An Evaluation of oVRcome, a Low-Cost Virtual Reality Exposure Therapy App

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Abstract

Emetophobia (fear of vomiting) is an understudied disorder that affects 0.2% of people, with extreme (non-phobic) fear affecting up to 8% of people. The most effective treatment for specific phobias is exposure therapy. One exposure therapy approach, virtual reality exposure therapy (VRET), has become a viable treatment alternative to traditional in vivo or imaginal exposure therapy in recent years. However, using VRET to treat emetophobia has not yet been explored. I used a within-subjects, multiple-baseline-across-participants design with six participants to evaluate the emetophobia programme of oVRcome, a low-cost, Aotearoa New Zealand-based VRET app. After using the oVRcome VRET app, all participants' phobia severity reduced on one or both measures, with two participants scoring below the threshold for a likely phobia diagnosis. The emetophobia programme of the oVRcome VRET app was effective at reducing emetophobia severity, and my results support research showing eHealth apps can be a low-cost and effective treatment for a range of psychological issues.

Keywords: app, emetophobia, exposure therapy, multiple baseline, virtual reality

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Everybody is afraid of something; fear is a normal and evolutionarily useful response. Though the physical sensations associated with fear are unpleasant, appropriate fear responses to specific stimuli can increase a person's chances of survival (Luchkina & Bolshakov, 2019), for example, an increase in adrenalin, tensed muscles, and quicker breathing may help us fight or escape an attacker more effectively. Fear can be divided into three broad components, motor behaviours (e.g., fight, flight, or freeze), physiological responses such as increased heart rate or muscle tension, and verbal reports of fear (Lang, 1968). Humans appear to be evolutionarily predisposed to some fears, such as snakes, spiders, or animals with large teeth (Hofmann et al., 2002; Öhman & Mineka, 2001; Seligman, 1971) but people can also acquire fear. One way fear responses can be acquired is through direct contact with an unconditioned aversive stimulus (e.g., injury, pain) in close proximity to neutral stimuli (e.g., location, sounds), conditioning an association between the neutral stimuli and physiological sensations experienced (Beckers et al., 2013; LeDoux, 2014). Other ways fear responses can be acquired include observational learning, where a person sees aversive consequences occurring for someone else, and learns to avoid the behaviours and contexts associated with those consequences (Lancaster & Smirnova, 2022; Mineka & Zinbarg, 2006); deriving relations between stimuli (e.g., learning stimulus A = B, and B = C, then if an aversive event becomes associated with C, responding to both A and B as if it were C) (Dymond et al., 2018); and from a person's verbal community, which may include verbal expressions of stimulus relations and lead to rule-governed behaviour, where verbally expressed stimulus-contingency relations affect a person's behaviour (Strosahl, 2002).

If a person's fear responses begin to occur in 'anticipation' of a future negative event in a way that impacts their current functioning, they may exhibit behaviours consistent with the way anxiety is typically described. Anxiety is often described as an excessive and pervasive worry about a perceived future event(s) and is somewhat distinct from the more specific and immediate term, 'fear' (Rachman, 2019). However, this definition of anxiety is problematic from a behavioural perspective, as future events cannot affect a person's present behaviour (Baum, 2017). Rather than attributing cause to future events, behavioural conceptualisations of anxiety are based on classical conditioning (Pavlov, 2010) and generalisation (Watson & Rayner, 1920). What may look like 'anticipation' of a future negative outcome is really a person responding to stimuli (including physiological sensations) that are associated with previous experiences of an aversive stimulus. The difficulty with a behaviour analytic conceptualisation of anxiety is identifying the triggers, which tend to be less obvious than fear-response triggers and can be spread throughout a person's learning history.

In instances when a person's heightened fear and anxiety responses to specific stimuli are severely disproportionate to the level of threat the stimuli present (e.g., experiencing an overt anxiety episode after hearing someone say "snake") for more than 6 months, they are said to have a specific phobia (American Psychiatric Association, 2013). Phobias can be learned in a single instance of the aversive stimulus and are highly resistant to extinction (Seligman, 1971). A specific phobia can seriously affect a person's life if the specific feared stimulus is relatively common in everyday life (e.g., insects, heights, social situations, or open spaces or crowds), which often leads to avoidance – at almost any cost – of feared and fear-related stimuli. Specific phobias affect between 3% and 15% of the population and are more commonly experienced by women than men. The most common phobic stimuli are animals, heights, flying, and enclosed spaces (Eaton et al., 2018).

Phobia Treatment

There have been multiple avenues of treatment explored for phobias, including (individually and combined) hypnosis (Iglesias & Iglesias, 2013; McNeal, 2001), pharmacotherapy (Hussain, 1971; Liebowitz et al., 1999; Rachman, 1990; Zitrin et al., 1983), participant modelling (Ladouceur, 1983), and eye-movement desensitisation reprocessing (EMDR) (McNeal, 2001; Wolitzky-Taylor et al., 2008). The most frequently used treatments are cognitive therapy (CT) (Clark et al., 2006; Rachman, 1990; Stangier et al., 2003; Wolitzky-Taylor et al., 2008), cognitive-behavioural therapy (CBT) (Maskey et al., 2019; Ponniah & Hollon, 2008; Wright et al., 2023), and exposure therapy (Böhnlein et al., 2020; Boulougouris & Marks, 1969; Jacquart et al., 2022; Jones, 1924; Öst, 1985; Rachman, 1990; Watson et al., 1971; Wolpe, 1969).

Cognitive Therapy

CT is premised on the idea that a person's thoughts and way of thinking impact their reality. CT has typically been used only for social phobia, and in more recent studies, CT has often been based on a cognitive model of social phobia developed by Clark and Wells (1995) (Clark et al., 2006; Clark et al., 2003; Mörtberg et al., 2011; Mörtberg et al., 2007; Piet et al., 2010; Stangier et al., 2003; Wells & Papageorgiou, 2001). CT using the Clark and Wells model involves reducing or reversing safety behaviours, self-focused attention, and negative beliefs (Mörtberg et al., 2011). First, an individualized cognitive model is developed using a patient's thoughts, images, anxiety symptoms, safety behaviours, and attentional strategies. Second, a client learns to modify distorted self-imagery and shift their attention away from themselves. Finally, safety behaviours and negative beliefs or assumptions are countered with behavioural experiments (Mörtberg et al., 2011). CT has been shown to be effective for reducing social phobia (Clark et al., 2006; Clark et al., 2003; Mörtberg et al., 2007; Piet et al., 2010; Stangier et al., 2003; Wells & Papageorgiou, 2001) with sustained improvement 5 years later (Mörtberg et al., 2011).

