 3-year project funded by the National Science Foundation. In this project, we examine the psychological effects of augmented reality technologies, including *personal embodied agents* (robotic pets with children and robotic pets as companions for the elderly), *telepresence* (a telegarden), and *real-time video* (a room with an augmented "window" view). For this workshop, we will focus on our physiological research that forms part of our Room with the Augmented 'Window" View experiment.

THE ROOM WITH AN AUGMENTED "WINDOW" VIEW EXPERIMENT

In the Room With an Augmented "Window" View experiment, we compare the benefits of working in an office with a view out the window of a beautiful nature scene (the fountain on the University of Washington campus) vs. an identical view (in real time) projected on a large video plasma display that covers the window in the same office. In this latter condition, we employ High Definition TV (HDTV) to capture state of the art technology for reproducing real-time images. Other control conditions will be investigated that involve a blank covering over the window, full spectrum artificial light, natural light, and Low Definition Video. We have just begun to collect pilot data.

Our psychological measures entail (a) physiological data (electrocardiogram [ECG], respiration, skin conductance, and salivary cortisol level); (b) behavioral data (performance on cognitive and creativity tasks); (c) social-cognitive data (based on an interview with each subject at the conclusion of the cognitive and creativity tasks wherein we garner each participant's perspective on the experience); and (d) video and audio data (of each participant as they are engaged in the cognitive and creativity tasks and the social-cognitive interview).

Our diverse psychological methods will allow for a large array of analyses. For example, it may be the case, based on the social-cognitive interview, that participants do not consciously find the HDTV display convincing; yet physiologically it may garner similar results to the real nature view (e.g., by lowing heart rate), and dissimilar results to the blank wall. Also note that our methods will allow a fair degree of precision in our analyses. For example, any time a participant looks out the window (or at the augmented "window") we will have synchronous physiological data, and can test the hypothesis that looking at natural and augmented nature scenes results in immediate physiological responses.

Our general research question is the following: to what extent can the HDTV video plasma display – the augmented "window" view – substitute psychologically for a real view of the identical nature scene? Our general hypotheses are that physiologically, behaviorally, and cognitively participants' well-being will be most enhanced in the real view condition, followed by the augmented window view condition, and then the no view condition.

For purposes of this submission, we describe below the physiological methods of this experiment. In general, we are obtaining a battery of physiological data using standard psychophysiological procedures (e.g., Cacioppo & Tassinary, 1990). BIOPAC physiological equipment is being used. Our measures include the following:

i. *Electrocardiogram Measures*: Disposable electrodes with electrolyte gel are placed in a bipolar configuration on opposite sides of the participant's chest and the center of the participant's stomach. The following indices will be measured using the electrocardiogram. Electrocardiogram measures are collected during the baseline, stressor, cognitive and creativity tasks, and startle condition.

a. <u>Cardiac interbeat interval</u> (IBI). The interval between R-waves of the electrocardiogram (ECG) will be measured. Shorter IBIs indicate faster heart rate, which usually indicates a state of higher cardiovascular arousal.

b. <u>T-wave amplitude</u>, which has been suggested by Furedy (e.g., Vincent, Craik, & Furedy, 1996) is negatively related to myocardial contractility, a beta-adrenergic sympathetic influence.

c. <u>S-T segment depression and slope</u>, which is related to the heart's repolarization.

d. <u>Vagal tone.</u> The parasympathetic influence on cardiovascular arousal.

ii. *Respiration Measure*: Respiratory effort is measured using transducers that measure abdominal and/or thoracic expansion and contraction while breathing. Respiration measures are collected during the baseline, stressor, cognitive and creativity tasks, and startle condition.

iii. *Skin Conductance Response Measure*: Increasing skin conductance indicates greater autonomic (sympathetic) activation. Disposable electrodes with electrolyte gel are placed on the study participant's ring finger and index finger on their non-dominant hand. Skin conductance response is measured during the baseline, stressor, cognitive and creativity tasks, and startle condition.

iv. *Salivary Cortisol Measure*: Before the experimental conditions begin, we restrict intake of milk or any-dairy product for 20 minutes. To obtain a salivary sample, participants rinse their mouths with water, wait 5 minutes, and then expectorate 6-10 mls of saliva through a short plastic straw into a collection vial. Two salivary samples are collected, one immediately following the baseline (prior to the stressor) and one immediately following the cognitive and creativity tasks (prior to the startle condition).

v. *Startle Condition.* Toward the end of the experimental condition, the participant is exposed to a series of auditory stimuli to determine whether the effects of the ambient environment of the office under the different conditions results in a prepulse inhibition (PPI) of the acoustic startle reflex (ASR). The acoustic startle response and the PPI inhibition of that response represent a behavioral paradigm that are thought to measure attentional changes in human and animal behavior. The ASR is an unconditioned behavioral measure of physiological reactivity to an external acoustic stimuli. When the auditory signal used to invoke this startle reflex is preceded by a nonstartling auditory stimuli (the prepulse), the amplitude of the startle response is reduced. This inhibition of the startle response, the PPI, is thought to measure central processes related to information processing and attention. In this study the ASR amplitude and PPI will be measured using BIOPAC's Stimulator Module and external speakers. Startle stimuli will be broadband (20 Hz to 20 k Hz) noise bursts with a duration of 50 milliseconds (ms.), a rise/fall time of .1 ms, and intensity of 95dB. Prepulse stimuli will be tones with a duration of 30 ms, a rise/fall time of 5 ms, an intensity of 60-70 dB, and a frequency of 1000-2000 Hz. Stimulus onset (the length of time between the prepulse and startle stimuli) varies but average about 120 ms. The trial types consist of 12 trials, two blocks of 6 trials each, with two trials in each block in each of the following conditions in random order: startle stimulus alone, and startle stimulus preceded by a 60-dB prepulse.

As noted above, the physiological data complements equally rigorous collection of behavioral, cognitive, creativity, and self-report data. The experimental situation takes about two hours per participant.

If our hypotheses are even roughly correct, important implications follow. Our results would speak to the psychological impoverishment of working in inside offices without a view of the natural world. Our results would also suggest that such impoverished working conditions can be substantially improved by equipping offices with augmented windows of nature. At the same time, our results would suggest that real nature is better than augmented nature, and that therefore the technology should not be employed as substitutes for the real thing, but as only partial remedies when real nature is unavailable.

CONCLUSION

The above work will contribute directly to the goals of the current conference workshop on physiological computing. We also want to emphasize that within our research program we aim to extend our use of physiological computation, including the use of a variety of human-computer interfaces (such as robotic dogs) as the means to collect physiological data. Thus we would be very excited to participate in this workshop.

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