Revista Brasileira de Psiquiatria. 2018;40:192–199
Brazilian Journal of Psychiatry
Brazilian Psychiatric Association
CC-BY-NC | doi:10.1590/1516-4446-2017-2270

ORIGINAL ARTICLE

Virtual reality exposure therapy for fear of driving: analysis of clinical characteristics, physiological response, and sense of presence

Rafael T. da Costa,[1,2,3,4] Marcele R. de Carvalho,[1,2,3,4] Pedro Ribeiro,[1,5] Antonio E. Nardi[1,2,3]

[1] *Instituto de Psiquiatria, Universidade Federal do Rio de Janeiro (UFRJ), Rio de Janeiro, RJ, Brazil.* [2] *Instituto Nacional de Ciência e Tecnologia (INCT), Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), Rio de Janeiro, RJ, Brazil.* [3] *Laboratório de Pânico e Respiração (LabPR), Rio de Janeiro, RJ, Brazil.* [4] *Núcleo Integrado de Pesquisas em Psicoterapia nas Abordagens Cognitivas e Comportamentais (NIPPACC), Instituto de Psiquiatria (IPUB), UFRJ, Rio de Janeiro, RJ, Brazil.* [5] *Escola de Educação Física e Desportos, UFRJ, Rio de Janeiro, RJ, Brazil.*

Objective: To investigate the reactions of women with driving phobia to a therapeutic program of scheduled virtual reality exposure treatment (VRET) sessions.
Methods: The study intervention consisted of a computer game with car-driving scenarios that included several traffic situations. We investigated the participants' sense of presence, subjective distress, and physiological responses during eight virtual-reality exposures. We also evaluated clinical characteristics, driving cognitions, and quality of life in the participants.
Results: Thirteen women were selected. Eight were able to complete the protocol. After VRET, there was a decrease in the frequency of distorted thoughts and state anxiety scores, as well as a slight improvement in quality of life. Subjective discomfort scores, heart rate variation, and sense of presence scores confirmed that there was sense of presence in the virtual reality environment.
Conclusion: All patients showed some degree of improvement and demonstrated different levels of anxiety in subsequent in vivo driving experiences. Our findings suggest that VRET could be used to facilitate in vivo exposure, because it can induce presence/immersion and reduce anxiety in patients with specific phobia. Furthermore, VRET is not associated with any type of risk.

Keywords: Virtual reality; behavior therapy; fear of driving

Introduction

Specific phobia is a marked and persistent fear that is excessive or unreasonable, cued by the presence or anticipation of a specific object or situation. Exposure to the phobic stimulus almost invariably provokes an immediate anxiety response, which may take the form of a situationally bound or situationally predisposed panic attack.[1]

Driving phobia is a specific phobia characterized by intense, persistent fear of driving (FoD), which increases as the individual anticipates or is exposed to driving stimuli.[1] This specific phobia typically occurs in young to middle-aged adult women,[2,3] and renders them either unable to drive or only able to drive with considerable distress.[4] Driving phobia does not improve or resolve without treatment, and it can become chronic.[2,3,5] Thus, driving phobia can cause problems such as restricted freedom, career impairment, and social embarrassment.[1,2]

FoD is generally attributed to traumatic experiences and personality traits, including accidents, dangerous traffic situations, being assaulted while driving, seeing someone else experience a traumatic event while driving, being a generally anxious individual, and being generally afraid of high speed.[6,7]

Road trauma can cause psychological symptoms that include irritability, anger, insomnia, nightmares, headaches, and avoidance behavior.[8] Regarding the latter, people with fear of driving may avoid it in certain situations, or may exhibit avoidance behaviors toward any situation related to driving.[9]

Accordingly, posttraumatic stress disorder is the psychiatric disorder most commonly associated with driving phobia; however, social phobia, panic disorder, and/or agoraphobia have also been reported in the research literature.[2,3,10-13]

People with FoD often display dysfunctional safety behaviors in an attempt to protect themselves from unpredictable dangers when driving.[9,14] An evaluation of accident survivors found that approximately 20% develop an acute stress reaction; out of this subgroup, 10% eventually develop a mood disorder, 20% present phobic travel anxiety, and 11% develop posttraumatic stress disorder.[2]

Overestimation of fear is a common cognitive distortion in cases of driving phobia. These thoughts can increase uncomfortable feelings of vulnerability, maintaining anxiety and fear reactions.[9,15] In addition, it is possible that people with driving phobia misjudge their own skills and

Correspondence: Rafael T. da Costa, Av. Pres. Vargas, 633, sala 1718, Centro, CEP 20071-004, Rio de Janeiro, RJ. Brazil.
E-mail: faelthomaz@gmail.com
Submitted Mar 08 2017, accepted Jun 13 2017, Epub Feb 15 2018.

abilities and those of other drivers, thereby increasing anticipatory anxiety as well as avoidance behavior.[16-18]

The most feared driving situation cited by driving phobics is a motor vehicle accident (MVA).[18,19] Nevertheless, subjects also mention the following issues: issues of control, such as losing control of the car, not being in control of the driving situation, and being in control of a powerful vehicle; issues surrounding specific driving situations, including driving at high speed, driving at night, driving in unfamiliar areas, driving over bridges, driving through tunnels, driving on steep roads or open roads, merging, and changing lanes; issues surrounding the skills required for driving, including reaction time, judgment errors, weather conditions, and road conditions[12,16,18,20,21]; as well as fear of being criticized by someone while driving.[11,18,21]

Research by the Brazilian Association of Traffic Medicine[22] revealed that FoD affects 10% of all Brazilians who are eligible to drive, which corresponds to about 2 million people. It is interesting to note that 85% of these are car owners. Bellina[22] investigated 4,000 subjects with FoD and found that 28% of these had never been involved in an MVA, while 40% had, but not as the driver; 85% of the subjects were women, and most were aged 30 to 48 years.

