Report on a Preliminary Study Using Breath Control and a Virtual Jogging Scenario as Biofeedback for Resilience Training

Jacquelyn Ford Morie, Eric Chance, and J. Galen Buckwalter

University of Southern California
USC Institute for Creative Technologies, 12015 Waterfront Drive,
Playa Vista, CA 90094-2536
{morie,chance,jgbuckwalter}@ict.usc.edu

Abstract. Alternative methods of treating psychological stress are needed to treat some veterans of recent military conflicts. The use of virtual world technologies is one possible platform for treatment that is being explored by the "Coming Home" project at the University of Southern California's Institute for Creative Technologies (ICT). One of the novel ways ICT is attempting to mitigate stress via virtual worlds is with a virtual jogging scenario, where the movement of an avatar is controlled via rhythmic breathing into a standard microphone. We present results from a preliminary study of 27 participants that measured the mood and arousal effects produced by engaging in this scenario.

Keywords: Breathing, Virtual World, Second Life, stress relief.

1 Introduction

With two million troops deployed to the recent conflicts of OEF/OIF and Afghanistan, it is not surprising that there has been an overall increase in the number of military personnel reporting varied health issues arising from psychological stresses encountered during their service. These issues range from confirmed diagnoses of Post Traumatic Stress Disorder (PTSD) to more general problems such as anxiety, sleep disorders, substance abuse, marital problems, aggressive behavior and other difficulties [1]. One in five returned service members are estimated to be suffering from PTSD or some form of stress that affects their mental health [2]. At the USC Institute for Creative Technologies (ICT), we have been working on a project called "Coming Home" that researches and develops novel techniques to bring stress relief activities to our returned troops. Our goal is not to replace current treatments, but to find alternative and innovative methods that can supplement standard treatments in ways that overcome known challenges to getting help, such as perceived social stigma, disability, and limited access to health care facilities.

The military is already taking steps to combat the first of these three barriers, the stigma toward treatment. The Defense Center for Excellence in Psychological Health and Traumatic Brain Injuries (DCoE/PH) is helping to address this by providing commanders both an awareness of the negative impact such stigma has on continued

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troop health, and new tools through projects such as Real Warriors (http://www.realwarriors.net/materials) to help mitigate its persistence.

It is more problematic to address the other two barriers –disability and limited access– to seeking treatment. Soldiers with physical injuries tend to have associated psychological issues. Simply going out in public may be emotionally difficult, and going for mental health help may be even more challenging. This problem is compounded by geographical barriers that affect even soldiers without physical injuries. Specifically, the veteran population is disproportionately located in rural areas and smaller towns with limited health care resources. According to a recent article in *Psychiatric News,* "Although only 20 percent of Americans live in rural areas, 41 percent of the patients getting their care through the VA live in sparsely populated regions." Appropriate medical infrastructure for these veterans does not exist within a reasonable distance, and mental health services are especially hard to come by in rural areas [3]. These soldiers still need such care, as well as access to a range of therapies and support groups, but the perceived and real difficulties of getting that care may prove overwhelming.

1.1 Rationale

In our search for novel solutions to address some of the issues preventing soldiers from getting care, we looked at new forms of technology, and decided to focus on today's popular social networking/game platforms called Virtual Worlds (VWs). Virtual world technologies have several affordances that might surmount obstacles to care; they are typically anonymous (as people log in with a fictitous name) and therefore help mitigate perceived stigma, do not pose a challenge to most people with disabilities (as long as they can use a computer), can connect people with others of common interest over broad distances (as they are networked), and are persistent and accessible to anyone with a computer and a broadband connection.

The Coming Home project chose the free-to-use virtual world *Second Life*™ (SL) as a primary platform of investigation because of its size, large number of users, and expanding scripting language that is useful for designing applications within the virtual world, as well as communicating with external applications. It may also have some inherent appeal for younger soldiers as a game-like platform. According to a recent study, younger veterans (18-24) also face more risk for mental health concerns than do more experienced soldiers [4].