Cognitive Behavioural Therapy

CBT has been used to successfully treat a wider range of phobias than CT, including blood-injection-injury (Lilliecreutz et al., 2010; Mason et al., 2022), small animal (Koch et al., 2004), flying (Kim et al., 2008; Triscari et al., 2011), and spider phobias (Soravia et al., 2016). In a recent review of 33 studies of phobia treatments, Thng et al. (2020) found CBT to be associated with more substantial positive treatment outcomes than other approaches, including pharmacotherapy, EMDR, applied muscle tension, psychoeducation, systematic desensitisation, and relaxation. The core assumption of CBT is that cognitions and behaviours are interrelated and that a change in one domain will be observed in the other. Like CT, CBT treatment addresses a person's distorted cognitions about themselves, their phobia (as a 'disorder'), the threat posed by their feared object/situation, internal sensations, and the social implications of their fear responses (Teachman et al., 2014). After several sessions of cognitive-centred therapy and discussion of behavioural goals, a person begins exposure practice. Exposure practice involves a person exposing themselves to progressively intense instances of their feared object/situation, while using the cognitive skills they have learned to reduce their fear responses.

Exposure Therapy

Exposure therapy is a crucial part of the treatment of phobias using CBT or the Clark and Wells (1995) CT model. Exposure therapies are also effective as standalone treatments and have been reported as the most efficacious forms of therapy for a range of phobias (Areas et al., 2023; Böhnlein et al., 2020; Craske et al., 2014; Jacquart et al., 2022; Kaczkurkin & Foa, 2015; Richard et al., 2006). Choy et al. (2007) reviewed phobia treatment approaches between 1940 and 2005. The most robust treatment was exposure therapy, while cognitive therapy was a useful adjunct to exposure in some circumstances. The following year, in a meta-analysis of 33 randomised treatment studies for specific phobia, it was reported that exposure therapies resulted in both statistically and clinically significant positive outcomes (Wolitzky-Taylor et al., 2008). Alternative (e.g., cognitive) therapies were found to be much better than no treatment, but not as effective as exposure-based therapies.

There are several approaches to exposure therapy: Graduated, flooding, in vivo, interoceptive, imaginal, and virtual. Graduated exposure is where a feared stimulus is presented, and progressively intensified when the client becomes comfortable at a specific intensity, while flooding is when the maximum level of the feared stimulus is presented until the client's anxiety responses have reduced. Exposure can also be in vivo, where the client is exposed to the actual stimulus they fear; imaginal, where the client imagines their feared stimulus; interoceptive, where the client recreates the physiological sensations associated with the presentation of their feared stimulus; or virtual, where a client experiences a computer-generated version of their feared stimulus. Each approach has been effective for treating phobias (Hirai et al., 2006; Jacquart et al., 2022) with in vivo being generally the most robust treatment (Choy et al., 2007; Wolitzky-Taylor et al., 2008). In some clinical settings, it has been suggested that approaches can be combined as needed if in vivo is not a realistic starting point (Jacquart et al., 2022), such as imaginal leading to in vivo exposure for fear of flying.

The mechanism by which exposure therapy can reduce fear and anxiety responses is based on the processes of conditioning and generalisation involved in the acquisition (learning) of fear and anxiety responses. By repeatedly presenting a (non-dangerous) feared stimulus in the absence of aversive outcomes and ability to escape, the association between that stimulus and aversive outcomes is weakened, and fear responses can be reduced or extinguished. Two common approaches to reducing fear and anxiety responses using exposure are counter-conditioning and systematic desensitisation. Counter-conditioning involves the addition of a pleasurable stimulus to the exposure procedure, which produces a pleasure response that is antagonistic to a fear response (Lancaster & Smirnova, 2022). Systematic desensitisation is based on the principle of reciprocal inhibition, which involves performing behaviours that are physiologically incompatible with a fear response (e.g., relaxation techniques) in the presence of a feared stimulus (Wolpe, 1968). In systematic desensitisation, a person is gradually exposed to progressively intense versions of their feared stimulus. Exposure to low-intensity versions of a person's feared stimulus produces a near zero fear response, and after repeated presentations, a new stimulus-no response relation is learned. The new stimulus-no response relation generalises to more intense versions of the feared stimulus, which a person is exposed to until they too produce no fear response, and so on until there is no fear response to the intensity of the stimulus that previously elicited their phobia (Butler et al., 2011).

Other factors suggested to be involved in behaviour change during exposure therapy that are beyond the scope of this thesis include neurobiological factors (Myers & Davis, 2007), derived stimulus relations (from relational-frame theory) (Dymond & Roche, 2009), expectancy violations (Craske et al., 2014), emotional processing (Foa & Kozak, 1986), personality, latent inhibition, and cognitive factors (Lancaster & Smirnova, 2022). However, what tends to remain across all factors is the need for a person to experience their feared stimulus to learn that aversive outcomes in proportion to their fear are unlikely and, in some cases, almost impossible.

Exposure therapy is not without drawbacks and limitations. Arguably the most significant drawback is that all forms of exposure therapy can reproduce strong fear responses and are often very confronting for a person already attempting to manage fear in their own ways. Reported rates of refusal and attrition for exposure treatments are 25% for OCD (Schruers et al., 2005; Stanley & Turner, 1995), 20%-27% for PTSD (Barrera et al., 2013; Goodson et al., 2013; Olatunji et al., 2009), and up to 45% for specific phobia (Choy et al., 2007). These percentages are all people who did not complete their treatment programme, and it is possible that they will be reluctant to seek treatment again.

Another limitation is that, even if the exposure therapy is successful, there is still a chance that a person's fear response will return. Stimulus-response relations are not 'unlearned' during exposure therapy, rather, a new relation is learned (i.e., stimulus-no response) (Craske et al., 2008). Future presentations of the aversive stimulus can either be excitatory (stimulus-response) or inhibitory (stimulus-no response), which helps explain why fear and anxiety responses can sometimes (seemingly) spontaneously recover (Craske et al., 2014). To reduce the likelihood of fear and anxiety responses re-emerging, exposure can be performed in multiple contexts (Bandarian-Balooch et al., 2012; Bandarian-Balooch et al., 2015; Neumann, 2006), using multiple or varied stimuli (Rowe & Craske, 1998; Shiban et al., 2015), occasionally (randomly) varying the intensity of the exposure exercises, or restricting the use of coping behaviours (Craske et al., 2008). These modifications to a typical exposure treatment may help generalise the inhibitory relations being learned to multiple real-world contexts.

Two further limitations of exposure-based therapies are practicality and acceptability from therapists. Though in vivo exposure is often the recommended treatment, there are practical issues that can make certain phobias unsuited to an in vivo approach (Freitas et al., 2021). For instance, it is not practical to have a person with flying phobia go to an airport and then buy (potentially expensive) tickets enough times to allow for sufficient exposure trials to overcome their phobia. There is also the risk that their fear response on a plane or in the airport will prompt a response from security, which could result in a range of negative outcomes. Another example is trypanophobia (needle phobia). If a person's response to the stress and fear of an injection is fighting or fleeing, they could cause injury to themselves or others, which may result in refusal of treatment in future (Stuesser & Roscoe, 2020).

Even though exposure therapies have been shown to be effective (Choy et al., 2007; Wolitzky-Taylor et al., 2008), therapists will often be reluctant to use them. Pittig and Hoyer (2017) reported that only 46.8% of their sample of behaviour therapists (n = 684) used exposure in their treatment of anxiety disorders, even when it was the recommended treatment. Pittig et al. (2019) found the largest barriers to implementing exposure therapies were practicality, followed by negative beliefs about exposure and the distress it causes to clients and therapists. As exposure therapy can be a confronting and unpleasant experience, a therapist might be concerned about breaching ethical codes regarding responsible caring and doing no harm. It is also possible that a therapist would be concerned about the impact of a challenging therapy on their therapeutic alliance with the client.

