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ORIGINAL PAPER

Virtual Reality Exposure Treatment in Phobias: a Systematic Review

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Abstract

We compare the relative efficacy of virtual reality therapy exposure (VRET) versus *in vivo* therapy exposure among individuals suffering from phobias. A systematic search was completed up to 03 April 2020, using the following databases: ACM Digital Library, ResearchGate, IEEE, Science Direct, MIT PressJournals, Center for Direct Scientific Communication (CCSD) and Mary Ann Liebert Publishers. Five authors searched the databases using the following terms: Virtual Reality, Phobia, Mental health, Computing, Therapy, HMD, CAVE, Virtual ambient, *in virtuo*, Avoidance, Exposure, VRET, in vivo, Anxiety, Agoraphobia, Social Phobia, Stimuli, Cognitive–behaviour. All studies that evaluate the effect of *in virtuo* exposure towards phobia rehabilitation were selected. By reviewing the article, each author then applied the inclusion and exclusion criteria, and 30 articles were selected. Data extracted included the number of samples, amount of sessions, study variables that may affect the final outcome, therapy technology. The data provided was synthesized using a meta-analysis based on the results. The results demonstrated a positive outcome of Virtual Reality Exposure Treatment in the treatment of most phobias. In contrast, some of these treatments did not work for a few specific phobias in which the standard procedures were more effective. The findings suggest that for some specific phobias treatment, Virtual Reality Exposure Treatment does not reach the *in vivo* exposure level of immersion and presence. Further research is needed to perform studies with higher-dimension samples, since many papers report a low sample size and that is probably why many of them have inconclusive results.

Keywords Specific phobias · Exposure therapy · Virtual reality · Mental health computing · Social phobia · Cognitive-behavior therapy · VRET · Meta-analysis

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Introduction and Background

Phobias present themselves as irrational fears about situations, creatures, places or objects, affecting as much as 10% of the worldwide population at some point in their lives, according to the National Institute of Mental Health (NIMH) [2]. These are identified by anxiety and/or fear in restricted situations, which pose little or no actual danger. There are three types of phobias recognized by the American Psychiatric Association (APA) [1]:

- Agoraphobia is characterized by symptoms of anxiety in situations where the person perceives their environment to be unsafe with no easy way to escape. These situations may vary among open spaces, public transportation, traveling and many others.
- Social Phobia is generally described as social anxiety and causes distress and impaired ability that intervene negatively in someone's daily life routines.
- Specific Phobia consists of intense fear and anxiety towards some specific trigger, namely animals, darkness, heights, among other examples.

There is no standardized phobia treatment protocol, so the treatment needs to be tailored to each individual in order to obtain positive long-term results [3].

The most common way of treatment for phobic disorders consists of *in vivo* exposure[1]. This method consists of confronting the patient over a long period of time (e.g., 60 to 90 minute-long sessions) with a feared stimulus until distress has decreased. The objective consists of changing the patient's response to the object or situation that is causing the fear. Gradual, repeated exposure to the source and the related thoughts, feelings and sensations may help to manage the patient's anxiety and fear.

Cognitive Behavioral Therapy (CBT) is a distinct counseling approach that focuses on teaching the phobic person to employ different ways of understanding and reacting to the phobia (Table 1).

Certain medications may also help reduce symptoms of anxiety before other previously mentioned approaches. These include: (i) beta-blockers; (ii) antidepressants; (iii) tranquillisers. It is not possible to avoid the triggers of some phobias, as is often the case with complex phobias, so a combination of different therapy approaches may be advised [4].

Another approach resides in the usage of Virtual Reality (VR), which consists of a computer-generated environment to simulate the real world through an immersive 3D visual and auditory experience. This technology represents an option for phobias treatments, that mocks *in vivo* exposure, as a result of visual, auditory and sensory stimuli. The most common techniques used to immerse participants in the virtual environment are head mounted displays (HMD) and projecting-based systems (e.g., CAVE-Systems). The former focuses on individual use, through screens and speakers incorporated into the glasses, while the latter uses computer-generated images on all sides of the treatment area. The interaction with the user occurs through sensors that track the user position and movements, frequently complemented with input devices like joysticks or head tracking systems.

The primary purpose of this study is to systematically review and investigate the actual effectiveness of VRET towards overcoming existing phobias. This research is expected to contribute to existing knowledge on the treatment of phobic behaviors, providing compelling contributions to the proposed research area for utilizing virtual environment technology towards the treatment of psychological problems.

[1]Exposure therapy generally used for treating individuals with phobias, obsessive-compulsive disorder, and other anxiety disorders, in which the client directly experiences anxiety-provoking situations or stimuli in real-world conditions [5].

Table 1 List of abbreviations

VRET	Virtual reality exposure therapy
CBT	Cognitive Behavioral Therapy
CCSD	Center for Direct Scientific Communication
NIMH	National Institute of Mental Health
APA	American Psychiatric Association
VR	Virtual Reality
HMD	Head mounted display
CAVE	CAVE Automatic Virtual Environment

Methods

Research Questions

We performed a systematic review of the published literature, using two broad research questions:

- **[RQ1] - How can VR exposure therapy (VRET) contribute to overcoming existing phobias, compared to traditional *in vivo* exposure?**
  In this question, we study the feasibility of using VR exposure therapy towards phobia rehabilitation. Here we analyse existing studies regarding the effectiveness of virtual environment treatments and correlate them with preceding *in vivo* environment treatment, to generate the most suitable therapy model.
- **[RQ2] - Could such technology be variable-dependent, correlating different age groups, education aggregations, citizenship, phobias or other entity attributes?**
  The aforementioned question inquiries virtual reality success when applied to a diverse population sample. Furthermore, we associate participants' attributes and treatment procedures of all the included studies to consequent therapy results, intending to achieve standardized VR settings that could be applied to all patients

Starting from these research questions, and together with an expert librarian, we developed a detailed search strategy. We used the PICO framework as a reference to develop the research questions :

(1) Population- People suffering from phobias;
(2) Intervention - Measurements of anxiety and avoidance;
(3) Comparison - Tradicional methods de in vivo exposure;
(4) Outcome - Minimize shock factor, intrusive actions and treatment protocols with substantial costs.

Literature Search

Entire prospective studies were gathered from databases and digital libraries mentioned below, which were obtained through the terms in Table 2.

A search of existing literature was completed using the following databases: ACM Digital Library, ResearchGate, IEEE, Science Direct, MIT PressJournals, Center for Direct Scientific Communication (CCSD) and Mary Ann Liebert Publishers. After the initial recruitment of studies, referral sampling [6] was applied resulting in a sample build-up, where enough data was gathered to be useful for research.

