

# Driving Rehabilitation for Military Personnel Recovering From Traumatic Brain Injury Using Virtual Reality Driving Simulation: A Feasibility Study

Daniel J. Cox, PhD\*; Margaret Davis, BA\*; Harsimran Singh, PhD\*; Brent Barbour, BA\*; F. Don Nidiffer, PhD†; Tina Trudel, PhD‡; Ronald Mourant, PhD‡; Rick Moncrief, BS§

**ABSTRACT** Objective: To investigate the feasibility of virtual reality driving simulation rehabilitation training (VRDSRT) with military personnel recovering from traumatic brain injury (TBI). Methods: Eleven men with TBI were randomly assigned as controls ( $n = 5$ ) receiving residential rehabilitation only or the VRDSRT group ( $n = 6$ ) receiving residential rehabilitation and VRDSRT. All subjects underwent pre- and postassessments including simulator driving, and completing road rage and risky driving questionnaires. Between assessments, VRDSRT subjects received 4–6, 60- to 90-min rehabilitation training sessions involving practicing progressively more complex driving skills (lane position, speed control, etc.) through progressively more demanding traffic. Results: VRDSRT was well received, considered realistic and effective, with no reported simulation sickness. Driving performance improved significantly in the VRDSRT group only ( $p < 0.01$ ). They also demonstrated a reduction in road rage ( $p = 0.01$ ) and risky driving ( $p = 0.04$ ) at post-assessment. Conclusion: VRDSRT showed promising results with respect to retraining driving performance and behavior among military personnel recovering from TBI.

## INTRODUCTION

Motor vehicle crashes are the leading cause of death for veterans in their early years after returning from deployment and a top priority for the Department of Defense (DoD) and the Department of Veterans Affairs (VA), which is currently being addressed with an information campaign ([www.safedriving.va.gov](http://www.safedriving.va.gov)). This high collision rate could in part be due to more risk taking while driving<sup>1</sup> and the high incidence of traumatic brain injury (TBI) both pre- and postdeployment.<sup>2</sup>

TBI can lead to significant cognitive, motor, perceptual, and behavioral deficits in an individual. Its impact varies widely between patients from “mild” (brief change in mental state or consciousness) to “severe” (an extended period of unconsciousness or amnesia following the injury) depending on the type of injury suffered. Recent reports suggest that 1.4 million Americans sustain a TBI each year, of whom 235,000 require hospitalization.<sup>3</sup> According to estimates from the Centers for Disease Control and Prevention, at least 5.3 million TBI survivors in the United States are dependent on their significant others to perform daily living activities.<sup>4</sup> TBI is also one of the most frequent causes of acquired disability for people under the age of 35 in the United States.<sup>5</sup> Although the majority of mishaps resulting in TBI in the civilian population are a result of falls and vehicular collisions,<sup>6</sup> for active duty military personnel blasts are the leading causes of TBI (Defense

and Veterans Brain Injury Center, DoD, unpublished report, 2005). Over the last 9 years, the incidence rate of TBI-related hospitalizations was 22% higher during postdeployment compared to predeployment service.<sup>2</sup>

Driving is important for functional independence and psychological well-being of most adults. Driving a vehicle safely and proficiently has been referred to as the “ultimate multitasking” experience that requires synchronization of driver’s physical, cognitive, and behavioral skills.<sup>7</sup> TBI, however, can seriously compromise an individual’s reaction time, hand-eye coordination, visual perception, memory, attention, and judgment. These impairments can result in poor driving performance, endangering not only the life of the TBI driver but lives of others on the road. According to a U.K. study, 64% of TBI patients who had reported driving before the injury had not resumed driving when inquired at a later time (3 months to 2 years after the head injury).<sup>8</sup> Individuals recovering from a TBI who do resume driving, typically recognize their driving difficulties, but do not make accommodations, e.g., avoid high traffic or night driving, and have 2.5 more collisions/miles than the general population or drivers recovering from a stroke.<sup>9</sup>

High-quality and engaging driving rehabilitation techniques that focus on improving such driving impairments could hasten and maximize recovery of driving skills in TBI patients. Given the extensive use of simulation in training military personnel, it is surprising that simulation has not been applied routinely for purposes of driving rehabilitation in the military. In the past few years, the advantages of using virtual reality driving simulators to promote and facilitate better and safer driving in clinical populations have become more apparent.<sup>10</sup> Simulation offers a safe environment for patients to practice and improve their impaired driving skills while being evaluated

\*University of Virginia Health System, Box 800223, Charlottesville, VA 22908.