There were two goals in mind when developing an application in this virtual world environment. The first was to create an engaging activity that could help alleviate stress. The second goal was to introduce concepts from proven systems of stress amelioration that are also being explored within the virtual world by ICT, such as Mindfulness Based Stress Reduction and Yoga. One concept that fit both criteria was controlled breathing. Potential physical health benefits due to controlled breathing have been indicated by research showing that regular breathing accompanied by biofeedback for as little as ten minutes a day can be effective in lowering blood pressure [5].

Research from Stanford's Virtual Human Interaction Lab (VHIL) led us to hypothesize that modeling an exercise behavior could potentially have psychological benefits. VHIL's research has shown that avatar usage manifests behavioral changes via what they have termed the “Proteus Effect.” Participants in a VHIL study who observed their avatar exercising reported significantly higher levels of exercise in the physical world following their session than those who watched a representation of someone else exercising, or watched themselves not exercising [6]. Research by Lim and Reeves [7], also at Stanford, shows that the act of allowing the user to choose their avatar, and viewing that avatar in a 3rd person perspective, leads to greater arousal and an increased sense of presence in a virtual environment, which correlates with increased engagement. These studies are influential in our thinking that activities done in the virtual world with one’s avatar may be an important means for affecting behavioral changes in the physical world.

We combined these two fields of research, biofeedback with controlled breathing and exercise with the Proteus Effect, to produce a virtual jogging activity within *Second Life*™. To go beyond the typical way people cause an avatar to run (keyboard and mouse clicks), we designed a virtual jogging path where control of the avatar is done via steady, rhythmic breathing. The avatar’s movement itself is a feedback mechanism indicating success at the activity: the avatar progresses from standing to walking to running depending on how long the user has successfully completed the activity. The user only influences the movement of the avatar; the direction of travel is handled automatically by scripts written in Linden Scripting Language (LSL) that guide the user’s avatar around a circular path circumnavigating a virtual island.

2 Design

Although rhythmic breathing was used as the control mechanism for the virtual jogging activity, we eschewed use of a spirometer for this implementation, although the SL viewer could be modified to be compatible with such a device. Using a spirometer would have required more costly alteration of the SL viewer, and would have also required additional maintenance to accommodate the frequent operational changes in the official SL platform. More importantly, it would have limited the target audience to those who had personal use of a spirometer. We wanted our implemntation to be usable without any specialized equipment to reach the largest number of people. We chose to use an ordinary microphone that most *Second Life*™ residents already used for voice chatting to others in the world. The microphone was used to “hear” the sound of the breath rather than measure the amount of air exhaled.

This novel approach of using the sound of rhythmic breathing to move an avatar was made possible by seldom used speech functions provided by *Second Life*™, which allow the use of a microphone to be detected, returning three levels of sound amplitude categorized as *low, medium,* and, *high* in value. Rather than use these functions to directly trigger animations or sounds, we altered them to transmit the information about which sound levels were detected via private chat channels accessible only by LSL scripts.

An LSL algorithm evaluates these *low*, *medium*, and *high* values and compares them to the time they were detected. By calibrating input settings for the microphone to return a *high* level when exhaling, the starting point of each exhalation can be determined. The length of time the participant sustains the exhalation can be determined by assuming that *high* values of low incidence indicate exhalation, while assuming that multiple *low* values or values of high incidence indicate interruption.

The speech functions do not continuously return values if the level of sound detected remains the same, so a comparison of recent values and their times detected is necessary.

This comparison process is also made crucial by the necessity of implementing error correction strategies: Initial testing with computer generated tones of constant amplitude revealed that the information received is not completely reliable as occasional glitches are encountered which briefly return lesser values before again returning the correct value. Values can become even more unreliable in practice because the sound of exhaling or the sound of air hitting the mic may not remain consistent. In addition to comparing incidence of values, strategies to exclude these deviations rely on proper calibration of the mic to return high values when exhaling (but not so high as to produce audio clipping), having a quiet room with little extraneous sound, and the use of headphones to block sounds from SL reaching the mic. The need for error correction is further compounded by the fact that there is no way to know if the volume level suddenly drops to zero, such as by accidentally or purposely muting the microphone. Because of this, we use "timeout" function that assumes nothing is happening if values have not changed after a sufficient amount of time.