Behavioral therapy, using in vivo exposure, has proven effective in the treatment of specific phobias. Wolitzky-Taylor et al.[23] conducted a meta-analysis of 18 studies comparing one or more in vivo exposure treatments to a wait-list control condition. This comparison yielded a large overall effect size ($d = 1.05$, $p < 0.001$) and significant heterogeneity across studies ($Q_{44} = 121.08$). Effect sizes for this comparison were similar for behavioral ($d = 1.16$) and questionnaire ($d = 1.00$) measures ($p < 0.001$).

Although we know the behavioral approach has good results in the treatment of specific phobias,[23] about 60% of people with driving phobia report such intense discomfort that they do not consider themselves able to start treatment or training that would involve in vivo exposure. Thus, alternative interventions that can increase the sense of self-efficacy are very important.[22]

Powers & Emmelkamp[24] analyzed 11 studies that applied virtual reality exposure treatment (VRET) for anxiety disorders. Most studies of such interventions have been conducted with specific phobias, especially fear of flying and acrophobia. Random-effects analysis yielded a mean overall effect size (Hedge's g = 1.08, standard error [SE] = 0.14, 95% confidence interval [95%CI] 0.80-1.35; Cohen's $d = 1.11$ [SE = 0.15, 95%CI 0.82-1.39]) indicating a large effect for VRET relative to control conditions ($p < 0.05$). This evidence suggests that VRET can be an important tool to increase sense of self-efficacy in individuals with FoD. Furthermore, virtual-reality interventions let driving phobics improve driving skills and identify and resignify cognitive distortions without any actual risk exposure.

Virtual reality exposure integrates real-time computer graphics, sounds, and other sensory inputs to create a computer-generated world in which the subject can participate.[16,22,23,25] A successful virtual experience occurs when the users have a sense of presence, defined as a sensation of being inside the virtual environment.[26-30]

According to Bellina,[22] recent literature has demonstrated that the more immersive the scenario is, the more intense the subsequent emotional state elicited. Specifically, immersive scenarios can increase the sense of presence, or the illusion of "being there."

Virtual reality allows assessment of clinically relevant verbal, motor, and physiological fear reactions.[20,23] It provides the observer with a level of sensory realism that approaches the experience of the real world, while controlling the situation and most of the stimuli, thus making it possible to simulate realistic situations and induce emotions in a controlled, standardized way.[31,32] Additionally, the artifacts usually induced by uncontrollable factors in real environments are eliminated.[22,23]

The objective of this paper was to investigate the reactions of driving-phobic women when placed in a virtual environment simulating driving. A computer game with car-driving scenarios that included several traffic situations was used to investigate the participants' sense of presence, subjective distress, and physiological responses during eight virtual sessions. The participants' clinical characteristics, driving cognitions, and quality of life (QoL) were also evaluated.

Methods

Participants

Thirteen women were originally enrolled in the study. However, five were excluded because they also met criteria for other mental disorders, as diagnosed using the Mini International Neuropsychiatric Interview (MINI)[30] (one each with panic disorder and agoraphobia, social anxiety disorder, posttraumatic stress disorder, generalized anxiety disorder, and bipolar disorder). These five subjects were referred for other treatment.

Mean (SD) age was 43.14 (13.91) years. Five subjects were married, one was divorced, and two were single. Regarding educational attainment, five had a university education (one incomplete), two had completed high school, and one had a primary education.

All eight selected participants had driving phobia as their only diagnosis, met all inclusion criteria, responded to all scales, and participated in all virtual exposure sessions. None of the subjects had prior exposure to computer games.

Instruments

All scales and questionnaires were administered by a researcher who did not participate in VRET.

- Questionnaires: used to collect personal data and information on driving, developed specifically for this study.
- MINI[33]: used to diagnose possible comorbid disorders.
- Structured Clinical Interview for DSM-IV Axis II (SCID-II)[34]: used to investigate personality disorders.
- Beck Depression Inventory (BDI)[35]: the BDI, a 21-item, self-report rating inventory, was used to assess mood symptoms before and after VRET.
- Hamilton Anxiety Scale (HAM-A)[36,37]: a scale of 14 items, each defined by a series of symptoms, that measures