†Virginia NeuroCare, Defense and Veterans Brain Injury Center, 1101-B East High Street, Charlottesville, VA 22902.

‡Department of Mechanical and Industrial Engineering, 334 Snell Engineering Center, Northeastern University, Boston, MA 02115.

§MBFARR, LLC, 93 Mt. Hamilton Rd., San Jose, CA 95140.

objectively. However, in our review of the literature<sup>11</sup> we found only one published study describing the use of virtual reality driving rehabilitation training with individuals recovering from a brain injury.<sup>12</sup> This study reported impressive results as 73% of simulator-trained poststroke patients legally resumed driving (as per the official driving assessment) compared to only 42% of the controls ( $p < 0.05$ ).

Here, we report a feasibility study investigating the possible use of virtual reality driving simulation rehabilitation training with military personnel recovering from a TBI.

## MATERIALS AND METHODS

### Subjects

Subjects were recruited through acute care Virginia NeuroCare, a residential rehabilitation center in Charlottesville, Virginia. All subjects had suffered one or more closed head injuries, primarily in the Iraqi theater and were participating in an intense 12-hour/day rehabilitation program including occupational, speech, and psychological therapies with work training. Eight subjects reported having had some previous military simulation training experience. Subjects were randomly assigned to the simulator VRDSRT group ( $n = 6$ ) or the control group ( $n = 5$ ) before commencing pretreatment evaluation. The VRDSRT group included three White subjects, two Hispanic, and one Black subject. Control subjects included three White and two Hispanic subjects. Demographics for all participating subjects are presented in Table I, A. As a measure of general cognitive functioning, upon admission to NeuroCare, participants were administered the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS). The RBANS is a brief, individually administered test used to determine the neuropsychological status of adults with cognitive impairment. As seen in Table I, A, mean scores for the controls and VRDSRT were 23.3 (range = 86%) and 19.2 (range = 0–53%), respectively, thereby, placing subjects in the normal to moderately impaired range.

### Procedure Overview

All subjects signed an IRB-approved consent form, continued routine residential rehabilitation at NeuroCare, and underwent pre- and postassessment at the University of Virginia. Between pre- and postassessment, six of the subjects received four to six, 60- to 90-min rehabilitation training sessions.

### Driving Simulator

The virtual reality Model T<sup>3</sup> driving simulator provides 180° field of view, with rear and side view “mirror” images, optional 5-speed manual transmission, turn signal, and real-size brake/gas pedals and steering wheel, and air conditioner for temperature control. Model T<sup>3</sup> has equivalent driving scenarios. Each scenario involves a 12-mile course that includes 3 miles of rural, 5 miles of highway, and 4 miles of urban driving, taking approximately 5–6 minutes to traverse each segment. Although

all driving scenarios involve the same road course, the traffic patterns and driving demands differ between scenarios, e.g., each scenario has one signaled sudden stop (such as a lead car’s brake lights suddenly come on and rapidly decelerates), and two sudden stops that are not signaled (such as a car in a parallel lane suddenly pulls into the driver’s lane). Subjects drove scenario 1A at preassessment and 1B at postassessment.