Fig. 1. The green bar rises and falls in response to the length of time volume is detected by the user's mic, providing the user real time feedback. Matching one's breathing to the pace of the red bar causes the avatar to run. The green icons above the user's head are SL's default indication that the microphone is in use.

The process of making the avatar move involves the user attempting to match a slow and steady "guide breath" that is both audibly and visibly represented. (See Figure 1) The audible guide breath heard by the user mirrors the rate of rise and fall of a visible, red "guide bar" that appears on the user's interface. The user's own breath is visually indicated by a green bar that rises and falls in response to their detected exhalation, providing real time feedback. When the user exhales during appropriate exhalation period as indicated by the guide bar, their avatar will begin to move along the predefined course. Values returned outside this exhalation period are ignored.

2.1 Additional Challenges

Choosing the *Second Life*™ platform for its strengths also meant tackling its constraints. Regular users often choose to override the default animations because they seem awkward, and there are LSL animation override solutions for this provided by third party developers. We also chose to use a custom set of animations that more closely resemble jogging. In addition to customized animations, we wanted to provide visual feedback in the form of progressively changing running speeds. Normally, the avatar in SL can only move at two different speeds. No solution existed to change this constraint because it is hard-coded into the platform itself, whose code exists on remote servers inaccessible to the end user, and cannot be directly altered.

Our solution to this challenge was to first have the avatar sit on a primitive geometric object, also known as a "prim." Using LSL, the prim is fully transparent, and made to navigate automatically through the world at a rate corresponding with animations matching various speeds of movement as triggered by the user's breath input. This process gives the overall appearance that the user's avatar walks and runs through the world at speeds not regulated by the *Second Life*™ platform.

With the final functionality in place, we were finally able to set up a study to determine the effectiveness of a breath-activated jogging scenario.

3 Study

We conducted a preliminary study with 27 participants that measured mood and arousal effects produced by engaging in this virtual jogging scenario. The participants were a mixed group of male and female subjects, though not specifically selected from the veteran population that is the intended beneficiary of our research. Veterans may already be suffering from psychological and health problems, and we therefore reasoned that a future study should be pursued with them only if random participants of a preliminary study demonstrated measurable mood and arousal effects that were desirable.

All participants for this study used a male avatar wearing Army fatigues, and were tested at the same virtual location within *Second Life*™. All users were given verbal instructions and used the same pair of headphones and microphone for the study. The avatar was viewed in 3rd person perspective.

Three instruments administered prior to and after the virtual jogging activity were used to measure the effects on mood and arousal states. These were the arousal section of the *Pleasure, Arousal, and Dominance* (PAD) scale, and the *Positive Affect*

(PA) and *Negative Affect* (NA) scales. We found participants' experience using the jogging path had effects on these measures, resulting in a significant decline in mean score for all three scales. The significance of the change was: .004 for PAD, .015 for PA, and .006 for NA. Given the significant findings for the overall scales, post-hoc item analyses were conducted to determine the specific nature of the change participants experienced. When these were done for the ten items of the PA, there were significant (drops) findings for two of the items ($p<0.05$), *interested* and *inspired*. One item that showed a more significant decline ($p<0.01$) was *enthusiastic.* Post-hoc analyses on the ten items of the NA found significance ($p<0.05$) for one item, *distressed*, and greater significance ($p<0.01$) for two items, *nervous* and *upset*.

4 Discussion

Overall, this indicates that this virtual jogging activity, in its totality, tends to help participants feel more relaxed and calm. Cognitively, there is a lessening of arousal, trending toward feeling more sluggish and dull. While there is a decline in some positive emotions such as inspired and enthusiastic, there was a significant decline in the negative emotions as well, notably in the amount of distress, nervousness, and upset that the participants reported. This decline in negative emotions may have notable implications for those with disorders such as anxiety and stress. We believe that the results may have implications for new avenues of research in the field of Resilience Training, an area of extreme interest to the military [8]. We also expect our intended audience (veterans) will experience greater psychological effects via the Proteus Effect because future users will create and use their own avatars and will therefore feel an association with the avatar as a projection of themselves, while the preliminary users did not.

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