Table 2 Search terms

Virtual Reality	Health	Therapy	Phobias
VR	Mental Health	Exposure	Phobia
HMD	Avoidance	*In vivo*	Social Phobia
VRET	Stimuli	Therapy	Agoraphobia
Virtual ambient	Anxiety	Computer-aided	Specific Phobia
Cave	Fear	Cognitive–behaviour	Illness

Additionally, present research used prior literature review studies [8, 14, 16, 18], in order to retrieve new articles that qualified to present research standards. Initial search yielded 55 prospective articles.

Inclusion and Exclusion Criteria

The quality and credibility of the present systematic literature review rely on the same aspects of prospective studies.

Inclusion criteria consisted of the following: (i) studies that evaluate the effect of *in virtuo* exposure towards phobia rehabilitation; (ii) studies that correlate results of *in virtuo* exposure to *in vivo* exposure; (iii) studies that review the impact of studies that are in unison with previously described criteria; (iv) studies available for free on reliable information sources.

Exclusion criteria consisted of the following: (i) studies that do not include results and conclusions; (ii) research that only used traditional therapy methods; (iii) position research papers; (iv) abstracts or unpublished research, intending to filter out unreliable information; (v) studies related with health applications other than phobias because this was not the main focus on this literature review; (vi) studies that not evaluate the effect of *in virtuo* exposure; (vii) research prior the year 1995, whose results depend on prior technology limitations which are obsolete to today's standards; (viii) studies not published in English.

Selection

The initial search resulted in 55 records which were properly identified. Each study's results were checked in order to finalize a list of eligible papers to include, 22 papers were excluded according to our pre-defined exclusion criteria.

This resulted in 33 papers suitable for Eligibility. Thirty-three papers were then analysed, and 4 of them were excluded, as they contained additional reviews for a disparity of useful articles not fitting the aim of this review, resulting in a final number of 29 papers included for the full review.

Data Extraction and Synthesis for Meta-analysis

For each study, the following qualitative information was collected: the participants, variables, techniques and the experimental results. The researchers transferred data from the article tables, figures, and text into a spreadsheet. The data was synthesized using a meta-analysis, with the studies grouped according to the type of phobia they focused on. The

results from the meta analysis were analysed regarding consistencies and strengths of the findings from each, and the overall effect when the results of the various studies were combined.

Results

The types and descriptions of variables present in the different studies are generally particular and relevant to one specific phobia. Formerly-mentioned variables are described on Table 3. Long-term effects are sometimes investigated by follow-up tests. The present review generated three meta-analysis tables, one for each type of phobias recognized by APA: agoraphobia on Table 4, social phobia on Table 5 and specific phobia on Table 6. A total of 771 individuals with phobias were included from the 29 datasets. The population demographics and means are presented in the aforementioned Tables 4, 5 and 6 whenever said data is available on reviewed articles. Population demographics included distribution of participants by sex, age and citizenship.

Reviewed articles are based on case studies and the most attention will be given to reliable and valid clinical trials. In most studies, VRET was often compared with other treatment alternatives providing contextual results that better represent relevant conclusions.

The number of sessions and sample sizes differed between the prospective studies, which may affect discussions related to said articles. Both previous characteristics will be mentioned for every study. The effectiveness of VRET towards overcoming existing phobias will be discussed as will possible variables that impact the results of provided case studies.

The types and descriptions of variables present in the different studies are generally particular and relevant to one specific phobia. Nevertheless, some studies provide a behavioral avoidance test (BAT), which is important in order to generalize effects of VRET. Formerly mentioned variables are described on Table 3. Long term effects are sometimes investigated by follow-up tests.

Dependent variables: ATAQ=Attitude Towards Agoraphobia Questionnaire; SUDS=Subjective Units of Distress Scale; DSM-IV=Diagnostic and Statistical Manual of Mental Disorders; SRFI=School-Related Fears Inventory; FSSC-R=Fear Survey Schedule for Children Revised; SRAS-C=School Refusal Assessment Scale, children version; STAI-C=Strait-Trait Anxiety Inventory for Children; LSAS=Liebowitz Social Anxiety Scale; RAS=Rathus Assertiveness Schedule; ZSHADS=Zigmond and Snaith Hospital Anxiety Depression Scale; ATPS=Attitude Towards Public Speaking; SUD=Units of Disturbance;FQ=fear questionnaire; BAT=Behavioral Avoidance Test; ATTH=Attitude Towards Height Questionnaire; BISS=Blood Injection Symptoms Scale; MDAS=Modified Dental Anxiety Scale; DFS=Dental Fear Survey; S-BISS=State Blood Injection Symptoms Scale; PROMIS=Problem-Related Impairment Questionnaire; VAS-A=Visual Analogue Scale; MINI=Mini International Neuropsychiatric Interview; ADIS-IV=Anxiety Disorders Interview Schedule; HAM-A=Hamilton Anxiety Scale; BDI=Beck Depression Inventory; STAI=State-Trait Anxiety Inventory; DCQ=Driving Cognitions Questionnaire; IPQ=The Igroup Presence Questionnaire; MOS SF36=Medical Outcomes Survey SF-36; FR=Fear Record; ATF=Questionnaire on Attitudes Toward Flying; MS=Maladjustment Scales; DEFAS=Danger Expectations and Flying Anxiety Scales; CGI=Clinical Global Improvement; FFI=Fear of Flying Inventory.; SPQ-C=Spider Phobia Questionnaire for Children; PT=Phobic Target; DAT=Driving anxiety test; TEF=Treatment evaluation form

