Virtual Reality Exposure Therapy for Fear of Needles:

A Pilot Feasibility Study with Non-Clinical Participants

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Abstract

Background: Virtual Reality Exposure Therapy (VRET) is increasingly recognized as an effective treatment for specific phobias. However, few studies have looked at VRET for needle phobia. The main hypothesis was that VRET for fear of needles would be able to induce and reduce subjective discomfort and be perceived as immersive by participants.

Method: Thirty-three non-clinical participants were recruited and tested consecutively. Prior to the intervention, participants' fear of needles was assessed using the Severity Measure for Specific Phobia. The participants then completed four VRET scenarios: A waiting room (1), images of needles and injections (2), interacting with syringes (3), and receiving a virtual injection (4). Afterwards, participants completed the Presence Questionnaire assessing how present they felt during the intervention.

Results: During the VRET intervention, participants reported significant changes in subjective discomfort. Individuals with a moderate/severe fear of needles reported higher SUD-ratings throughout the VRET intervention compared to those with none/mild fear of needles. However, neither group had discomfort ratings comparable to their highest level of needle fear ever experienced. Repeated training using VRET reduced participants' discomfort ratings. Overall, the participants experienced the VRET intervention as immersive.

Conclusion: The VRET protocol was able to induce and reduce discomfort in participants suggesting it could be a helpful intervention for people with fear of needles, and it should therefore be tested in randomized controlled trials. Future research should also explore factors potentially influencing the efficacy of VRET for needle phobia, such as inclusion of additional sensory stimuli and virtual limbs.

Keywords: virtual reality (VR), exposure therapy, subjective discomfort, SUDs, fear of needles, immersion, presence.

Sammendrag

Bakgrunn: Virtual Reality Exposure Therapy (VRET) blir stadig mer anerkjent som en effektiv behandlingsmetode for spesifikke fobier. Få studier har derimot undersøkt effekten av VRET for sprøyteskrekk. Denne studien undersøkte hvorvidt en VRET-intervensjon for sprøyteskrekk var i stand til å indusere og redusere ubehag i et ikke-klinisk utvalg. Sekundært undersøkte studien deltakernes opplevelse av tilstedeværelse i det virtuelle miljøet.

Metode: Trettitre ikke-kliniske deltakere ble rekruttert og testet fortløpende. Før intervensjonen ble deltakernes grad av sprøyteskrekk målt med Severity Measure for Specific Phobia. Deretter fullførte alle deltakerne fire VR-scenarioer: et venterom (1), bilder av injeksjoner og sprøyter (2), interaksjon med sprøyter av ulik lengde (3) og mottak av en virtuell injeksjon i armen (4). Etter fullført intervensjon ble grad av opplevd tilstedeværelse i det virtuelle miljøet målt med Presence Questionnaire.

Resultater: Deltakerne rapportere betydelige endringer i ubehag i løpet av intervensjonen. Deltakere med en moderat/alvorlig frykt for sprøyter rapporterte mer ubehag i alle scenarioene sammenlignet med deltakerne med mild eller ingen frykt for sprøyter. Ingen av gruppene rapporterte ubehag tilsvarende det de oppga å kunne få i det virkelige liv. Gjentatt trening i det virtuelle miljøet reduserte ubehag hos deltakerne. Samlet sett opplevde deltakerne høy grad av tilstedeværelse i VRET-intervensjonen.

Konklusjon: Intervensjonen var i stand til å indusere og redusere ubehag hos deltakerne. VRET kan potensielt være en effektiv intervensjon for sprøyteskrekk, og bør testes videre i randomiserte kontrollerte studier. Fremtidig forskning bør også utforske faktorer som potensielt kan påvirke effekten av VRET for sprøyteskrekk, som eksempelvis virtuelle representasjoner av kroppsdeler og inkludering av ytterligere sensoriske stimuli.

Nøkkelord: virtuell virkelighet (VR), eksponeringsterapi, subjektivt ubehag, SUDs, sprøyteskrekk, tilstedeværelse.

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Specific phobia is a type of anxiety disorder characterized by an intense and persistent fear of a specific object, situation, or activity (American Psychiatric Association, 2013). Blood-Injection-Injury (BII) phobia is a subtype of specific phobia, comprising phobias related to blood, injuries, injections, and other medical procedures (e.g. dental phobia) (American Psychiatric Association, 2013). BII phobia is a common subtype, with epidemiological studies estimating a lifetime prevalence of approximately 3% (Wardenaar et al., 2017). Specific phobia is found to have substantial comorbidity with other anxiety and mood disorders, and it is estimated that over 60% will experience an additional mental health disorder during their life (Wardenaar et al., 2017).

Needle phobia is a form of BII phobia characterized by an excessive and irrational fear of needles or injections (McMurtry et al., 2016; American Psychiatric Association, 2013). Severe needle phobia can increase the risk of negative health outcomes, as phobic individuals are more likely to avoid common medical procedures, such as injections, blood draws, and vaccinations (Kleinknecht, 1994; Hamilton, 1995; Taddio et al., 2012; American Psychiatric Association, 2013). Persistent avoidance of necessary medical treatment can lead to the development of additional health problems and reductions in quality of life (Öst, 1992; Sokolowski et al., 2010; McMurtry et al., 2015).

In vivo exposure therapy is highly efficacious in treating phobic fears (Choy et al., 2007), and is widely considered to be the gold-standard treatment for specific phobias in general (Choy et al., 2007; Wolitzky-Taylor et al., 2008). In vivo exposure has been shown to be effective in treating both BII- and needle phobia as well (Öst et al., 1991; Öst et al., 1992). Despite its effectiveness, exposure-based therapies are underused in clinical practice (Pittig et

al., 2019). Several factors likely contribute to the observed treatment gap, such as treatment acceptability (Scheveneels et al., 2023), therapists' beliefs about exposure (Olatunji et al., 2009), and practical challenges when conducting exposure (Pittig et al., 2019). The underutilization in clinical practice highlights the need for innovative approaches to delivering exposure therapy.

Virtual reality exposure therapy (VRET) is an emerging treatment that allows for gradual, repeated exposure to the fear-provoking objects or situations in a virtual environment. In the last decade, VRET has increasingly been recognized as an effective treatment option for specific phobia and anxiety-related disorders (Carl et al., 2019; Opriş et al., 2012; Parsons & Rizzo, 2008; Powers & Emmelkamp, 2008). The most recent meta-analysis of 30 randomized controlled trials (N = 1057) found VRET to have a large effect size compared to waitlist control (g = 0.90) and a medium to large effect size when compared to psychological controls (g = 0.78) (Carl et al., 2019). The psychological controls included relaxation, treatment as usual, attention control, an information pamphlet, and present-centered therapy. When compared specifically to in-vivo exposure, VRET was found to have an equal effect size (g = -0.07) - further indicating that VRET could be considered a viable way of delivering exposure-based therapies (Carl et al., 2019).

VRET also has the potential to overcome or mitigate potential limitations associated with traditional exposure therapy, such as dropout rates and treatment acceptability (Choy et al., 2007). Individuals with specific phobias are often reluctant to seek treatment, and if they do previous studies have reported refusal and drop-out rates up to 45% (Scheveneels et al., 2023; Choy et al., 2007; Emmelkamp et al., 2002; Marks & O`Sullivan, 1988). Some studies suggest that phobic individuals may prefer VRET to in vivo exposure (Scheveneels et al., 2023; Garcia-Palacios et al., 2007, 2001), as well as evidence showing that drop-out rates might be slightly lower for VRET compared to in vivo exposure (Benbow & Anderson,

2019). Providing exposure in a virtual environment could therefore increase treatment acceptability, resulting in more phobic individuals seeking and receiving treatment for their specific phobia (Scheveneels et al., 2023; Garcia-Palacios et al., 2007, 2001).