### Simulation Adaptation Syndrome Prevention Protocol

Simulation adaptation syndrome (SAS) refers to nausea, disorientation, headache, and problems with focusing, sometimes experienced while or shortly after operating a simulator. To minimize or avoid SAS, we employed the following protocol:

- (1) All components of the projected image were displayed at the correct geometric angle. As a result, visual flow was not compressed or expanded.
- (2) The air conditioner in the Model T<sup>3</sup> was activated before each drive, maintaining air movement and comfortable temperature.
- (3) To desensitize subjects to the simulator, the driving scenario was initially introduced in 3-min “doses,” after each of which subjects looked away from the screen, relaxed, and were asked to rate their SAS symptoms on a “0” (feel fine) to “4” (feel so bad, I have to stop right now) scale. These scenarios involved no traffic.
- (4) Subjects were introduced to the simulated scenarios progressively. During the initial exposure to the Model T<sup>3</sup> only the center projector was illuminated. Once the center screen could be tolerated for 3 min without SAS, the two side projectors were activated with half brightness for the next 3-min dose. Subsequently, the side projectors were turned up to full brightness for the next dose.
- (5) All subjects wore a Relief Band (Woodside Biomedical Systems, Inc., Carlsbad, CA). This device looks similar to a wristwatch but when activated administers mild electrical stimulation to the pericardium 6 or the Neiguan point located on the inner side of the wrist. It has demonstrated effectiveness in reducingvection-induced motion sickness<sup>13</sup> and postoperative nausea and sickness in patients.<sup>14,15</sup> The Relief Band did not need to be activated for any of our subjects.

### Assessment Procedure

To assess driving behavior, subjects completed the Road Rage Questionnaire<sup>16</sup> and the Cox Assessment of Risky Driving Scale (CARDS).<sup>17</sup> Subjects were then oriented to the simulator and the SAS prevention protocol was administered. Next subjects drove the preassessment driving course 1A, which included demanding traffic situations. The examiner observed and rated subjects’ driving performance on the variables presented in Table I, C.

**TABLE I.** Subject Characteristics, Ratings, and Performance

Variable	Time	Control	VRDSRT
<b>A. Demographics</b>			
Sample size		5	6
Mean age, range	Pre	26.6, 21–39	26.2, 23–31
Mean education, range	Pre	12.4, 10–14	13.7, 10–20
Percentage White	Pre	60%	50%
Percentage currently driving	Pre	60%	50%
Repeatable battery for the assessment of neuropsychological status	Pre	23.3, 0–86	19.2, 0–53
<b>B. Simulator Variables Mean Ratings: Scale: 0 = “not at all” to 4 = “very”</b>			
How do you feel right now? (SAS postdrive)	Pre	0	0
How realistic was it to drive the simulator?	Pre	3.0, 2–4	3.0, 2–4
How useful was driving the road course to improve your driving skills?	Post		4
How useful was driving the stockcar race course to improve your driving skills?	Post		3.2, 3–4
How important was the stockcar drive for you as an incentive to keep coming back for driving training?	Post		4
If the military were to routinely provide virtual reality driving rehabilitation to military personnel recovering from a TBI, to what extent would it encourage your positive attitude to the military and its commitment to support service personnel?	Post		3.3, 2–4
<b>C. Performance Variables</b>			
Maintain lane position, i.e., staying in the center of lane on straight and curvy roads.	Pre	0 ± 0.7	−0.3 ± 0.8
	Post	0 ± 0.7	1.2 ± 0.8**
Maintain speed control relative to posted speed limits.	Pre	−0.4 ± 0.5	−0.3 ± 0.5
	Post	−0.2 ± 0.8	−0.2 ± 0.7
Steering through turns appropriately in terms of timing, lane position, and speed.	Pre	−0.2 ± 1.1	−0.5 ± 0.5
	Post	0 ± 1.2	1 ± 0.6**
Stop/brake appropriately at stop lines and with traffic.	Pre	−0.5 ± 1.3	0 ± 0.6
	Post	−0.8 ± 1	0.3 ± 0.5
Deal with unexpected events like lead cars suddenly braking.	Pre	0 ± 0.7	0 ± 0.9
	Post	0.2 ± 0.8	1.2 ± 0.4**
Follow the rules of the road/traffic laws like slowing in school zones.	Pre	0.4 ± 1.1	0 ± 0.6
	Post	0 ± 0.7	1 ± 0.6*
Follow instructions of the simulator in terms of where to turn and pass lead vehicles.	Pre	0.4 ± 1.1	0.25 ± 0.4
	Post	0.2 ± 0.8	1.3 ± 0.8**
Composite score (sum of above 7 scales)	Pre	−0.6 ± 6	−0.9 ± 2
	Post	−0.4 ± 5	5.8 ± 3**
<b>D. Questionnaire Data</b>			
Road rage	Pre	28 ± 7	27.2 ± 6.4
	Post	28.4 ± 7	23.6 ± 9.9**
Cox Assessment of Risky Driving	Pre	22 ± 10	23.6 ± 15.3
	Post	22.3 ± 9	11.2 ± 7*

