Expert Reviews

Could virtual reality be effective in treating children with phobias?

Expert Rev. Neurother. 11(2), 207–213 (2011)

Stéphane Bouchard

Université du Québec en Outaouais, Cyberpsychology Lab, PO Box 1250, Station Hull, Gatineau, Québec, J8X 3X7, Canada
Tel.: +1 819 595 3900
Fax: +1 819 595 2250
stephane.bouchard@uqo.ca

The use of virtual reality to treat anxiety disorders in adults is gaining popularity and its efficacy is supported by numerous outcome studies. Similar research for children is lagging behind. The outcome studies on the use of virtual reality to treat anxiety disorders in children currently address only specific phobias, and all of the available trials are reviewed in this article. Despite the limited number of studies, results are very encouraging for the treatment of school and spider phobias. A study with adolescents suggests that, at least for social anxiety, exposure stimuli would be more effective if they were developed specifically for younger populations. Virtual reality may not increase children's motivation towards therapy unless their fearful apprehension is addressed before initiating the treatment.

Keywords: anxiety • children • cognitive–behavior therapy • exposure therapy • phobia • virtual reality

Virtual reality (VR) is an application that lets users navigate and interact in real time with a 3D computer-generated environment [1]. Several factors differentiate VR from the use of other computer or audio–visual technologies, especially interactivity and the strong impression of being immersed in the synthetic environment. Even if phobogenic stimuli are presented on slides, a computer or an IMAX theater screen, this is not VR. The mediated experience becomes a VR when participants can interact and explore the surroundings (e.g., turn his or her head, grab an object or walk out of a room) and the displayed images change accordingly. VR has been around for decades and used extensively for training purposes (e.g., for pilots), to reproduce environments for a variety of educational or entertainment purposes (e.g., museums), or for engineering and design purposes (e.g., designing planes). However, it has only become affordable and useful for clinical psychologists in the last few years, mostly owing to decreases in equipment costs and the increasing possibility to use it on Windows-based computers (see [2] and [3] for details).

Virtual reality offers many opportunities for clinicians. Anybody who needs to recreate standard environments or situations could consider VR as a fruitful option. Its usefulness is currently been studied in research laboratories working on eating disorders [4,5], attention-deficit disorders [6], autism [7], acute pain [8], patients suffering from cognitive impairments [9], schizophrenia [10], sex offenders [11] and specific phobia [12,13], to name only a few.

Despite the fact that it requires the use of computers in psychotherapy, VR offers many advantages to psychologists treating anxiety disorders in children [13]. The lifetime prevalence of specific phobia has been estimated to range between 2.6 and 9.1%, with an average of 5% across studies [14]. Applying the epidemiological data to the estimated number of children and adolescents in the USA in the year 2000, Davis and Ollendick estimated that over 350,000 US children and adolescents have clinically significant specific phobias at any one point in time [15]. Effective treatment of phobias and other anxiety disorders usually involves some kind of exposure to the feared stimuli. The classical approach is known as *in vivo* exposure [16]. Exposure in VR, or *in virtuo* exposure, provides more control over the situation. For example, in the treatment of the phobia of flying in an airplane, the therapist can control the occurrence and intensity of turbulences and the duration of the flights. Such control is difficult with phobias such as thunderstorms, wind or dogs. Using VR could also be safer, notably in the case of exposure to heights, where for example, parents can be afraid their

10.1586/ERN.10.196

ISSN 1473-7175

child could fall during the therapy session. Conducting *in vivo* exposure can sometimes cause confidentiality problems, such as when exposing a child in front of classmates (e.g., for the treatment of public-speaking phobia), which is not a problem with *in virtuo* exposure. During any exposure session, a key task of the therapist is to monitor and reduce avoidance as much as possible. Given that *in virtuo* exposure is highly standardized, conducted in the privacy and comfort of the therapist's office, and that the therapist sees the same thing as the patient on the computer screen, it is much easier to detect subtle avoidance behaviors such as looking for reassuring cues in the environment or avoiding eye contact. *In virtuo* exposure also allows the child to go over the exact same situation again and again, or to go far beyond what they could try during *in vivo* sessions (e.g., intimidation at school or flushing a 'dirty' toilet in a public bathroom). For the therapist who treats animal or insect phobias, the need to care for the pets is also eliminated. For some situations such as a flying phobia, it is also less expensive than having to pay for flight tickets.

