Does Notebook-Based, Accessible Simulation Training Create Cybersickness?

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Abstract. Accessibility to simulated environments generally is limited by the availability of sophisticated hardware and software. An alluring option could be to use a portable computer, thereby availing simulation training to a wider-ranging client base in a more economical and efficient way. However, one problem associated with some of the screen-based simulation environments can be the client reports of unpleasant symptomatic responses such as cybersickness. In this study we investigated whether watching considerable simulated motion on a notebook computer for six minutes would induce significant cybersickness symptoms in a healthy sample population. We hypothesized that there would be no reports of cybersickness in response to simulated movement on a notebook computer. The hypothesis was tested using a Wilcoxon Matched-Pairs Signed Rank Test. The prediction that there would be no significant difference between the Pre-Test and the Post-Test SSQ symptom scores was supported on eleven out of sixteen symptoms. Nevertheless, the hypothesis was not supported on five SSQ Pre-/Post-test scores (General Discomfort, Eyestrain, Difficulty in Focusing, Difficulty in Concentrating, Dizziness Eyes Closed) indicating that participants were moderately distressed by the movement in the simulation. We suggest that the reported eyestrain resulted from technical issues related to the screen refresh rate, and that the difficulty in concentration was a consequence of the tedious content of the simulation – both important technical considerations when designing a system. If these results can be verified by a larger and more diverse client population, then the results would appear to suggest that using notebook computer simulations for training, even when there is a significant amount of simulated movement is not likely to initiate symptoms of nausea, headache or fatigue as has been observed in previous research using large immersive virtual reality environments.

1. INTRODUCTION

Simulated environments whether for serious games (Garris, Ahlers, & Driskell, 2002), cognitive behavioral therapy (Tworus, Szymanska, & Ilnicki, 2010) or educational training (Holzinger, Kickmeier-Rust, Wasertheurer, & Hessinger, 2009) are designed with the intention of engaging the client. Clients who attend sessions in a virtual world do so in order to be entertained, treated for a clinical condition or learn a new skill.

Fundamental to games, therapy and education is the cognitive learning that takes place within the environment. Regardless of the learning outcomes, immersion and interaction with the computer-generated environments involves concentrating on a task for an extended period, often with multiple sessions.

Computer generated, virtual reality environments can provide a safe means of exposing a client to otherwise perilous scenarios. Virtually learning a new competency (Holzinger, Kickmeier-Rust, Wasertheurer, & Hessinger, 2009; Schenkmman, 2008) can offer an efficient learning environment for allowing students to engage in the learning process by managing their cognitive learning strategies and maximizing their learning process (Kesici, Sahin, & Akturk, 2009).

Accessibility to simulated environments can be restricted by the availability of sophisticated hardware, software, specialized professional simulation training and technical support. An appealing alternative could be the use a portable computer, thereby providing simulation training to a broader client base in a more effective way.

Computer generated immersive, three dimensional environments are generally considered safe and reliable for use in anxiety treatment (Parsons & Rizzo, 2008; Powers & Emmelkamp, 2008); and simulation-based training (Rushby & Seabrook, 2007); (Sturm et al., 2008). However, if we are to use more accessible tools such as portable computers for treatments and training, then health and safety issues needs to be investigated.

In this study we propose using the non-immersive technology of a standard notebook computer as a cost-effective and easily portable simulation device. We aim to investigate whether a non-immersive notebook computer would create sensory conflict (Reason & Brand, 1975) and thus the unpleasant symptoms of cybersickness as rated on the standardized Simulator Sickness Questionnaire (SSQ) (Kennedy, Lane, Berbaum, & Lilienthal, 1993) including nausea, headache and eyestrain as has been reported in response to immersive environments (Bruck & Watters, 2009a, 2009b; Kim, Kim, Kim, Ko, & Kim, 2005). We hypothesize that there will be no reported
increase in cybersickness symptoms, as measured by the SSQ (Kennedy, Lane, Berbaum, & Lilienthal, 1993), in response to significant simulated motion on a non-immersive environment as compared to a baseline SSQ completed before exposure to the notebook environment.