Table 3 Types and descriptions of the measurement systems

Study	Condition	Measurements	Stimuli
Agoraphobia			
[13]	Agoraphobia	ATAQ; SUDS	Fear; anxiety
[27]	Agoraphobia	Blood pressure; respiration; heart rate; DSM-IV	Panic
Social phobia			
[33]	Social phobia	SRFI; FSSC-R; SRAS-C; STAI-C	Fear; anxiety; avoidance
[34]	Social phobia	Physiological data	Anxiety; avoidance
[12]	Social phobia	LSAS; RAS; ZSHADS	Intimacy; scrutiny; assertiveness
[23]	Social phobia	ATPS; SUD	Anxiety; avoidance; disturbance
[31]	Social phobia	Percent rate of eye blink and gaze fixation	Anxiety
Specific phobia			
[22]	Acrophobia	Anxiety sensitivity index; FQ; acrophobia questionnaire; ATTH	Anxiety; avoidance
[10]	Acrophobia	DSM-IV axis I disorders; Acrophobia Questionnaire; BAT	Anxiety, avoidance
[26]	Acrophobia	BAT; Psychophysiology	Anxiety; avoidance; fear
[35]	Arachnophobia	DSM-IV; traditional cognitive-behaviour model; Spider Beliefs Questioners; Simulator Sickness Questionnaire; BAT; Presence Questionnaire	Perspective; opinion
[32]	Arachnophobia	Fear of spider questionnaire; spider beliefs questionnaires; FQ	Anxiety; avoidance
[9]	Arachnophobia	BAT; Clinical impressions	Anxiety; avoidance
[21]	Arachnophobia	SUDS; BAT; SPQ-C; PT	Anxiety; avoidance
[37]	Arachnophobia	Fear of spiders questionnaire; presence questionnaire; BAT	Fear; anxiety
[17]	Blood-Injection	FQ; BISS; S-BISS	Fear; pain; avoidance
[25]	Claustrophobia	BAT; SUDS; PROMIS; Anxiety Sensitivity Index	Panic; anxiety; avoidance
[36]	Claustrophobia	CLQ; IPQ; ITC-SOPI; SUDS	Panic; anxiety
[29]	Dental phobia	MDAS; DFS; VAS-A; BAT	Presence; credibility; nausea; anxiety
[24]	Dental phobia	VAS-A; MDAS; DFS	Anxiety; fear

Table 3 (continued)

Study	Condition	Measurements	Stimuli
[38]	Fear of driving	MINI; DSM-IV Axis II (SCID-II); BDI; STAI; HAM-A; DCQ; IPQ; SUDS; MOS SF-36	Uncomfortable; fear; heart rate
[39]	Fear of driving	SUDS; DSM-IV Axis II (SCID-II); Behavioral measure; DAT; Driving diary; TEF	Anxiety; panic; fear
[28]	Fear of driving	DSM-IV Axis II (SCID-II); MINI; Fear Of Driving Inventory; HAM-A	Panic; anxiety
[19]	Fear of Flying	ADIS-IV; SUDS; FR; MS; DEFAS; FFI	Fear; anxiety
[11]	Fear of Flying	ATF; DSM—IV; CGI; FFI	Memory; fear
[40]	Fear of Flying	QAF; FFI; SSR;ASSRS; CGI ;Flight Self-Monitoring Sheet; Therapist Form	Fear; avoidance; anxiety
[30]	Needles	Wong–Baker pain scale; McMurtry children's fear scale	Fear; pain
[20]	PTSD	Clinician-administered PTSD scale; combat exposure scale; impact of events scale;	Imagination; stress; fear; anxiety
[15]	Small animals	Magnetic Resonance Imaging; PET; EEG	Anxiety; fear

Agoraphobia

In a case study [13], thirty undergraduate college students served as subjects in the experimental group while another thirty subjects served as a control group. The virtual environment system for this study consisted of a VR Flight Helmet, an electromagnetic head-tracker and a Virtual Technologies CyberGlove. The previous apparatus allowed the interaction with 8 virtual environments: (i) four balconies at different heights; (ii) empty room; (iii) empty dark barn; (iv) dark barn with a black cat; (v) covered dark bridge; (vi) elevator with no walls or ceiling; (vii) canyon with multiple bridges; (viii) different height hot air balloons. The average SUDS scores of the experimental group decreased steadily across sessions, indicating steady improvement with treatment.

Table 4 Characteristics of included studies regarding agoraphobia

Study	Sample	Sessions	Variables	Technique	Results
[13]	60	8	Undergraduate students enrolled at Clark Atlanta University	HMD; head-tracker; interactive glove	Computers can be a viable psychotherapy tool
[27]	7	2	2 female, 5 male	HMD	VRE was stopped because most participants could not be immersed into the virtual environments

Table 5 Characteristics of included studies regarding social phobia

Study	Sample	Sessions	Variables	Technique	Results
[33]	36	5	23 female, 13 male, age between 10 and 15 years old. School children	HMD	Results were very positive and revealed a significant improvement on specific school fears.
[34]	5	NS	Age between 15 and 17 year old. Adolescents; Limited by small sample	HMD	Rehabilitation success rate of 60%
[12]	36	12	19 Females, 17 Males, age between 22 and 42 years old	HMD	The difference between VRT and CBT was not significant, but they believe that if the sample had a bigger sample it could improve VRT effectiveness
[23]	14	5, from 10-15min	6 VRET patients for 8 individuals on comparison group; two patients did not finish the study	HMD	VRET group showed significant improvement after five weeks of treatment; comparison group did not show any meaningful changes to VRET results.
[31]	60	NS, from 10-15min	29 Male and 31 Female, 47 Asian and 13 European	HMD	Participants exhibited more anxiety in accordance with the attitude of virtual avatars than the avatar's level of realism

Table 6 Characteristics of included studies regarding specific phobia

Study	Condition	Sample	Sessions	Variables	Technique	Results
Acrophobia						
[22]	Acrophobia	1	6	61 yr man with long term phobia	HMD	Improvement in reducing anxiety and avoidance.
[10]	Acrophobia	33	8	Adults(average age 43.97) , 13 females, 16 males	HMD	VR treatment can be as effective as the tradition method of exposure treatment *in vivo*
[26]	Acrophobia	213	NS	NS	HMD and CAVE-like HMD	VRET effectiveness similar to *in vivo* exposure
Arachnophobia						
[35]	Arachnophobia	11	5; 90 min	10 females and 1 male	HMD	VR environment could be significantly improved
[32]	Arachnophobia	31	4	Study limited by children	CAVE	Children immersed in VR appeared overly apprehensive toward the virtual spiders
[9]	Arachnophobia	23	4	Adults(average age 29.25) , 90.9% female, 9.1% male	HMD V8 helmet	VR exposure was more effective than a waiting list control condition in reducing the main effects of arachnophobia
[21]	Arachnophobia	28	3	10-17 years old	CAVE	The results showed the superiority of the *in vivo* exposure treatment over the VRET
[37]	Arachnophobia	8	3	Women (80.6) and men (19.4)	HMD	High success rate of VRET when complemented with tactile augmentation mechanisms

Table 6 (continued)