Creating and using virtual environments is possible with different technologies, the two most frequently mentioned in the literature being with head-mounted displays (HMDs) and immersive rooms. Traditional computer monitors could be used to recreate and interact with synthetic environments. Large monitors could provide an interesting immersive experience and are the least expensive virtual experience. Behaviors and cognitions could be learned, studied or even changed using that technology [9,17]. However, other technologies can provide a much more powerful feeling of being immersed in the virtual environment. HMDs essentially consist of a pair of goggles with small monitors mounted before each eye. An additional and essential device is a motion tracker transmitting information to a computer on the position and movements of the head. With this equipment (see Figure 1), a user immersed in a 3D computer-generated environment has the impression of being in a virtual world where the environment changes according to his/her head movements. Additional devices can allow the user to move and explore the virtual environments (e.g., additional motion trackers, joystick and mouse), to feel force feedback or to interact using the sense of touch (i.e., haptic devices), to benefit from stronger 3D impressions (by using stereoscopic images) or to enjoy 3D sounds and even smell [2,18]. The advantages of HMD systems are their affordable costs and the fact that they can work on standard PC computers [13].

At the other end of the immersive spectrum there is the immersive room, the C-Automatic Virtual Environment, often referred to by the trademark name CAVE®. The typical immersive room system consists of images projected simultaneously on three 10 × 10 foot walls and a floor, a pair of glasses providing a 3D stereoscopic effect, a motion tracker and a joystick (see an illustration of an immersive room in Figure 2) [2]. The advantages of this technology are also the source of its limitations. The user can see himself or herself immersed in a large space, with a wide field of view controlled by highly powerful computers. The equipment, physical space and computer science expertise required to use an immersive room is currently a significant deterrent to the widespread dissemination of this technology from the research laboratories to the clinicians' office. The cost of this technology is usually assessed in millions of US dollars, and it is rarely used in clinical studies [13,19,20]. As people, especially children, will get used to stereoscopic 3D movies (e.g., Avatar), such realistic devices may be needed to meet their expectations and implicit criteria to consider a 3D stimuli believable.

Although there is strong support for the efficacy of conducting exposure in VR (*in virtuo* exposure [12]), very few studies have addressed the treatment of specific phobia in children. Most studies on VR and children are for distraction during painful procedures, which is different from the treatment of a chronic mental disorder. For the current article, a systematic search of the published literature was conducted using the SCOPUS database, with the following key words: VR, children and phobia. The search revealed nine articles, but several of them were theoretical or positions articles. All those with empirical data regarding the treatment of phobia in children are reviewed in the current article.

The first study used a single-case multiple-baseline across participants design with nine children suffering from spider phobia [21]. The cognitive–behavioral treatment was delivered according

Figure 1. A patient immersed in virtual reality using the head-mounted display technology and a joystick.
Picture courtesy of the Cyberpsychology Laboratory of Université du Québec en Outaouais ©.

to a standardized treatment manual and allowed children to enter different rooms in which spiders of various sizes and behaviors were found. The exposure was progressive, from spider webs on walls to a room with a small spider staying still and larger moving spiders. Children reported very positive comments toward their therapy and the use of VR. As illustrated on Figure 3, daily self-reports of spider fear were reduced after the beginning of a four-session *in virtuo* exposure-only treatment. These children, who were on average 11.3 years old, also reported a significant reduction in specific measures of arachnophobia (e.g., Fear of Spider Questionnaire and Spider Beliefs Questionnaires) and on a more general measure of anxiety (Fear Questionnaire).