\* $p \leq 0.05$ ; \*\* $p = 0.01$ .

The researcher who administered the pre- and postassessments was not involved in providing or observing rehabilitation training to avoid bias in assessments. The entire preassessment took approximately 1 hour to complete. The postassessment was identical to the preassessment, except that the postassessment did not include the SAS prevention protocol and therefore, took only 30 min. Additionally, postassessment was conducted using a new driving course (1B), which included different but equivalent traffic situations to scenario 1A. At postassessment, subjects were asked to rate their experiences driving the simulator to the questions in Table I, B's simulator variables.

### Rehabilitation Training Procedure

VRDSRT was commenced after subjects had completed their preassessment. Training was administered by a researcher

(a college graduate, ex-Marine) with no formal experience of delivering rehabilitation training. The training protocol was informed by our literature review<sup>11</sup> and was in consultation with the Woodrow Wilson Rehabilitation Center (Virginia) and the McGuire Veterans Administration Hospital (Virginia). The training procedure was primarily based on patients' rehearsal/practice of progressively more demanding skills. It involved alternating between driving for 15 min on the road course and for 15 min on a popular stockcar racing game. The stockcar race course was used to address common TBI issues of inattention and minimal motivation. It involved driving a 2.5-mile trioval course in a simulated 700 horsepower stockcar. While this race course was experienced as very enjoyable, it nevertheless required gradual development of driving skills to maintain control as complexity was progressively increased.

Rehabilitation training in both the road and the race courses followed the same sequence. During low demand/no traffic conditions, subjects practiced:

- (1) Maintaining center lane position:
  - (a) while driving on a straight road and curvy roads.
  - (b) when executing both right and left hand turns.
- (2) Maintaining speed control with the accelerator:
  - (a) following posted speed limits.
  - (b) detecting and responding to speed limiting/altering conditions, e.g., road construction and school zones.
- (3) Appropriate application of brakes:
  - (a) stopping at stop lines.
  - (b) smooth deceleration at signaled stops and rapid deceleration at sudden stops.
  - (c) avoidance of foot confusion, that is, not hitting the clutch or the gas pedal when applying the brakes suddenly.
- (4) Appropriate use of turn signals:
  - (a) using signals at every turn and lane merger.
  - (b) using signals sufficiently before the maneuver so that the rear traffic was adequately notified of the pending maneuver.
- (5) Appropriate use of side and rear view mirrors:
  - (a) periodic checking of mirrors.
  - (b) checking mirrors when passing a slow lead vehicle and merging into traffic.

Once these basic skills were mastered, trainees applied these skills while negotiating progressively heavier and more demanding traffic. Training on these more demanding scenarios focused on tactical driving skills, such as:

- (6) Decision-making on how to manage distracting activities on the side of the road.
- (7) Complex driving maneuvers such as how to pass a slow lead car or how to merge onto the highway.

Trainees were asked to apply the acquired skills to progressively more demanding traffic scenarios using the following 5 training scenarios shown in the order they were presented to the VRDSRT subjects:

- (a) Course 1A4 had no traffic.
- (b) Course 1A3 had only oncoming traffic.
- (c) Course 1A2 had oncoming, same lane and cross traffic.
- (d) Course 1A1 had oncoming, same lane, cross and signaled sudden stop traffic.
- (e) Course 1A had oncoming, same lane, cross, signal sudden stop, and nonsignaled sudden stop traffic.

