

SIDE EFFECTS OF IMMERSIONS IN VIRTUAL REALITY FOR PEOPLE SUFFERING FROM ANXIETY DISORDERS

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Side effects caused by immersions in virtual reality (VR) have been documented in experimental studies and with healthy people. With the growing interest of VR applications to assess and treat mental disorders, empirical information on side effects in clinical populations is needed. Three studies were conducted to: (a) describe symptoms and scores on the Simulator Sickness Questionnaire (SSQ) in a sample of 157 adults immersed in VR to treat their phobias, (b) compare exposure treatments involving more or less actions and motions (N = 34); and (c) document the usefulness of assessing symptoms prior to the immersion in VR and following up 26 phobic patients 24 hours post-immersion. Overall, results show that most participants experienced slight side effects, symptoms were strong even before immersion in VR and there are no reasons to be generally concerned with health and safety issues within 24 hours after therapy sessions. Exposure in VR to treat fear of flying was associated with fewer side effects than for other anxiety disorders. The scores on the SSQ were much higher than in studies conducted with non-clinical samples, raising several research questions. Side effects should not be a source of worries but they must be closely monitored and systematically reported in outcome studies.

Keywords: Simulator Sickness, Cybersickness, Adverse Events, Virtual Reality, Phobias

INTRODUCTION

In the last decade, the use of virtual reality (VR) has been of great interest to clinicians and researchers because it enables patients to be placed in a standardized and replicable situation in order to elicit emotions, cognitions or behaviors. It is now used in several clinical settings (for illustrations, see Gaggioli, Keshner, Weiss & Riva, 2009; Wiederhold & Riva, 2009).

Although VR offers several advantages, issues concerning the health and safety implications of this technology remain poorly studied in clinical settings. This constitutes a frequent concern raised by research ethics boards and committees. For example, there are warnings against the use of VR within clinical populations such as people suffering from claustrophobia, substance abuse or schizophrenia (Stanney, Kennedy & Kingdon, 2002). Virtual environments have been designed for use with these populations, but testing these applications or implementing them in private practice settings means ethical questions may be raised. There is a lack of data available to address these questions. Worries sometimes associated with VR come from the induction of unwanted side effects such as nausea or eyestrain. Virtual reality-induced side effects, also commonly referred to as cybersickness (McCauley & Sharkey, 1992), may include symptoms such as discomfort, vertigo, nausea, eyestrain, headaches, dizziness, epigastric awareness, cold sweats, hot flashes, increased salivation, burping, drowsiness, vomiting, etc. (Kennedy, Lane, Berbaum & Lilienthal, 1993; Lawson, Graeber, Mead & Muth, 2002).

Cobb et al. (1999) and Wilson (1997) conducted a systematic analysis of the symptoms and effects of VR immersions. The technology they used is over a decade old, therefore, some of their results may not apply to the more efficient VR systems. Yet, they found that 20 percent of their participants did not notice any side effects and five percent of their sample experienced side effects severe enough to stop the immersion. Side effects are monitored in an increasing number of studies, including anxiety (Jang et al., 2002), schizophrenia (Fornells-Ambrojo et al., 2008) and substance abuse (Girard, Turcotte, Bouchard & Girard, In press). Unfortunately, in most studies conducted with clinical populations, VR-induced side effects are not systematically reported. Only the number of participants excluded due to strong side effects, also known as adverse events in the pharmacological industry, is mentioned and the scoring procedures are unclear.

VR-induced side effects may be caused by a variety of factors (Harm, 2002; Lawson et al., 2002; Sharples, Cobb, Moody & Wilson, 2008; Viirre & Bush, 2002), including individual susceptibility to motion sickness, update lag of the computer, technologies used for the immersion, mode of interaction, weight and characteristics of the head mounted display, field of view, content of the visual display, or characteristics of the tasks performed by the user, such as significant motion.