2. METHOD

2.1 Participants

Nineteen (17 male, 2 female) healthy Macquarie University students aged between 18 and 35 years volunteered to participate in the experiment. All had normal or corrected to normal vision. Macquarie University Ethics Approved Consent was obtained. Participants were given a chocolate bar in acknowledgement for their contribution to the experiment.

2.1.1 Procedures and Equipment

Each participant completed a Simulator Sickness Questionnaire before and after viewing a six minute simulation on a standard 14 inch screen notebook computer. The experimental condition presented a rollercoaster ride with considerable simulated movement. The environment shown was the same as was reported in previous studies (Bruck & Watters, 2009b, 2010). In contrast, the previous experiments tested the simulated environment in an immersive three dimensional (3D) Cave virtual reality environment (VRE) displayed on a 1.7 meter 160° field of view parabolic screen with 3D shutter glasses (Bruck & Watters, 2009b) and a portable media device (Bruck & Watters, 2010).

In our earlier study (Bruck & Watters, 2009b) the authors presented results that indicated ten out of sixteen cybersickness symptoms, using the standardized Simulator Sickness Questionnaire (SSQ) (Kennedy, Lane, Berbaum, & Lilienthal, 1993), significantly increased in response to an increase in simulated motion. We questioned whether similar responses would be reported on the smaller screen with a non-immersive environment.

Previous work by the authors reported that the VRE (Bruck & Watters, 2009b) and the portable media device (Bruck & Watters, 2010) show no significant response in either an immersive or a non-immersive condition for low simulated movement; there was therefore no reason to further expose participants to this experimental condition. In fact, the requirement to ensure reasonable and non-exploitive use of the participants (Sieber, 1999), provides a strong ethical reason not to expose participants to this condition. Since the goal of this experiment, specifically, was to detect whether significant simulated movement on a non-immersive computer platform is likely to cause significant discomfort, the previous studies provided an adequate control condition.

3. RESULTS

A Wilcoxon Matched Pairs Signed Ranked Test was used to test the hypothesis that there would be no significant increase in SSQ responses after exposure to significant motion on a notebook computer.

The analysis of the data rejected our hypothesis that exposure to considerable simulated movement on a notebook computer would not cause an increase in discomfort on five of the sixteen symptoms: General Discomfort, Eyestrain, Difficulty in Focusing and Dizziness with Eyes Closed. These results suggest that a six minute exposure to considerable simulated motion can cause distress.

Table 1: Wilcoxon Matched Pair Signed Rank Test

<table>
<thead>
<tr>
<th>SSQ Symptom</th>
<th>Considerable Simulated Movement (n=19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Discomfort</td>
<td>z = -2.236, p = 0.025*</td>
</tr>
<tr>
<td>Eyestrain</td>
<td>z = -2.887, p = 0.004*</td>
</tr>
<tr>
<td>Focusing</td>
<td>z = -2.000, p = 0.046*</td>
</tr>
<tr>
<td>Concentrating</td>
<td>z = -2.000, p = 0.046*</td>
</tr>
<tr>
<td>Dizziness Eyes Closed</td>
<td>z = -2.000, p = 0.046*</td>
</tr>
<tr>
<td>Fatigue</td>
<td>z = 0.000, p = 1.000</td>
</tr>
<tr>
<td>Headache</td>
<td>z = -0.577, p = 0.564</td>
</tr>
<tr>
<td>Salivation</td>
<td>z = -1.414, p = 0.157</td>
</tr>
<tr>
<td>Sweating</td>
<td>z = -1.000, p = 0.317</td>
</tr>
<tr>
<td>Nausea</td>
<td>z = -1.324, p = 0.180</td>
</tr>
<tr>
<td>Fullness of Head</td>
<td>z = -1.732, p = 0.083</td>
</tr>
<tr>
<td>Blurred Vision</td>
<td>z = -1.857, p = 0.063</td>
</tr>
<tr>
<td>Dizziness eyes Open</td>
<td>z = -0.577, p = 0.564</td>
</tr>
<tr>
<td>Vertigo</td>
<td>z = 0.000, p = 1.000</td>
</tr>
<tr>
<td>Stomach Awareness</td>
<td>z = 1.633, p = 0.102</td>
</tr>
<tr>
<td>Burping</td>
<td>z = 0.000, p = 1.000</td>
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</tbody>
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4. DISCUSSION