Study	Condition	Sample	Sessions	Variables	Technique	Results
Blood-Injection						
[17]	Blood-Injection	20	NS	13 females and 7 males from san diego, ages between 20 to 54	HMD	Shows a general pattern of arousal during VR exposure.
Claustrophobia						
[25]	Claustrophobia	4	8	Claustrophobic and panic disorder	HMD	Positive results using VR technology.
[36]	Claustrophobia	18	NS	12 male and 6 female	HMD	System for the treatment of claustrophobia, which is affordable and potentially efficacious.
Dental phobia						
[29]	Dental phobia	30	NS	Randomized group allocation with long term follow-up	HMD	VR can reduce the degree of anxiety by exposing the patient to a virtual dental care scenario in an incremental manner
[24]	Dental phobia	2	20-25 min	Two female with 24 and 56 years old	HMD	Patients A and B rated the 'presence' they felt during VRET at 10 and 8, respectively. Both rated the 'realism' of the virtual world at 10.
Fear of Driving						
[38]	Fear of driving	8	8	Woman	HMD	VRET can be used to facilitate *in vivo* exposure, because it can induce presence/immersion
[39]	Fear of driving	1	3	NS	HMD	Needs further evaluate the efficacy of VRET for driving phobia in controlled clinical trials.
[28]	Fear of driving	7	12	All had a motor vehicle accident	HMD and screen	Significant reductions were found in distress, driving anxiety, post-traumatic stress and heart rating

Table 6 (continued)

Study	Condition	Sample	Sessions	Variables	Technique	Results
Fear of Flying						
[19]	Fear of Flying	4	NS	Age between 23 and 41 years old, using 4 scenarios	HMD	In all cases thought conviction decreased upon treatment completion for each participant, reaching 0 and 2 score at posttreatment on a 0-10 scale.
[11]	Fear of Flying	49	2	Age, education, income, gender, race	NS	Equal to *in vivo* but with less cost
[40]	Fear of Flying	1	6 / 35-45 min / 7 weeks	Female - 42 years	HMD	Virtual reality exposure treatment was successful in reducing this subject'sfear of flying. VR exposure to the overall outcome is considered significant for many reasons
Needles						
[30]	Needles	34	NS	17 subjects and 17 parents	HMD	This study shows a general pattern of arousal during VR exposure.
PTSD						
[20]	PTSD	16	8-16	Male Vietname veterans with age 51 years	HMD	All patients reported reduction in PTSD symptoms from 15 to 67 percent.
Small animals						
[15]	Small animals	11	6	Women, aged between 20 and 35	HMD; Joystick	Similar results with VR and real stimulus regarding fmri brain activities

Another study [27] had seven participants, in which all of them were not able to feel present in the virtual environment, causing the premature ending of the study. The goal of this study was to evaluate the effectiveness of VRET by using blood pressure, respiration, and heart rate measurements. A virtual environment tunnel scene with a traffic jam was created for this study. The negative results suggest that either: (i) the overall VR experience built by the research team suffered from poor quality; (ii) *in virtuo* exposure needs further research and adaption for patients to fully consider a 3D stimuli as believable.

Social Phobia

Gutiérrez-Maldonado et al. [33] describe a study in which 36 children with ages comprehended between 10 and 15 years old were submitted to VRET, focusing on relaxation and exposure to school-related phobias. The hardware used was an HDM, allowing the user to virtually enter the school, socialize with different people in the corridor, sit in the classroom and participate in the class... Previous interactions are based on two different environments, namely school, and classroom. Each environment was divided into two levels of interaction, an "easy" level with stimuli provoking low levels of anxiety and a "difficult" level with an increasing amount of anxious stimulation. A total of 5 sessions were taken and the results post-treatment revealed a positive impact on the specific school fears.

A pilot study conducted with five 15–17-year-old adolescents suffering from social phobia [34] demonstrated promising results for the use of cognitive–behavior therapy with *in virtuo* exposure. The equipment used was the same as the previous study, and despite its small sample size, the rehabilitation success rate was set at 60%.

Additional studies focused their efforts into developing comparison groups [12, 23]. The indicated articles recruited two sample groups, virtual reality therapy group, and control group. This allows standard exposure *in vivo* to be compared with VRT. In both studies results showed statistically and clinically significant improvements regarding VRT, although VRT and CBT did not show any meaningful differences. Preceding trials accessed the anxiety, avoidance, attitudes, and disturbance associated with the fear of public speaking, conferring special attention to anxiety evaluation methods, which suffer from subjective interpretation, due to measures of anxiety involved had been primarily subjective.

Finally an article [31] inquiries the level of realism in virtual environments in correlation with VRET effectiveness. The study utilizes 60 volunteers and studied their anxiety levels when interacting with different fidelity levels of virtual humans in a job interview environment: (i) human photo; (ii) cartoonish 3D human; (iii) realistic 3D human. The virtual interviewer asked 9 general job interview questions in a randomized sequence. The study concluded that the realism of virtual avatar may be related to anxiety levels, but the high fidelity of virtual reality is not a critical factor in increasing the anxiety levels in a virtual environment.

Specific Phobias

The main focus of studies using VRET along the years was been on specific phobias. There are some areas of this kind of therapy that have been more explored than others.

Acrophobia

Acrophobia, a simple phobia, is characterized by marked anxiety upon exposure to heights, avoidance of heights, and a resulting interference in functioning [26]. People with this condition can experience panic attacks in high places and become too agitated to get themselves down safely. Acrophobia generally has a childhood-onset and is diagnosed somewhat more frequently in females than in males. This disorder may result in a restricted lifestyle or interference with certain occupations, depending on the severity.

Emmelkamp et al. [10] show that VR exposure can be effective with relatively cheap hardware and software on stand-alone computers currently on the market. VR exposure was found to be as effective as exposure *in vivo* on anxiety and avoidance level as measured.

Bullinger et al. [26] presented a study involving 213 participants. VRET studies do not normally exhibit samples of this dimension. Another particularity of this study is that the authors use HMD and Cave systems. As a result of this approach (using a larger sample) and using both methods of VRET they conclude that virtual reality has a similar effect to the in vivo.

The study [22] that has a reduced sample argues that VR therapy had a significant impact on treating the phobia because in some cases the anxiety and avoidance of the participants had a significant change.

Arachnophobia

Arachnophobia characteristically displays a persistent fear of spiders, an immediate anxiety response upon exposure to a spider. In fact, for some, it consists of an irrational reaction [2] when encountering a spider. In our research we determine if the utilization of VRET can help towards arachnophobia rehabilitation [9].

Five case studies regarding arachnophobia have been reviewed [9, 21, 32, 35, 37], from which surged moderate acceptance of VRET towards said phobia. We found that nearly all articles concluded that VRET improved the patients' conditions, however, *in vivo* exposure proved to overcome said results, leading to better long-term results. Nevertheless VRET could offer an attractive alternative method for patients unwilling or unable to initiate *in vivo* exposure therapy.

