CyberPsychology & Behavior
Volume 6, Number 3, 2003

Exploring the Use of Computer Games and Virtual Reality in Exposure Therapy for Fear of Driving Following a Motor Vehicle Accident

DAVID G. WALSHE,[1] ELIZABETH J. LEWIS,[2] SUN I. KIM, Ph.D.,[3] KATHLEEN O'SULLIVAN,[4] and BRENDA K. WIEDERHOLD, Ph.D., M.B.A., BCIA[5]

ABSTRACT

Specific phobia, situational type-driving, induced by accident (accident phobia) occurs in 18–38% of those involved in a vehicular accident of sufficient severity to warrant referral to the emergency departments of a general hospital.[1] The objective is to investigate, in an open study, the effectiveness of the combined use of computer generated environments involving driving games (game reality [GR]) and a virtual reality (VR) driving environment in exposure therapy for the treatment of driving phobia following a motor vehicle accident (MVA) program. Fourteen subjects who met DSM-IV criteria for Simple Phobia/Accident Phobia and were referred from the emergency department of a general hospital were exposed to a Virtual Driving Environment (Hanyang University Driving Phobia Environment) and computer driving games (London Racer/ Midtown Madness/ Rally Championship). Patients who experienced "immersion" (i.e., a sense of presence with heightened anxiety) in one of the driving simulations (defined as an increase in SUD ratings of 3 and/or an increase of heart rate > 15 BPM in a 1-h trial session of computer simulation driving) were exposed to a cognitive behavioral program of up to 12 1-h sessions involving graded driving simulation tasks with self-monitoring, physiological feedback, diaphragmatic breathing and cognitive reappraisal. Subjects were assessed at the beginning and end of therapy with measurements of: physiological responsivity (heart rate), subjective ratings of distress (SUD), rating scales for severity of fear of driving (FDI), Posttraumatic Stress Disorder (CAPS) and depression (HAM-D) and achievement of target behaviors. Of all patients 7/14 (50%) became immersed in the driving environments. This immersed group (n=7) completed the exposure program. Pre- and post-treatment comparisons showed significant post treatment reductions on all measures SUDS (p = 0.008), FDI (p = 0.008), CAPS (p = 0.008), HR (p = 0.008), CAPS (p = 0.008), HAM-D (p = 0.031). Further analysis of the FDI showed significant reductions in all three subscales: travel distress (p = 0.008), travel avoidance (p = 0.008), and maladaptive driving strategies (p = 0.016). The findings of this study suggest that VR and GR may have a useful role in the treatment of driving phobia post-accident even when co-morbid conditions such as post-traumatic stress disorder and depression are present.

[1]Department of Psychiatry, University College Cork, St. Stephens Hospital, Cork, Ireland.
[2]St. Stephens Hospital, Cork, Ireland.
[3]Department of Biomedical Engineering, Hanyang University, Seoul, Korea.
[4]Department of Statistics, University College Cork, Ireland.
[5]Virtual Reality Medical Center, San Diego, California.

INTRODUCTION

MOTOR VEHICLE ACCIDENTS (MVAs), including those of a non-serious nature, increase the risk of severe psychiatric morbidity in survivors. Fear of driving is a significant consequence of exposure to an MVA. Specific phobia, situational type-driving, occurs in 18–38% of those involved in accidents of sufficient severity to warrant referral to emergency departments of general hospitals.[1] Within the *Diagnostic and Statistical Manual of Mental Disorders*, 4th ed., specific phobia-driving post MVA may be subsumed under the diagnosis of Posttraumatic Stress Disorder where clinical features of both conditions co-exist (specific phobia, criterion F).[2] This may have resulted in focusing on generalized treatments for PTSD in MVA victims to the detriment of treatments for driving phobia. A literature search of treatments for driving phobia/driving anxiety in *Medline, and Psychinfo*, using the phrases *DRIVING PHOBIA TREATMENT/ DRIVING ANXIETY TREATMENT* revealed only six papers, all but one relating to case studies.

The ability of a VR program to desensitize driving fears has been demonstrated in case studies and the advantages of treating phobias in an office environment, in terms of control over exposure stimuli and minimizing exposure of the patient to possible harm or embarrassment, has been discussed.[3–5]

Computer games have recently been successfully adapted to generate environments, and treat specific phobias through again relying on their potential to generate three-dimensional VR environments.[6] An earlier presentation of the first subjects from this study highlighted that, for some phobic drivers, computer game reality (GR) induced a strong sense of presence sometimes to the point of inducing panic.[7]

We sought to investigate in an open study the effectiveness of the combined use of computer generated environments, involving driving games GR and a VR driving environment, in the treatment of driving phobia following MVA, through an exposure program.