Some of the limitations of exposure therapy can be addressed by using the less confronting modalities of exposure therapy. Imaginal exposure can cause a similar fear response to a real experience of the stimulus, while still allowing the opportunity to practice relaxation techniques that can inhibit the fear response with no 'real' danger to them or others. An imaginal approach may also be more practical than in vivo exposure, as it can be less costly than contacting the feared object in real life (Jacquart et al., 2022). Interoceptive exposure allows a person to experience their feared somatic symptoms without the feared stimulus present, without the ability to escape, and in a safe environment. There is also the benefit of potentially reducing the client's fear responding towards their somatic symptoms, an issue where their symptoms become conditioned stimuli that evoke their fear response (Cahill & Foa, 2002). Neither interoceptive nor imaginal exposure require the client to actually confront the feared object or situation, which may be more practical and acceptable to both client and therapist.

A potential limitation of interoceptive and imaginal exposure is that they may be too far removed from the experience of in vivo exposure to produce the same effect on a person's specific phobia. One solution to this limitation could be virtual exposure via computer or mobile phone. Internet-delivered exposure therapy and CBT treatments have been shown to be effective for treating panic disorder (Stech et al., 2021), illness anxiety disorder and somatic symptom disorder (Hedman et al., 2016), social phobia and agoraphobia (Schneider et al., 2005), and severe health anxiety (Hedman et al., 2014). In recent years, the computing power of mobile phones has surpassed that of the computers used for early virtual reality exposure therapy (VRET), which has led to mobile app-based VRET being used to successfully treat a range of phobias including spiders (Lindner et al., 2020), flying (Donker et al., 2022), and heights (Donker et al., 2019). There are even apps with VRET programmes that can be used with little input from a therapist, remotely, or completely independent of a therapist (Cherestal et al., 2021; Donker et al., 2022; Freeman et al., 2018; Lacey et al., 2022; Lindner et al., 2020). Some of the benefits of using technology to deliver therapy are increased accessibility if people do not have time to see a therapist or live in rural areas; reduced workload for therapists, which may prevent therapist burnout; and reduced treatment costs, as apps can be one-off purchases and revisited multiple times. With the advantages of reduced cost and increased practicality and accessibility, app-based VRET could become a replacement for traditional therapist-led exposure therapy.

Virtual Reality

A broad definition of virtual reality (VR) is a computer-generated simulation of the physical world that an operator can directly interact with (Martirosov & Kopecek, 2017; Schroeder, 1993). VR usually includes visual and aural stimuli but can also have motion tracking and haptic (touch/force) feedback, depending on the system. VR dates to the mid-1800s with the stereoscope. Charles Wheatstone and David Brewster independently created their own devices for viewing two offset but identical images; this offset created the perception of depth to a single image and remains one of the principles used to simulate depth in modern VR (Paro et al., 2022). Almost 100 years later, pilots were training in simulated cockpits to emulate the physical sensations of flying an aircraft (Paro et al., 2022), and in the 1950s, Morton Heilig combined visual, aural, and physical immersion into their Sensorama device (Lum et al., 2020). With the advent and rapid advancement of computer technology, by the late 1980s, it was possible to create somewhat realistic virtual representations of reality (Schroeder, 1993), but the devices were bulky, cumbersome, expensive (Martirosov & Kopecek, 2017), and not generally commercially viable throughout the 1990s (Jörnmark et al., 2005; Kurland, 2017). More recently (post 2010), VR systems have become more advanced and cheaper to produce. Companies such as HTC, Sony, and Meta produce high performance head-mounted VR systems, while there are many options for mounting a smartphone into a headset and using a phone app to generate the virtual world (Dredge, 2016; Hume, 2022).

VR is not only used for entertainment. By 1992, VR was being discussed as a potential avenue for future medical (including psychological) treatments (Lanier & Biocca, 1992; Whalley, 1993). Exposure therapy was identified as an area where VR might be useful. By using a virtual environment for exposure therapy, it could be easier logistically for a therapist to arrange the presentation of fear hierarchies, in a safe, private environment for clients to work in, and without reliance on a client's imagination of feared situations (McMahon & Boeldt, 2022; Olatunji et al., 2009). The first studies of VR exposure therapy (VRET) emerged around 1995. North et al. (1995) and Hodges et al. (1995) ran early studies of the use of VR for psychological treatment. North et al. studied the effect of a virtual environment desensitisation (VED) system for the treatment of agoraphobia with a sample of North American university students ($N = 60$). For the VED group ($n = 30$), mean subjective units of distress (SUD, adapted from Wolpe, 1969) scores dropped significantly from Session 1 ($M = 5.66$, $SD = 0.74$) to Session 8 ($M = 2.42$, $SD = 1.38$) but did not change significantly for the no-treatment control group. North et al. suggested theirs was one of the first known extensive controlled studies of a virtual environment-based treatment of a psychological disorder. Around the same time, Hodges et al. were studying the effect of virtual environment exposure on acrophobia (fear of heights) in a sample ($N = 17$) of North American university students. Participants in the experimental group ($n = 10$) completed an acrophobia questionnaire (adapted from Cohen, 1977) pre- and post-exposure, and provided a 0-100 SUD score during exposure sessions. Hodges et al. claimed participant SUD scores increased in response to height changes in the virtual environment and eventually decreased as participants habituated to the virtual environment. Post-treatment scores ($M = 20.3$, $SD = 13.2$) were significantly lower than pre-treatment scores ($M = 70.9$, $SD = 34.4$) and there was no significant difference for the control group ($n = 7$). Despite a small sample size for a between-subjects design and the large *SD*s, Hodges et al. suggested these results were remarkable and provided initial support for the use of VRET in the field of psychology.

For the remainder of the 1990s and into the early 2000s, more studies and case studies into the use of VRET for the treatment of anxiety-related disorders and phobias emerged, including treatment of amaxophobia (fear of driving) (Wald, 2004; Wald & Taylor, 2000), aviophobia (fear of flying) (Botella et al., 2004; Klein, 1998; Rothbaum et al., 2000; Rothbaum et al., 1996), claustrophobia (fear of enclosed spaces) (Botella et al., 1998; Botella et al., 2000), and arachnophobia (fear of spiders) (Carlin et al., 1997; Garcia-Palacios et al., 2002); in all these cases using VRET reduced anxiety and/or distress scores for participants. In a review, Krijn, Emmelkamp, Olafsson, et al. (2004) examined 32 studies of VRET for a range of phobias. The authors suggested that VRET was better than no treatment for acrophobia, aviophobia, and arachnophobia, and that there was promising evidence for VRET being as-good-as in vivo exposure for acrophobia and aviophobia. However, they also suggested more work was needed on treatment for the other phobias in their review and VRET had some limitations. These limitations included whether VRET had any value over in vivo for certain phobias (e.g., arachnophobia), whether effects would generalise outside lab settings, and the reliance on self-report follow-ups, high attrition rates, and small sample sizes (Krijn, Emmelkamp, Olafsson, et al., 2004). The generalisability and attrition-rate concerns would be addressed to some extent by technological advances, as VR technology prior to 2004 was understandably bulkier, poorer in computer-graphic ability, sensor ability, and processing power than today's VR, which likely had an impact on immersion and user-friendliness.