both psychic anxiety (mental agitation and psychological distress) and somatic anxiety (physical complaints related to anxiety). It was used to assess anxiety symptoms before and after VRET.
- State-Trait Anxiety Inventory (STAI)[38,39]: this instrument consists of 20 items for assessing trait anxiety and 20 for state anxiety. All items are rated on a 4-point scale (e.g., from almost never to almost always). It was applied to evaluate trait and state anxiety before and after VRET.
- Driving Cognitions Questionnaire (DCQ)[40,41]: used to investigate cognitive distortions before and after VRE. The DCQ is a 20-item scale that measures three areas of driving-related concerns: panic-related, accident-related, and social concerns.
- The Igroup Presence Questionnaire (IPQ)[42]: used to measure the sense of presence experienced at the end of each virtual exposure. The IPQ has three subscales (Spatial Presence, Involvement, Experienced Realism) and one additional general item not belonging to a subscale.
- Subjective Units of Distress Scale (SUDS)[43]: used to measure subjective discomfort during each 10-minute segment of VRET. The SUDS has a score range between 0-100.
- The Medical Outcomes Survey SF-36 (MOS SF-36)[44,45]: used to evaluate QoL before and after VRET. The MOS SF-36 was designed to measure health status (broadly defined) and to examine limitations in functioning related to physical activity, social activities, functioning in specific areas, and general health.
- Heart rate monitoring was undertaken as part of the procedure, to provide physiological feedback during sessions, and as a measure of change from the first session to the last.

Inclusion and exclusion criteria

Participants were required to be between 18 and 60 years old, meet the DSM-IV criteria for driving phobia, and have a driver's license or at least have completed driving school training up to the final practical exam (i.e., they had completed the theoretical test and the practical driving lessons).

Potential participants were excluded if they had a comorbid personality disorder and/or any other Axis I psychiatric disorder, as were those with any severe physical illness and those who were using sedative drugs (barbiturates and benzodiazepines), those who abused alcohol or illicit drugs, and those with any problem that made it impossible for them to drive.

Research procedures

Prior approval of the study protocol was obtained from our local ethics committee at Instituto de Psiquiatria, Universidade Federal do Rio de Janeiro, in compliance with the principles of the Declaration of Helsinki.

Participants were recruited from Universidade Federal do Rio de Janeiro (UFRJ) and driving schools. Recruitment of subjects was done through posters containing information on the study, which were posted in the outpatient Institute of Psychiatry and Psychology at UFRJ and at local driving schools, and through posts on social media online. The first contact was made via email, which allowed collection of personal data. The second contact, with the purpose of scheduling the evaluation interview, was done by telephone.

Patients were considered eligible if they complained of FoD and provided written informed consent for participation. They then completed questionnaires to collect personal data and information on driving, and were interviewed using the MINI.[33] If the participants met the inclusion and exclusion criteria, the additional clinical data scales were administered.

After these steps, subjects participated in virtual exposure sessions. Heart rate was monitored during VRET (in Hz resolution), but spot measurements were also obtained every 10 minutes. Patients were asked to report their level of discomfort (on a scale of 0-100) before VRET sessions (baseline) and every 10 minutes during the 50-minute exposure. Heart rate and SUDS scores at the last session were compared to measures from the initial assessment under standard exposure conditions.

During the first session, the patients received instructions about how to use the device. The hierarchy of stimuli in the virtual environment, which was used to expose participants gradually to uncomfortable situations over a 50-minute period, was as follows: Session 1, Getting a driver's license – parallel parking; Session 2, Residential road – no others cars on the street; Session 3, Residential road – normal traffic and few pedestrians; Session 4, Street with heavier traffic and pedestrians; Session 5, Street with very heavy traffic and many pedestrians; Session 6, Highway – normal traffic; Session 7, Highway – many cars, high speed, tunnel; and Session 8, Street with traffic jam, tunnel, roadworks.

During virtual exposure, patients could talk to the researcher, who was sitting in the "passenger seat." There was no standard tool for restructuring dysfunctional thoughts. The only verbal interventions performed aimed to test the evidence for or against the cognitive distortions (e.g., "Why do you believe this thought is true/false?") and to encourage the subject to continue the exposure (e.g., "Let's go, you can do it," "Don't give up," "You've already overcome other challenges.").

After each virtual exposure session, the participants completed the IPQ.

Statistical analysis

All statistical procedures were performed using SPSS version 17.0. To compare, correlate and analyze the scale scores, we used the Wilcoxon test (a nonparametric hypothesis test used to compare repeated measurements on a single sample to assess whether their population mean ranks differ) and Spearman's rank-order correlation (a nonparametric version of the Pearson product-moment correlation). The level of significance was defined as $p < 0.05$.

Apparatus

The virtual driving software used was 3D Driving School – Europa Edition 5.1 (Softonic, Germany). This computer game provides basic driver training in a small-town environment, featuring different traffic rules and countries (France, Netherlands, Belgium, and Germany). Elements of the game that can be controlled include the weather, time of day, number of pedestrians, traffic density, and setting (e.g., highway, city, countryside, etc.).

The computer used in the current study consisted of a 350 MHZ Pentium III processor with 256 MB RAM and an ATI video card. A Sport Racing steering wheel with force feedback, accelerator, and brake foot pedals (attached to a desk) and a 32-inch LCD TV/monitor with 3440 × 1440 resolution, which provides a pixel density of 109.68 PPI – UltraWide quad-high definition (QHD) display, were attached.