4.1 Learning within games and simulations

Virtual reality environments have immense potential for outcome based education and training giving clients opportunities to perform complex procedures and develop higher order cognitive processes without compromising personal safety. Computer simulations offer a facility of repeated practice of skills with feedback, in a timely and economical process (“Summit on Educational Games - Harnessing the Power of Video Games for Learning”, 2006). However, simulations expose the client to more than the specific pursuit that was intended.

Considering that the authors’ previously reported experiment (Bruck & Watters, 2009b) found that cybersickness increased significantly in an immersive, moderately high simulated movement experimental environment, it is interesting to note general discomfort, eyestrain, difficulty in concentrating and difficulty in...
focusing were significantly worse after exposure to the environment in both the immersive VRE and the non-immersive notebook screen.

We have investigated cybersickness responses to considerable simulated movement on three different computer platforms (Bruck & Watters, 2009b, 2010). On each of these platforms (3D Cave, portable media devices and notebook) we have found that healthy young adults report significant increases in unpleasant symptoms.

Although these studies have involved only small sample populations the results have been consistent. It appears that it is not the presentation platform that is causing the adverse sensations, but the effect of looking at simulated movement traversing an X and Y axis trajectory and thus creating a pseudo Coriolis effect (Bonato, Bubka, & Palmisano, 2009). The outcome of watching this virtual movement appears to generate a feedback sensation of general unwellness and dizziness in response to the illusion of vection. The Sensory Conflict Theory (Reason & Brand, 1975), suggests that variance between the movement that is registered by the brain and inferred through eyes is what is perceived by the vestibular system, and in turn generates the uncomfortable physical symptoms. Our results appear to support this theory.

In each of our experiments, eyestrain was demonstrated to be worse after a six minute exposure to the considerable simulated movement. Difficulty in focusing, and difficulty in concentrating are symptoms that would not be unexpected when eyestrain is reported. Further studies are required to investigate whether the duration of exposure impacts on the responses, and whether multiple exposures would produce an habituation effect. The reported eyestrain may result from a technical issue related to the screen refresh rate – an important consideration when designing a system.

Moreover, the increase in difficulty in concentrating we reported may be a function of the content that was viewed within the environment. A two minute journey which was repeated in a loop three times, may account for the reports of lack of concentration on the content. In follow up studies more interesting and variable scenery with interactive content will need to be investigated in order to identify whether difficulty in concentrating is a function of the content or the platform on which the simulation is displayed.

If these results can be verified by a larger and more diverse client population, then the results would appear to suggest that using notebook computer simulations for training is unlikely to initiate symptoms of nausea, headache, or fatigue and therefore may offer an accessible simulation option.

4.2 Usability
The question of whether virtual environments are safe for health services delivery and expertise training appears to be slightly clearer. Our study suggests that although a significant increase in general unwellness were reported when viewing significant simulated movement on the notebook computer screen, the severity of the discomfort was not so uncomfortable so as to make the participant discontinue the experiment. Considering the mild responses to the considerable simulated movement we infer that notebook computers may have a role as a portable technology in simulation treatment. As a result of our research findings we advocate that more studies need to be undertaken to investigate the optimal duration for exposure to virtual environments as well as different sample populations including different age ranges and clinical profiles. Furthermore, additional studies are needed to identify a) whether there is an habituation to the unpleasant side effects after multiple exposures and b) the optimal duration of usability of the portable computers, as observed in immersive environments (Hill & Howarth, 2000; Howarth & Hodder, 2008).