Some measures have been published to assess VR-induced side effects. For example, some instruments specifically measure ocular symptoms (Ames, Wolffsohn & McBrien, 2005), others

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provide crude subjective estimates using only one-item self-rating (Hoffman, Garcia-Palacios, Carlin, Furness III & Botella, 2003), or measure potential diagnostic criteria for motion sickness (Miller & Graybiel, 1970). The most frequently used measurement is the final version of the Simulator Sickness Questionnaire (SSQ Kennedy et al. 1993) which measures 16 symptoms – general discomfort, fatigue, headache, eyestrain, difficulty focusing, increased salivation, sweating, nausea, difficulty concentrating, fullness of head, blurred vision, dizzy (eyes open), dizzy (eyes closed), vertigo, stomach awareness and burping. Kennedy et al. (1993) found a three-factor solution composed of nausea (nausea, burping, increased salivation), oculomotor symptoms (eyestrain, difficulty concentrating) and disorientation (dizziness, vertigo). According to Kennedy et al., (1993), the procedure to score the subscales of the SSQ required the addition of all items that load on a factor and, in order to have a standard deviation of 15, multiply that sum by a constant weight. The same procedure is performed for the total score, despite the fact that some items load on two factors, meaning some items are counted twice. The factor structure of the SSQ has been questioned (Bouchard, Robillard & Renaud, 2007) and a two-factor solution may be more appropriate with all items loading only on the nausea or oculomotor subscale.

The phenomenon of simulator sickness is not yet perfectly understood but there is already a large deal of information available on its signs, causes and potential mechanisms (Harm, 2002; Lawson et al., 2002; Sharpless et al., 2008; Welch, 2002). However, most information on simulator sickness comes from non-civilian samples such as Navy pilots (Kennedy, Lane, Lilienthal, Berbaum & Hettinger, 1992), astronauts (Reschke et al., 1994) or healthy civilians (Sharpless et al., 2008). Problematically, these individuals may be in better shape than the average population and is also important to mention the experience in a flight simulator or an experimental study is very different from the use of VR in mental health applications.

The aim of this paper is to report three studies documenting side effects associated with immersions in VR conducted to treat anxiety disorders. Data collected from a large sample of patients immediately after their first therapeutic immersion in VR is described in Study 1 to provide empirical data on the strength and distribution of SSQ scores. Due to the association between physical motion and cybersickness, a comparison was made between patients involved in therapies that require more or less significant motion in the virtual environment (Study 2). Finally, Study 3 was conducted to test the usefulness of administering the SSQ prior to immersion in VR and report symptoms measured at a follow-up 24 hours after the immersion.

STUDY 1

METHOD

The goal of this study is to document, using the SSQ, the severity of side effects reported after a therapy session with people suffering from an anxiety disorder. Participants were recruited in the general community following medical referrals and self-referral following publicity in a local daily newspaper. A structured clinical diagnostic interview (First, Spitzer, Gibbon & Williams, 1996) was performed in order to establish the diagnoses of specific phobia of spiders ($n = 57$), heights ($n = 53$), flying ($n = 25$) or enclosed spaces ($n = 22$) according to the Diagnostic and Statistical Manual of Mental Disorders (APA, 1994/2000). The exclusion criteria imposed on the recruitment were: (a) being aged less than 18 years, (b) not meeting the diagnostic criteria for a specific phobia, (c) suffering from comorbid disorders (for example depression, psychotic disorders, other anxiety disorders, etc.) requiring immediate treatment, (d) taking drugs prescribed for anxiety (for example benzodiazepines, anti-depressants), (e) having previously been immersed in a virtual environment, (f) suffering from migraine headaches and (g) considering oneself very susceptible to motion sickness. The total sample was comprised of 157 participants, with 122 females and 35 males whose age varied between 18 and 68 years old ($M = 39.73$; $sd = 12.57$).

Therapists with basic training in cognitive-behavioral therapy and the use of VR carried out the procedures and the treatment. The patients came to the clinic for therapy sessions lasting approximately 60 minutes long. The treatment consisted essentially of exposure to feared stimuli using VR and followed a standardized treatment manual. The protocol required the therapists to devote the pre-treatment session to diagnostic, selection procedures, informed consent and assessment. During the first therapy session, the patient was introduced to the treatment and became familiar with case conceptualisation, understanding the cognitive-behavior model and approach to treatment and the basics of exposure. The patient also tried the VR system for 10 minutes in a neutral virtual environment or a VR environment irrelevant to their phobia. Exposure to VR before initiating therapy was introduced in the protocol to make sure participants were familiar with key concepts, such as VR-induced side effects, before beginning use of VR to face their fears. From the second therapy session onward, the treatment consisted essentially in in virtuo exposure to feared situations (Bouchard, Côté & Richard, 2006). After the therapy session, all participants were required to remain in the clinic's waiting room for 15 minutes before leaving. This time allowed patients to fill out questionnaires and make sure no significant VR side effects were present. It is worth noting that after the 15-minute waiting period, none of the participants in the three studies reported side effects. However, no empirical data was recorded before they left to substantiate that information.