After each drive the instructor reviewed the successes and shortcomings of the trainee's performance. Immediately before beginning a new scenario the instructor reviewed goals for the upcoming trial. The instructor individualized the training sessions for each subject, in that he determined the number of training sessions required for each subject on the basis

of the rapidity of their progress and aspects of simulator driving that still needed improvement.

## RESULTS

Given the small sample size, descriptive statistics have been presented in Table I. Where appropriate, paired *t*-tests and Pearson's correlations were performed. Since it was predicted that VRDSRT would improve driving performance, one-tailed *p* levels were used.

### Reactions to the Simulator

None of our subjects reported any symptoms related to simulation sickness (SAS) during any of the drives (Table I, B). With regard to the realism of the Model T<sup>3</sup>, the mean subject rating was 3.0 (maximum score = 4), indicating that the simulator provided a realistic driving experience for both the control and VRDSRT subjects (Table I, B). Following training, VRDSRT subjects rated the utility of the road course in improving their driving skills as 4 (maximum score = 4) and the utility of the stockcar race course a mean score of 3.2. VRDSRT subjects consistently rated the race course as 4 in terms of motivating them to return to rehabilitation training. They also felt that providing VRDSRT as a routine clinical service would promote a positive attitude toward the military (mean rating 3.3).

### VRDSRT Effects

Specific performance variables were rated by the examiner at the conclusion of both pre- and postassessment using a 5-point scale that ranged from -2 = "very poor" to +2 = "very good" (Table I, C). Significant pre-post improvements are designated with an asterisk (\*).

VRDSRT led to improvement in driving performance as reflected by several parameters:

- (a) While the controls demonstrated small and random changes in performance variables from pre- to post-assessment, for the VRDSRT group all variables improved at postassessment.
- (b) Statistical analyses demonstrated that none of the pre-post changes for the control group were significant, whereas 5 of 7 performance variables significantly improved from pre- to post-training for the simulator training (STR) group. Specifically, VRDSRT resulted in improved steering on the open roads and when executing turns, better accommodation to unexpected events (e.g., parked car suddenly pulling out in front of driver), and improved compliance to the simulator's instructions where and when to turn and adherence to traffic laws.
- (c) The composite score significantly improved for the VRDSRT group ( $p < 0.01$ ), but not for the controls. As concurrent validation of the composite score, the RBANS significantly correlated with the pre-assessment composite score +0.76 ( $p < 0.01$ ), RBANS did not

correlate with the improvements in the composite score, indicating the effectiveness of VRDSRT was independent of baseline neuropsychological functioning.

Generalization of patients' driving performance from virtual reality driving to routine driving is critical but was not assessed in this feasibility study. However, we assessed certain important aspects of driving behavior with a road rage and a driving risk-taking questionnaire. Control subjects demonstrated a nonsignificant worsening on both of these scales. The VRDSRT group, however, demonstrated a reduction in road rage ( $p = 0.01$ ) and risky driving behaviors ( $p = 0.04$ , Table I, D).

## DISCUSSION

Considering the limited sample size and use of a relatively generic training program delivered by a nonspecialist, the results of the present study are encouraging. Simulator-based driving rehabilitation training was well received by our participants. They found the driving experience realistic and the training useful in improving their driving skills. In addition, they did not experience SAS symptoms in the process, which could have been a major limiting factor for the routine application of VRDSRT.

Although we had anticipated "inattention" and "minimal motivation" as potential barriers to driving rehabilitation, our subjects remained very motivated. They participated in training sessions that went from 60 to 90 min and frequently asked for more time on the simulator. In part and as expected, this was attributable to the "exciting" stockcar race course as part of the rehabilitation training.