Each participant sat at a desk with two stereo speakers and a subwoofer adjacent to the sides of her head, and a Biopac MP data acquisition system was used to record heart rate.

Results

Personal characteristics

More than half of the participants had a higher education. All eight participants had a driver's license, and had held it for a mean (SD) of 13.14 (12.92) years (range, 1 month to 30 years).

There was a high percentage of participants who reported a first-degree relative with driving phobia (57.14%).

The most-feared driving scenarios were rush hour, passing/overtaking, and mountain driving. The least frequently cited scenarios were parking in the garage at home and parking at 90 degrees (Table 1).

Mood scales

In the BDI, clinical scores are categorized as indicative of subclinical, mild, moderate, or severe depression (0-11, 12-19, 20-35, and 36-63, respectively).[34,35] The mean score of 12.86 in the sample indicated mild depression levels. Low anxiety scores at baseline were identified in the HAM-A (14.29).[36,37]

In contrast, participants' state and trait anxiety scores were high. The range of scores for each subtest on the State Anxiety scale is 20-80, and a cutoff score of 39-40 has been suggested to indicate clinically significant symptoms.[46,47] As expected, the participants scored higher than normal. However, when comparing the baseline and 8th session scores, the only significant difference was found in the state anxiety scores (p = 0.01) (Table 2).

Table 1 Driving information (n=8)

Variable	Result
Time as licensed driver (years), mean ± SD	13.14±12.92
Family	
Any relatives with fear of driving	57.14
Motor vehicle accident	
Yes	71.43
As driver	0
Feared driving situations	
Home garage	14.29
Parking at 90 degrees	14.29
Parallel parking	28.57
Parking on a hill	57.14
Highway	57.14
Rush hour	85.71
Mountain driving	71.43
Traffic jam	57.14
Natural events (torrential rain/hail/mist/strong winds)	28.57
Overtaking	71.43
Crossing intersections	42.86

Data presented as percentages (%), unless otherwise specified.

Driving cognitions

DCQ scores were lower after eight sessions of VRE. Dysfunctional thoughts while driving were less frequent, but the difference was not statistically significant.

Quality of life

Analysis of SF-36 scores at each time point revealed that all scores were similar or higher after the 8 sessions compared to baseline, with statistically significant differences on two subscales: vitality and mental health.

Data for all QoL subscales are shown in Table 2.

Sense of presence

Measurement of the sense of presence at the end of each VRET session showed no significant differences between scores when comparing the current session to the subsequent session. However, when comparing the first and last sessions, a significant difference in sense of presence was observed (Table 3).

SUDS and physiological data

Table 4 shows mean subjective discomfort scores and heart rate during VRET.

Figure 1 shows the mean SUDS scores and heart rate (beats per minute) at baseline and after each 10-minute increment of the total 50 minutes of a virtual exposure session.

Table 5 shows the correlation between mean SUDS scores and heart rate.

At the end of eight virtual exposure sessions, two patients said they would seek individual psychotherapy, three said they would take driving lessons with an instructor, three preferred to attend a specialized driving school for clients with FoD, one participant started driving with the help of her fiancé, and one started driving with or without her husband, but still reported severe discomfort.

Discussion

VRET was well tolerated by all participants, as evidenced by the fact that 100% of them completed the eight intervention sessions.

When evaluating the most feared situations cited by participants, it is important to consider the city context in

Table 2 Mean mood, anxiety, cognitive distortions and quality of life scores (n=8)

	Baseline			8th session		
	Mean (SD)	Min	Max	Mean (SD)	Min	Max
Beck Depression Inventory	12.86 (4.67)	6.00	19.00	10.00 (3.05)	4.00	13.00
Hamilton Anxiety Scale	14.29 (6.29)	6.00	23.00	12.00 (5.57)	5.00	21.00
Trait anxiety (STAI)	43.71 (8.77)	27.00	52.00	41.86 (8.05)	29.00	53.00
State anxiety (STAI)	43.57* (9.27)	29.00	55.00	38.43* (6.08)	28.00	45.00
Driving cognitions questionnaire	49.29 (12.11)	35.00	69.00	42.57 (11.82)	28.00	56.00

	Mean (SD)	**Mean (SD)**
SF-36 – Quality of life		
Physical functioning	75.714 (14.56)	82.14 (9.51)
Role physical	75.00 (38.19)	86.43 (16.26)
Bodily pain	62.00 (24.25)	66.29 (22.46)
General health	73.86 (11.22)	79.14 (8.59)
Vitality	59.29 (19.24)	67.14 (18.22)*
Social functioning	62.50 (26.02)	75.00 (20.41)
Role emotional	71.43 (29.99)	71.43 (23.00)
Mental health	54.86 (6.41)	65.14 (9.99)*

Data presented as mean (standard deviation)
Max = maximum; Min = minimum; SD = standard deviation; STAI = State-Trait Anxiety Inventory.
* Significant differences between the baseline and week 8: $p < 0.05$.