4.3 Engagement with the treatment
By providing a safe means of exposing clients to what could otherwise be risky scenarios, portable computers can offer an accessible therapeutic tool. Immersive technologies have been shown to engage the client (Bouchard, St-Jacques, Robillard, & Renaud, 2008; Coelho, Silva, Santos, Tichon, & Wallis, 2008; Emoto, Sugawara, & Nojiri, 2008). When we consider that the results from this study of non-immersive technology presented consistent symptomology with previous studies of immersive technology (Bruck & Watters, 2009a; Flinton & White, 2009), it not implausible to suggest that the participants in this study were sufficiently engaged with the content of the environment when reporting the undesirable side effects.

Further research into the underlying physical mechanisms for the side effects of exposure to non-immersive environment, which present limited simulated movement, is required.

4.4 Accessibility
Minimizing financial outlay, when readily available equipment such as a portable computer could be used in a treatment or training scenario, makes eminent sense when accessibility to facilities is not always practical. Previous research into the use of personal computers for Virtual Reality Exposure Therapy is promising (Tichon & Banks, 2006). Transportability of the equipment provides the potential for wide distribution of therapy within a community.

(Cth) and Related Measures", 2009) making it unlawful to “discriminate against a person on the grounds of a disability” (“Commentary on the 2009 Changes to the Disability Discrimination Act 1992 (Cth) and Related Measures”, 2009). Accessible treatment options, using equipment such as a notebook, may be one part of the an achievable goal of meeting the requirements of the Convention.

4.4.1 Distance
Simulation training equipment that is portable provides the ideal opportunity for taking the treatment or training options to the client. In conjunction with appropriate counselor expertise, remoteness need not be an inhibitor to simulation training.

Reports claim that up to 45% of United States military veterans from Afghanistan and Iraq have a definitive or probable diagnosis of Post Traumatic Stress Disorder (PTSD) (Tanielian & Jaycox, 2008, pp. 60-69; Tuerk, Grubaugh, Hamner, & Foa, 2009). The delivery of psychological therapy for PTSD for war-battle returnees is most often implemented when the Defence Force member returns from the war zone and symptoms have been present for a period of time (Russell & Friedberg, 2009; Vitzthum, Mache, Joachim, Quarcoo, & Groneberg, 2009; Wood et al., 2009). Availability of portable equipment which is resistant to environmental factors such as sand and intense heat (Spira et al., 2010) could provide the opportunity for accessible treatment in the battlefield when symptoms begin to present, possibly limiting the symptom severity.

4.4.2 Economic
Treatment for individual United States Afghanistan and Iraq returnees diagnosed with combat PTSD, who participate in a two year treatment, costs approximately between $6,000 - $10,000 (Tanielian & Jaycox, 2008, p. xxiii). The advantage of earlier intervention, due to improved accessibility to equipment in conjunction with adequately qualified clinicians who are experienced with simulation therapeutic techniques may ease the economic load due to earlier intervention.

In Australia, the Australian Defence Force (ADF) and the Department of Veterans’ Affairs in a Committee Review “were unable to provide full and complete details of the incidence of PTSD in ADF peace keepers” (Senate, 2008, p. 297), although estimated costs associated with post deployment welfare for the East Timor and Solomon Islands peace keeping missions were over three million dollars (Senate, 2008, p. 297). Despite the ADF affirming it has “comprehensive programs to assist with the diagnosis and treatment of mental health problems, including PTSD” (Senate, 2008, p. 300), more accessible technology may improve the advancement of treatment options available.

5. CONCLUSIONS
Accessibility to simulation technology that provides an economical option for treatment or training, when there is limited movement on the computer screen, may be another tool that offers opportunities to a wider client base. The results from this study conclude that notebook computers are less likely to induce discomfort in the client than the more immersive environments. Notwithstanding the encouraging potential for this technology, we recommend that users be screened for susceptibility for cybersickness symptoms prior to using an accessible simulation training system.

REFERENCES