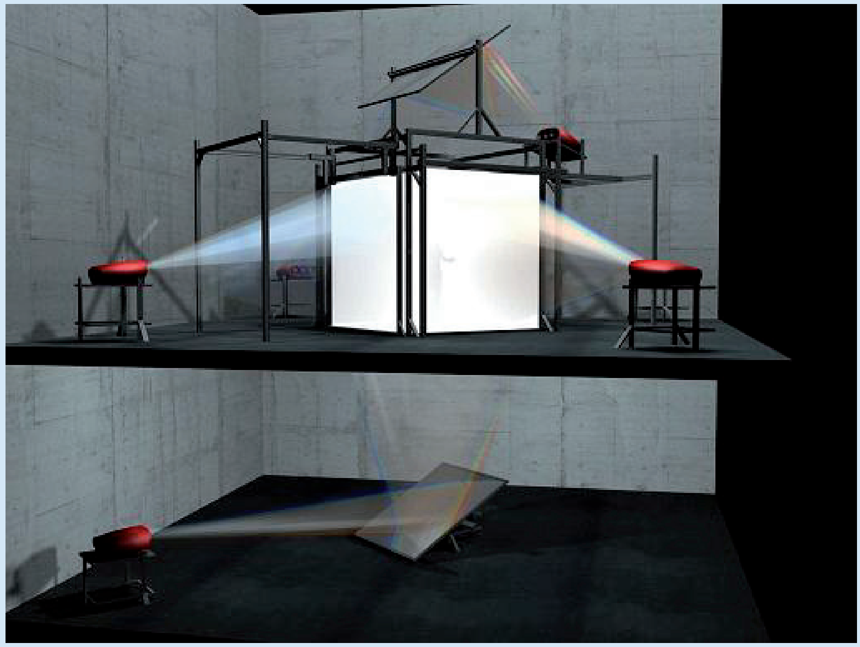

Figure 2. Illustration of of a 10 × 10 × 10 foot immersive room (in this case Psyche, from Université du Québec en Outaouais) where images are retro-projected on the six surfaces and the user is fully immersed inside the 'cube'.
Image courtesy of the Cyberpsychology Laboratory of Université du Québec en Outaouais ©.

This study was followed by a larger scale project aiming at determining whether offering cognitive–behavior therapy in VR would increase children's motivation toward therapy [22]. Since VR may be perceived as 'cool' by children, it was expected that they would show a stronger motivation if their treatment involved VR. A sample of 31 arachnophobic children aged 8–15 years old were randomly assigned to an exposure-only treatment composed of either five sessions of *in vivo* exposure or four sessions of *in virtuo* exposure followed by a fifth session of *in vivo* exposure. Outcome was assessed after the fourth therapy session, at the end of the treatment and at 6-month follow-up. Extrinsic motivation was assessed from the participant's point of view and reluctance to come to the therapy session was assessed as perceived by the parent. Contrary to expectations, delivering exposure-based therapy in VR did not increase the children's motivation compared with traditional *in vivo* exposure. No significant difference was found in the motivation of children in either group. In fact, adding *in vivo* exposure with a live tarantula had a small positive impact on the motivation of children who only received *in virtuo* exposure. This study also revealed that motivation was already strong in the sample and that integrated extrinsic motivation predicted treatment outcome. Although the study by St-Jacques *et al.* was designed to address motivation and treatment process, as opposed to a randomized control trial, the data reported at post-treatment and follow-up demonstrated a significant improvement in fear (see Figure 4), avoidance behavior and dysfunctional beliefs [22]. The addition of an *in vivo* exposure session to four *in virtuo* ones may have increased treatment effectiveness, but such conclusions remain tentative given the sample size and method. Information gathered from the participants after the study and while listening to the audio recordings of the therapy sessions to document treatment integrity may provide an explanation as to why motivation was not higher in the *in virtuo* condition. Children immersed in VR appeared overly apprehensive toward the virtual spiders – a phenomenon not observed in therapy with adolescents and adults, where patients prefer to receive VR rather than *in vivo* exposure [23]. Participants reported being afraid of the potential size and behavior of virtual spiders they were about to encounter. The researcher's team later hypothesized that adolescents and adults implicitly know that therapists will not try to scare them with virtual spiders that are threatening and extremely disgusting, but children may not. Imagination plays a significant role in VR, and children's imagination may need to be contained and corrected before using VR in exposure to scary or disgusting stimuli. This hypothesis is currently being tested and preliminary results indeed show that younger children expect virtual spiders to be larger and more aggressive than adults do [24].