Table 3 Mean sense of presence scores (n=8)

	Mean (SD)	Median	Minimum	Maximum
Session 1	27.71 (8.01)*	29.00	16.00	36.00
Session 2	21.43 (6.35)	22.50	11.00	29.00
Session 3	23.43 (13.06)	25.50	10.00	28.00
Session 4	21.57 (13.88)	23.00	9.00	26.00
Session 5	21.57 (12.57)	22.00	10.00	26.00
Session 6	20.29 (10.48)	22.00	9.00	24.00
Session 7	18.29 (10.29)	21.50	9.00	23.00
Session 8	18.29 (11.21)*	21.50	10.00	23.00

SD = standard deviation.
* Significant differences between baseline and week 8: $p < 0.05$.

Table 4 Mean subjective discomfort scores and heart rate during VRET (n=8)

Session	Baseline	0 min	10 min	20 min	30 min	40 min	50 min
SUDS							
Session 1	0 (0)	58.33 (19.41)	65.00 (19.75)	78.33 (14.38)	74.17 (17.44)	81.67 (18.35)	70.83 (16.25)
Session 2	0 (0)	9.17 (11.14)	46.00 (20.74)	52.00 (26.83)	56.00 (37.81)	64.00 (21.91)	62.00 (25.88)
Session 3	0 (0)	16.00 (20.73)	52.00 (34.20)	62.00 (14.83)	72.00 (19.23)	47.00 (4.47)	54.00 (11.40)
Session 4	0 (0)	8.00 (17.89)	37.00 (15.65)	70.00 (24.49)	66.00 (23.02)	67.00 (29.92)	44.00 (18.17)
Session 5	0 (0)	20.00 (23.45)	44.00 (25.10)	65.00 (31.22)	58.00 (28.63)	60.00 (30.82)	65.00 (39.37)
Session 6	0 (0)	12.00 (21.67)	55.00 (22.36)	57.00 (23.34)	59.00 (27.02)	64.00 (26.08)	48.00 (13.04)
Session 7	0 (0)	22.00 (21.68)	56.00 (27.02)	61.00 (15.16)	54.00 (18.17)	59.00 (18.84)	36.00 (21.91)
Session 8	0 (0)	20.00 (18.26)	50.00 (29.44)	52.50 (29.86)	55.00 (36.97)	55.00 (36.97)	37.50 (18.93)
Heart rate (bpm)							
Session 1	79.33 (4.32)	90.00 (6.69)	91.67 (8.43)	94.33 (8.71)	92.33 (9.83)	95.33 (11.64)	89.67 (9.99)
Session 2	78.23 (5.40)	82.00 (4.47)	86.00 (4.00)	85.60 (4.77)	88.40 (7.13)	91.60 (10.81)	90.00 (10.95)
Session 3	79.10 (4.50)	81.60 (5.17)	89.00 (5.38)	88.40 (5.37)	92.60 (10.85)	84.40 (4.34)	86.00 (6.32)
Session 4	80.10 (5.51)	80.80 (2.28)	84.80 (2.28)	93.20 (8.67)	90.40 (3.58)	91.20 (6.26)	85.20 (4.60)
Session 5	79.45 (4.47)	83.20 (5.40)	85.00 (7.00)	88.80 (7.82)	89.20 (8.32)	89.20 (8.90)	91.60 (7.54)
Session 6	80.15 (6.17)	82.80 (5.76)	87.60 (5.18)	88.80 (5.40)	89.80 (7.89)	91.00 (7.28)	84.00 (2.45)
Session 7	78.17 (4.67)	83.40 (6.23)	88.80 (7.56)	87.60 (4.39)	86.40 (4.33)	86.00 (3.16)	81.60 (4.34)
Session 8	79.17 (5.17)	78.00 (7.48)	84.50 (4.12)	86.50 (5.74)	87.00 (7.02)	86.75 (6.40)	81.50 (3.41)

Data presented as mean (standard deviation).
bpm = beats per minute; min = minutes; SUDS = Subjective Units of Distress Scale.

which the study participants live and the settings they will have to overcome if they start driving in real-life situations. Rio de Janeiro is a large city with heavy traffic and highly stressed drivers, especially during rush hour. The topography of the city features many hills and tunnels, and the vast majority of cars have manual transmission ("stick shift").