The VR systems used for immersion remained the same within the course of a patient's therapy, but changed during data collection. Although this lack of standardization limits conclusions on hardware factors and content of the virtual environment associated with potential side effects, it has the advantage of increasing the ecological validity of our results. The computers used ranged from a IBM Pentium III (866 Mhz, 128 Meg of RAM with an ATI Radeon 64 Meg graphic card) to a HP wx4600 workstation (3 GHz, 3.48 GB of RAM, with an ASUS GeForce 8800GTX 768 Meg graphics card). Three sets of head mounted displays and trackers were used over the years – a VFX3D (resolution of 640x480, FoV 35° diagonal; IISVR Systems) with build-in 3 dof tracker, an I-Glass (resolution of 640x480, FoV 26° diagonal; I-O Display Systems) coupled with an Intertrax2 tracker (3 degrees of freedom; InterSense) and a z800 (resolution of 800x600, FoV 40° diagonal; eMagine) with build-in 3dof tracker. Forward and backward motions were enabled using a Microsoft joystick or a Gyration wireless mouse. A variety of VR environments were used in order to maximize ecological validity. Some were developed using 3D game engine (Unreal Tournament 2000®, Max Payne®) and other were purchased from Virtually Better (<http://www.virtuallybetter.com/>). All have been previously described in outcome studies (Bouchard, Côté, Robillard, St-Jacques & Renaud, 2006; Bouchard, St-Jacques, Côté, Robillard & Renaud, 2003; Bouchard, St-Jacques, Robillard, Côté & Renaud, 2003; Rothbaum et al., 1996).

MEASURES

THE SIMULATOR SICKNESS QUESTIONNAIRE (SSQ; KENNEDY ET AL., 1993).

The 16 items of the SSQ are scored on a zero, meaning none, to three, or severe, scale. Kennedy et al. (1993) proposed to score the SSQ using the following procedure: (a) for the nausea subscale, sum items 1, 6, 7, 8, 9, 15, 16 and multiply by 9.54; (b) for oculomotor subscale, sum items 1, 2, 3, 4, 5, 9, 11 and multiply by 7.58; (c) for disorientation subscale, sum items 5, 8, 10, 11, 12, 13, 14 and multiply by 13.92; (d) for the total score, sum all items used in a subscale (i.e., items 1, 5, 8, 9 and 11 are counted twice) and multiply by 3.73. Because many researchers and clinicians do not follow this scoring procedure, we also calculated the raw total score of all 16 items, meaning there was no weighting and no items counted more than once. With the proposed revised factor structure, Bouchard et al. (2007) also suggested to simplify the scoring of the SSQ by dropping the

weighting procedure for the subscales. Only scores measured after the first in virtuo exposure session are reported in Study 1.

A ONE-ITEM RATING OF CYBERSICKNESS

This rating was also completed by a subset of 66 patients every five minutes during the immersions using a 0 to 100 scale using the prompt "To what extent do you feel cybersickness right now?" A similar procedure has already been used by Hoffman et al., (2003). Much like using Subjective Units of Discomfort during exposure therapy, the one-item rating allows therapists to follow the evolution of side effects during exposure while trying to be the least intrusive as possible. Participants had been educated about the symptoms and potential causes of VR-induced side effects, referred to as cybersickness. At the pre-treatment session, they received a leaflet describing the most important symptoms. Only scores measured during the first in virtuo exposure session have been collected.