Virtual Reality Treatment of Phobias

Height and Flying Phobia

Aviophobia (fear of flying) and acrophobia (fear of heights) have a lifetime prevalence of 1.3% and 2.8% in the general population (Wardenaar et al., 2017), and were among the first studied applications of VRET (Hodges et al., 1995; Rothbaum et al., 1996). The primary benefits of VRET for treating aviophobia or acrophobia are practicality and safety. Buying a plane ticket and going to an airport for each exposure trial or finding a range of high places is prohibitive for people seeking treatment, and if they have a significant fear response in these places, they may risk injuring themselves or others. A flying or height-related scenario can be relatively easily created in VR, while allowing for a therapist to be present, and maintains a client's privacy (Coelho et al., 2009). VRET is effective for treating aviophobia as a standalone treatment (Cherestal et al., 2021; Maltby et al., 2002; Rothbaum et al., 2000; Rothbaum et al., 1996; Rus-Calafell et al., 2013; Wiederhold et al., 2002; Wiederhold & Wiederhold, 2003) and as part of other treatments (Abuso et al., 2023; Donker et al., 2022; Hirsch, 2012). VRET is also effective for treating acrophobia as a standalone treatment (Bentz et al., 2021; Freeman et al., 2018; Hodges et al., 1995; Hong et al., 2017; Rothbaum et al., 1995). VRET for aviophobia and acrophobia often results in similar treatment outcomes to in vivo exposure (Morina et al., 2015; Ribé-Viñes et al., 2023; Wechsler et al., 2019) but with some practicality and safety benefits that in vivo exposure may not have. It seems possible that VRET could eventually replace in vivo exposure as the primary treatment for aviophobia and acrophobia, with in vivo exposure practice occurring after VRET if necessary.

Claustrophobia

Claustrophobia has a lifetime prevalence of 2.2% (Wardenaar et al., 2017) and subclinical symptoms affect 12.5% of people. While experiencing small, enclosed spaces is not necessarily a guaranteed occurrence in everyday life, it is sometimes hard to avoid (e.g., elevators in a tall building or tunnels on a commute) and is sometimes necessary (e.g., having an MRI scan or flying overseas). VRET has been effective for treating claustrophobia (Botella et al., 1998; Botella et al., 2000; Botella et al., 1999; Malbos et al., 2008), but there is a lack recent studies using modern technology. One might assume that if VRET for claustrophobia worked using older technology, it must be as good or more effective with modern technology. However, in current studies of VRET for claustrophobia, authors tend to report more on the development of a new VRET system and whether it can induce anxiety responses, rather than assessing existing VR systems for treating claustrophobia (Li et al., 2017; Rahani et al., 2018; Rajarathinam et al., 2022; Tsai et al., 2018), which makes it difficult to conclude if any of the proposed systems are truly effective.

Driving Phobia

There is limited support for the efficacy of VRET treatment for amaxophobia (fear of driving). It has been demonstrated that VRET can reduce driving anxiety and avoidance of driving situations (Costa et al., 2018; Kaussner et al., 2020; Wald & Taylor, 2000, 2003; Walshe et al., 2003), but the reductions in phobic symptoms did not result in increased driving behaviour in many cases (Wald, 2004). It has been suggested that VRET may be better used as practice for in vivo exposure, rather than as a standalone treatment (Costa et al., 2010; Elphinston et al., 2023). Part of the challenge when using VRET for amaxophobia appears to be that a comprehensive range of possible driving scenarios would be costly and time consuming to create in a single VR system, and using generic driving scenarios means factors specific to the client's phobia (e.g., a motor vehicle accident, years of prior driving experience) are unlikely to be accurately represented (Taylor et al., 2007). In reviews of VRET for amaxophobia, authors have reported a notable lack of high-quality studies and significant heterogeneity across studies (Costa et al., 2010; Elphinston et al., 2023), making it difficult to determine how effective VRET is for treating amaxophobia. It appears that VRET can reduce driving-related anxiety responses and avoidance of driving situations but is not yet as effective as in vivo exposure.

Needle Phobia

Trypanophobia (fear of needles) affects 3% of people (Wardenaar et al., 2017). It is a phobia where an excessive fear response could result in significant injury to client and practitioner (Stuesser & Roscoe, 2020), for example, breaking of a needle during injection. Compared to in vivo exposure, using VRET can remove the potential for harm for the entire therapy process, as it could be done with no needle being present. Meindl et al. (2019) found VRET to be effective for treating a person with trypanophobia, autism spectrum disorder, and moderate intellectual disability. Elsewhere, Jiang et al. (2020) reported significant differences between groups on some self-reported measures of fear, concluding that their VRET procedure may be useful as a first step to in vivo exposure, or as a treatment adjunct. Given that injections are generally infrequent, short-lived events, it is common for VR to be used only as a distraction from the injection event. In cases where a full exposure procedure is unnecessary, such as with fear, rather than full phobia, distraction can be effective in reducing anxiety responses and pain. Improvements in pain and anxiety ratings have been demonstrated when using VR technology as a distractor (Dunn et al., 2019; Gerçeker et al., 2021; Rudnick et al., 2018). Gerçeker et al. (2020) found VR exposure as a distractor resulted in lower anxiety and pain scores from children, and lower observed (child) pain scores from parents and clinicians. There have also been several recent reviews and meta-analyses (Czech et al., 2021; Gao et al., 2023; Wang et al., 2022) of the use of VR as a distractor for reducing anxiety responses and pain during needle injection procedures. Both Wang et al. (2022) and Gao et al. (2023) concluded that VR interventions could become an important tool for reducing pain, and anxiety and fear responses related to needles and puncture-related procedures for child and adolescent patients. Czech et al. (2021) found significant differences between VR care and standard care groups on pain scores but failed to find a difference between groups when pain, anxiety, and satisfaction were analysed together. Czech et al. did note the importance of psychophysical comfort for participants, which may be enhanced with VR, and that favourable post-VR procedure results support the legitimacy of VR use.

Animal Phobia

Another fear or phobia that occurs relatively frequently is zoophobia (fear of animals), which affects 3.8% of people (Wardenaar et al., 2017). Zoophobia may include musophobia (rats, mice), cynophobia (dogs), ornithophobia (birds), entomophobia (insects), and arachnophobia (spiders). In a relatively early VRET study, Garcia-Palacios et al. (2002) reported that VRET resulted in statistically and clinically significant improvements in spider phobia. In another study, automated VRET resulted in significant reductions in spider fear that were maintained at 6 months and were not significantly different to in vivo exposure at 12 months (Miloff et al., 2019).