VRET could also have the capacity to alleviate some of the practical difficulties associated with in vivo exposure to blood and needles in particular. It can be challenging for the therapist to set up exposure environments involving blood or injections, as they can require medical equipment, as well as assistance from trained medical professionals. These constraints could make in vivo exposure to blood and injections a time- and resource-intensive process. Virtual exposure might circumvent these issues, as treatment can be carried out in nearly any convenient and safe location, such as the therapist's office. In the last decade, virtual reality (VR) equipment has become cheaper and more accessible to the public as well (Lindner et al., 2017; Anderson & Molloy, 2020), contributing to lower the cost of VRET in general.

However, research on the efficacy of VRET for needle phobia is lacking. None of the trials included in the most recent meta-analysis of VRET for anxiety and related disorders examined needle- or BII phobia (Carl et al., 2019). It did include one RCT ($N = 30$) investigating the efficacy of VRET for dental phobia, which is usually regarded as a subtype of BII phobia (Gujjar et al., 2019; American Psychiatric Association, 2013). The study compared a single-session VRET intervention to a psychological control group receiving an information pamphlet on treating dental phobia. They found large between-group differences at post-treatment (Cohen's $d = 0.98$-1.42) and 6-month follow-up ($d = 1.29$-1.44) in favor of VRET (Gujjar et al., 2019).

Recently, a randomized controlled pilot trial examined the acceptability and efficacy of VRET for Blood-Injection-Injury (BII) phobia (Jiang et al., 2020). Participants ($N = 43$) were randomized to either a single-session VRET intervention or a waitlist control group, and

assessed at baseline, one-week post-treatment and 3-month follow-up. All participants met the DSM-V criteria for either a clinical or subclinical BII-phobia. The study yielded mixed results, indicating that VRET may lead to improvements on some measures related to BII phobia: self-reported fear of injections (g = 0.63-1.14), fear of injury (g = 0.80), and fear of fainting (g = 0.84) at 3-month follow-up. They found no significant between-group differences on measures of fear of sharp objects, dentists, blood, medical examinations, or hospitals. Although their results suggested that VRET for BII-phobia can lead to some improvements, their overall findings indicated that a single-session VRET might not be sufficient as a stand-alone treatment for BII phobia.

Nevertheless, Jiang et al. (2020) found that their VRET intervention was successful in inducing self-reported fear and anxiety in participants. As with traditional in vivo exposure, the ability to elicit fear is a necessary precondition for VRET to be effective. The fear and distress reported by participants suggests that VRET has the potential to generate an appropriate stimulus response in individuals with blood- or injection-related phobia. This is in line with findings from a preliminary study (2005), showing that virtual exposure to blood and injections via a head-mounted display increased both self-reported anxiety and objective physiological measures of arousal in non-phobic participants (N = 20) (Wiederhold, 2005). This study provided some initial evidence to indicate that the virtual environment can deliver potent and effective exposure cues to blood and injections, with results demonstrating that individuals who reported higher levels of subjective distress during virtual exposure exhibited more intense physiological arousal in the virtual environment.

The study by Jiang et al. (2020) did not measure or include other factors that might have influenced the effectiveness of their VRET intervention, such as perceived realism and sense of presence. The effectiveness of VRET is based on the assumption that the users consistently feel “present” or “immersed” in the virtual environment (Slater & Wilbur, 1997;

Krijn et al., 2004; Botella et al., 2017). As such, sense of presence is thought to be an important moderating variable (Botella et al., 2017; Price & Anderson, 2007). While presence does not necessarily exert a general effect on treatment outcome (Krijn et al., 2004; Price & Anderson, 2007; Botella et al., 2017), it is consistently associated with fear-activation during VR exposure (Ling et al., 2014; Bouchard et al., 2008; Botella et al., 2017). Some studies further suggest that presence might be a prerequisite for the experience of fear during VRET (Parsons & Rizzo, 2008; Price et al., 2007; Price & Anderson, 2011). Trost et al. (2017) found that the use of additional sensory stimuli while undergoing a virtual blood draw enhanced participants' immersion, generating significant changes in both self-reported and physiological measures of anxiety (Trost et al., 2017). Similar results were reported in a study on VRET for arachnophobia, where Peperkorn et al. (2016) found that inclusion of a virtual hand, perceived as participants' own, modulated fear-response in a clinical sample (Peperkorn et al., 2016).

Objective of the Study

This study used a non-clinical community sample, with varying levels of needle fear: ranging from no fear at all to a moderate/high fear of needles. As such, it did not seek to establish the efficacy of the VRET intervention as a treatment for people with needle phobia. Instead, the aim of this study was to extend previous research, focusing on elicitation of subjective arousal and sense of presence during VRET. Primarily, the study examined whether the VRET intervention would be able to both induce and reduce discomfort in participants, regardless of their level of needle fear. Secondly, the study sought to establish how present the participants felt during the intervention.

This study tested the following hypotheses: 1. The VRET intervention will be able to induce and reduce discomfort in the participants, and 2. The participants will experience a sense of presence during the VRET intervention.

Method

The study protocol was approved by the Norwegian Centre for Research Data (NSD, reference number: 717189). Data collection took place from the middle of August 2021 to the beginning of December 2021 at the Norwegian University of Science and Technology in Trondheim. Participants did not receive any compensation for partaking in the study.

Participants and Procedure

Inclusion criteria were (i) aged 18 years or over, and (ii) providing written consent. There were no exclusion criteria; all consenting adults were invited to participate, regardless of whether they experienced needle fear.

Potential participants were recruited using a combination of convenience and snowball sampling. Participants were recruited and tested consecutively. The final sample consisted of 33 adults (13 male, 20 female). To comply with requirements from NSD, the exact age of participants was not obtained - only their respective age category. Sample characteristics are presented in Table 1.

Prior to the intervention, each participant had to complete a self-report measure assessing their level of needle fear. Participants were then categorized as having either none, mild, moderate, or severe levels of needle fear (see Table 1). Participants were also asked to rate the most distress ever experienced in a situation involving needles and/or injections on a scale ranging from 0-100. The intervention consisted of 4 scenarios. Participants' distress ratings (SUDs) were recorded at peak level in each scenario. In the last scenario (4), distress ratings were also collected after training in the environment for 2 minutes. After completing the scenarios, the participants had to fill out a questionnaire measuring their experience of presence during the intervention. The intervention lasted approximately 40 minutes, including filling out forms.

Table 1

Characteristics of participants

Baseline characteristic	*n*	%
Gender		
Male	13	39.4
Female	20	60.6
Age group		
18-24	16	48.5
25-29	12	36.4
30-34	1	3
35-39	2	6.1
55-59	2	6.1
Phobia severity		
None	4	12.1
Mild	22	66.7
Moderate	5	15.2
Severe	2	6.1

Note. $N = 33$. Total score on phobia severity ranges between 0-4. A score of 0 = no fear, 0.1-0.9 = mild fear, 1-2 = moderate fear, and 3-4 = severe fear.

Intervention

Testing was carried out in an empty classroom at the Norwegian University of Science and Technology (NTNU). There was no need for movement space, as all four scenarios only required the participant to be seated in a chair (Figure 1). Prior to exposure, participants were given a verbal description of what they would encounter in each scenario. They were also told to move through the different scenarios at their own pace, staying in each scenario until they felt ready to move on. The test leader then introduced the participants to

the VR-headset. They were given brief verbal instructions on how to interact with the program, including an explanation of the different hand gestures used when moving through scenarios. They were also told that they could take a break and remove the headset if they were feeling any cybersickness, dizziness or too much distress. The test leader observed and monitored the exposure session by streaming the scenarios from the VR-headset to her phone.