RESULTS

The descriptive data provided in Table 1 revealed that SSQ scores are high when participants are involved in an in virtuo exposure therapy session for the first time. When looking at Figure 1, it appeared that more than 80 percent of the participants reported raw scores of 10 or less. Using a subjective cut-off of reporting "slight" symptoms on each of the 16 items, 7.6 percent of our sample reported a raw score above 16. The mean for each of the 16 items ranged between .09 to .80 and the standard deviation ranged between .33 and .89, suggesting that side effects were generally rated as less than "slight" on all items. None of the participants had to stop the immersion due to side effects, even though they had been told they could if needed. An ANOVA comparing the diagnostic groups revealed significant differences among the participants ($F(3,134) = 4.27, p < .01$), with those being immersed in VR to treat their claustrophobia reporting a significantly higher score on the SSQ (60.81, $sd = 43.47$), than all other phobias (arachnophobia = 35.42, $sd = 27.25$; acrophobia = 33.04, $sd = 29.4$; aviophobia = 27.81, $sd = 28.34$).

The one-item self-rating provides additional insight into the severity of the side effects. On the subjective scale ranging from zero to 100, most scores were very low but a few patients reported feeling up to 95 percent cybersick. The change in self-ratings over the course of the therapy session was not significant (repeated ANOVA, $F = .48, ns$).

Table 1

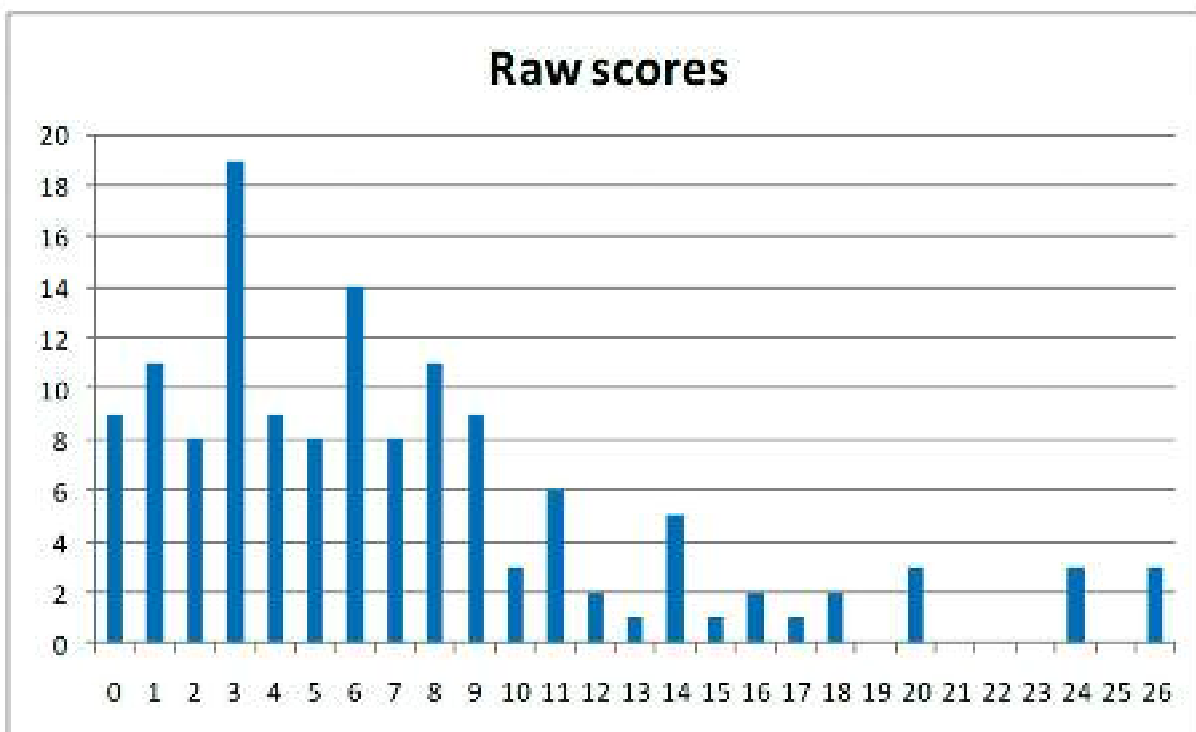
Virtual reality induced side effects in a sample of 157 phobics immersed in VR during their first exposure therapy session