Virtual reality has also been used with children suffering from 'school phobia', which is a form of school refusal associated with the fear of events occurring in school. Gutiérrez-Maldonado and colleagues randomly assigned 36 school-age children (aged 10–15 years) to either a waiting list control condition or to five cognitive–behavior therapy sessions [25]. The treatment included relaxation training, imaginal exposure to a hierarchy of school-related fears, and *in virtuo* exposure. The virtual environment allowed the child to enter a school, find his or her classroom, deal with progressively more people in the corridors, take a seat in a classroom, answer questions from a professor, present in front of the classroom and solve difficult problems while classmates

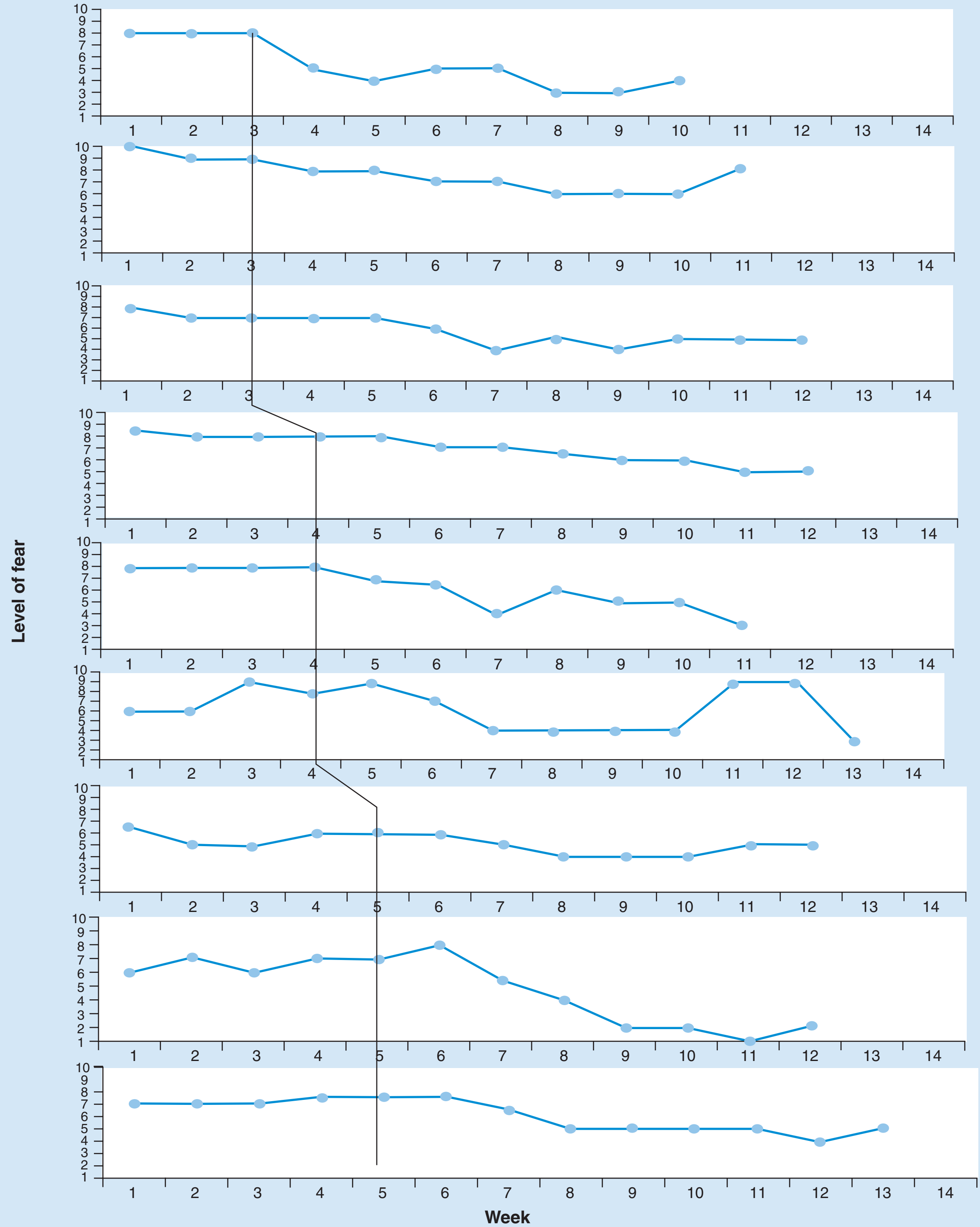

Figure 3. Weekly ratings of fear of spiders in nine children enrolled in a multiple baseline across-subjects single-case trial.
The vertical line illustrates the introduction of treatment after the baseline self-monitoring weeks.
Reproduced with permission from [21] © Elsevier Masson SAS, Editor.

are critical of the child. The exposure was conducted using a computer monitor instead of a more complete immersion with a HMD. Results were very positive and revealed a significant improvement on specific school fears from pre- to post-treatment.