The first scenario was a typical waiting room at the doctor's office. The participants were seated in one of the chairs in the waiting room, with their back against the wall (Figure 2). There were two other patients in the waiting room, as well as a receptionist. The participants were encouraged to look around the room and were free to continue to the next scenario whenever they felt finished with the waiting room.

In the second scenario, the participant was seated in front of a table with a computer screen on top (Figure 3). In front of the computer there were five physical photos lying face-down on the table. The participant was asked to press the “start” button in front of the computer, which would then allow them to browse through thirteen different images of syringes and injections appearing on the screen. They were also encouraged to pick up the physical photos for a closer look. The participants could move freely back and forth between the different photos, viewing them at their own pace.

In the third scenario, the participant was situated in front of a table with four boxes lying on top (Figure 4). Each box contained a different syringe varying in needle length. All boxes were labeled with a description of the syringe in question. The first syringe had no needle, the second syringe had a shorter than average needle, the third needle was of standard length, and the fourth needle was longer than average. The participants were asked to open the different boxes to reveal the syringe underneath. They were also encouraged to pick up each syringe for a closer inspection before moving on to another box. Participants were told

they could go back and forth between the different boxes until they felt ready to continue to the next scenario.

In the fourth and final scenario, the participant was seated in a chair located in an open room - similar to the rooms typically found in hospitals and other clinical settings (Figure 5). The room was furnished with some equipment commonly found in clinical settings, including a portable monitor and a hospital bed. A doctor was seated next to the participant, with a clearly visible syringe lying on a table next to him. To initiate the injection, the participant had to press the “start”-button next to the doctor and subsequently place their hands in their lap. When pressed, the doctor would pick up a syringe and inject the needle into the participant's arm. This process was repeated until the participant either moved their hands out of their lap or stopped the scenario.

Figure 1

Outer Perspective of the VRET Intervention

Figure 2

Inner Perspective of Scenario 1 (Waiting Room)

Figure 3

Inner Perspective of Scenario 2 (Images)

Figure 4

Inner Perspective of Scenario 3 (Interaction)

Figure 5

Inner Perspective of Scenario 4 (Injection)

Measures

The Subjective Units of Distress Scale (SUDS) (Wolpe, 1969) is a scale used to measure the subjective intensity of discomfort or distress currently experienced by an individual, typically when encountering a stress-triggering stimulus. It is a self-assessment

tool with a scale ranging from 0 -100, where 0 indicates *absolutely no distress/anxiety* and 100 indicates the *highest levels of anxiety/distress you have ever felt*. Prior to exposure, participants were asked to rate the most discomfort ever experienced in a situation involving needles and/or injections. To track participants' subjective levels of distress during exposure, they were frequently asked to provide a self-report of where they were on the scale (0-100) throughout the VR-scenarios. Participants then reported the peak distress experienced in each scenario. In the last scenario (scenario 4) the participants were asked to rate their discomfort again after training in the environment for 2 minutes.

The Severity Measure for Specific Phobia (SMSP; Craske et al., 2013) is a 10-item self-report scale used to assess the severity of specific phobia symptoms along several dimensions, including avoidance behavior, interference with daily functioning, and levels of distress (Craske et al., 2013). The SMSP can be used to assess the severity of symptoms across all subtypes of specific phobia found in the DSM-5, including needles and/or injections (MacLeod et al., 2022).

Participants are asked to rate the degree to which each item applies to them on a 5-point Likert Scale, ranging from 0 (never) to 4 (always). Higher total scores indicate greater severity of specific phobia. Participants' average total score is calculated by dividing their total raw score (ranging from 0-40) by the number of items in the measure (10). This yields a mean item score ranging from 0-4. When used in a clinical setting, the average total score is used by clinicians to conceptualize the severity of the patient's specific phobia as either none (0), mild (1), moderate (2), severe (3), or extreme (4) (Craske et al., 2013).

As the present study assessed needle fear in an undiagnosed sample, participants with an average total score between 1 or 2 were categorized as having a “moderate” fear of needles, while participants with an average total score of 3 or 4 were categorized as having “severe” needle fear. Participants with a score of 0 were categorized as having “no fear” of

needles, while participants with an average total score ranging between 0.1-0.9 were categorized as having “mild” needle fear. Twenty-six participants were categorized as having either “none” or “mild” fear of needles (78.8%). Of the remaining seven participants, five were categorized as “moderate” (15.2%) and two were categorized as “severe” (6.1%).

An initial study on the psychometric properties of the SMPS indicates good internal consistency in both clinical ($\alpha = .96$) and non-clinical ($\alpha = .83$) samples (Lebeau et al., 2012). This is supported by a more recent study (2022), reporting excellent internal consistency with Cronbach's $\alpha = .93$ (MacLeod et al., 2022). Similar numbers have been reported in studies assessing translated versions of the measure in other populations (e.g. DeSousa et al., 2017; Möller & Bögels, 2016; Vidal-Arenas et al., 2021). The SMSP had excellent internal consistency in this study ($\alpha = .93$).

The Presence Questionnaire (PQ) by Witmer and Singer (1998) is a self-report measure assessing the experience of "presence" in virtual environments. In this context, presence refers to the subjective sense of being "present" in a virtual environment, even when one is physically located elsewhere (Witmer & Singer, 1998). The study utilized an abbreviated version of the PQ (UQO Cyberpsychology Lab, 2004). The scoring procedure for the abbreviated version of the PQ (PQ-19) was employed including the five factors: realism, possibility to act, possibility to examine, self-evaluation of performance and quality of interface. Questions related to sound effects were excluded from the study (question 20, 21 and 22), as were questions related to sense of touch (question 23 and 24), as the VRET program did not include these features. The final questionnaire consisted of 19 items, each scored on a 7-point Likert scale with different endpoints on the response choices. Most of the scales ranged from (1) *not at all* to (7) *completely*, while other scales for example ranged from (1) *never* to (7) *always*, or (1) *extremely artificial* to (7) *completely natural.*

Previous studies utilizing this version of the PQ-19 report good internal consistency, (α = .81-.84) (Michaliszyn et al., 2010; UQO Cyberpsychology Lab, 2004). No other comparable Cronbach's α were found, due to both lack of reporting and studies utilizing other versions of the questionnaire. The Presence Questionnaire had good internal consistency in this study (α = .85). Cronbach's α for each of the five factors can be found in Table 2.

Apparatus

The study utilized the VR hardware *Oculus Quest 2* (Released by Facebook Reality Labs, 2020), later rebranded as the *Meta Quest 2* (2022). The Quest 2 is a wireless head-mounted display with an internal, Android-based operating system. This enables the Quest to run as a standalone headset, eliminating the need for additional equipment. The Quest 2 utilizes Oculus insight tracking, which accurately calculates the real-time position of both headset and controllers every millisecond, making the virtual world correspond with the user's precise movements (Hesch et al., 2019)

The application software was developed by Fornix, a student company at NTNU developing VRET programs for common specific phobias. The program utilizes a hand-tracking feature, which allows the user to interact with the exposure scenarios using their hands instead of a physical controller. The user's virtual hands move in a way highly similar to the real-time movements of their physical hands. Specific hand signals are used to navigate the program.

Statistical Analyses

The data was analyzed using the statistical package for the social sciences (SPSS). The main hypothesis (“the VRET intervention will induce and reduce discomfort in participants”) was tested using repeated measures ANOVA. The dependent variable was the SUDs ratings. The ANOVA was repeated five times in chronological order of the specific scenarios: 1) Waiting room, 2) Images, 3) Interaction, 4) Injection scenario (Peak SUD), and

5) Injection scenario (after 2 minutes). The Greenhouse-Geisser estimate of sphericity (ε) was calculated as part of the repeated measures ANOVA to adjust the degrees of freedom of the *F*-statistic.