	Mean	SD	Minimum	Maximum
<i>Original SSQ Scoring</i>				
Total score (weighted)	36.27	31.46	0	145.86
Nausea subscale (weighted)	27.47	28.51	0	133.56
Oculomotor subscale (weighted)	30.49	25.6	0	106.12
Disorientation subscale (weighted)	38.83	41.32	0	208.8
<i>Alternative SSQ scoring</i>				
Total score (not weighted)	7.12	6.04	0	26
Nausea subscale (not weighted)	3.51	3.69	0	20
Oculomotor subscale (not weighted)	2.86	2.58	0	11
<i>One-item subjective self-rating (%)</i>				
After 5 minutes	4.09	12.82	0	90
After 10 minutes	4.28	13.84	0	95
After 15 minutes	4.47	12.94	0	80
After 20 minutes	6.23	14.81	0	75
After 25 minutes	6.89	17.39	0	83
After 30 minutes	6.3	14.98	0	65
After 35 minutes	6.65	16.81	0	88
After 40 minutes	7.01	16.03	0	75

Note. SSQ = Simulator Sickness Questionnaire

Figure 1

Distribution of raw (not weighted) SSQ total scores in Study 1 (N = 157)



STUDY 2

Given differences observed between the diagnostic groups in Study 1, a decision was made to compare side effects experienced by participants in virtuo exposure sessions requiring either more or less physical motion. In order to maximize ecological validity of our results, an open-trial naturalistic approach was favored over a more-controlled experimental design (i.e., instead of using a homogenous sample involved in a standardized experimental manipulation). Clinical observations showed that patients involved in more active in virtuo exposure sessions, such as walking in the virtual environment, report more side effects than those involved in less active sessions, such as acting as passengers in an airplane.

The recruitment and selection procedures performed similarly to Study 1, except for diagnoses and administration of the measures (see below). Based on the diagnostic interview, the sample consists of participants treated with VR for a specific phobia of flying (n = 22), driving (n = 7), enclosed spaces (n

= 1), public speaking (n = 1), height (n = 1), or for panic disorder with agoraphobia (n = 1) and post-traumatic stress disorder (n = 1). Of those 34 participants, 27 were women (mean age = 44.30, sd = 12.59) and seven were men (mean age 38.71, sd = 16.07). Since exposure therapy for a phobia of flying requires patients to move significantly less in the virtual environment than exposure for other disorders, participants were assigned to two groups – "more passive" exposure with participants receiving exposure for flying phobia (n = 22) and "more active" exposure with those receiving exposure for other anxiety disorders mentioned above (n = 12).

The treatment consists of in virtuo exposure delivered over an average of nine weekly 60-minute sessions. The treatment was delivered by therapists who had received preliminary training in CBT aided by the use of VR. Like Study 1, the treatment protocol focused essentially on in virtuo exposure to feared a situation. For the more passive group, exposure entailed observing surroundings from a passenger seat and

while the therapist controlled the events occurring to the patient such as taxi, take off, flying under good or bad conditions and landing. Participants in the more active group were invited to move around in the virtual environment, approach feared stimuli and turn 360 degrees to explore the virtual environment. The hardware used for this study consisted of a Pentium IV PC with a DirectX 3D Accelerator VGA graphics card, an I-Visor DH-4400VPD head mounted display (resolution of 800x600, FoV 31° diagonal; Daeyang Inc.), an Intertrax2 tracker (3 degrees of freedom; InterSense) and a Microsoft joystick.

Participants completed the Simulator Sickness Questionnaire (Kennedy et al., 1993) after every exposure session and results were averaged over the treatment program. The SSQ was scored following Kennedy et al. (1993) procedures.

RESULTS

An ANOVA was performed to compare the SSQ scores over the course of therapy (see Table 2). Results revealed that more active exposure-based treatment in VR led to significantly more side effects, both on the total score and the nausea subscale of the SSQ.