A pilot study conducted with five 15–17-year-old adolescents suffering from social phobia demonstrated promising results for the use of cognitive–behavior therapy with *in virtuo* exposure with adolescents [26]. The virtual environments used for this study were developed to treat phobia of public speaking in adults. Stimuli were limited to giving speeches in a small or large classroom filled with adults whose reactions were under the therapist's control. Although the virtual people did not represent other adolescents, the visual analysis of the weekly anxiety ratings suggests a strong improvement in three participants, a moderate improvement in a fourth participant and no improvement in the fifth one.

In summary, very few studies have been conducted on the use of *in virtuo* exposure with children suffering from specific phobia. One control trial with school fears demonstrated a clear and positive impact of this form of treatment [25]. Another study also suggested that VR was effective for specific phobia [22], but the lack of an adequate control group limits the interpretation of the results. However, the St-Jacques *et al.* study was designed to address motivation toward therapy and provided interesting findings [22]. Children were well motivated toward their treatment and motivation was a significant predictor of treatment outcome. The fact that children were not reassured before the treatment about what to expect from the virtual spiders may explain why their motivation to be exposed to virtual spiders was not stronger than to be exposed to a live tarantula. Children are frequently exposed to frightening or disgusting insects on television, in cartoons and in horror movies [27,28]. Therefore, it is important to reassure them that they will not be exposed to such horrific scenes.

Using a technology such as VR comes with the need to know a few concepts that may be novel to clinicians, such as presence and 'cybersickness'. A popular concept in the field of VR is the sense of presence [17]. The potential to induce powerful emotional responses by immersion in VR is thought to be related to the sense of presence [2,13,17]. Presence is intuitively defined as the subjective sense of 'being there' in the virtual environment [2,29,30]. Researchers agree on this simplistic definition, although much debate remains about the exact nature of presence. Some insist on the contrast between 'arriving' into the virtual environment and 'departing' from the physical one [31], others insist on forgetting that the experience is computer-generated (the illusion of nonmediation [29]) and others propose subtypes of presence [30]. It is believed that a subjective sense of presence allows the user to think, feel and behave as if they were in the physical reality. Given a sufficient sense of presence, the virtual environment does not have to be a perfect and realistic reproduction of reality. Interestingly, people suffering from phobias feel more present in a virtual environment designed to expose them to their phobia than nonphobics [32]. Experimentally inducing anxiety causes an increase in the feeling of presence [33], which may be a useful trick for therapists. If a phobic patient does not feel very present in a virtual environment, increasing anxiety (e.g., by asking to let a virtual spider crawl on the user's feet) can lead to a sufficient increase in presence for the virtual environment to be felt as realistic and credible. A measure of presence has been adapted for children [21,22] and is currently being validated.

An important issue to be aware of is the side effects of VR [2,13,34]. Immersion in a virtual environment could induce what is commonly known as cybersickness. Cybersickness, or more precisely the side effects induced by immersion in VR, could be related either directly to the equipment, or to conflict between sensory information. The equipment issue (e.g., a heavy HMD causing neck strain in children or looking closely at LCD monitors for a long period of time inducing eye strain) becomes less and less of a problem given the fast pace of technological advances. For example, HMDs can now offer a clear 920,000-pixel resolution with a 1024 × 768 video graphics array and can weigh less than 3.3 ounces [35]. The conflicts between sensory information are still an issue in VR. Take the example where an individual with a phobia of heights is immersed in VR with a HMD. When he/she turns her head around, he/she can contemplate the scenery. If he/she looks down he/she can see the depth of the cliff, and by pressing a mouse button with a finger he/she can walk forward to the edges of the cliff. When that user 'walks' in the virtual environment, the visual system signals movement based on the information seen in the HMD, while part of the vestibular and the proprioceptive systems do not detect forward motion. When the user turns his/her head around, the vestibular system immediately detects motion, but there may still be a small lag while the computer processes the information from the tracker and the corresponding visual stimuli are displayed in the HMD. These incongruities between sensory systems could cause symptoms of nausea, vertigo, headache and blurred vision. [34]. Finally, looking down a virtual cliff could induce vertigo. While the first two examples of cybersickness are related to motion sickness, the last one is 'natural' in the sense that it is not caused by VR *per se*, but is a normal reaction in some people when they perform the same behavior in the physical world. Studies have documented that cybersickness is usually transient, not severe [22] nor dangerous and often disappears during the immersion in VR, among adults suffering from anxiety disorders [36] or in a sample of nonclinical children [37]. Yet, ethically, it is considered best practice that VR is used by clinicians previously trained in the use of VR who are following some established safety protocol [2] and that parents are informed about potential side effects.