MATERIALS AND METHODS

Fourteen subjects with driving phobia post MVA were exposed to a VR driving environment using; a VR simulation developed by Hanyang University and GR simulation with computer driving games (London Racer, Midtown Madness II, Rally Championship) in a graded exposure program.

Participants

To participate in this project, all participants had to meet current DSM-IV criteria for specific phobia, situational type-driving, or posttraumatic stress disorder with the clinical criteria for specific phobia, situational type driving. Subjects with a history of schizophrenia, bipolar affective disorder or other psychoses, or suicidal ideation were excluded. Half of the participants received a diagnosis of specific phobia, situational type, driving (n = 7; 50%), and half received a diagnosis of posttraumatic stress disorder with clinical diagnostic criteria for specific phobia, situational type, and driving (n = 7; 50%).

Five subjects had one current diagnosis (n = 5; 35%), four had two diagnoses (n = 4; 29%), four had three (n = 4; 29%), and one had four (n = 1; 7%). Major depression was the most common co-morbid diagnosis (n = 6).

Screening assessment

To assess if the computer driving tasks would induce a sense of immersion/presence for exposure therapy, inclusion in the study required that subjects rated an increase in distress/anxiety with exposure to driving simulations (VR/GR) over a 1-h session. This was defined as an increase of SUDs rating >3 and/or an increase in measured heart rate >15 beats per minute during driving exposure.

Measures

The Mini International Neuropsychiatric Inventory (MINI) is a structured interview for major Axis I psychiatric disorders in DSM-IV and ICD 10. This was used to screen for current co-morbid diagnoses in the affective, neurotic and substance disorder areas.

The Fear Of Driving Inventory is a 20-item scale with three subscales measuring Travel distress, Travel avoidance and Maladaptive driving strategies designed to measure components of vehicular travel anxiety.

Heart Rate monitoring was undertaken as part of the screening procedure, to provide physiological feedback during sessions and also as a measure of change from first to last session. Maximum heart rate increase and SUD increase at the last treatment visit were compared to readings from the initial assessment visit under standard exposure conditions.

Clinician Administered PTSD scale (CAPS) is a structured clinical interview for assessing both the frequency and the intensity of the seventeen symptoms of PTSD.

Hamilton Depression Scale (HAM-D) is a 21 item screening instrument designed to measure severity of illness in adults already diagnosed as having depression.

Apparatus

The computer used consisted of a 350 MHZ Pentium III processor with 256 RAM and a ATI video card. The virtual driving software for Driving Phobia was created by Sun I Kim, Hanyang University. The computer games utilized were London Racer (Davilex), Midtown Madness II (Microsoft) and Rally Championship (Packard Bell). A WingMan Formula Force GP steering wheel with force feedback and accelerator and brake foot pedals were attached to a desk with 17" monitor. The participant was seated on a car seat positioned on a platform with embedded 2 × 25 W subwoofers and two stereo speakers adjacent to sides of head. A VFX-3D Head Mounted Display transmitted the VR images to the subject and the computer game images were displayed on the monitor or by HMD. VR-generated scenes involved the subject driving in a city scene, in open country, and through a tunnel. The computer games included driving through country and city scenes with varying traffic densities and differing weather and lighting conditions. A heart rate monitor (Healthcare Technology Limited) was used to record heart rate for the screening assessment, for feedback to the subject and as a measure of change.

Hypothesis

A combined VR/GR driving environments would prove effective in inducing a sense of immersion in a cohort of subjects with driving phobia or PTSD with driving phobia. We also proposed that participation in an VR/GR Exposure program of up to 12 sessions would reduce driving anxiety as measured by FDI ratings and subscale ratings, SUD ratings and Heart Rate monitoring, and scoring on CAPS and HAM-D ratings.

Procedure

Subjects were consecutive Accident/Emergency and General Practitioner referrals to a trauma clinic. At first visit all measures above were administered. Thereafter the screening assessment was undertaken to ascertain if the driving simulations (VR and GR) were sufficiently immersive to evoke anxiety (SUDS rating increase >3 and/or heart rate rise >15 BPM).

Fourteen subjects consented to treatment and undertook the screening assessment. Of all subjects, 7/14 (50%) demonstrated an anxiety response on exposure to the simulated driving environments over a one-hour period, this "immersed" group continued to the treatment phase of the study. All screening measures were repeated on conclusion of treatment program.

Treatment

The exposure program took place in a darkened room. Subjects were introduced to computer game driving environments of graded difficulty and to the VR program. The VR program involved driving through a city environment and through a connecting tunnel while wearing a HMD. The GR program involved driving along empty rural roads for initial sessions gradually building up to driving at greater speeds with greater traffic density in rural and city environments. As patients became more comfortable in the GR driving environment, they were set tasks such as overtaking, handling skids, negotiating obstacles and finally entering accident situations including crashing into other vehicles with loss of control. Weekly sessions lasted approximately 1 h, broken into, on average, three driving exposures lasting approximately 15 min.