Another relatively common phobia is cynophobia (Rentz et al., 2003), perhaps because of the frequency with which we encounter dogs in everyday life, though there is very little research on using VR to treat this specific phobia. In one recent study, Farrell et al. (2021) used a one-session VRET procedure with eight children with cynophobia, finding significant decreases in symptom severity across the treatment and follow-up, and 75% of the children were considered ‘recovered’. Further, no child would approach the dog pre-treatment and 88% approached the dog and patted it during the follow-up. In other studies of cynophobia, the authors tend to examine which variables in a dog encounter provoke or heighten fear responses in an VR environment (Suied et al., 2013; Taffou et al., 2012; Viaud-Delmon et al., 2008), which can be helpful in determining if fear responses can be elicited by a VR system. However, there does appear to be a need for more study of whether a VRET approach to treat cynophobia is effective, rather than focusing only on whether a VR dog scenario can elicit fear responses.

There has also been some research on the effect of augmented reality (AR) exposure therapy on phobias of small animals. AR is a variant of VR where the viewer sees their current (real) environment through a headset/glasses but with some virtual elements overlaid on that environment (e.g., looking at their kitchen with a virtual mouse scurrying about). Wrzesien et al. (2015) used AR exposure to treat cockroach phobia, with results indicating improvement across most measures, and three of the four participants were able to interact with a live cockroach at the 12-month follow-up. Botella et al. (2016) reported similar findings when using AR exposure to treat spider and cockroach phobia, with significant improvements in phobia symptoms and behaviours, and no differences between AR and in vivo exposure at a 6-month follow-up. Whether full VR or AR, VR technologies have demonstrated efficacy in treating insect, arachnid, and small animal phobia (Botella et al., 2016; Farrell et al., 2021; Miloff et al., 2019; Yapan et al., 2023).

Social Phobia

Social fear and anxiety are among the most common psychological struggles for people (Emmelkamp et al., 2020; Horigome et al., 2020). In instances when fear and anxiety responses are at phobic levels, the gold standard treatment is in vivo exposure (Wechsler et al., 2019). The advent of VRET has allowed for research into another way of treating anxiety-related disorders. In a meta-analysis of 92 publications, Lim et al. (2022) found VRET to be a quick, effective treatment for public speaking anxiety. Several reviews and meta-analyses that examined VRET for social phobia have been published recently. Emmelkamp et al. (2020) reviewed research on VRET for social anxiety and found that there was general evidence for the efficacy of VRET.

Chesham et al. (2018) published a two-part meta-analysis of 13 VRET studies. In Part 1, the efficacy of VRET for addressing social phobia was analysed, with Chesham et al. reporting a significant medium-to-large reduction of anxiety. In Part 2, there was no evidence that VRET performed worse than in vivo exposure, though Chesham et al. suggested more trials investigating the optimal application of VRET were needed. Horigome et al. (2020) published a review and meta-analysis investigating the efficacy of VRET for social anxiety and public speaking anxiety, finding that VRET was significantly more effective than waitlist or treatment-as-usual conditions and at 3-, 12-month, and 6-year follow-ups, in vivo performed only slightly better than VRET. Horigome et al. concluded that VRET could be considered as-good-as, or only slightly inferior to in vivo exposure, which is generally the consensus across these reviews and meta-analyses.

Limitations of VR

There are, however, several limitations and drawbacks to the use of VR as a treatment. One factor is cost. Throughout most of the history of VR, personal ownership of a VR system was unrealistic (Lindner et al., 2019). Early VR devices were highly specialised and expensive items, with headsets costing $5,000-$8,000 USD, headsets and software over $18,000 USD (Brooks, 1999), with anecdotal evidence of full systems costing €35,000- €100,000 depending on specifications (Slater, 2018). Even today, VR headsets are often quite expensive, with most selling for between $550-$1,100 USD (HTC, n.d.; Meta, n.d.; Sony, 2023) and the new apple VR product priced at $3,500 USD (Apple, 2023). While there are more affordable VR hardware options such as headsets that mount a user's mobile phone, hardware capability is often sacrificed when using less expensive equipment, which may impact immersion and presence or increase cybersickness in more interaction-focused VR scenarios (Young et al., 2014). There is also the issue of software cost in addition to the initial cost of hardware, and there may be restrictions on cross-platform use of that software as is common for Apple and Microsoft products. Less powerful and less expensive equipment can still be effective for VRET - technology has advanced so fast that VR systems from 5-10 years ago that were effective for VRET can be more cheaply produced now - but there is a need to find a balance between manageable cost and the most effective VRET technology.

A second issue is presence and immersion. Presence refers to the degree to which a person perceives and interacts with the virtual environment as if it were real. Immersion refers to the realism of the virtual environments created by the VR system and specifications of the VR equipment such as display resolution, number of senses simulated, or framerate (Diemer et al., 2015; Jicol et al., 2021). Put simply, presence is how much a person believes the VR environment is real and immersion is the ability of the hardware to generate a realistic environment. Immersion manipulation can affect elicited fear responses (Mühlberger et al., 2005), and presence in a virtual scenario impacts a person's response to that environment (Gromer et al., 2018; Jicol et al., 2021; Price & Anderson, 2007; Price et al., 2011; Robillard et al., 2003). However, the effect of presence and immersion on treatment outcomes remains inconclusive. Price et al. (2011) found that 'involvement', a subscale of presence that refers to the extent to which a person is paying attention to the virtual environment, was associated with positive treatment outcomes, while scores on the overall presence scale and the realness and spatial presence subscales were not. It has also been suggested that the importance of presence may be related to the disorder being treated. In their meta-analysis of 33 articles, Ling et al. (2014) reported that correlations between presence and anxiety responses in VRET for anxiety disorders varied by disorder, with flying (r = .52) and animals (r = .50) having the largest and social phobia (*r* = .001) having the smallest. Krijn, Emmelkamp, Biemond, et al. (2004) found that increased presence did not affect treatment outcome and Price and Anderson (2007) reported a similar finding, noting that presence may be necessary to elicit anxiety responses, but presence alone will not produce positive treatment outcomes. It appears that immersion and presence in a virtual environment can be specific to an individual client and that while the level of immersion and presence does not necessarily influence VRET treatment outcomes, it does appear to be important in eliciting responses so new stimulus-response relations can be learned. This means, like most therapies, there needs to be a degree of tailoring the treatment to suit the client.

A third issue with VR technology is cybersickness, a condition caused by using VR devices, which is arguably the most significant drawback when considering using VRET. If the treatment is for phobias or disorders associated with extremely aversive somatic symptoms, introducing more of those symptoms or entirely new ones could impact adherence to treatment and treatment outcomes. Cybersickness is very common, with reports of some degree of cybersickness occurring for 60-95% of participants (Caserman et al., 2021; Garrido et al., 2022), and susceptibility to cybersickness is elevated among people with phobias (Howard & Van Zandt, 2021). Early termination of a VR experience due to cybersickness has been reported for between 5%-13% of participants, and sometimes more than 50% (Dennison et al., 2016; Martirosov et al., 2022). Cybersickness symptoms can include nausea, dizziness, fatigue, eye strain/fatigue, headaches, vomiting, and vertigo (Bouchard et al., 2009; McCauley & Sharkey, 1992). Onset and severity of symptoms varies across people and VR tasks and systems but they can emerge within 6-10 minutes in more immersive VR scenarios (Davis et al., 2014; Dennison et al., 2016; Martirosov et al., 2022) and Kourtesis et al. (2019) have recommended VR sessions not exceed 70 minutes. There are ways to reduce cybersickness. One way to is to have the participant's virtual and physical self remain stationary (Risi & Palmisano, 2019) to reduce motion sickness caused by a mismatch between perceived virtual movement and the physical feeling of being stationary. Another is to shorten the length of VRET sessions (Kourtesis et al., 2019). A third is to ensure the user-friendliness of a VR system in terms of computing power, display quality, physical comfort when wearing it, and design of the virtual environment (Ramaseri Chandra et al., 2022). Some amount of cybersickness will be unavoidable in many cases, though the exact nature of it will vary between people and VR systems and scenarios.