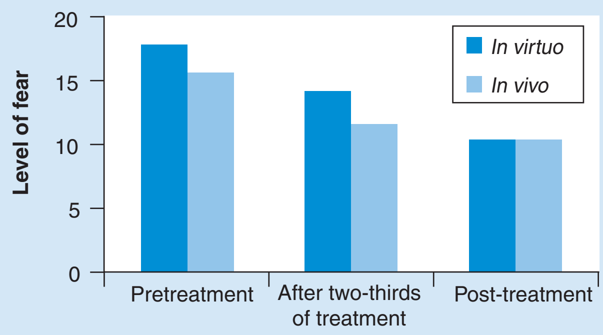

Figure 4. Level of fear of spiders before, after two-thirds of a treatment program and after a five-session treatment program comparing *in virtuo* and *in vivo* exposure.

Expert commentary

It is clear that VR is more than a science-fiction toy for computer engineers. The technology offers many opportunities for the treatment of specific phobias in children. The current programs that have been empirically validated with children are limited to school phobia and arachnophobia. Using VR to conduct exposure was effective in treating these phobias, although large randomized control trials with control conditions and long-term follow-up are still needed in order to reach firm conclusions. Using programs depicting stimuli that were developed specifically for adults may be useful to some extent, such as for social anxiety, but ideally, stimuli used for *in virtuo* exposure should be developed specifically for children. A cautionary note about motivation must be formulated to clinicians using VR with children suffering from anxiety disorders. It is important to explain to the child what will, and will not, happen in VR. Children have a strong imagination and are probably more likely to expect horrific situations compared with older patients.

Five-year view

Four trends are expected to appear in the next 5 years. First, more empirical evidences will be published to document the efficacy and effectiveness of VR with specific phobias. More outcome studies are needed to be conducted on phobias because these disorders are well circumscribed, usually not leading to other complex comorbid disorders that blur treatment process, and for which treatments can remain very focused. The second trend will be the use of VR with children suffering from more complex anxiety disorders, such as obsessive–compulsive disorder and post-traumatic stress disorder. Once basic knowledge about *in virtuo* exposure with children is mastered, applications will be validated for conditions where VR is most needed. Newer technologies will definitively appear and improve our clinical tools. Lighter HMDs, more efficient computers, portable devices allowing the virtual environment to be brought home, and augmented reality are all at our doorstep. Finally, VR becoming a well-documented evidence-based approach for a variety of disorders, and the technological improvements leading to more affordable and attractive technologies, will lead to wider dissemination of VR from research centers to clinical settings. Practically, that means more VR will be available for patients where this technology would really make a positive difference in their treatment.

Financial & competing interests disclosure

The preparation of this article was made possible by peer-reviewed research grants from the Canada Research Chairs program, the Canada Foundation for Innovation, the Natural Sciences and Engineering Research Council of Canada and the Social Science and Humanities Research Council of Canada. The study was conducted at the Laboratoire de Cyberpsychologie de l'UQO (www.uqo.ca/cyberpsy/), where the author is conducting research and developing virtual reality environments. The author has no other relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript apart from those disclosed.

No writing assistance was utilized in the production of this manuscript.