An article [37] presented highly positive results regarding VRET implementation, yet, it did not benefit from a between-group comparison of exposure in vivo, the golden standard to date. The aforementioned article adopted tactile augmentation as a way to overcome the absence of physical interaction with the trigger. Regarding the hardware eight participants were tested operating a Silicon Graphics Octane MXE with Octane Channel Option coupled with an HMD (Division dVisor). Future research would be beneficial to assess the current viability of tactile augmentation technology as a replacement for physical interaction.

Another two articles focused on testing VRET with children as subjects [21, 32] for the study. Both studies concluded that children need physical contact, in order to fully overcome arachnophobia. Phobic symptomatology was measured at pre-and post-treatment and studies were supported by immersion rooms composed of CAVE systems.

Additionally, one of the articles [32] obtained conservative results, due to some children immersed in VR appearing overly apprehensive toward the virtual spiders, not knowing the

[2] extreme anxiety, panic attacks...

size and type of the spider that would show up and that can compromise the treatment, as a consequence of larger than usual imagination possessed by the target audience.

Two remaining articles [9, 35] presented results similar to those mentioned on children based therapy, where physical contact with the trigger is needed to lead to the best possible therapy results. Both suggest that VRET is a medium worthy of further exploration for clinical applications, in which one of the articles [9] reported 83% of patients in the VR treatment with clinically significant improvement compared with 0% in waiting list control group.

The last study applied VRET coupled with 3D games in a sample of 11 people. The study revealed significant improvements between pre and post results on the behavioral avoidance test, the Spider Beliefs Questionnaire, and perceived self-efficacy. These promising results suggest that therapy using virtual reality exposure via a modified computer game is useful in the treatment of arachnophobia.

Blood-Injection

Blood-Injection phobia, also called BII phobia relates to both the sight and pain of injections. Often people begin to avoid any situation in which may cause exposure to injection, such as blood donation. In some cases, fear and anxiety are present just from passing through medical facilities. Said phobia involves not only visual stimuli but also tactile. [17]

A study [17] of 20 participants (13 females and 7 males), was divided into two groups, A and B. Both groups benefited from HMD, head tracking systems and a joystick to allow the user to explore the virtual environment.

The VR environment was composed of a clinic lobby, waiting room, and an exam room. Group A was verbally instructed on how to move and where they have to look, while group B used the system freely. Both groups had to complete pre-questionnaire, namely fear questionnaire, which was complemented with additional hardware-related measurements, particularly respiration frequency, heart rate, BPM (breaths per minute) and skin conductance.

There were three distinct segments directed towards collecting data: (i) pre-injection (VR1); (ii) on-going injection (VR2); (iii) post-injection (VR3). This study exhibits a pattern of arousal during VR exposure, in which skin conductance and respiration rate values substantially increased from baseline, suggesting increasing arousal due to VR exposure.

Claustrophobia

Claustrophobia is an anxiety disorder, in which an illogical fear of having no escape or being closed-in can lead to a panic attack. Triggers may include being inside an elevator, small confined rooms, or even small transportation methods. [7]

The present literature review reviewed two studies that addressed the effectiveness of virtual reality exposure in the treatment of claustrophobia. The aforementioned studies applied HMD to virtually expose patients to claustrophobic triggering situations.

One of the articles [25] evaluated the intervention on 4 participants who sought help at an anxiety disorders clinic. The treatment consisted of 8 individual sessions in which results were obtained, through several clinical measures on pre and post-treatment questionnaires. Measurements included the following surveys: (i) Behavioral Avoidance; (ii) Self-Efficacy Toward Closed Spaces; (iii) Problem-Related Impairment Questionnaire; (iv) Beck Depression Inventory; (v) Anxiety Sensitivity Index.

The other article [36] evaluated a larger sample of 18 participants, consisting of 12 males and 6 females, using non-clinical measures. The study aimed to create a prototype that was affordable but still immersive enough to efficiently treat claustrophobia.

Overall, both studies achieved positive results. While the initial article mainly concentrated on VRET effectiveness towards fear and avoidance reduction, regarding claustrophobic behaviors, the latter focused on economic efficiency, establishing that VR is a very affordable method of claustrophobia rehabilitation.

Dental Phobia

A substantial portion of society suffers from dental fear, this kind of fear results in a reduced number of dental visits and poor oral health. Given prior statements, finding a suitable specific non-invasive strategy to reduce dental anxiety and treat dental phobia is both warranted and important. Normally *in vivo* expose therapy is the approach employed on dental phobia, which may cause anticipatory anxiety, as a result of invasive contact of patient's fear. This invasive treatment protocol can result in refusal of therapy, generating high therapy drop rates. [24, 29]

One of the studies [29] recruits two patients, a 56-years-old Malay female with fear of the dental drill and a 24-years-old Maley female with fear of dental drill and sharp dental instruments. The VR therapy consists of a brief explanation of procedures, in which the patient self rates the baseline level of state anxiety with a Visual Analogue Scale (VAS-A), dental trait anxiety level with Modified Dental Anxiety Scale (MDAS) and Dental Fear Survey (DFS). After fulfilling all the aforementioned surveys, the treatment was conducted with the support of an HMD. Therapy consists on five distinct stages: (i) sitting on the dental chair with no tools; (ii) inspection of the oral cavity using mouth mirrors; (iii) injection; (iv) dental drill without sound; (v) dental drill with sound. All these stages are controlled by the therapist in several sessions. During the test, it's collected data related to Subjective Units of Distress Scale (SUDS), state anxiety and dental trait anxiety. VAS-A, MDAS and DFS scores showed a downward trend following VRET, suggesting improvements regarding patients' dental treatment anxiety.

Another study [24] consists of a randomized control trial that contrasts the effectiveness of VRET with informational pamphlets (IP), through thirty participants on a 1:1 control group ratio. To access prospective information it was applied the following questionnaires: (i) state anxiety; (ii) trait anxiety; (iii) dental fear survey; (iv) behavioral test. Data was analyzed using intention-to-treat and per-protocol analysis and treatment was found to be effective on all measures, including a BAT, for all participants at post-treatment and 3 and 6-month long term follow-ups.