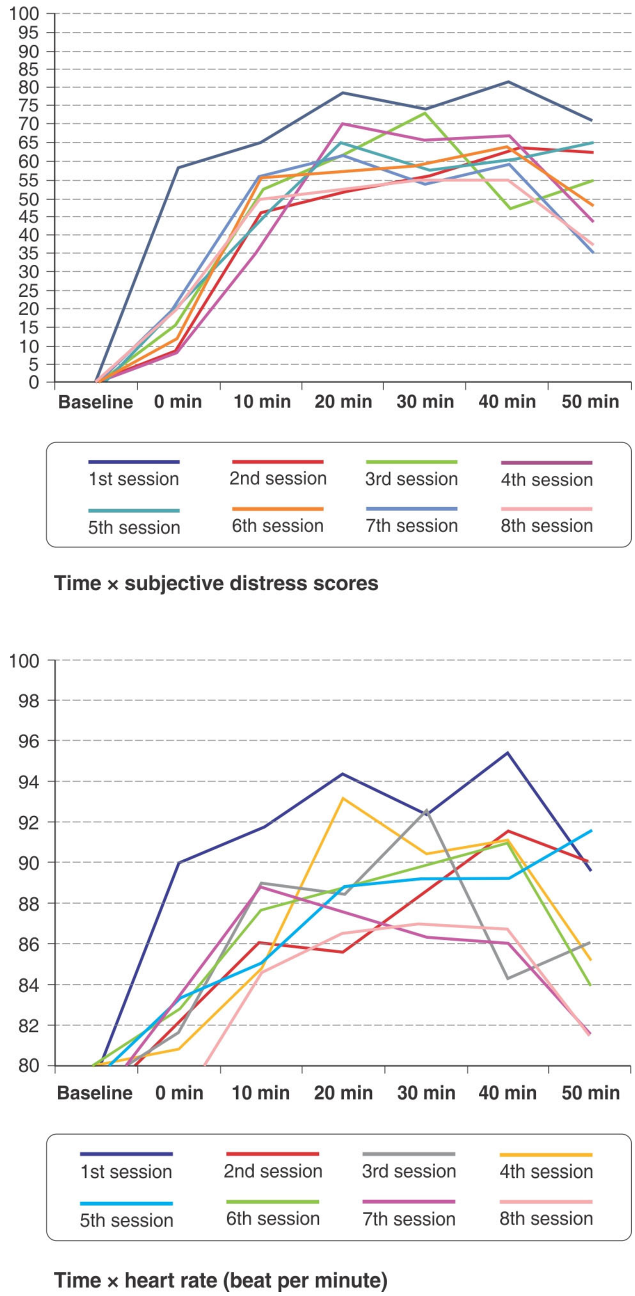

Figure 1 Subjective distress scores and heart rate over time

Five of the eight participants had experienced an MVA, although none was driving when the accident occurred. This finding may indicate the influence of classic or Pavlovian conditioning[48] as well as operant conditioning of avoidance behavior (negative reinforcement).[49]

Although there was no significant reduction in BDI and HAM-A scores, it is important to note that the participants already had low scores at baseline. Regarding STAI scores, it is interesting to observe the significant reduction in state anxiety scores. State anxiety can be defined as fear, nervousness, discomfort, and arousal of the autonomic nervous system induced temporarily by situations perceived as dangerous. In turn, trait anxiety can be defined as a relatively enduring disposition to feel stress, worry, and discomfort. Thus, it is understandable that there would be a change in state anxiety, but not trait anxiety, scores after VRET.

Regarding QoL, we observed an increase in almost all of SF-36 subscale crude scores, although there were statistically significant differences for only two subscales (vitality and mental health). Another article that investigated QoL after VRET showed improvement in three subscales – physical functioning, social functioning, and mental health.[18] We cannot state that a direct correlation exists between improvement in FoD and better QoL; further research is needed.

According to Jang et al.,[8] heart rate can be used as an objective measure for monitoring participant reactions during VRET, and it may be useful for assessing the emotional state of participants. There was a high correlation between SUDS scale scores and heart rate in the present studies. Both of these findings, as well as their correlation, are important to show that subjective and objective measures can be combined to increase study reliability. Taken together with the IPQ scores, the SUDS scores and heart rate variation measured provide evidence that participants experienced a sense of presence during the exposures; in other words, participants felt immersed in the virtual environment.

It is important to point that our VRET protocol was designed with progressive difficulties of generic driving situations rather than with the driving stimuli specifically feared by each subject in mind. This makes it impossible to speculate as to the specificity of desensitization to the phobic stimulus; however, we assume the possibility that the reduction in state anxiety depends on a generic

Table 5 Correlation between subjective discomfort scores and heart rate (n=8)

SUDS × bpm correlation	0 min	10 min	20 min	30 min	40 min	50 min
Session 1	0.627	0.721	0.530	0.868	0.698	0.882
Session 2	0.686	0.844	0.710	0.954	0.811	0.846
Session 3	0.773	0.855	0.741	0.819	0.335	0.832
Session 4	0.181	0.649	0.658	0.154	0.359	-0.079
Session 5	0.872	0.580	0.667	0.975	0.459	0.921
Session 6	0.918	0.200	0.200	0.900	0.763	0.328
Session 7	0.527	0.872	0.700	0.105	0.051	0.368
Session 8	0.600	0.316	0.500	0.800	0.800	0.316
Mann-Whitney *U**		0.013	0.005	0.001	< 0.001	< 0.001

bpm = beats per minute; min = minutes; SUDS = Subjective Units of Distress Scale.
* $p < 0.05$.

habituation effect. We intended to establish a standard protocol with increasing degrees of difficulty in each challenge, and allowed the participants to drive freely in the virtual environment.

Figure 1 shows a gradual decrease in discomfort scores and heart rate during the subsequent exposures. Notably, we can link the observed reduction in perceived discomfort from one session to the next with the decrease in sense of presence, i.e., the gradual decrease in IPQ scores, which might suggest that enriching the virtual environment and the apparatus (e.g., by tilting and shaking the car seat) may be necessary to enhance perceived immersion in the virtual environment.