Independent samples t-tests were conducted to determine if there was a difference between the two groups (none/mild vs. moderate/severe) in their experience of presence during the VRET intervention. Pearson's Correlation was utilized to assess the relationship between subjective discomfort (SUDs) and sense of presence (Total score on the PQ).

Cronbach's alpha (α) was calculated to measure the internal consistency of the SMSP and PQ as a whole, as well as separately for each of the five factors of the PQ. Effect sizes were calculated using Cohen's *d*. Cohen's *d* was calculated for all SUDs combined, as well as separately for both groups (none/mild and moderate/severe). The effect sizes were utilized to describe the amount of change in SUDs ratings between the different scenarios, and to compare the two groups across the intervention.

Nine participants had missing SUDs values for scenario 1 (Waiting Room). The missing data points for scenario 1 were replaced with the values for scenario 2 (Images), using a Last Observation Carried Backward (LOCB) approach. There were no other missing values.

Results

No participants reported feeling any cybersickness throughout the intervention. Two participants removed the head-mounted display during the first scenario due to difficulties navigating. This was likely due to technical errors in the program, as neither participant reported feeling any cybersickness, dizziness, or overwhelming anxiety. The experimenter was able to fix the errors by restarting the program, and both participants completed all scenarios.

Changes in Subjective Discomfort During the Intervention

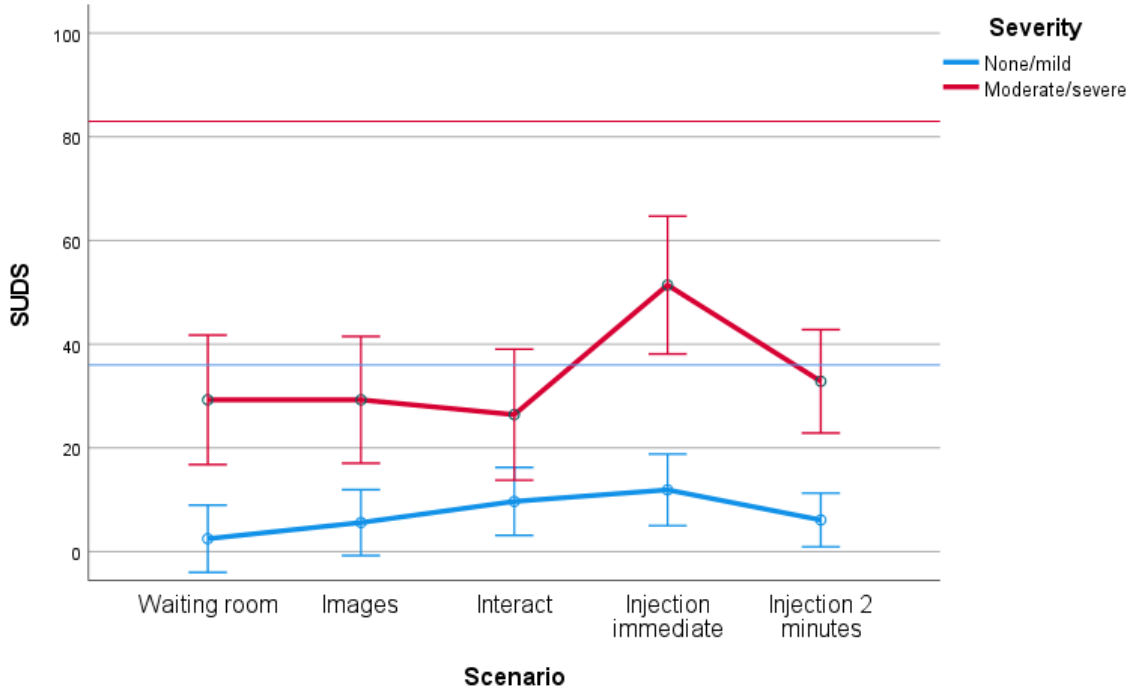
The SUDs for each VR-scenario were compared to each other throughout the intervention. The Greenhouse-Geisser estimate of the departure from sphericity was $\epsilon = 0.72$. There was a significant effect of the VR-intervention, $F(2.89, 89.68) = 6.62$, $p < .001$.

Pairwise comparisons showed that SUDs ratings were significantly higher in the Injection (Peak)-scenario ($M = 20.3$, $SD = 23.6$), compared to the Waiting Room-scenario ($M = 8.18$, $SD = 19.43$), $p < .001$, $d = 0.56$. This indicated a medium effect. The SUDs in the Injection (Peak)-scenario were also significantly higher when compared to both the Interaction-scenario ($M = 13.24$, $SD = 17.56$), $p < .001$, $d = 0.34$), as well as the Image-scenario ($M = 10.64$, $SD = 18.46$), $p < .001$, $d = 0.46$, indicating a small to medium effect. Finally, SUDs ratings were significantly lowered in the Injection 2 min-scenario ($M = 11.79$, $SD = 16.89$) compared to the Injection (Peak)-scenario, $p < .001$, $d = -0.42$, suggesting that the intervention was able to reduce discomfort in participants as well. The effect size of this difference indicated a small to medium effect. No other scenarios were significantly different.

The SUDs ratings for the none/mild ($n = 26$) and moderate/severe ($n = 7$) participants were compared throughout the VR-scenarios (Figure 1). As seen in Figure 1, the moderate/severe group consistently had higher SUDs ratings than the none/mild group all throughout the VR-intervention - with non-overlapping error bars with 95 % confidence intervals in all scenarios, except scenario 3 (Interact). The overlapping error bars in scenario 3 could suggest that the scenario was able to provoke some discomfort even in the none/mild-group. However, the overlap could also be partly explained by the moderate/severe group having a small decline in SUDs from scenario 2 (Images) to scenario 3 (Interact).

Figure 5

Changes in SUDs Throughout the Intervention for Participants with None/Mild and Moderate/Severe Needle Fear



Note. The red and blue horizontal lines indicate the highest level of needle fear ever experienced for each group. Error bars represent standard errors.

When looking at the SUDs for each group separately, the mean score for the moderate/severe group was 33.86 (4.50). By contrast, the none/mild group had a mean SUDs rating of 7.17 (2.33). For the moderate/severe-group, SUDs ratings were much higher in the Injection (Peak)-scenario (M = 51.43, SD = 32.8), compared to the Waiting Room-scenario (M = 29.28, SD = 35.87), indicating a medium effect (d = 0.64). Moreover, their SUDs in the Injection Peak-scenario also constituted a substantial increase from scenario 3 (Interaction), M = 26.43, SD = 26.09, d = 0.84. This indicated a large effect. After training in the Injection scenario for 2 minutes, SUDs scores for the moderate/severe-group were lowered to 32.85

(22.88), suggesting the participants experienced a reduction in discomfort. The effect size was medium, d = -0.66.

Although their scores did not increase as much as the moderate/severe group, the none/mild group also showed a pattern of somewhat increased SUDs in the Injection (Peak)-scenario (M = 11.92, SD = 10.46) compared to their scores in the Waiting Room-scenario (M = 2.5, SD = 4.06), d = 1.19 (Figure 1). However, unlike the moderate/severe group, their SUDs in scenario 4 (Injection Peak) were only slightly higher than in the Interaction-scenario (M = 9.69, SD = 13.02), d = 0.19, indicating a small effect. Finally, the none/mild group also reported a decrease in SUDs after training in the scenario for 2 minutes (M = 6.11, SD = 9.03), suggesting that they also experienced a small reduction in discomfort after prolonged exposure. The effect size was medium, d = 0.59.