Key issues

- The benefits of virtual reality (VR) for children include increased control, confidentiality, availability of stimuli and safety.
- The head-mounted display technology is affordable and can be used in private practice settings.
- Large and costly high-end immersive rooms are essentially dedicated for research purposes.
- Presence, or the illusion that is felt during immersion is not artificially created, is considered by many as an important feature of VR.
- Immersion in VR may induce small and transitory side effects. They are not a major source of concern, but given the state of knowledge with children, they should be monitored during therapy sessions.
- There is a need for well-designed randomized clinical trials with children.
- Available data on children support findings observed with adults that using VR to conduct exposure to feared stimuli in the treatment of phobias is effective.
- Studies have covered school phobia/refusal, arachnophobia and, to some extent, social anxiety.
- Motivation towards therapy does predict treatment outcome.
- VR may increase motivation towards exposure-based therapy if children are not afraid to be put in virtual situations where they will face horrific or disgusting stimuli.

References

Papers of special note have been highlighted as:
• of interest
•• of considerable interest

1 Pratt DR, Zyda M, Kelleher K. Virtual reality: in the mind of the beholder. *IEEE Computer* 28, 17–19 (1995).

2 Stanney KM. *Handbook of Virtual Environments: Design, Implementation, and Applications*. IEA, NJ, USA (2002).

•• **Comprehensive textbook on virtual reality (VR), although not specific to the treatment of phobias and children.**

3 Zhou NN, Deng YL. Virtual reality: a state of the art survey. *Int. J. Architect. Comput.* 6(4), 319–325 (2009).

4 Aimé A, Cotton K, Bouchard S. Reactivity to virtual reality immersions in a subclinical sample of women concerned with their weight and shape. *J. Cyberther. Rehab.* 2(2), 111–120 (2009).

5 Riva G, Bacchetta M, Baruffi M, Molinari E. Virtual reality-based multidimensional therapy for the treatment of body image disturbances in obesity: a controlled study. *Cyberpsychol. Behav.* 4(4), 511–526 (2001).

6 Rizzo AA, Buckwalter JG, Bowerly T *et al.* The virtual classroom: a virtual reality environment for the assessment and rehabilitation of attention deficits. *Cyberpsychol. Behav.* 3(3), 483–499 (2000).

7 Strickland D, Marcus LM, Mesibov GB, Hogan K. Brief report: two case studies using virtual reality as a learning tool for autistic children. *J. Autism Dev. Disord.* 26(6), 651–659 (1996).

8 Botella C, Garcia-Palacios A, Banos R, Quero S, Breton-Lopez J. Virtual reality in the treatment of pain. *J. Cyberther. Rehab.* 1(1), 93–100 (2008).

9 Gaggioli A, Keshner EA, Weiss PL, Riva G. Advanced technologies in rehabilitation. In: *Studies in Health Technology and Informatic*. IOS Press, Amsterdam, The Netherlands, 145 (2009).

10 Kim SI, Ku J, Han K *et al*. Virtual reality applications for patients with schizophrenia. *J. Cyberther. Rehab.* 1(1), 101–112 (2008).

11 Renaud P, Rouleau J, Granger L, Barsetti I, Bouchard S. Measuring sexual preferences in virtual reality: a pilot study. *Cyberpsychol. Behav.* 5(1), 1–9 (2002).

12 Côté S, Bouchard S. Virtual reality exposure's efficacy in the treatment of specific phobia. *J. Cyberther. Rehab.* 1(1), 75–92 (2008).

- **Overview of outcome studies in adults.**

13 Wiederhold BK, Wiederhold MD. *Virtual Reality Therapy for Anxiety Disorders. Advances in Evaluation and Treatment*. American Psychological Association Press, DC, USA (2005).

- **Textbook on the use of VR with adults suffering from anxiety disorders.**

14 Ollendick TH, King NJ, Muris P. Fears and phobias in children: phenomenology, epidemiology, and aetiology. *Child Adolesc. Ment. Health* 7, 98–106 (2002).

15 Davis TE 3rd, Ollendick TH. Empirically supported treatments for specific phobia in children: do efficacious treatments address the components of a phobic response? *Clin. Psychol. Sci. Pract.* 12, 144–160 (2005).

16 Bouchard S, Mendlowitz SL, Coles ME, Franklin M. Considerations in the use of exposure with children. *Cognit. Behav. Pract.* 11(2), 56–65 (2004).