Diaphragmatic breathing was taught to manage physical symptoms of anxiety and cognitive restructuring to challenge irrational thoughts. No formal exposure homework tasks were set but subjects were encouraged to drive to the degree that they felt comfortable.

Statistical analysis

Fishers Exact Tests was performed to investigate if the "immersed" and the "failure to immerse" groups differed with respect to gender, a diagnosis of PTSD with driving phobia, and co-morbid diagnoses. Mann-Whitney *U* tests were performed to test for differences between these two groups on the FDI and subscales (two-tailed test). The Wilcoxon Signed Ranks Test (W.S.R.T.), a non-parametric test was used to test for differences between scores recorded at pre- and post-treatment for the "immersed" group who went forward for the exposure

program (one-tailed test). The level of significance was determined at $p < 0.05$. The median and interquartile range (IQR) was used to summarize scores for each variable. Subscales from the FDI were further analyzed with the W.S.R.T.

RESULTS

The immersed group did not differ significantly from the failure to immerse group with respect to gender ($p = 0.266$), presence of PTSD with driving phobia ($p = 0.286$), and presence of co-morbid diagnoses ($p = 1.00$) (Table 1).

Again the two groups did not differ significantly with regard to scoring on the FDI and its subscales (Table 2).

For the treatment group ($n = 7$), pre-treatment scores were higher than post-treatment scores across all variables measured. Significant reductions were found in subjective distress (SUDS; $p = 0.008$), driving anxiety (FDI; $p = 0.008$), post-traumatic stress disorder rating (CAPS; $p = 0.008$), heart rate rise (HR; $p = 0.008$), and depression ratings ($p = 0.031$) with repeated exposure to the simulations (Table 3).

Subscale analysis of the FDI showed significant reductions in all three subscales: travel distress

TABLE 1. COMPARISON OF IMMERSED AND FAILURE TO IMMERSE GROUP

	Immersed group, n = 7	*Failure to immerse group, n = 7*	*p*
Gender	4 f/3 m	1 f/6 m	0.266
Driving phobia/ PTSD with driving phobia	5/2	2/5	0.286
Co-morbid diagnoses	4	3	1.00

TABLE 2. COMPARISON OF THE IMMERSED AND FAILURE TO IMMERSE GROUP ON THE FDI AND ITS SUBSCALES

	Immersed group (n = 7)		*Failure to immerse group (n = 7)*		
	Median	*IQR*	*Median*	*IQR*	p
FDI (total score)	**43**	**36–55**	**35**	**30–43**	**0.244**
Distress subscale	16	11–22	14	7–16	0.315
Avoidance subscale	13	11–17	9	8–15	0.244
Strategies subscale	17	10–19	14	10–20	0.977

TABLE 3. MEDIAN AND I.Q.R. SCORES OF TREATED GROUP ON THERAPY OUTCOME MEASURES

	Pre-treatment		*Post-treatment*		
	Median	*IQR*	*Median*	*IQR*	*p*
SUDS ($n = 7$)	6	4–7	0.5	0.5–1.5	0.008
FDI ($n = 7$)	43	36–55	16	10–19	0.008
CAPS ($n = 7$)	21	15–33	9	2–15	0.008
HR ($n = 7$)	20	13–27	7	4–7	0.008
HAM-D ($n = 6$)	10	4–15.25	3	2–6.75	0.031

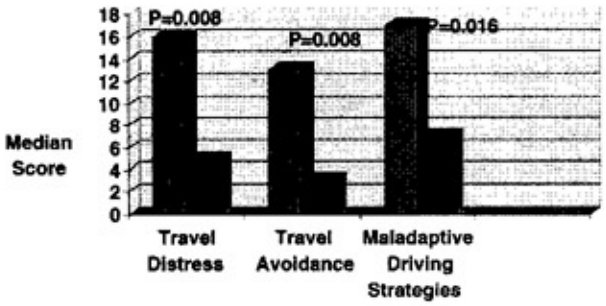

FIG. 1. Median scores of treated group on FDI subscales. ▒, pretreatment; ■, post-treatment.

($p = 0.008$), travel avoidance ($p = 0.008$), and maladaptive driving strategies ($p = 0.016$) (Fig. 1).