Participants' Experience of Presence in the Virtual Scenarios

The Presence Questionnaire consisted of 19 items, with a Cronbach's α of .85. Mean scores (range 1-7) on the five factors of the PQ are presented in Table 2. Overall, participants reported high levels of presence during the intervention. The total presence score (ranging from 75-124 of a possible 19-133) had a mean of 98.51 (SD = 12.44). Additionally, mean scores on all factors are above the midpoint (score of 4), indicating that participants on average rated all aspects of their VR-experience favorably. Realism had the lowest mean score of 4.93 (SD = 0.77), while self-evaluation of performance was the factor with the highest mean score (M = 5.39, SD = 1.12). However, self-evaluation of performance also had a questionable internal consistency (α = .64).

Comparisons of the two groups are presented in Table 2. The moderate/severe-group had a total mean score of 5.38 (SD = 0.59), whereas the none/mild group had a mean score of 5.13 (SD = 0.67). There was no significant difference in the overall experience of presence

between the two groups, t = -.90, p = .375. There were no significant differences between the two groups on any of the five factors either (Table 2).

There were no differences in the overall experience of presence between younger participants (n = 16) aged 18-24 (M = 5.05, SD = 0.66), and participants (n = 17) between the age of 25-59 (M = 5.31, SD = 0.65), t = -1.16, p = .254. There were no differences between males (M = 5.33, SD = 0.62) and females (M = 5.09, SD = 0.67) in the study either, t = 1.04, p =.306. There were no significant correlations between the PQ and SUDs in the different scenarios (r = -.04 to .22).

Table 2

Participants' Scores on the Presence Questionnaire and Comparisons Between the Two Severity Groups

Presence variables	Total		α	Items	None/mild		Moderate/severe		*t*	*p*
	M	*SD*			*M*	*SD*	*M*	*SD*		
Realism	4.93	0.77	.79	7	4.84	0.76	5.29	0.74	-1.38	.18
Poss. To act	5.36	0.87	.58	4	5.29	0.88	5.61	0.86	-0.82	.42
Qual. Interf.	5.24	1.11	.71	3	5.39	0.97	4.67	1.48	1.58	.12
Possib. To exam.	5.33	1.09	.79	3	5.22	1.12	5.76	0.92	-1.18	.25
Self-eval. Of perf.	5.39	1.12	.64	2	5.29	1.11	5.78	1.11	-1.05	.30
Total	5.18	0.65	.85	19	5.13	0.67	5.38	0.59	-0.90	.38

Note. "Poss. To act" = Possibility to act. "Qual. Interf." = Quality of interface. "Possib. To exam." = Possibility to examine. "Self-eval. Of perf." = Self-evaluation of performance.

Discussion

The purpose of this study was to 1) examine whether this VRET protocol would be able to induce and reduce subjective discomfort in non-clinical participants, and 2) see if the intervention would be perceived as immersive by participants. The results were in line with the main hypothesis, showing that the VR intervention was capable of both inducing and reducing discomfort in participants. Furthermore, when compared to the none/mild group, the group with moderate/severe fear of needles consistently reported more discomfort during the intervention. However, neither group had discomfort ratings comparable to their highest level of needle fear experienced in real life. In line with the secondary hypothesis, results from the PQ indicated that participants on average experienced the intervention as immersive. A comparison of the two groups showed that there was no significant difference in the experience of presence during the intervention: not on any of the five factors, nor on total presence score.

Did the Intervention Induce and Reduce Discomfort in Participants?

The VRET intervention was able to induce discomfort in participants. However, results show that neither group reported discomfort comparable to their highest level of needle fear ever experienced. As fear-activation is essential for extinction, the effectiveness of VRET as a stand-alone treatment is in part contingent upon its ability to induce fear to a similar degree as the original stimuli (Maples-Keller et al., 2017; Foa & Kozak, 1986). The intervention did nevertheless manage to induce fear, suggesting that VRET might have the potential to serve as a less threatening way of introducing reluctant patients to exposure therapy (Jiang et al., 2020; Scheveneels et al., 2023). In their study on BII-phobia, Jiang et al (2020) highlighted the possibility of VRET as a useful treatment adjunct or a first step in a graded exposure hierarchy, preparing phobic patients to eventually engage in subsequent in vivo exposure. Seeing as previous studies have suggested that VRET might be a more

acceptable alternative for some phobics (E.g. Scheveneels et al., 2023), offering virtual exposure as an interim step before in vivo exposure could prove beneficial. To date, it seems only one study has looked at the potential utility of VRET as a stepping stone towards in vivo exposure (Scheveneels et al., 2023). This study found that while VRET reduced spider-anxious participants' negative beliefs towards in vivo exposure, it did not increase their willingness to engage in subsequent exposure in vivo. More research is needed to further examine the potential of utilizing VRET as an initial or intermediate step towards subsequent in vivo needle exposure

The moderate/severe group consistently reported more discomfort throughout the VRET intervention, further supporting the main hypothesis as higher SUDs is indicative of a stronger fear reaction amongst fearful participants. The difference in distress between the two groups was most striking in scenario 4, with the moderate/severe group having a mean score of 51, contrasted with the none/mild group reporting a mean of 12 on the SUDs scale. In scenario 4, participants were in a stationary position while receiving a virtual injection in their virtual arm. This was the only scenario involving virtual injections, as the others consisted of approaching and/or interacting with images and immobile needles. Fear of injection constitutes a large part of needle-fear, and as such a stronger fear response in scenario 4 is in line with what one would expect. Scenario 4 was also the only scenario involving virtual limbs. As embodiment (i.e. the involvement of a bodily representation) is thought to intensify the emotional response during VR (Gall et al., 2021), it is possible that the inclusion of a virtual arm further contributed to the increase in fear observed in the moderate/severe group. This is in line with previous research demonstrating that virtual limbs can modulate fear responses during VRET (Peperkorn et al., 2016).

Central to all exposure-based therapy is the process of extinction, in which exposure to the feared stimulus eventually causes the fear response to weaken and disappear (Craske et

al., 2008). As such, SUDs scores were also hypothesized to decrease when participants were repeatedly exposed to the injection in scenario 4. The results showed a decrease in distress ratings after training in the injection scenario for two minutes, demonstrating that the VRET intervention was successful in reducing participants' discomfort as well. As expected, the moderate/severe group reported the biggest decline in SUDs – with a decrease from 51 to an average score of 33. This suggests that the intervention has the essential qualities needed for exposure therapy to work, as it is capable of reducing the fear it induces in participants. These results fit with previous research on specific phobias in general, where VRET has repeatedly been shown to effectively reduce fear (e.g. Carl et al., 2019). Research further indicates that a reduced fear-response in VRET generalizes to in vivo equivalent stimuli (Morina et al., 2015), making it essential for the transfer of learning to real life (Lindner et al., 2021). However, the present study did not examine whether the observed fear-reduction translated to participants' real-life fear of needles. In their study, Jiang et al. (2020) only found improvements on some measures related to BII phobia even though their intervention managed to reduce fear in participants as well. Their study did not report SUDs, making any direct comparison difficult.

Unlike other specific phobias, BII phobia involves both tactile and visual stimuli (Wiederhold et al., 2005). It has therefore been suggested that BII phobia might differ from other, primarily visual, phobias in how it will respond to VRET (Wiederhold et al., 2005). Some authors argue that adding additional sensory stimuli, specifically tactile stimuli, might be necessary to maximize the efficacy of VRET for BII phobia (Gujjar et al., 2019; Jiang et al., 2020). Gujjar et al. (2019) used additional tactile and olfactory sensory stimuli to enhance the effect of VRET in his study on dental phobia. Participants were stationed in a real-life dental chair while undergoing VRET, with smells mimicking the smells typically found in a dental clinic. This could be part of the explanation as to why Gujjar found stronger effects of

VRET on dental phobia (d = 1.29-1.44) compared to Jiang et al. (2020), who only found small differences (g = 0.38) at follow-up. Future research should explore whether the inclusion of additional sensory stimuli could enhance the effect of VRET for BII- and needle phobia.

