Assessing And Improving Attention In TBI Patients Using Virtual Reality Environments With Haptic Robots

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Introduction

- Traumatic Brain Injury (TBI) is a principal cause of life-long disability.
- Attention deficits are frequently observed after TBI.
- Attention training in engaging virtual environments, have been used for TBI survivors [1-2].
- Although successful, these methods have shown to improve attention in chronic and higher functioning patients. To date, there have been no studies on how training in virtual environments may improve attention in the inpatient TBI population.
- Spatial attention has been shown to be cognizably linked between vision and touch, such that haptic activation of attention automatically captures and directs visual attention.
- A previous study in our lab showed that the TBI inpatients do tolerate and enjoy haptic and graphic reality environments and that the environment was able to assess attentional deficits.[3]
- Recent advances in virtual reality allow the augmentation of virtual environments with physical space, allowing the use of a haptic device within virtually generated environments.

AIM
- To develop a minimal, interactive haptic/graphic reality virtual environment to assess and improve attention in the early stage of recovery in the inpatient TBI population.

HYPOTHESES:
- Subjects will accumulate proficiency throughout the experiment.
- Subjects will show an improvement in movement speed, deviation of a haptic nudge will capture and redirect subjects' attention to the task at hand.
- Breakthrough forces will provide an engaging environment, aiding the subject to remain on task.

Methods

- Subjects were immersed in a 3D wide field of view virtual environment using a haptic graphics system called the Virtual Reality and Robotic Optical Operations Machine (VRROOM) [4]. Current perspective and stereo projections of the scene were updated using the head position and orientation supplied by a ‘Toss of Ring’ tracking sensor attached to the stereo shutter glasses (Crystal Eyes, StereoGraphics Inc.).
- The minimal interactive virtual environment consisted of a cursor and a target in the field of view that can be both seen and felt, with no distractions. Virtual targets (generated as 3D ball-shaped targets) appeared one at a time in different locations in space. Virtual targets (generated as 3D ball-shaped targets) appeared one at a time in different locations in space.
- Each patient made two visits on successive days. During each visit, patients reached toward targets, completing three treatment phases. Each phase consisted of two blocks of four minutes each, and one of the following haptic feedbacks:
  - Control
  - Nudge
  - Balloon

- During loss of attention as evidenced by decrease in movement speed, a noticeable haptic nudge will capture and redirect subjects' attention to the task at hand.
- Breakthrough forces will provide an engaging environment, aiding the subject to remain on task.
- Spatial attention has been shown to be crossmodally linked between vision and touch, such that haptic activation of attention automatically captures and directs visual attention.

Subjects were immersed in a 3D wide field of view virtual environment using a haptic graphics system called the Virtual Reality and Robotic Optical Operations Machine (VRROOM) [4]. Current perspective and stereo projections of the scene were updated using the head position and orientation supplied by a ‘Toss of Ring’ tracking sensor attached to the stereo shutter glasses (Crystal Eyes, StereoGraphics Inc.). The minimal interactive virtual environment consisted of a cursor and a target in the field of view that can be both seen and felt, with no distractions. Virtual targets (generated as 3D ball-shaped targets) appeared one at a time in different locations in space. Each patient made two visits on successive days. During each visit, patients reached toward targets, completing three treatment phases. Each phase consisted of two blocks of four minutes each, and one of the following haptic feedbacks:

- **Control:** no haptic feedback.
- **Nudge:** a “breakthrough” force of 1 cm from target, which gives way to a small attractive force once within the target, similar popping a balloon.
- **Balloon** 4 N, 250 ms nudge exerted in the direction of the target after one second of no movement over a threshold.

In each trial, the subject held the handle of a PHANTOM 3.0 robot and moved the handle toward the targets with their right hand. A target disappeared and the next target appeared in the scene when the subject entered the cursor to the target or 10 sec elapsed.

Most patients showed improvement on the first visit and leveled off on the second.

Results

- **Movements and Haptic Feedback**
- **Nudges Alter Individual Movements**

Conclusions

- Haptic nudges were able to refocus patients' attention.
- In some cases, nudges were able to solicit patients in completing the task.
- One patient resisted the nudge, and this in turn, decreased task performance.
- Overall, nudges improved performance.
- Balloon forces had no significant effects on overall performance.
- Patients improved on Day 1 and in between days, but leveled off on the second.
- More demanding tasks are necessary as patients become more functional.
- The VR system is a powerful and versatile environment for attentional therapy, but requires a larger, more intensive study.

References


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