In summary, it is very likely a client will experience cybersickness. The experience of cybersickness could deter a client from any future use of VR, exacerbate their phobic symptoms, establish an association between VR and their fear responses, or reinforce their avoidance behaviours. Shorter VR sessions, remaining stationary in the VR world, and more user-friendly equipment can reduce the likelihood and severity of cybersickness. A secondary issue is that the equipment can be expensive but must also be of sufficient quality to enable a client to have a sense of immersion and presence in the virtual environment to elicit a fear response. This is generally more likely with more capable VR hardware, so there needs to be a balance between cost and client considerations.

A final issue or consideration when using VR for exposure therapy are the VRET studies themselves. In several meta-analyses of VRET studies, the authors have reported that the studies they included tended to have relatively low statistical power due to small sample sizes (Chesham et al., 2018; Morina et al., 2015; Opriş et al., 2012; Parsons & Rizzo, 2008). A further limitation was too few studies meeting authors' inclusion criteria (Carl et al., 2019; Chesham et al., 2018; Horigome et al., 2020; Opriş et al., 2012; Parsons & Rizzo, 2008) due to methodological inconsistency, VR environment difference, or low study quality. In analyses of VRET for trypanophobia, authors have noted issues with the heterogeneity of the studies analysed. Approaches varied across the studies in both VR procedures and control groups, which made it difficult to draw meaningful conclusions about what was of clinical significance when using VRET (Czech et al., 2021; Gao et al., 2023; Wang et al., 2022). A second issue was the non-blind nature of the studies, which will likely be the case in any between-subjects design using VR that is not completely 'hands off', as the VR equipment will identify which group the participant is in. If a treatment administrator knows the groupings beforehand, there is potential for treatment to be given beyond what is intended in the intervention (Gao et al., 2023), which can reduce the validity of findings. Further, Emmelkamp et al. (2020) reported other limitations in their review of VRET for social phobia, such as that most randomised control trials (RCT) examining VRET efficacy were confounded by VRET being implemented in conjunction with cognitive interventions, so the stand-alone effect of VRET was difficult to determine. The conclusions drawn from the limitations of VRET studies appear to be that consistency in approaches and quality of study procedures should be addressed, and that VRET should be the sole intervention.

Exposure therapy has been the standard approach to treating specific phobia for some time. Since the advent of computer technology, VRET has become a viable alternative to in vivo exposure for treating a range of phobias, while being almost as effective and addressing some of the drawbacks regarding practicality and acceptability of in vivo exposure. There have been some issues with VRET however, such as the cost of the hardware, cybersickness, and non-standardised approaches to VRET research but these can be overcome or mitigated to varying extents and should not exclude VRET from being used to treat phobias.

Emetophobia

While there has been extensive study of phobias such as flying and height phobia, some phobias are relatively under-studied. One of these is emetophobia (fear of vomiting) (Maack et al., 2013). Estimates of prevalence indicate it affects 0.2% of people (Becker et al., 2007), with extreme (non-phobic) fear or anxiety of vomiting affecting 1.7% to 3.1% of men and up to 7% of women (Philips, 1985; Van Hout & Bouman, 2012). The first systematic review of existing research on emetophobia was published in 2018 and included only 24 studies published in English from 1846 to May 2016 (Keyes et al., 2018). For sufferers of emetophobia, fear of themselves vomiting was greater than fear of seeing someone else vomit, there was significant comorbidity with other anxiety disorders and depression, and internal cues such as nausea or feelings of disgust can sharply increase anxiety and fear of vomiting. Exposure was the basis of most treatments (e.g., CBT, exposure plus medication) but exposing a person to themselves vomiting presents an extreme challenge, as it is not practical to achieve or likely to be acceptable to participants, and may even worsen the phobia (Keyes et al., 2018; Riddle-Walker et al., 2016). Keyes et al. (2018) concluded that there were too few well-designed studies and sample sizes were too small to determine which processes maintain the fear of vomiting and what treatment approaches would be best, but exposure therapy tends to be the most common.

Several case reports on emetophobia treatment have been published since the review by Keyes et al. (2018). The treatments used in these case reports included CBT (Fix et al., 2016; Paulus & Norton, 2016), exposure plus psychoeducation (Dosanjh et al., 2017), and acceptance and commitment therapy (ACT) plus exposure (Mitamura, 2019). Exposure therapy was the common treatment factor across these reports and in all cases vomiting phobia was effectively reduced. With the available evidence, it appears that exposure therapy plays an important part in reducing anxiety responses associated with vomiting and can work well in conjunction with other treatments.

I was unable to find any studies on the use of VRET to treat emetophobia. Part of the reason for this may be that emetophobia is under-researched in general (Maack et al., 2013), which means a non-traditional treatment approach like VRET is less likely to be used. There is also an argument that people with emetophobia are highly sensitive to interoceptive cues (Boschen, 2007) such as dizziness or nausea, and that some symptoms of cybersickness could lead to avoidance of VR experiences, which prevents the use of VRET in an intervention. Another reason may be that sensory factors such as smell, or the realism of visual imagery are more difficult to replicate in VRET than in in vivo exposure. However, with the increased use of VRET for treating a range of specific phobias and the existing emetophobia studies featuring exposure as a core part of the intervention, it is plausible that VRET could be as effective for emetophobia as it has been for other phobias. Further, the fear hierarchies reported by Dosanjh et al. (2017), Graziano et al. (2010), Fix et al. (2016), and Maack et al. (2013) are almost all achievable using VR technology. Finally, the risk of worsening anxiety symptoms is likely present when using VRET for any anxiety issue, as some cybersickness and anxiety symptoms overlap (Pot-Kolder et al., 2018). The potential for worsening a person's anxiety symptoms and responses when using VRET for emetophobia treatment should be considered, but it is not likely to be much greater than the risks of using exposure therapy for any other anxiety issue, and a person's time in VR can be managed and the experience optimised to reduce the likelihood and severity of cybersickness. Therefore, it seems that VRET for emetophobia is a treatment worth examining.