While our VRDSRT participants showed significant improvement in their driving performance at post-test, there was further room for improvement. The composite driving performance score ranges from -14 (completely impaired performance) to +14 (perfectly good driving performance) and the mean group performance for VRDSRT subjects was 5.9. Further inspection showed that improvements could be made on all driving parameters assessed but especially in terms of "executing appropriate stops" and "speed control." All VRDSRT participants received the same rehabilitation program, i.e., it was not individualized and patients' specific areas of driving impairment were not specifically considered. We can hypothesize that if VRDSRT was specifically individualized to account for improvements and deficiencies in the driving performance of patients, and appropriately structured (based on the principles of neurologic scaffolding<sup>18</sup>) to account for each patient's strengths and weaknesses, it may have resulted in a more effective rehabilitation program.

This is the first known study to investigate road rage among military personnel recovering from TBI. Our subjects' baseline road rage scores of  $27.5 \pm 6.4$  was significantly higher ( $t = 2.88$ ,  $p < 0.001$ ) than that of an age- and gender-matched non-TBI group ( $20.9 \pm 6.3$ ). However postassessment was not different from the non-TBI sample ( $t = 0.73$ , NS). Consistent

with one other study investigating risky driving (driving without a seat belt and drinking and driving),<sup>1</sup> this study found that at baseline, our TBI subjects reported more risky driving than non-TBI matched subjects ( $22.8 \pm 12$  vs.  $18.3 \pm 5$ ,  $t = 2.01$ ,  $p < 0.05$ ) but not at post-treatment.

In addition to efficacy, it is essential to account for the cost of providing such a rehabilitation service before considering it a success. The Model T<sup>3</sup> costs approximately \$20,000. In this study, training was delivered by a recent college graduate, although in another one of our studies,<sup>19</sup> that demonstrated transfer of training from the simulator to on-road driving, training services to participating novice drivers were delivered by a teenage driver. On the basis of our research experiences, we feel that costs for training services could be quite reasonable, while the benefits could be quite significant in terms of reduced collisions, associated mechanical, medical, and occupational costs in terms of sooner return to active duty.

## Limitations to Our Feasibility Study

As the first published article on driving rehabilitation for individuals recovering from TBI, this study has several limitations: (1) The control group did not receive a placebo condition for driving rehabilitation. (2) There was no demonstration of transfer of training from virtual reality to on-road driving. (3) The sample size was small, and (4) training was provided by a single trainer, which restricts external validity of our findings. The next generation of studies should involve a larger sample size, from multiple centers, delivered by multiple trainees for external validity, with an active placebo condition such as a PC-based driving game to control for attention and time involvement with either an on-road driving exam or the use of in-car video monitoring of routine driving with a device such as DriveCam or SmartDrive to investigate transfer of training.

While generalization from a small sample size should only be done with extreme caution, the reduced power that accompanies a small sample size requires a much larger effect size to achieve statistical significance. Therefore, the significant results from the current study are important to consider. It should also be pointed out that our control subjects were actively engaged in an intense residential rehabilitation program involving occupational, speech, and psychotherapies. Improvement in simulator performance was mirrored by questionnaire results and subjects' self-reports. Further, using a similar training procedure, except without a NASCAR course, delivered by a teenage trainer to novice drivers, we found that virtual reality driving training significantly improved on-road driving.<sup>17</sup>

## CONCLUSION

This feasibility study has shown promising results with respect to the benefits of virtual reality driving simulation rehabilitation techniques in retraining military personnel with TBI to drive better and more safely. It is hoped that these procedures

and findings encourage and facilitate future research and funding in driving rehabilitation.

## ACKNOWLEDGMENTS

The authors gratefully acknowledge the support offered by Dr. Jeffery Barth (director of research), Mr. Gary Levine (speech therapist), and Ms. Kate Bennett (case manager) all at Lakeview Virginia, NeuroCare, Charlottesville, Virginia 22902. The study was supported by a grant from DARPA (Defense Advanced Research Projects Agency) through a Phase 1 SBIR (Small Business Innovation Research) Program.