Did the Participants Experience the VRET Intervention as Immersive?

Presence is thought to mediate the experience of emotions in a virtual environment. Research on the topic consistently reports a strong association between presence and the experience of fear during VRET, even though the causality of this relationship remains unclear (E.g. Ling et al., 2014; Price & Anderson, 2007; Gromer et al., 2019). As such, the secondary aim of this study was to establish if the participants experienced the VRET intervention as immersive. Results from the PQ indicate that participants felt present in the VRET intervention. All factors, except realism, had an average score above 5 (on a 1-7 scale). This being above the midpoint (4) provides support for the secondary hypothesis, indicating that participants on average experienced the intervention as immersive.

This study did not include any additional components with the potential to influence sense of presence, as the intervention was without both auditory, tactile, and olfactory stimuli. In his study on dental phobia, Gujjar et al. (2019) used additional sensory stimuli (olfactory and tactile) to specifically enhance participant immersion, as this was hypothesized to increase the efficacy of the VRET intervention. In addition to the positive effect of the exposure itself, their results showed that participants had a strong sense of presence throughout the intervention (Gujjar et al., 2019). This fits well with previous research indicating that both visual, olfactory, and auditory cues during VRET contributes to activating the underlying fear-structure (Gujjar et al., 2019; Mapler-Keller et al., 2017; Price et al., 2011), as successful extinction learning is dependent on the effective activation of fear (Craske et al., 2014; Foa & Kozak, 1986). Assuming that presence could have the potential to

influence fear-activation, future studies on VRET for needle phobia should explore factors potentially underlying or influencing the experience of presence.

The results showed no significant difference in the experience of presence between the two groups: not on any of the five factors, nor on total presence score. There was no significant correlation between the PQ and SUDs in the different scenarios either. This contrasts previous studies on the topic, suggesting that anxiety increases the sense of presence during VRET (Bouchard et al., 2008). The current findings might be due to a small sample size, which reduces the ability to detect potential differences between the two groups. It is possible that the difference between the groups would have been significant with sufficient statistical power. These results can also suggest that while presence might be a necessary precondition, allowing fear to be felt in the intervention (Gromer et al., 2018; Price & Anderson, 2007), a fear of needles is not required to feel present in the intervention.

Additionally, newer studies investigating causal links between presence and fear indicate that the relationship might be more complex than previously assumed (Gromer et al., 2019). Gromer et al (2019) found that while the experience of emotion did lead to a stronger sense of presence, experimentally increasing the sense of presence did not seem to influence the strength of the elicited fear-response in a sample of height-fearful participants. However, this study manipulated presence primarily through low vs. high visual realism, as well as turning the sound on and off. It has been suggested that relative to the addition of tactile, olfactory, and auditory cues, increasing the level of visual detail alone does not result in an increased sense of presence (Maples-Keller et al., 2017).

Limitations

The findings of this study have to be considered within the context of several limitations. Most notably, the present study had a small sample size. This makes it difficult to detect potential between-group differences. The group with high needle fear was especially

small, consisting of only seven participants. This reduces the reliability of the findings, and limits the possibility to generalize to a broader population. Furthermore, all participants were undiagnosed. While this allowed for a larger sample size, results need to be interpreted with caution. Future studies are needed to explore whether similar effects are observed in clinical samples.

This was not a treatment study, and therefore it did not examine if the intervention resulted in any reductions in the needle fear experienced in real-life. Consequently, the results do not provide any direct indication on whether the reduced fear response observed during VRET has the potential to generalize to real life situations, or to subsequent in vivo exposure to needles. Furthermore, the participants' ratings of most discomfort ever experienced in a situation involving needles and/or injections were subjective estimates, which could differ from their actual response. The absence of an equivalent in vivo control is also considered a limitation, as it disables any comparison of discomfort experienced during VRET to the discomfort experienced in vivo.

Two subscales of the Presence Questionnaire exhibited low Cronbach's alpha coefficients, impacting data interpretability. The "self-evaluation of performance" subscale had questionable internal consistency ($\alpha = .64$), while the "possibility to act" subscale showed poor internal consistency ($\alpha = .58$). This suggests that the scores obtained from these subscales may not accurately represent the intended concepts, raising questions about whether these subscales are truly capturing the concept they were designed to measure. Prior research has highlighted a lack of comprehensive validity assessments for presence scales in general (Ling et al., 2014; Morina et al., 2015).

Finally, this study only included peak discomfort-ratings from scenario 1-3. Recording discomfort again before switching scenarios is needed to measure the effect of

exposure in each scenario. Knowledge of the reduction in discomfort would enable a more accurate comparison of the increase experienced throughout the scenarios as well.

Conclusions

The findings of this study have demonstrated the intervention's effectiveness in inducing and reducing discomfort within a non-clinical sample. Due to the use of a non-clinical sample, this cannot be viewed as a clear indication of potential clinical utility. Nevertheless, these results do suggest the potential viability of VRET as a treatment option for needle phobia. Further research is warranted through randomized controlled trials involving clinical populations.

The promise exhibited by VRET as a treatment modality for needle phobia also calls for further exploration into its supplementary role, potentially acting as both a treatment adjunct and a preparatory tool for subsequent in vivo needle exposure. Future research should explore factors potentially influencing and/or enhancing the efficacy of VRET for needle phobia as well, such as the inclusion of virtual limbs and the incorporation of tactile and olfactory stimuli.

References

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). https://doi.org/10.1176/appi.books.9780890425596

Anderson, P. L., & Molloy, A. (2020). Maximizing the impact of virtual reality exposure therapy for anxiety disorders. *Current opinion in psychology*, *36*, 153–157. https://doi.org/10.1016/j.copsyc.2020.10.001

Benbow, A. A., & Anderson, P. L. (2019). A meta-analytic examination of attrition in virtual reality exposure therapy for anxiety disorders. *Journal of anxiety disorders*, *61*, 18–26. https://doi.org/10.1016/j.janxdis.2018.06.006

Botella, C., Fernández-Álvarez, J., Guillén, V., García-Palacios, A., & Baños, R. (2017). Recent Progress in Virtual Reality Exposure Therapy for Phobias: A Systematic Review. *Current psychiatry reports*, *19*(7), 42. https://doi.org/10.1007/s11920-017-0788-4

Bouchard, S., St-Jacques, J., Robillard, G., & Renaud, P. (2008). Anxiety increases the feeling of presence in virtual reality. *Presence: Teleoperators and Virtual Environments*, *17*(4), 376-391. https://doi.org/10.1162/pres.17.4.376

Carl, E., Stein, A. T., Levihn-Coon, A., Pogue, J. R., Rothbaum, B., Emmelkamp, P., Asmundson, G. J. G., Carlbring, P., & Powers, M. B. (2019). Virtual reality exposure therapy for anxiety and related disorders: A meta-analysis of randomized controlled

trials. *Journal of anxiety disorders*, *61*, 27–36. https://doi.org/10.1016/j.janxdis.2018.08.003

Choy, Y., Fyer, A. J., & Lipsitz, J. D. (2007). Treatment of specific phobia in adults. *Clinical psychology review*, *27*(3), 266–286. https://doi.org/10.1016/j.cpr.2006.10.002

Craske, M. G., Kircanski, K., Zelikowsky, M., Mystkowski, J., Chowdhury, N., & Baker, A. (2008). Optimizing inhibitory learning during exposure therapy. *Behaviour research and Therapy*, *46*(1), 5-27. https://doi.org/10.1016/j.brat.2007.10.003

Craske, M., Wittchen, U., Bogels, S., Stein, M., Andrews, G., & Lebeau, R. (2013). *Severity Measure for Specific Phobia Adult.* https://www.psychiatry.org/File%20Library/Psychiatrists/Practice/DSM/APA_DSM5_Severity-Measure-For-Specific-Phobia-Adult.pdf