Table 2

Virtual reality-induced side effects in patients involved in more or less active in virtuo exposure session (N = 34)

Simulator Sickness Questionnaire	More active exposure	More passive exposure	ANOVA F (1,32)
Total score	42.08 (33.91)	23.12 (17.79)	4.63*
Nausea subscale	41.34 (36.23)	18.21 (12.80)	7.43**
Oculomotor subscale	30.32 (19.92)	23.77 (18.01)	.952
Disorientation subscale	40.60 (46.53)	15.82 (32.52)	3.32

Note. Mean score, with standard deviation in brackets. * $p < .05$, ** $p < .01$

STUDY 3

METHOD

The goal of the third study was to follow-up on participants 24 hours after their immersion in VR to explore whether or not they were still experiencing side effects. The study was also used to test the suggestion from Kennedy et al. (1993) to administer the SSQ prior to immersion in order to take into account pre-existing symptoms.

The selection criteria were the same as Study 1, except participants suffered from a phobia of snakes. The sample consisted of

26 adults aged between 27 and 68 years old (Mean = 43.65, sd = 11.58). The participants were mostly female, making up 81.5 percent of the study.

A therapist with preliminary training in CBT using the aid of VR carried out the procedures. Following their recruitment, participants were immersed for 15 minutes in a virtual environment designed to elicit fear in sufferers of snake phobias. The VR immersions were conducted using an IBM computer (Pentium III, 866 Mhz, 128 Meg RAM), an ATI Radeon 64 Meg graphic card, an I-Glass head mounted display (resolution of 640x480,

FoV 26° diagonal; I-O Display Systems), an Intertrax2 tracker (3 degrees of freedom; InterSense) and a Microsoft joystick. The virtual environment used a modified map from the 3D game Unreal Tournament®. The participants completed the Simulator Sickness Questionnaire (Kennedy et al., 1993) on three occasions – before the experiment, immediately after the immersion and 24 hours after the immersion. The SSQ was scored according to procedures outlined by Kennedy et al. (1993).

RESULTS

A repeated-measures analysis of variance (ANOVA) was performed on the total score of the SSQ as well as the three subscales proposed by Kennedy et al. (1993). Descriptive statistics and results from the repeated measures contrasts are reported in Table 3. The SSQ scores were already high before beginning the experiment. The repeated measures ANOVA for the total score revealed a significant decrease over time [$F(2,50) = 14.09$, $p < .001$]. The repeated measures contrasts revealed the immersion in virtual reality did not cause a significant increase in symptoms' severity from pre to post-immersion (partial eta squared

measure of effect size = .001) and the severity of patients' symptoms was significantly lower on the day following the experiment (partial eta squared measure of effect size = .43).

Similar findings were found for all three subscales of the SSQ: (a) nausea [$F(2,50) = 8.33$, $p < .01$]; (b) oculomotor [$F(2,50) = 11.54$, $p < .001$]; and (c) disorientation [$F(2,50) = 5.95$, $p < .01$]. Pre-experiment scores on the SSQ subscales suggested the presence of symptoms although no immersion had been performed. The immersion in VR did not have any significant impact on the nausea and oculomotor subscales, with non-significant decreases in symptoms associated with extremely small effect sizes (.001 and .02, respectively). For the disorientation subscale, a non-significant increase in symptoms of a medium-effect size (partial eta squared measure of effect size = .08) was found. For all three subscales, a significant reduction in symptoms in the 24 hours following the immersion (see Table 3) was observed. Even though symptoms were much lower on the day post-immersion than before the experiment, there were close to none only on the disorientation subscale.

Table 3

The evolution of virtual reality induced side effects in phobics from pre-immersion to post-immersion and 24 hours later (N = 26)

				Repeated measures contrasts	Repeated measures contrasts
Simulator Sickness Questionnaire	Pre immersion	Post immersion	24 hours follow-up	Pre vs Post F (1,25)	Post vs follow-up F (1,25)
Total score	11.36 (10.44)	11.8 (12.23)	.86 (2.66)	.04	18.9***
Nausea subscale	8.81 (10.77)	8.43 (11.86)	.37 (1.87)	.02	11.25**
Oculomotor subscale	13.12 (13.99)	11.37 (13.09)	1.46 (4.3)	.59	13.63***
Disorientation subscale	5.35 (11.19)	10.71 (17.3)	0.00 (0.0)	2.28	9.96**

Note. Mean score, with standard deviation in brackets. * $p < .05$, ** $p < .01$, *** $p < .001$