## REFERENCES

1. Fear NT, Iversen AC, Chatterjee A, et al: Risky driving among regular armed forces personnel from the United Kingdom. *Am J Prev Med* 2008; 35(3): 230–6.
2. Armed Forces Health Surveillance Center: Frequencies, rates, and trends of use of diagnostic codes indicative of traumatic brain injury (TBI), July 1999–June 2008. *MSMR* 2008; 15(10): 2–9.
3. Zoroya G: 360,000 veterans may have brain injuries, *USA Today*, 2009. Available at [http://www.usatoday.com/news/military/2009-03-04-braininjuries\\_N.htm](http://www.usatoday.com/news/military/2009-03-04-braininjuries_N.htm); accessed on June 3, 2009.
4. Langlois JA, Rutland-Brown W, Thomas KE: Traumatic brain injury in the United States: emergency department visits, hospitalizations, and deaths. Atlanta, GA, Centers for Disease Control and Prevention, National Center for Injury Prevention and Control, 2006.
5. Tamietto M, Torrini G, Adenzato M, Pietrapiana P, Rago R, Perino C: To drive or not to drive (after TBI)? A review of the literature and its implications for rehabilitation and future research. *NeuroRehabilitation* 2006; 21: 81–92.
6. Thurman D, Alverson C, Dunn K, Guerrero J, Snizek J: Traumatic brain injury in the United States: a public health perspective. *J Head Trauma Rehabil* 1999; 14(6): 602–15.
7. Rocchio C, Novack TA: Driving after brain injury: issues, obstacles, and possibilities. Vienna, VA, Brain Injury Association of America, 2007.
8. Hawley CA: Return to driving after head injury. *J Neurol Neurosurg Psychiatry* 2001; 70: 761–6.
9. Rike P, Schanke A: Critical factors for safe driving after brain injury: a 6–9 years follow-up study. The International Traffic Medicine Association Annual Conference 2009; paper presentation.
10. Rizzo AS, Kim GJ: A SWOT analysis of the field of VR rehabilitation and therapy. *Presence* 2005; 14(2): 119.
11. Singh H, Barbour BM, Cox DJ: Driving Rehabilitation as Delivered by Driving Simulation (In Press, anticipated date of publication November 2010), in Fisher D, Rizzo M, Caird J, Lee J (Eds.), *Handbook of Driving Simulation for Engineering, Medicine and Psychology*. Boca Raton, FL, CRC Press.
12. Akinwuntan AE, Weerdt WD, Feys H, et al: Effect of simulator training on driving after stroke: a randomized controlled trial. *Neurology* 2005; 65: 843–50.
13. Hu S, Stern RM, Koch KL: Electrical acustimulation relieves vection-induced motion sickness. *Gastroenterology* 1992; 102: 1854–8.
14. White PF, Hamza MA, Recart A, et al: Optimal timing of acustimulation for antiemetic prophylaxis as an adjunct to ondansetron in patients undergoing plastic surgery. *Anesth Analg* 2005; 100: 367–72.
15. Coloma M, White PF, Ogunnaike BO, et al: Comparison of acustimulation and Ondansetron for the treatment of established postoperative nausea and vomiting. *Anesthesiology* 2002; 97: 1387–92.
16. DePasquale JP, Geller ES, Clarke SW, Littleton LC: Measuring road rage development of the propensity for angry driving scale. *J Safety Res* 2001; 32: 1–16.
17. Cox DJ, Mikami A, Cox BS, et al: Impact of long-acting Methylphenidate on routine driving of adolescents with attention-deficit/hyperactivity disorder (ADHD): two case reports. *Arch Pediatr Adolesc Med* 2008; 162(8): 793–4.
18. Park NW, Ingles JL: Effectiveness of attention rehabilitation after an acquired brain injury: a meta-analysis. *Neuropsychology* 2001; 15(2): 199–210.
19. Cox CV, Wharam R, Mourant R, Cox DJ: Does virtual reality driving simulation training transfer to on-road driving in novice drivers? A pilot study. *The Chronicle for Driver Education Professionals* 2009; 57(1): 9–22.