This study points us to the findings of Wald and Taylor,[4,5] who suggested that VRET alone may not be sufficient in the treatment of driving phobia for some individuals, but can play a useful role in the management of this condition and could be used initially to facilitate subsequent in vivo exposure, as it induces a sense of presence/immersion and can reduce fear in patients. Furthermore, six of the eight participants were able to experience in vivo exposure after the VRET, and we confirmed that VRET posed no risk at all to participants.

Despite these interesting results, our study has several limitations, such as the small sample size; use of nonparametric statistical methods; and the fact that we did not record other physiological parameters of interest, such as respiratory rate and electroencephalography.[50] In addition, it is known that more realistic forms of VR can elicit more intense experiences of awe. Towards this end, we intend to improve the software and apparatus used in future studies.

To the best of our knowledge, this was the first experimental study of VRET for FoD conducted in Brazil. We hope this will be an important first step for further investigation on this issue. We encourage future studies to assess whether the use of cognitive restructuring methods during the virtual exposure sessions could enhance the reduction of anxiety levels in participants.

Acknowledgements

This work was supported by the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq; grant 470382/2006-6).

Disclosure

The authors report no conflicts of interest.

References

1 Associação Americana de Psiquiatria. Manual Diagnóstico e Estatístico de Transtornos Mentais, 5ª edição (DSM-5). Porto Alegre: Artmed; 2014.
2 Mayou R, Tyndel S, Bryant B. Long-term outcome of motor vehicle accident injury. Psychosom Med. 1997;59:578-84.
3 Taylor JE, Deane FP. Acquisition and severity of driving-related fears. Behav Res Ther. 1999;37:435-49.
4 Wald J, Taylor S. Efficacy of virtual reality exposure therapy to treat driving phobia: a case report. J Behav Ther Exp Psychiatry. 2000; 31:249-57.
5 Wald J, Taylor S. Preliminary research on the efficacy of virtual reality exposure therapy to treat driving phobia. Cyberpsychol Behav. 2003;6:459-65.
6 Ehlers A, Hofmann SG, Herda CA, Roth WT. Clinical characteristics of driving phobia. J Anxiety Disord. 1994;8:323-39.
7 Rothbaum BO, Hodges LF, Smith S. Virtual reality exposure therapy abbreviated treatment manual: fear of flying application. Cogn Behav Pract. 1999;6:234-44.
8 Jang DP, Kim IY, Nam SW, Wiederhold BK, Wiederhold MD, Kim SI. Analysis of physiological response to two virtual environments: driving and flying simulation. Cyberpsychol Behav. 2002;5:11-8.
9 Taylor JE, Deane FP, Podd JV. Driving fear and driving skills: Comparison between fearful and control samples using standardised on-road assessment. Behav Res Ther. 2007;45:805-18.
10 Herda CA, Ehlers A, Roth WT. Diagnostic classification of driving phobia. Anxiety Disord Pract J. 1993;1:9-16.
11 Taylor JE, Deane FP, Podd JV. Determining the focus of driving fears. J Anxiety Disord. 2000;14:453-70.
12 Blanchard EB, Hickling EJ. After the crash: assessment and treatment of motor vehicle accident survivors. Washington: American Psychological Association; 1997.
13 Rothbaum BO, Hodges L, Kooper R. Virtual reality exposure therapy. J Psychother Pract Res. 1997;6:219-26.
14 Antony MM, Craske MG, Barlow DH. Mastery of your specific phobia: client workbook. San Antonio: The Psychological Corporation, USA; 1995.
15 Côté S, Bouchard S. Documenting the efficacy of virtual reality exposure with psychophysiological and information processing measures. Appl Psychophysiol Biofeedback. 2005;30:217-32.
16 Rothbaum BO, Hodges LF. The use of virtual reality exposure in the treatment of anxiety disorders. Behav Modif. 1999;23:507-25.
17 Pull CB. Current status of virtual reality exposure therapy in anxiety disorders: editorial review. Curr Opin Psychiatry. 2005;18:7-14.
18 Costa RT, Carvalho MR, Cantini J, Freire RC, Nardi AE. Demographics, clinical characteristics and quality of life of Brazilian women with driving phobia. Compr Psychiatry. 2014;55:374-9.
19 Wilhelm FH, Pfaltz MC, Gross JJ, Mauss IB, Kim SI, Wiederhold BK. Mechanisms of virtual reality exposure therapy: the role of the behavioral activation and behavioral inhibition systems. Appl Psychophysiol Biofeedback. 2005;30:271-84.
20 Costa RT, Carvalho MR, Nardi AE. Exposição por realidade virtual no tratamento do medo de dirigir. Psic Teor Pesq. 2010;26:131-7.
21 Taylor JE, Deane FP. Comparison and characteristics of motor vehicle accident (MVA) and non-MVA driving fears. J Anxiety Disord. 2000;14:281-98.
22 Bellina C. Fobia de dirigir. Rev Assoc Bras Med Traf. 2003;42:30-2.
23 Wolitzky-Taylor KB, Horowitz JD, Powers MB, Telch MJ. Psychological approaches in the treatment of specific phobias: a meta-analysis. Clin Psychol Rev. 2008;28:1021-37.
24 Powers MB, Emmelkamp PM. Virtual reality exposure therapy for anxiety disorders: a meta-analysis. J Anxiety Disord. 2008;22:561-9.
25 Riva G, Wiederhold BK. Guest editorial: introduction to the special issue on virtual reality environments in behavioral sciences. IEEE Trans Inf Technol Biomed. 2002;6:193-7.
26 Anderson P, Jacobs C, Rothbaum BO. Computer-supported cognitive behavioral treatment of anxiety disorders. J Clin Psychol. 2004;60:253-67.
27 Wiederhold BK, Rizzo AS. Virtual reality and applied psychophysiology. Appl Psychophysiol Biofeedback. 2005;30:183-5.
28 Krijn M, Emmelkamp PM, Olafsson RP, Biemond R. Virtual reality exposure therapy of anxiety disorders: a review. Clin Psychol Rev. 2004;24:259-81.
29 Krijn M, Emmelkamp PM, Biemond R, de Wilde de Ligny C, Schuemie MJ, van der Mast CA. Treatment of acrophobia in virtual reality: the role of immersion and presence. Behav Res Ther. 2004;42:229-39.
30 Gregg L, Tarrier N. Virtual reality in mental health: a review of the literature. Soc Psychiatry Psychiatr Epidemiol. 2007;42:343-54.
31 Hoffman HG. Virtual Reality: a new tool for interdisciplinary psychology research. Cyberpsychol Behav. 2009;1:195-200.
32 Loomis JM, Klatzky RL, Golledge RG, Philbeck JW. Human navigation by path integration. In: Golledge RG, editor. Wayfinding: cognitive mapping and other spatial processes. Baltimore: Johns Hopkins; 1999. p. 125-51.
33 Amorin P. Mini International Neuropsychiatric Interview (MINI): validação de entrevista breve para diagnóstico de transtornos mentais. Rev Bras Psiquiatr. 2000;22:106-15.