DISCUSSION

In this open trial of VR and GR for driving phobia post-MVA, the combination of exposure to VR driving simulation and GR driving tasks induced task specific anxiety or immersion in the task in 50% (7/14) of the sample. Significant reduction in scoring was found across a number of outcome variables between the pre treatment and post treatment phase of the program for the seven treated subjects. Subjective distress ratings (SUDS) reduced over the course of the treatment program for treated subjects, as one would predict with repeated exposure. This reduction in distress was reflected in a reduction in reported driving fears on the FDI with a reduction in each of the three subscales travel distress, travel avoidance and maladaptive driving strategies. These findings were in keeping with clinical reports that participants were expanding their driving practices and traveling by vehicle with less anxiety, showing that skills learned in the simulated environment were generalized to real-world tasks. Heart rate increases reduced significantly between first and last session suggesting that habituation on a psychological level was matched with physiological habituation. Of further interest, scores on our measure of posttraumatic stress disorder also reduced significantly with treatment although no attempt was made to focus on the accident experiences of subjects. This supports Rothbaum et.al. findings with Vietnam veterans that VR can play a role in treating PTSD.[8] Again, depression scores reduced also suggesting that treatment effects may extend beyond phobia treatment.

For half of the study group, GR/VR did not induce a sense of presence/immersion as defined by physiological and/or subjective report of increased anxiety with exposure to the driving environments. Other clinicians have noted that some patients require several sessions to achieve immersion or presence. Further refinement of VR/GR environments could increase the "hit" rate in achieving immersion for patients. Some subjects had considerable prior exposure to computer games and were dismissive of GR and, to a lesser extent, VR environments. The mindset of some subjects may also have been a factor. VR/GR requires a willingness to enter into an altered reality with a "suspension of disbelief." These issues were not addressed in preparation for the exposure. Force feedback in the steering wheel was not available for 2/3 GR environments or for VR. Subjects reported a stronger sense of presence where force feedback was available.

Viewing the driving GR scenes on a 17-inch monitor predominantly may have been a further limiting factor. However some subjects reported that use of a HMD was disorientating as the steering wheel could not be seen and the image was not as clear. We presently use a projector projecting onto a screen 5 × 4 feet and subjects report an augmented effect.

The VR exposure appeared particularly useful for those with a claustrophobic or agoraphobic sense to their disorder and those who were not driving prior to the program. However as with GR some subjects found it difficult to navigate wearing a HMD during the VR exposures and were unsettled if inadvertently they drove through buildings or walls.

Projection onto a large screen or CAVE environment as recommended by the developer would be beneficial. Some of those with restricted driving prior to treatment did not find the VR simulations sufficiently challenging with regard to near accident situations. The Hanyang VR driving program has recently been further developed and refined. Comparative studies are required to investigate the relative advantages on GR/VR and also whether there are advantages in progressing to accident situations in simulated driving.

In conclusion, the findings of this study suggest that VR and GR may have a useful role in the treatment of driving phobia post accident even when co-morbid conditions such as post-traumatic stress disorder and depression co-exist, though findings would suggest that further refinement of programs could result in a higher "hit rate," that is, inducing presence/immersion in a greater percentage of subjects and in turn increasing the viability of VR/GR as an exposure treatment for driving anxiety.

Limitations of study

This study was exploratory. There was no control group to control for time effects, no comparison with treatment *in vivo*, no direct measures of driving exposure or driving anxiety *in vivo*, and no follow-up post-treatment.

Further investigations should focus on these limitations and in-depth comparison of VR and GR as treatment modalities.

ACKNOWLEDGMENTS

This study was supported by an educational grant from Pfizer Pharmaceutical Ireland.

REFERENCES

1. Blanchard, E.B., & Hickling, E.J. (1988). Motor vehicle accident survivors and PTSD. *PTSD Research Quarterly* 9:1–6
2. *Diagnostic and Statistical Manual of Mental Disorders,* 4th ed. (1994). Washington, DC: American Psychiatric Association.
3. Wald, J., & Taylor, S. (2000). Efficacy of virtual reality exposure therapy to treat driving phobia: a case report. *Journal of Behavior Therapy and Experimental Psychiatry* 31:249–257.
4. Wiederhold, B.K., Jang, D.P., Kim, S.I., et al. (2001). Using advanced technologies in the treatment of fear of driving. Presented at Medicine Meets Virtual Reality: Outer Space Inner Space Virtual Space.
5. Rothbaum, B.O., & Hodges, L.F. (1999). The use of virtual reality exposure in the treatment of anxiety disorders. *Behavior Modification* 23:507–525.
6. Bouchard, S., Renaud, P. (2002). Using 3D computer games to conduct VR exposure for phobias. *MMVR 02/10 Digital Upgrades: applying Moores Law to Health.* p. 44.
7. Walshe, D.G., Lewis, E.J., Brosnan, A., et al. (2002). Computer games and VR in the treatment of accident phobia. *MMVR 02/10 Digital Upgrades: applying Moores Law to Health.* p. 175.
8. Rothbaum, B.O., Hodges, L.F., Alarcon, R., et al. (1999). Virtual reality exposure therapy for PTSD Vietnam veterans: a case study. *Journal of Traumatic Stress.* 12:263–272.

Address reprint requests to:
David G. Walshe
Department of Psychiatry
University College Cork
St. Stephens Hospital
Cork, Ireland