The Present Study

I examined the efficacy of an Aotearoa New Zealand-based, self-guided, low-cost VRET app for the treatment of phobias called oVRcome (https://www.ovrcome.io/). The efficacy of the oVRcome app has been evaluated by one completed RCT with promising results (Lacey et al., 2022) and is currently being evaluated a second time. I aimed to examine the effect of use of the oVRcome app on self-reported emetophobia severity using behaviour analytic research methods, namely, a small-*N* within-subject (single-subject), multiple-baseline-across-participants design. I selected the emetophobia programme in the oVRcome app as it was not examined in the study by Lacey et al. (2022).

There are several benefits of a within-subject design compared to an RCT. First, each participant serves as their own control, by providing baseline 'no treatment' data before the intervention. With each participant serving as their own control, a researcher can ignore inter-subject variability, error variability is reduced, fewer participants are needed to demonstrate an effect, and all participants receive the intervention (Butler et al., 2011; Singh et al., 2017). Second, as participants are completing repeated measures across the study, it is possible to assess the stability of the behaviour change over time (Butler et al., 2011). Third, small-*N*, within-subject designs can be completed quicker than RCTs, which often have a long lag between recruitment and publication. In VR and mobile technology, this time lag may not keep pace with technology development and cause researchers and developers to avoid full-scale RCTs in favour of quicker, less robust methods (Kumar et al., 2013).

A multiple-baseline design involves systematically varying the length of baselines for each participant and is conducted across settings (e.g., home and school), participants, or behaviours (Cooper et al., 2020). Participants experience the intervention in a staggered fashion which continues until the end of the study (Dallery et al., 2013). For example, all participants start baseline at the same time, Participant 1 may complete 5 days in baseline, then start the intervention; Participant 2 completes 7 days in baseline, then starts the intervention; and so on. The effect of the intervention is demonstrated when change occurs only when each participant begins the intervention. If this effect is replicated across multiple participants it can be more confidently claimed the intervention is causing the change (Dallery et al., 2013). I selected a multiple-baseline as opposed to a reversal design because a person's phobia treatment progress is unlikely to immediately reverse upon withdrawal of the intervention (as in reversal designs) and more importantly, it would be unethical to withdraw the intervention to demonstrate control when the dependent variable is level of phobia.

A feature of the oVRcome app is that it can be used independently of a therapist, which I aimed to mimic in this study. Remaining as 'hands off' as possible reduces the effect of my (the researcher's) behaviour on the participants' behaviour and will reflect how effective the app is as an independent therapy. One potential issue was whether participants would use the app properly (e.g., time spent in each module, daily practice). There has been evidence of a dose-response relationship in studies of VRET for anxiety disorders and PTSD, where more sessions of VR resulted larger effects (Deng et al., 2019; Opriş et al., 2012; Powers & Emmelkamp, 2008). Some (limited) participant engagement data was provided by oVRcome after data collection had ceased, so the question of a dose-response relationship could be explored to some extent.

Based on previous findings regarding the effectiveness of exposure therapy and VRET for treating phobias, as well as oVRcome's own research, I hypothesised that using the oVRcome VRET app would reduce participants' reported levels of emetophobia symptoms and behaviours compared to baseline levels prior to beginning app use.

Method

Participants

Eight participants were recruited through posters (Appendix A) to University of Waikato students, an e-bulletin post by the Mental Health Foundation of New Zealand, and with an email (Appendix B) to oVRcome's existing list of people who had expressed interest in the first clinical trial involving oVRcome. Interested participants were provided with an information sheet (Appendix C). To qualify, participants had to be based in Aotearoa New Zealand, have access to a smartphone and internet, be between 18 and 90 years old, and not currently seeing a mental health professional for their fear of vomiting. Potential participants were then provided a consent form (Appendix D) and screened using the Patient Health Questionnaire 9 (PHQ-9) (Appendix E) and Specific Phobia of Vomiting Inventory (SPOVI) (Appendix F), where exclusion criteria were a total score > 19, or = 3 on the suicidality item on the PHQ-9, or a total score less than 10 on the SPOVI. All eight participated for the length of the study, however the data for two participants were excluded from analysis as they started using the oVRcome app before baseline data had been collected. The two excluded participants continued in the study and their data are described anecdotally. Participant characteristics are in Table 1. The mean age of participants was 29 years (*SD* = 8.12) with a mean of 20 years (*SD* = 9.90) of reported emetophobia. Seven of the eight participants identified as female, one as male, and reported ethnicity included NZ European, Pākehā, Māori, and Middle Eastern. Participant engagement with the oVRcome app is in Table 2.

Table 1

Participant Characteristics

Participant	Group	Age	Gender	Ethnicity	Years of Phobia	PHQ-9	SPOVI
P1	1	33	Female	Pākehā	23	8	14
P2	1	23	Female	NZ European	10	5	36
P3	1	28	Female	NZ European	20+	8	17
P4	None	50	Female	NZ European	45	7	52
P5	2	20	Male	Middle Eastern	9	13	29
P6	2	29	Female	European	22	2	48
P7	2	43	Female	NZ European	36	4	46
P8	None	26	Female	Māori	19	15	38

Design

I used a single-subject, multiple-baseline-across-participants design. Participants were arranged into two baseline groups, with four participants in each.

Ethical Approval

Ethical approval was given by the Human Research Ethics Committee of The University of Waikato (Approval no. 2023#07). This ethical approval was amended to include oVRcome having access to some participant data (e.g., email, physical address, name) as per oVRcome's user agreement and privacy policy to provide access to the app and head mounted display (HMD). Participants were informed of this change and asked again for their consent.

Project Registration

This project was pre-registered with Open Science Framework (OSF; https://osf.io/) and the pre-registration can be found at https://doi.org/10.17605/OSF.IO/6N3M9. Three changes were made to the pre-registered project after it was underway. First, I added a *t* test to my data analysis to determine if there was a difference between pre- and post-app SPOVI scores. Second, the data collection period changed from ‘approximately 6 weeks’ to 11 weeks. As the intervention was largely self-directed, it became clear during the early part of participants’ app use that they were progressing through the app at different rates, so to allow each participant enough time to experience the whole VRET app and to record sufficient data points from each participant, the data collection period was extended. Each participant was asked, and agreed, to extend the data collection period. The third change was to add a follow-up administration of the severity measure for specific phobia (SMSP) questionnaire 6 weeks after the final administration of the SMSP. This follow-up SMSP could help to determine if the effect of the app on phobia symptoms and behaviours is maintained over time, and early in data collection it was observed that most participants were completing the SMSP within 1 minute, so completing a follow-up SMSP would not be a burden. Only participants who agreed to the follow-up were contacted for the follow-up.

Table 2

Participant Engagement With the oVRcome App

Participant	Days in Baseline	Days of App Use	Total Time in App***	Sessions****	Mean Session Length	Completed Psychoeducation	Entered VR Exposure	Total VR Videos watched	Unique VR Environments
P1	12	61 (43**)	6:25	13	30mins	Yes	Yes	27	16
P2	11	57 (43**)	2:17	9	15mins	Yes	Yes	7	7
P3	19	54 (43**)	3:18	9	22mins	Yes	Yes	17	13
P4*	15	57 (8**)	5:43	11	48mins	Yes	No	0	0
P5	8	61 (26**)	1:21	3	27mins	Yes	No	0	0
P6	11	57 (43**)	8:07	14	35mins	Yes	Yes	29	20
P7	15	54 (36**)	1:48	5	22mins	Yes	Yes	0	0
P8*	8	61 (40**)	3:58	9	26mins	Yes	Yes	16	11

Note. *Participant data were excluded from analysis. **Days participant indicated they were in VR module. ***Is presented in hours and minutes format. ****App was opened, and an activity completed.