34 First MB, Spitzer RL, Gibbon M, Williams JBW. Structured Clinical Interview for DSM-IV Axis II Personality Disorders, (SCID-II). Washington: American Psychiatric Press Inc.; 1997.
35 Beck AT, Ward CH, Mendelson M, Mock J, Erbaugh J. An inventory for measuring depression. Arch Gen Psychiatry. 1961;4:561-71.
36 Hamilton M. The assessment of anxiety states by rating. Br J Med Psychol. 1959;32:50-5.
37 Freire MO, Figueiredo VLM, Gomide A, Jansen K, Silva RA, Magalhães PVS, et al. Escala Hamilton: estudo das características psicométricas em uma amostra do sul do Brasil. J Bras Psiquiatr. 2014;63:281-9.
38 Spielberger CD, Gorssuch RL, Lushene PR, Vagg PR, Jacobs GA. Manual for the state-trait anxiety inventory. Palo Alto: Consulting Psychologists Press; 1983.
39 Andrade L, Gorenstein C, Vieira Filho AH, Tung TC, Artes R. Psychometric properties of the Portuguese version of the state-trait anxiety inventory applied to college students: factor analysis and relation to the beck depression inventory. Braz J Med Biol Res. 2001;34:367-74.
40 Ehlers A, Taylor JE, Ehring T, Hofmann SG, Deane FP, Roth WT, et al. The driving cognitions questionnaire: development and preliminary psychometric properties. J Anxiety Disord. 2007;21:493-509.
41 Carvalho MR, Costa RT, Sardinha A, Melo-Neto VL, Nardi AE. Driving cognitions questionnaire: estudo de equivalência semântica. Rev Psiquiatr Rio Gd Sul. 2011;33:35-47.
42 igroup.org. igroup presence questionnaire (IPQ) overview [Internet]. [cited 2008 Aug 21]. www.igroup.org/pq/ipq/index.php
43 Wolpe J. The Practice of behavior therapy. New York: Pergamon; 1969.
44 Ware JE Jr, Sherboume CD. The MOS 36 item short-form health survey (SF-36). I. Conceptual framework and item selection. Med Care. 1992;30:473-83.
45 Ciconelli RM. Translation into Portuguese and validation of the generic questionnaire for assessing quality of life: ''Medical Outcomes Study 36 – Item Short-Form Health Survey'' (SF-36) [dissertation]. São Paulo: Universidade Federal de São Paulo; 1997.
46 Knight RG, Waal-Manning HJ, Spears GF. Some norms and reliability data for the state-trait anxiety inventory and the zung self-rating depression scale. Br J Clin Psychol. 1983;22:245-9.
47 Addolorato G, Ancona C, Capristo E, Graziosetto R, Di Rienzo L, Maurizi M, et al. State and trait anxiety in women affected by allergic and vasomotor rhinitis. J Psychosom Res. 1999;46:283-9.
48 Pavlov IP (1927). conditioned reflexes: an investigation of the physiological activity of the cerebral cortex. London: Oxford University; 2003.
49 Skinner BF. Science and human behavior. New York: MacMillan; 1953.
50 Fan J, Wade JW, Key AP, Warren Z, Sarkar N. EEG-based affect and workload recognition in a virtual driving environment for ASD intervention. IEEE Trans Biomed Eng. 2018;65:43-51.