- **Description of what exposure is and how it should be conducted with children.**

17 Youngblut C. *What a Decade of Experiments Reveals About Factors That Influence the Sense of Presence: Latest Findings*. Institute for Defense Analysis, VA, USA (2007).

18 Baus O, Bouchard S. The sense of olfaction: its characteristics and its possible applications in virtual environments. *J. Cyberther. Rehab.* 3(1), 31–50 (2010).

19 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.* 42, 229–239 (2004).

20 Bouchard S, Côté S, Richard DS. Virtual reality applications of exposure. In: *Handbook of Exposure.* Richard DS, Lauterbach D (Eds). Academic Press, NY, USA, 347–388 (2006).

21 Bouchard S, St-Jacques J, Robillard G, Renaud P. [Effectiveness of an exposure-based treatment for arachnophobia in children using virtual reality: a pilot study]. *Journal de Thérapie Comportementale et Cognitive* 17(3), 101–108 (2007).

22 St-Jacques J, Bouchard S, Bélanger C. Is virtual reality effective to motivate and raise interest in phobic children towards therapy? *J. Clin. Psychiatry* 71(7), 924–931 (2010).

•• **Role of motivation in VR exposure with children – a comparative study and an analysis of predictors of outcome.**

23 Garcia-Palacios A, Botella C, Hoffman H, Fabregat S. Comparing acceptance and refusal reates of virtual reality exposure vs *in vivo* exposure by patients with specific phobia. *Cyberpsychol. Behav.* 10, 722–734, (2007).

24 Silva C. Preliminary analyses of thesis results. Universite du Quebec en Outaouais, Québec, Canada (2010)

25 Gutiérrez-Maldonado J, Magallon-Neri E, Rus-Calafell M, Penaloza-Salazar C. Virtual reality exposure therapy for school phobia. *Anuario de Psicologia* 40(2), 223–236 (2009).

•• **Randomized trial on *in virtuo* exposure in children.**

26 Doré F, Bouchard S. Using virtual reality to treat social anxiety disorders in adolescents. Presentated at: *The 11th Annual CyberTherapy Conference*. Gatineau, Canada, 12–15 June, 2006.

27 Worth KA, Chambers JG, Nassau DH, Rakhra BK, Sargent JD. Exposure of US adolescents to extremely violent movies. *Pediatrics* 122(2), 306–312 (2008).

28 Sargent JD, Heatherton TF, Ahrens MB, Dalton MA, Tickle JJ, Beach ML. Adolescent exposure to extremely violent movies. *J. Adolesc. Health* 31(6), 449–454 (2002).

29 Lombard M, Ditton T. At the heart of it all: the concept of presence. *J. Comput. Med. Commun.* 3(2), (1997).

30 Heeter C. Being there: the subjective experience of presence. *Presence (Camb.)* 1(2), 262–271 (1992).

31 Kim T, Biocca F. Telepresence via television: two dimensions of telepresence may have different connections to memory and persuasion. *J. Comput. Med. Commun.* 3(2), (1997).

32 Robillard G, Bouchard S, Fournier T, Renaud P. Anxiety and presence during VR immersion: a comparative study of the reactions of phobic and non-phobic participants in therapeutic virtual environments derived from computer games. *Cyberpsychol. Behav.* 6(5), 467–476 (2003).

33 Bouchard S, St-Jacques J, Robillard G, Renaud P. Anxiety increases the sense of presence in virtual reality. *Presence (Camb.)* 4(1), 376–391 (2008).

34 Lawson BD, Graeber DA, Mead AM, Muth ER. Signs and symptoms of human syndromes associated with synthetic experience. In: *Handbook of Virtual Environments: Design, Implementation, and Applications.* Stanney KM (Ed.). IEA, NJ, USA, 589–618 (2002).

35 Vuzix Corporation. iWear VR920 user's manual. NY, USA (2009).

36 Bouchard S, St-Jacques J, Renaud P, Wiederhold BK. Side effects of immersions in virtual reality for anxious people. *J. Cyberther. Rehab.* 2(2), 127–137 (2009).

37 St-Jacques J, Bouchard S. Clinical applications of virtual reality and cybersickness. Poster presented at: *The 10th Cybertherapy Conference.* Basel, Switzerland, 7–10 June, 2005.