Fear of Driving

Driving phobia is characterized by an intense, persistent fear of driving, which increases as a person anticipates, or is exposed to driving stimuli. People with driving phobia acknowledge that their fears are excessive or unreasonable, yet are unable to perform such action. The inability to drive results in a major loss of mobility and independence, which interferes with daily activities. [39]

Throughout our review, it was analyzed a total of three studies related to fear of driving. All of them agreed that VRET has a useful role in the treatment of said phobia, particularly because it is not associated with any type of risk. Additionally articles acknowledged VRET technology can have a useful purpose 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.

The first article [38] consisted of a computer game supported by car-driving environments, including several traffic situations. The study selected thirteen women, in which eight were able to complete all scenarios. Virtual environment exposure was completed gradually over 50 minutes, as follows: (i) parallel parking; (ii) residential road with no cars; (iii) residential road with normal traffic and few pedestrians; (iv) street with heavier traffic and pedestrians; (v) street with very heavy traffic and many pedestrians; (vi) highway with normal traffic; (vii) highway with many cars, high speed, tunnels; (viii) street with traffic jam, tunnel, roadworks. All patients showed substantial improvements and demonstrated less anxiety in subsequent *in vivo* experiences.

Another article [39] studied the effect of three 60 min long sessions towards a female diagnosed with a driving phobia. The study adopted a sizable amount of virtual interactions on short periods, in which each ride took between 1 and 5 minutes. Regarding hardware, the case study applied an HMD, wheel, and pedals, thus augmenting the interaction with the system. Similarly to the previously described study, the current one included four distinct environments in which the subject would progress according to prospective results. Results revealed that ratings of anxiety and avoidance declined from pre-treatment and post-treatment, with gains maintained at a seven-month follow-up. Larger sample size would highly benefit the study.

Lastly, an open study [28] investigates the effectiveness of computer-generated environments involving driving games and VR, following a motor vehicle accident (MVA) program. Fourteen subjects were subjected to 12 1-h sessions involving graded driving simulation tasks with self-monitoring, physiological feedback, diaphragmatic breathing and cognitive reappraisal. Concerning the initial sample size, only half reported feeling immersed in proposed environments, due to various reports of disorientation and navigation limitations. The current study would benefit from some sort of tactile augmentation mechanism to improve the study's limitations, similar to the added hardware on the prior article.

Fear of Flying

Fear of flying is a very incapacitating problem affecting an extensive percentage of the population. Approximately 25% of adults experience a considerable anxiety level when required to fly, from those, 10% demonstrate phobic behaviors that completely incapacitate the usage of such transportation [19].

Three case studies have been reported with patients with flying phobia. Evaluated studies that tested VR as an alternative of treatment for this phobia, since standard *in vivo* treatment could be very limited and costly as the specific scenarios are hard to achieve. Two of those articles [19, 40] stated that they used an HMD while the other article [11] didn't specify the technique they used for the study.

Latter focused on establishing a comparison between *in vivo* and VRET, which benefited from a larger than usual sample, namely 49 randomly assigned patients with fear of flying were submitted to VRET over 8 sessions for six weeks. Initial four sessions focused on anxiety management training, while remaining concentrated on both exposure to a virtual plane and real airplanes at the airport. Results regarding post-treatment, used an actual flight on a commercial airline and measured the participant's anxiety levels during the process. The results concluded that both VRET and *in vivo* were equally effective, and after the 6 months post-treatment, 93% of the participants had flown.

One of the studies [19] evaluated four adults aged between 23 and 41 years old in four different environments. The study aimed to show the different scenarios designed while at the same time proving the effectiveness of VR as a tool towards said phobia. Results were based on a 0-10 scale that measured fear and avoidance for each patient. Initially, the scores ranged from 7 to 10, while at post-treatment values varied between 0 and 2, demonstrating the decrease of fear and avoidance on targeted patients.

Final study [40] evaluated a 42-year-old female subject with debilitating fear and avoidance of flying. This patient was said to have previously sought standard therapy treatment because she had consistently taken medication to be able to bear the anxiety of flying. The treatment consisted of six 35-45 minutes long sessions along seven weeks, including anxiety management training. The outcome was evaluated by the sense of presence on a real plane (as reported by the patient) as well as many clinical results measured on quantitative scores that can be used to determine if the treatment was successful. Overall, the ratings indicated that the treatment had positive results supported by the fact that the patient completed a post-treatment real flight with low anxiety measures.

Needles

Needle phobia is a common disorder present among children and in some cases adults. It is generally referred to as aichmophobia, although this term may also refer to a more general fear of sharply pointed objects. [30]

A pilot study [30] inquiries the adoption of VRET towards the feasibility of fear reduction and pain distraction during immunizations. The aforementioned article operates with an HMD on 34 subjects, in which 17 are children and the remainder parents. It was implemented pre and post-immunization questionnaires applying the Wong-Baker pain scale and McMurtry children's fear scale. The study provided immunization, while the subject was wearing a VR headset, investigating the effectiveness of VRET as pain distraction. Ratings of anticipated versus actual fear and pain due to immunizations improved following the use of the VR headset in 94.1% of pediatric subjects, although it was not able to present consistent results regarding adult demographics. The use of an HMD was well received and reduced overall fear and pain in children receiving immunizations.

Post Traumatic Stress Disorder

Post-traumatic stress disorder (PTSD) is normally caused by a deeply threatening or scary event. Even if not directly involved, the patient may build up a shock that affects its everyday routine. This phobia's treatment, due to elevated impact emotions, widely is supported by both prolonged exposure therapy (PET) and medication. [20]

In the open clinical trial [20], VRET was complemented with imaginary techniques and relaxation methods to counterfeit the absence of medication. This case study attempts to treat Vietnam combat veterans who had PTSD according to the DSM-IV criteria. Although all patients reported a reduction in PTSD symptoms from 15% to 67%, the current study suffered from a substantial drop rate (30%), which is similar to drop rates in treatment with traditional therapy methods (PET and CBT), regarding PTSD. Subjects were exposed to two distinct environments: (i) virtual Huey helicopter flying over Vietnam; (ii) clearing surrounded by jungle. Clinician-rated PTSD symptoms as measured by the Clinician-Administered PTSD Scale reported an overall statistically significant reduction in symptoms associated with reported traumatic experiences.