DISCUSSION

In this paper, data was presented on the SSQ as a measure of side effects experienced by anxiety disorder sufferers exposed to their fears in virtual reality. Side effects of VR, also referred to as cybersickness, are symptoms not purposefully induced by the treatment. Hence, signs of anxiety and panic experienced by patients during in virtuo exposure should not be considered side effects, as opposed to headache, blurred vision or dizziness. The deliberate focus on clinical applications and populations influenced methodological decisions and led the authors to favor ecological validity over internal validity and standardization. It is hoped that these findings will encourage experimental scientists to conduct more robust investigations, help clinical researchers answer questions raised by research ethics boards and guide clinicians in their application of in virtuo exposure.

The side effects reported by the clinical sample in Study 1 suggest that most participants experienced side effects yet the severity of the symptoms remained generally low. This is consistent with previous reports that minor VR-induced side effects occur in most people (Cobb et al., 1999; Lamson et al., 2002). Yet, some participants scored very high on the SSQ, showing that it is important for therapists to monitor side effects during in virtuo exposure for phobias. It is also important to note that SSQ scores in our sample were much higher than those reported by Kennedy et al. (1993) with their normative sample of Navy and Marine corps involved in flight simulations. Based on 1099 participants, Kennedy et al. (1993) proposed an average total (weighted) score of 9.8 ($sd = 15$), with scores above 30 fitting in the 90th percentile. Their maximum score was 108.6. Our average total score was 36, meaning the symptoms in our sample occupied, in general, the 90th percentile. In addition, our maximum scores strongly exceeded those in the normative sample provided by Kennedy et al. (1993). The procedure proposed by Kennedy et al. (1993) requires counting some symptoms twice, which may have contributed to a higher total score. For example, a patient reporting only slight general discomfort (item 1) would obtain a total score of 7.48, placing them in the 60th percentile. Looking at raw scores provided a clearer picture and revealed that symptoms were varied and generally mild. High total scores appear to originate from many symptoms receiving a rating of slightly present. It is worth noting that participants in Kennedy et al.'s (1993) normative sample consist only of healthy people since people who were not considered in their usual state of fitness prior to the immersion were excluded. In addition, their participants had already been through simulator training and may not be representative of the middle-aged civilian population generally consulting for anxiety disorders. Yet, based on the profile of SSQ scores amalgamated over 29 studies (Stanney et al., 2002), our results still fit among the 95th percentile. According to Stanney et al. (2002), such high scores should be associated with sig-

nificant drop-out from immersions, which was not the case in our three studies. Since people suffering from anxiety disorders, including claustrophobia, may be more susceptible to motion sickness (Faugloire, Bonnet, Riley, Bardy & Stoffregen, 2007), higher SSQ scores may be specific to the population studied here. This is partially corroborated by Robillard, Bouchard, Fournier and Renaud's (2003) study comparing reactions of people with phobias and those without phobias being immersed in the same VR environments. Given the small sample size of 13 participants per group, the differences they reported on the total score and the nausea subscale of the SSQ did not reach statistical significance. However, the effect sizes were in the medium range and the differences would have been significant with a sample of 90 participants. The results of the three studies call for a controlled comparative study of anxious and non-anxious people immersed in VR, and probably even a comparison between the different anxiety disorders.

Results of the one-item self-rating scale support the contention that symptoms are low for most, but not all, participants. The intensity of cybersickness was rated by participants as four to seven percent when measured during the immersion, yet a few people rated their symptoms as high as 90 percent. Symptoms also remained stable during the exposure session. Testing is needed to explore whether side effects change over longer and repeated immersions (Kennedy, Stanney & Dunlap, 2000; North, North & Coble, 1996). Another important factor that must be studied more thoroughly is the potential overlap between symptoms induced by exposure and those caused by the immersion in virtual reality. When patients are exposed to feared stimuli, it is expected that they will feel anxious. Exposure causes patients to sweat and may lead to general discomfort, difficulty concentrating, fatigue, blurred vision and other symptoms. These symptoms, and even those of the apprehension that builds up before the exposure session, may be confused with cybersickness. Further research should be conducted on this potential overlap to delineate which symptoms are caused by exposure and which symptoms are side effects of the immersion.