Craske, M. G., Treanor, M., Conway, C. C., Zbozinek, T., & Vervliet, B. (2014). Maximizing exposure therapy: an inhibitory learning approach. *Behaviour research and therapy*, *58*, 10–23. https://doi.org/10.1016/j.brat.2014.04.006

DeSousa, D. A., Moreno, A. L., Osório, F. L., Crippa, J. A. S., LeBeau, R., Manfro, G. G. … Koller, S. H. (2017). Psychometric properties of the dimensional anxiety scales for DSM-5 in a Brazilian community sample. *International Journal of Methods in Psychiatric Research*, 26(3), e1531. https://doi.org/10.1002/mpr.1531

Emmelkamp, P. M., Krijn, M., Hulsbosch, A. M., de Vries, S., Schuemie, M. J., & van der Mast, C. A. (2002). Virtual reality treatment versus exposure in vivo: a comparative

evaluation in acrophobia. *Behaviour research and therapy*, *40*(5), 509–516. https://doi.org/10.1016/s0005-7967(01)00023-7

Foa, E. B., & Kozak, M. J. (1986). Emotional processing of fear: Exposure to corrective information. *Psychological Bulletin, 99*(1), 20–35. https://doi.org/10.1037/0033-2909.99.1.20

Gall, D., Roth, D., Stauffert, J. P., Zarges, J., & Latoschik, M. E. (2021). Embodiment in Virtual Reality Intensifies Emotional Responses to Virtual Stimuli. *Frontiers in psychology*, *12*, 674179. https://doi.org/10.3389/fpsyg.2021.674179

Garcia-Palacios, A., Hoffman, H. G., Kwong See, S., Tsai, A., & Botella, C. (2001). Redefining therapeutic success with VR exposure therapy. *Cyberpsychology and Behavior*, *4*, 431-348. https://doi.org/10.1089/109493101300210231

Garcia-Palacios, A., Botella, C., Hoffman, H., & Fabregat, S. (2007). Comparing acceptance and refusal rates of virtual reality exposure vs. in vivo exposure by patients with specific phobias. *Cyberpsychology & behavior : the impact of the Internet, multimedia and virtual reality on behavior and society*, *10*(5), 722–724. https://doi.org/10.1089/cpb.2007.9962

Gromer, D., Reinke, M., Christner, I., & Pauli, P. (2019). Causal Interactive Links Between Presence and Fear in Virtual Reality Height Exposure. *Frontiers in psychology*, *10*, 141. https://doi.org/10.3389/fpsyg.2019.00141

Gromer, D., Madeira, O., Gast, P., Nehfischer, M., Jost, M., Müller, M., Mühlberger, A., & Pauli, P. (2018). Height Simulation in a Virtual Reality CAVE System: Validity of

Fear Responses and Effects of an Immersion Manipulation. *Frontiers in human neuroscience*, *12*, 372. https://doi.org/10.3389/fnhum.2018.00372

Gujjar, K. R., van Wijk, A., Kumar, R., & de Jongh, A. (2019). Efficacy of virtual reality exposure therapy for the treatment of dental phobia in adults: A randomized controlled trial. *Journal of anxiety disorders*, *62*, 100–108. https://doi.org/10.1016/j.janxdis.2018.12.001

Hamilton, J. G. (1995). Needle phobia: a neglected diagnosis. *Journal of family practice*, *41*(2), 169-182.

Hesch, J., Kozminski, A., & Linde, O. (2019, 22. August). Powered by AI: Oculus Insight. https://ai.facebook.com/blog/powered-by-ai-oculus-insight/

Jiang, M. Y. W., Upton, E., & Newby, J. M. (2020). A randomised wait-list controlled pilot trial of one-session virtual reality exposure therapy for blood-injection-injury phobias. *Journal of affective disorders*, *276*, 636–645. https://doi.org/10.1016/j.jad.2020.07.076

Kleinknecht R. A. (1994). Acquisition of blood, injury, and needle fears and phobias. *Behaviour research and therapy*, *32*(8), 817–823. https://doi.org/10.1016/0005-7967(94)90161-9

Krijn, M., Emmelkamp, P. M., Olafsson, R. P., & Biemond, R. (2004). Virtual reality exposure therapy of anxiety disorders: A review. *Clinical psychology review*, *24*(3), 259-281. https://doi.org/10.1016/j.cpr.2004.04.001

Lebeau, R. T., Glenn, D. E., Hanover, L. N., Beesdo-Baum, K., Wittchen, H. U., & Craske, M. G. (2012). A dimensional approach to measuring anxiety for DSM‐5. *International Journal of Methods in Psychiatric Research*, 21(4), 258–272. https://doi.org/10.1002/mprt.1369

Lindner, P., Miloff, A., Hamilton, W., Reuterskiöld, L., Andersson, G., Powers, M. B., et al. (2017). Creating state of the art, next-generation virtual reality exposure therapies for anxiety disorders using consumer hardware platforms: design considerations and future directions. *Cogn. Behav. Ther.* 46, 404–420. doi:10.1080/16506073.2017.1280843

Lindner, P., Dafgård, P., Miloff, A., Andersson, G., Reuterskiöld, L., Hamilton, W., & Carlbring, P. (2021). Is Continued Improvement After Automated Virtual Reality Exposure Therapy for Spider Phobia Explained by Subsequent *in-vivo* Exposure? A First Test of the Lowered Threshold Hypothesis. *Frontiers in psychiatry*, *12*, 645273. https://doi.org/10.3389/fpsyt.2021.645273

Ling, Y., Nefs, H. T., Morina, N., Heynderickx, I., & Brinkman, W.-P. (2014). A meta-analysis on the relationship between self-reported presence and anxiety in virtual reality exposure therapy for anxiety disorders. *PloS one*, *9*(5), e96144. https://doi.org/10.1371/journal.pone.0096144

MacLeod, S., Schneider, L. H., & McCabe, R. E. (2022). Investigating the psychometric properties of the Severity measure for specific phobia. *Journal of Psychopathology and Behavioral Assessment*, *44*(3), 826-835. DOI:10.1007/s10862-022-09976-6

Maples-Keller, J. L., Yasinski, C., Manjin, N., & Rothbaum, B. O. (2017). Virtual Reality-Enhanced Extinction of Phobias and Post-Traumatic Stress. *Neurotherapeutics : the journal of the American Society for Experimental NeuroTherapeutics*, *14*(3), 554–563. https://doi.org/10.1007/s13311-017-0534-y

Marks, I., & O'Sullivan, G. (1988). Drugs and Psychological Treatments for Agoraphobia/Panic and Obsessive–Compulsive Disorders: A Review. *The British Journal of Psychiatry, 153*(5), 650-658. doi:10.1192/bjp.153.5.650

McMurtry, C. M., Pillai Riddell, R., Taddio, A., Racine, N., Asmundson, G. J., Noel, M., Chambers, C. T., Shah, V., & HELPinKids&Adults Team (2015). Far From "Just a Poke": Common Painful Needle Procedures and the Development of Needle Fear. *The Clinical journal of pain*, *31*(10 Suppl), S3–S11. https://doi.org/10.1097/AJP.0000000000000272.