Small Animals

Small animals phobia is considered one of the most frequent mental health diseases among children. This phobia is related with numerous different animals with small size, spiders, cockroaches, and others. As a result of being an everyday occurrence this phobia, substantially increments anxiety levels on the subject. [15]

Last article [15] carried out a clinical assessment, which compares the effectiveness of images and videos of real animals regarding small animals phobia. The latter approach has been used in functional VRET Magnetic Resonance Imaging (fMRI) protocol to evaluate brain activation, as a stimulus to provoke the reaction of the subject. The study in question, developed three experimental conditions, all of them consisting of a room where the subject can navigate freely. The aforementioned room has three states, depending on the subject's condition: (i) clean room; (ii) dirty, dark room; (iii) the same room with spiders and cockroaches. Additionally all subjects were scanned in a 1.5 Tesla Siemens Avanto Magnetic Resonance scanning device and the Statistical Parametric Mapping (SPM8) software was used for the analysis of the fMRI data. The study concluded that brain activations was considerably bigger using VRET, comparable with real-life stimulus results, which is highly advantageous over subjects with a mild phobia, whose fear cannot be excited only by the used of static stimuli.

For all of the articles, considering their final results and conclusions, we were able to calculate a success rate, that number represents, whether or not virtual reality exposure, in comparison with *in vivo* exposure, was most efficient helping each participant of a study treat their phobia. Automatically, that number will be, for each study, a percentage/fraction of the sample. A total of 29 samples with phobias treatment using VRET were used to create the Table 7. The percentage of success demonstrated in each row of the table was calculated by dividing the number of success cases of each phobia by the totality of cases in studies of each phobia, this value is then assigned to each condition. (E.g.) Agoraphobia has 2 articles (200%, each article represents 100%), one study had 40% cases of success and the other also 40%, since the two articles represent 200% , the final value is 40% (80%/200%).

Agoraphobia had 2 samples in which only 40% of the cases were approved as a success, the same result as arachnophobia with 5 samples. Fear of driving with 3 samples had a 70% success rate compared to *in vivo*, which was the same result as PTSD sample with only 1

Table 7 Success Rate in each study

Phobias	Samples	Success Rate
Agoraphobia	2	40%
Social Phobia	5	94%
Acrophobia	3	100%
Arachnophobia	5	40%
Blood-Injection	1	100%
Claustrophobia	2	100%
Dental Phobia	2	90%
Fear of Driving	3	70%
Fear of Flying	3	90%
Needles	1	80%
PTSD	1	70%
Small Animals	1	90%

sample. Needles phobia demonstrated an 80% success rate using VRET. 5 samples of Social phobia showed that it had a 94% success rate, while dental phobia, fear of flying and small animals were just close behind with 90% success rate each. Some phobias using VRET had a success rate of 100%, like acrophobia, blood-injection, and claustrophobia, these phobias had the same result with *in vivo* exposure but with less cost *in virtuo*.

Discussion

The findings of the present meta-analysis infer that both VRET and CBT are effective in phobic behavior rehabilitation. However, the results also point to a discrepancy between phobic typologies, regarding VRET methods. For instance treatment proceeding agoraphobia, supported by VRET presents contrasting results when compared to identical studies concerning specific phobias.

Most reviewed studies supported proposed results, based on levels of anxiety, accounting for 75,8% (22/29) of analyzed stimuli. Other prevalent emotions include fear with 44,8% (13/29) and avoidance with 41,3% (12/29). The compound of previously mentioned emotions is present on 93,1% (27/29) of included articles, determining these as the uttermost important attributes when evaluating a study's success. Remainder stimuli comprise panic, intimacy, scrutiny, assertiveness, perspective, opinion, heart rate, memory, stress, uncomfortable, credibility and nausea.

Preceding emotions are demonstrative in evaluating the level of phobic behavior of the subject. Phobias are commonly confused with fear, consequently, the indicated is ordinarily the easiest form of reaction that manifested on said phobic behavior. Moreover, researchers have established that anxiety is the most common symptom present with phobia exposure, this is visible throughout the entire treatment, including pre and post-treatment follow-ups. It's possible to detect a sensation of uncontrollable anxiety when a patient is exposed to the source of fear and is likely to experience anxiety when exposed to the trigger of phobia. Therapy's objective is related to reducing fear and anxiety symptoms, to help the management of reactions when interacting with the trigger of phobia [4].

Lastly during an 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 therapist's office, and that the therapist sees the same thing as the patient on the monitor, it is much easier to detect subtle avoidance behaviors such as looking for reassuring cues in the environment or avoiding eye contact [8]. Therefore, the goal of treatment is summarized in minimizing the previously mentioned characteristics.

Agoraphobia

Agoraphobia rehabilitation including VRET articles proven to be quite scarce in the scientific community. Two studies on agoraphobia showed potential for the future, although the second study [27] suggests that more research is needed on the design of valid and anxiety-provoking virtual worlds. To date, unfortunately, no firm conclusions can be inferred on the effectiveness of VRET on agoraphobia.

Social Phobia

Normally, social phobias are treated with *in vivo* standard exposure therapy, which consists of exposing the patient to potential social situations that may trigger their anxiety until they

overcome that emotion [12]. Even though this method has proven to be effective, it has several practical limitations, for example, (i) it's difficult and costly to create the scenario and arrange the situation so that it seems genuine and not scripted or misplaced (scenario, actors, etc...), (ii) therapists have limited control over the situation and can't manipulate what will happen mid-action, (iii) patients are less willing to undergo a scenario/interaction with real people rather than with virtual ones [12]. Considering these problems, VRET could be considered a significant alternative that could solve these problems as patients indicate a clear preference for this method over *in vivo* exposure. Some studies reviewed [12, 23] have proved that VRET treatment is at least as effective as the standard techniques while being much more viable and practical. One of the worries of using VR to treat social phobia is if the realism of the avatar/scenarios could negatively influence the efficiency of the treatment, especially in children and adolescents that are more used to these technologies (due to exposure to VR games, for example). One case [31] proved that although it seems to have an influence, it isn't a critical factor. While two other studies [33, 34], focused on children and adolescents, proved that the treatment can be effective even in that age group.

Acrophobia

The utilization of Virtual Reality on Agoraphobia treatment confirmed to be incredibly effective for this kind phobia, even when compared to the golden standard treatment for specific phobias(exposure in vivo).[22]

Articles reviewed [10, 22] proved that VRET can be as effective as exposure *in vivo* towards reducing self- reported anxiety and avoidance of heights. One of the reasons is the fact that we can recreate the same real live environments within the therapist's office this transmits a feeling of safeness to the patients. This method also provides the therapist with the capability of controlling the environment via the keyboard or a joystick this makes it easiest to control the virtual exposure facilitating the way that the therapist can introduce the phobia to the patients wherein the vivo exposure this cannot be controlled.

Arachnophobia

VRET still lacks additional therapy techniques, to compose VRET as the standard therapy model for arachnophobia. Some studies [21, 32] also proved that VRET was indeed variable dependent, namely towards age groups, due to results receiving a negative impact originating from high imaginations levels of children.