The significant difference between the patients treated for claustrophobia and the other phobias deserves attention. It is known that various factors such as computer lag and moving visual fields contribute to simulator sickness (Lawson et al., 2002). Since the virtual environment used with some phobia sufferers required them to walk and explore the virtual environments significantly more than others, we decided to compare the side effects of in virtuo exposure for patients whose therapy involved a much smaller range of motion than others. The results of Study 2 show that people suffering from flight phobia reported less symptoms than those suffering from other

anxiety disorders. Consistent with the hypothesis of activity and range of motion involved during the exposure session, the difference was specific to the nausea subscale. Given the lack of random assignment, measures of actual physical motion and homogeneity in the virtual stimuli, we cannot conclude that our finding is specific to the amount and type (e.g., rotations, forward motion) of movement performed during the therapy. While the medical and psychological communities are waiting for such studies to be conducted, found results support the clinical impressions that more active in virtuo exposure sessions are associated with more cybersickness than what is found when treating people for flying phobia.

Measuring symptoms of VR-induced side effects prior to and long after the immersion led to very interesting observations. First, the high SSQ scores found in Study 1 and 2 may be inflated by the physical and emotional state of the participants before the immersion. The symptoms in Study 3 were already quite strong and the immersion did not cause any significant increase in SSQ scores. Previous studies have already reported the existence of symptoms prior to immersions (Fornells-Ambrójo et al., 2008; Kennedy et al., 1993; Sharples et al., 2008), but not with people undergoing in virtuo exposure. Also, symptoms reported in Study 3 prior to and after the immersion were lower than in Study 1 and 2. Second, the low SSQ scores reported 24 hours after the immersion support the clinical impressions that, if in virtuo exposure caused side effects, they do not last long after the immersion. In addition, the lower scores during the follow-up sessions suggest that symptoms reported prior to the experiment may be more related to situational factors, such as anxious apprehension, than chronic conditions like poor health. Our findings are important for researchers because they highlight the need to systematically administer the SSQ prior to immersion to provide control for the state of the patient. They also suggest that the high SSQ scores reported in Study 1 and 2 should be interpreted with caution as they may be inflated by pre-immersion discomfort, apprehension and health status. Finally, the findings provide reassuring information for clinicians, showing that side effects do not last as long as 24 hours. To offer a more complete picture on the lasting effects of side effects, the assessment of change in

symptoms should be conducted at shorter time intervals, such as every 10 minutes during a few hours, and with a more fine-grain analysis of symptoms.

As clinicians are venturing further into the field of VR, side effects should not be a worry but it is important to monitor them regularly. Researchers, however, should be mandated to systematically measure and report side effects in their outcome studies. Symptoms should be measured before each immersion or before beginning treatment and participants dropping out because of side effects must be reported as well. Procedures to score the SSQ should be made explicit in peer-reviewed papers. Based on informal discussions with clinicians, it appears many were not aware of the scoring procedures of the SSQ and used the raw scores from the 16 items to compare patient's results with the Kennedy et al., (1993) normative sample. In addition, results may be biased by sample characteristics specific to anxiety disorders, potential differences among anxiety disorders, and tasks performed during in virtuo exposure.

One of the challenges of studying health and safety issues lies in the complexity of VR-induced side effects. Factors such as hardware and software used for immersion, visual content of the virtual environment, actions performed by the user and population characteristics all influence the side effects that can be experienced by the patient (Cobb et al., 1999; Harm, 2002; Lawson et al., 2002; Sharpless et al., 2008; Stanney et al., 2002; Viirre & Bush, 2002; Welch, 2002). With technology evolving rapidly, hardware and software issues change over time. The pharmacological approach of documenting adverse events and listing side effects specific to each product cannot be applied directly to virtual reality because of the diversity of VR environments and actions performed by patients. Therefore, neither the results of rigorous experimental studies or naturalistic and ecological studies are sufficient on their own to provide a complete picture of cybersickness in clinical populations. Both are needed and systematic examination of VR-induced side effects must be conducted within other clinical populations (e.g., obesity, substance abuse), with different age groups (e.g., children, elderly) and with a variety of actions performed in VR (e.g., assessment, therapy.)

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