McMurtry, C. M., Taddio, A., Noel, M., Antony, M. M., Chambers, C. T., Asmundson, G. J., Pillai Riddell, R., Shah, V., MacDonald, N. E., Rogers, J., Bucci, L. M., Mousmanis, P., Lang, E., Halperin, S., Bowles, S., Halpert, C., Ipp, M., Rieder, M. J., Robson, K., … Scott, J. (2016). Exposure-based Interventions for the management of individuals with high levels of needle fear across the lifespan: a clinical practice guideline and call for further research. *Cognitive behaviour therapy*, *45*(3), 217–235. https://doi.org/10.1080/16506073.2016.1157204

Michaliszyn, D., Marchand, A., Bouchard, S., Martel, M.-O., & Poirier-Bisson, J. (2010). A randomized, controlled clinical trial of in virtuo and in vivo exposure for spider phobia. *Cyberpsychology, Behavior, and Social Networking*, *13*(6), 689-695. https://doi.org/10.1089/cyber.2009.0277

Morina, N., Ijntema, H., Meyerbröker, K., & Emmelkamp, P. M. (2015). Can virtual reality exposure therapy gains be generalized to real-life? A meta-analysis of studies applying behavioral assessments. *Behaviour research and Therapy*, *74*, 18-24. https://doi.org/10.1016/j.brat.2015.08.010

Möller, E. L., & Bögels, S. M. (2016). The DSM-5 Dimensional Anxiety Scales in a Dutch non‐clinical sample: Psychometric properties including the adult separation anxiety disorder scale. *International Journal of Methods in Psychiatric Research*, 25(3), 232–239. https://doi.org/10.1002/mpr.1515

Olatunji, B. O., Deacon, B. J., & Abramowitz, J. S. (2009). The cruelest cure? Ethical issues in the implementation of exposure-based treatments. *Cognitive and Behavioral Practice, 16*(2), 172–180. https://doi.org/10.1016/j.cbpra.2008.07.003

Opriş, D., Pintea, S., García‐Palacios, A., Botella, C., Szamosközi, Ş., & David, D. (2012). Virtual reality exposure therapy in anxiety disorders: a quantitative meta‐analysis. *Depression and anxiety*, *29*(2), 85-93. https://doi.org/10.1002/da.20910

Parsons, T. D., & Rizzo, A. A. (2008). Affective outcomes of virtual reality exposure therapy for anxiety and specific phobias: A meta-analysis. *Journal of behavior therapy and experimental psychiatry*, *39*(3), 250-261. https://doi.org/10.1016/j.jbtep.2007.07.007

Peperkorn, H. M., Diemer, J. E., Alpers, G. W., & Mühlberger, A. (2016). Representation of patients' hand modulates fear reactions of patients with spider phobia in virtual reality. *Frontiers in psychology*, *7*, 1-11, Article 268. https://doi.org/10.3389/fpsyg.2016.00268

Pittig, A., Kotter, R., & Hoyer, J. (2019). The Struggle of Behavioral Therapists With Exposure: Self-Reported Practicability, Negative Beliefs, and Therapist Distress About Exposure-Based Interventions. *Behavior therapy*, *50*(2), 353–366. https://doi.org/10.1016/j.beth.2018.07.003

Powers, M. B., & Emmelkamp, P. M. (2008). Virtual reality exposure therapy for anxiety disorders: A meta-analysis. *Journal of anxiety disorders*, *22*(3), 561-569. https://doi.org/10.1016/j.janxdis.2007.04.006

Price, M., & Anderson, P. (2007). The role of presence in virtual reality exposure therapy. *Journal of anxiety disorders*, *21*(5), 742–751. https://doi.org/10.1016/j.janxdis.2006.11.002

Price, M., Mehta, N., Tone, E. B., & Anderson, P. L. (2011). Does engagement with exposure yield better outcomes? Components of presence as a predictor of treatment response for virtual reality exposure therapy for social phobia. *Journal of anxiety disorders*, *25*(6), 763–770. https://doi.org/10.1016/j.janxdis.2011.03.004

Scheveneels, S., De Witte, N., & Van Daele, T. (2023). The first steps in facing your fears: The acceptability of virtual reality and in vivo exposure treatment for specific fears. *Journal of anxiety disorders*, *95*, 102695. https://doi.org/10.1016/j.janxdis.2023.102695

Slater, M. & Wilbur, S. (1997) A Framework for Immersive Virtual Environments (FIVE): Speculations on the Role of Presence in Virtual Environments. Presence: Teleoperators & Virtual Environments, 6, 603-616. https://doi.org/10.1162/pres.1997.6.6.603

Sokolowski, C. J., Giovannitti, J. A., Jr, & Boynes, S. G. (2010). Needle phobia: etiology, adverse consequences, and patient management. *Dental clinics of North America*, *54*(4), 731–744. https://doi.org/10.1016/j.cden.2010.06.012

Taddio, A., Ipp, M., Thivakaran, S., Jamal, A., Parikh, C., Smart, S., Sovran, J., Stephens, D., & Katz, J. (2012). Survey of the prevalence of immunization non-compliance due to needle fears in children and adults. *Vaccine*, *30*(32), 4807–4812. https://doi.org/10.1016/j.vaccine.2012.05.011

Trost, Z., Jones, A., Guck, A., Vervoort, T., Kowalsky, J. M., & France, C. R. (2017). Initial validation of a virtual blood draw exposure paradigm for fear of blood and needles. *Journal of anxiety disorders*, *51*, 65–71. https://doi.org/10.1016/j.janxdis.2017.03.002

UQO Cyberpsychology Lab. (2004). Presence Questionnaire (Rev. ed.). Retrieved 22. January 2021, from https://marketinginvolvement.files.wordpress.com/2013/12/pq-presence-questionnaire.pdf

Vidal-Arenas, V., Ortet-Walker, J., Ibáñez, M. I., Ortet, G., & Mezquita, L. (2021). Self-reported DSM-5 Anxiety Severity Measures: Evidence of validity and reliability in Spanish youths. *Psicothema*, 33(2), 312–319. https://doi.org/10.7334/psicothema2020.398

Wardenaar, K. J., Lim, C. C. W., Al-Hamzawi, A. O., Alonso, J., Andrade, L. H., Benjet, C., Bunting, B., de Girolamo, G., Demyttenaere, K., Florescu, S. E., Gureje, O., Hisateru, T., Hu, C., Huang, Y., Karam, E., Kiejna, A., Lepine, J. P., Navarro-Mateu, F., Oakley Browne, M., Piazza, M., … de Jonge, P. (2017). The cross-national epidemiology of

specific phobia in the World Mental Health Surveys. *Psychological medicine*, *47*(10), 1744–1760. https://doi.org/10.1017/S0033291717000174

Wiederhold, B. K., Mendoza, M., Nakatani, T., Bullinger, A. H., & Wiederhold, M. D. (2005). VR for blood-injection-injury phobia. *Annual Review of CyberTherapy and Telemedicine*, *3*, 109-116.

Witmer, B. G., & Singer, M. J. (1998). Measuring Presence in Virtual Environments: A Presence Questionnaire. *Presence*, *7*(3), 225-240. https://doi.org/10.1162/105474698565686

Wolitzky-Taylor, K. B., Horowitz, J. D., Powers, M. B., & Telch, M. J. (2008). Psychological approaches in the treatment of specific phobias: a meta-analysis. *Clinical psychology review*, *28*(6), 1021–1037. https://doi.org/10.1016/j.cpr.2008.02.007

Wolpe, J. (1969). *The Practice of Behavior Therapy*. Pergamon Press.

Ost, L. G., Fellenius, J., & Sterner, U. (1991). Applied tension, exposure in vivo, and tension-only in the treatment of blood phobia. *Behaviour research and therapy*, *29*(6), 561–574. https://doi.org/10.1016/0005-7967(91)90006-o

Ost L. G. (1992). Blood and injection phobia: background and cognitive, physiological, and behavioral variables. *Journal of abnormal psychology*, *101*(1), 68–74. https://doi.org/10.1037//0021-843x.101.1.68

Öst, L., Hellström, K., & Kåver, A. (1992). One versus five sessions of exposure in the treatment of injection phobia. *Behavior Therapy, 23*, 263-281. https://doi.org/10.1016/S0005-7894(05)80385-5