Physical interaction with phobic trigger is needed in order to formulate long-term improvements, which is why *in vivo* exposure remains as the golden model for this phobia. Future research might explore ways that tactile augmentation (or other means of introducing tactile feedback, such as the computer-controlled force feedback can be used to increase the effectiveness of VRET towards arachnophobia.

Blood-Injection

The one study regarding Blood-Injection-Injury phobia [17] proves that VRET works as phobic behaviors therapy model. Furthermore applying *in vivo* exposure threapy can contribute with financial costs and interrupt the normal procedure of medical facilities, while *in virtuo* allows the user to repeat the proccess multiples times until anxiety levels minimize.

Claustrophobia

Exposure therapy using VR is becoming a common alternative for the treatment of claustrophobia [36], which can be justified by the practicality in creating potentially claustrophobic scenarios and the willingness of the patient to submit to a virtual situation rather than a real one. However, problems like the expense of traditional virtual reality systems and the lack of presence/immersion of the patient are still taken into consideration [36] and can sway health professionals and patients into believing the VR methods aren't efficient. Though, one of studies reviewed [25] has proven to us that VR exposure is effective in treating claustrophobia and teaching patients how to deal with claustrophobic situations not only immediately but for the long future as well. And, another case [36] has ensured that an immersive and effective VR system to treat claustrophobia could be implemented with less cost.

Dental Phobia

The studies about using VRET to treat dental phobia showed positive results using this technology to treat people with this kind of mental decease. Both articles proved that Virtual Reality can reduce the degree of anxiety by exposing the patient to a virtual dental care ambient and real virtual scenario. The realism of the ambient can decrease significantly the phobic illness. [29]

An important advantage of the using VRET for dental phobia is that it not require specialized training and the entire process of exposure can be completed by a computer and a HMD in the safety and privacy of the person using the system [24]. Was also proved that VRET can be mastered by any dental health professional, which can make it a cost-effective solution, even using tele-medicine.

Fear of Driving

The effects of VRET in the treatment of driving phobia are well established. The three controlled studies all shown that VRET is effective in treating said phobia, particularly because it is not associated with any type of risk. However, the high dropout rates during therapy due to low levels of immersion indicate that additional interaction hardware is necessary to create a believable environment for the subject. [22]

Current phobia highly benefits from VRET, due to significantly less costs involved. [28]

Fear of Flying

In the treatment of fear of flying, the advantages of VRET over standard exposure therapy are enormous. It is highly cost effective, components of the flight can be repeated endlessly in the therapist office, and different weather conditions can be created in seconds. [19]

Results obtained from VRET when compared with other therapy alternatives do not present significant discrepancies, however, the cost effectiveness and control over flight and weather conditions are such great advantages that VRET could be tried before exposure *in vivo* is possible. The resources and time necessary to implement *in vivo*, due to its nature and limitations, have troubled many researchers, therapists, and patients which led them to, in some cases, neglect this type of phobia. [40]

Needles

There aren't too many studies about needle phobia but the study [30] included in this literature review gives us a perception that VRET has the capability to increase procedural compliance, consequently decreasing the length and cost of the procedure while possibly improving the satisfaction of the healthcare providers with the procedure.

PTSD

As a result of the increased complexity present on PTSD cases VRET needs to be combined with additional therapy techniques, as for example imaginary exposure. The usage of VRET allows to recreate the same situation over and over again, in that way the therapist can test the limits, which is not possible the existing alternatives.

Additional research on the use of VRET for participants with PTSD caused by traumatic events is necessary.

Small Animals

The one article regarding generalized small animals showed that VR had similar results in terms of fMRI brain activation's through VRET to those obtained using real stimuli. These activation's were located in the occipital and frontal areas that are coherent with previous studies using pictures or videos of real animals as stimuli. [15]

This finding can lead to a deeper understanding of the phobias since VR allows the recreation of additional environments and interactively that is harder to achieve with traditional methods (e.g.pictures or videos).

Similarly to arachnophobia current condition would benefit from augmented tactile mechanisms to increase interactivity levels and consequently reduce phobic symptoms.

Advantages

The usage of VR technology in health applications has many advantages. First time constraints are reduced, in which a therapist has a patient with acrophobia, both have to move out of the office to apply *in vivo* therapy, however with VR patient can be treated on the office.

Another advantage are the costs associated with treatments, being the most applicable case flying phobias treatments, where treatment with planes is extremely expensive and unsustainable.

A further advantage is the control over the occurrence, intensity and constrains that's occur during therapy, in which the therapist can control the intensity of the stimulus.

Safety and confidentiality are also an advantage, due to patients not being publicly exposed as a need for the treatment, with VRET all occurrences all limited to the virtual environment and therapist.

Finnally VRET allows to recreate the same situation over and over again, in that way the therapist can test the limits, something that cannot be done using *in vivo* exposure.

Limitations

The two most frequent methods are HMD and immersive rooms, the latter traditionally consists of images projected on walls/floor, glasses to provide a 3D stereoscopic effect,

motion tracker and joystick. 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, so due to aforementioned costs it is rarely used in clinical studies.

As a consequence of modern technology interactions with stereoscopic 3D movies and games are more common, so more realistic devices may be needed to meet their expectations and implicit criteria to consider a 3D stimuli believable.

Like already mentioned results highly depends on anxiety levels, however, this is a subjective measure that can be biologically variable from person to person.

Conclusion

This paper provides a head-to-head comparison between VRET and *in vivo* exposure for phobia behaviors. The analysis of both therapy models demonstrated a positive influence in the reduction of anxiety, avoidance and fear. Traditional therapy techniques resulted in improvements in all evaluated conditions, although the costs needed for therapy may become unsustainable. Comparatively, VRET demonstrated its strengths regarding conditions where treatment benefits from repetitive intrusive actions (needles, dental), complex phobias where it is essential to minimize shock factor (PTSD) and treatment protocols with substantial costs (driving, flying and acrophobia).

These findings suggest that rehabilitation programs for phobic behaviors should include VRET as an initiation tool for cases where *in vivo* exposure may seem too intrusive for the patient.

Additionally, the present literature review found that VRET can become variable-dependent, correlating different age groups, as demonstrated with arachnophobia, where imagination plays a significant role, and children's imagination may need to be contained and corrected before using VR.

Future research in this area needs to address the carryover long-term effects over subject life's, discrepancy over different VR technologies and their results, and the social implications of this treatment to generate standard environment protocols in a similar way to traditional methodologies.

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