Materials

Participants were given an oVRcome HMD to mount their smartphones and full access to the emetophobia programme of the oVRcome VRET app (www.ovrcome.io). The HMD can mount a smartphone with outer dimensions of 80 x 150mm (4.7”–6.0” display), weighs 282 g and has focus and interpupillary adjustment wheels. The VR presented in the app allows for vertical, horizontal, and tilt movements to view 360˚ videos. Participants could select their own relaxation scene but interaction with the virtual world presented in the app was limited to ‘gaze control’, where a user looks at a start, pause, or stop button in the virtual world for 3–5 seconds to activate the button. The emetophobia programme in the app has six modules and a ‘Toolbox’ tab which allows quick access to 16 practice sessions relating to the content taught across modules. Any issues with the functioning of the app or HMD were forwarded to oVRcome and they contacted participants directly to help resolve the issues.

Module 1: Knowledge

Module 1 has four audio lessons about the fight, flight, freeze response, how avoidance maintains phobias, understanding how and why exposure works, and why VR is an effective treatment approach.

Module 2: Calm

This Module has two audio lessons. The first explains and teaches diaphragmatic breathing, which here is 3s inhale, hold for 1s, and exhale for 4s. The second lesson is learning ‘safe place’ imagery to help relax during moments of sharply increased anxiety, such as in VR exposure, and selecting a ‘safe place’ from a range provided in the app (e.g., a waterfall, top of a mountain, standing by a stream).

Module 3: Mindset

The Mindset Module has seven audio lessons about cognitive factors involved in anxiety and avoidance. In Lessons 1–3, the thought-feeling connection, understanding self-talk, and thinking traps such as over-estimating a negative outcome, catastrophising, underestimating your ability to cope, and misinterpreting physical symptoms are presented. The remaining four lessons describe thought reframing and outline a 4-step process of thought reframing: noticing your thoughts, determining which thinking trap this thought is, logically questioning those thoughts, and counter-thinking to create more realistic thoughts.

Module 4: Flexibility

There are four audio lessons in the fourth Module that introduce mindfulness practice. In the first two lessons, mindfulness and the challenge of focusing on the present moment are described. The third and fourth lessons teach users how to stay in the present moment (e.g., noticing your surroundings, listing facts about your environment, listing sensations), and to acknowledge and accept anxious sensations by practicing ‘sitting with’ their anxiety while imagining an anxiety inducing scenario.

Module 5: VR-Graded Exposure

In the fifth Module, the user is prompted to state a goal for the exposure programme. The user then builds a fear hierarchy (minimum eight scenarios) from a range of vomiting-related scenarios (23 total scenarios) and learns how to rate and monitor their anxiety throughout the exposure. A user then experiences the feared scenarios from their hierarchy in VR, selecting progressively intense scenarios once they become comfortable at their current level. Users are reminded to manage their anxiety by using the relaxation and mindfulness techniques they have learned in previous modules.

Module 6: Guided Meditation

The final Module includes seven lessons and most of the content is common across Module 6 in all the programmes oVRcome provides. The first lesson (specific to this programme) is an audio track congratulating participants on their completion of the programme and discussing what to expect from a real-world exposure to vomiting. The remaining lessons in the module are guided meditation sessions that teach post-therapy meditation, fourfold breathing, body scanning, present-moment awareness, noting (feelings, thoughts, and sensations), and breathing exercises to calm yourself.

Measures

Severity Measure for Specific Phobia

The primary measure used across this study was the SMSP (Appendix G) (Craske et al., 2013). The SMSP is a 10-item, self-report questionnaire for people 18 years and older that assesses the severity of specific phobia symptoms and behaviours over the last 7 days. Items are scored on a 5-point scale where 0 = never and 4 = all of the time, with the maximum score summed across the 10 items being 40. Raw scores on each item are averaged to produce an average total score where 0 = no phobia and 4 = extreme phobia. The SMSP has been found to be a reliable, valid, and clinically useful measure (Macleod et al., 2022) that has been successfully translated into several languages (Kaloeti et al., 2022; Sapmaz et al., 2018), and has been used in previous studies with a VR component (De Witte et al., 2020; Lacey et al., 2022; Ramírez-Fernández et al., 2022; Yapan et al., 2023). I adjusted the SMSP wording from "*in the last 7 Days*" to "*since the Last Time I answered this questionnaire*" in all except the first and follow-up administration of the SMSP.

Patient Health Questionnaire - 9

For initial screening, I used the PHQ-9 (Kroenke et al., 2001), a measure that has been used extensively since its introduction (Mitchell et al., 2016). A cut-off score of >19 or = 3 on Item 9 was used because the typical cut-off score of 10 could produce too many false positives (Levis et al., 2019), and this criteria aligned with oVRcome's existing clinical study, so allows for more direct comparison with results obtained from studies using the same intervention.

Specific Phobia of Vomiting Inventory

The other measure used for screening was the SPOVI (Veale et al., 2013). The SPOVI is a 14-item questionnaire for assessing severity of emetophobia symptoms over the last 7 days. It is scored on a 5-point scale where 0 = none at all and 4 = all of the time. A summed score of 10 or more over the 14 items indicates a likely diagnosis of emetophobia (Veale et al., 2013). The SPOVI was found to be a reliable and valid measure by Maack et al. (2018). I also used the SPOVI as a pre- and post-intervention (app use) measure.

Cybersickness Question

I created a cybersickness question, which combined (for brevity) some elements of the cybersickness in virtual reality questionnaire (CSQ-VR) (Kourtesis et al., 2022). The question was "*In the last 7 Days have you experienced any of the following while using the oVRcome VR system: Dizziness, Nausea, Headaches, or Fatigue?*". It was scored on a 5-point scale where 0 = no and 4 = yes, every time. The first time a participant indicated anything above 'no' on the cybersickness question, I contacted them about their symptoms and symptom severity. I then suggested some management strategies such as reducing continuous time in VR (e.g., 2-x-10 min sessions vs 1-x-20 min session), reducing overall time in VR, upright posture and general body stability while wearing the HMD, and ensuring the HMD was being used correctly. If symptoms worsened, I contacted the participant again to determine if more management strategies were needed or to discuss options regarding their further participation in the study.

Procedure

Respondents to the poster or the email distributed by oVRcome contacted me by email. I sent them an introductory message and an information sheet. If they wished to proceed, I emailed respondents a link to the initial screening questionnaire on Qualtrics (www.qualtrics.com/au/), which hosted all questionnaires for this study. Participants were mailed an oVRcome HMD and were asked not to begin using the app until the intervention began.

Once all participants had received a HMD, the study began. Participants were asked to complete an SMSP questionnaire twice weekly, except for the during the first and final weeks of the study, where participants were asked to complete one SPOVI questionnaire in addition to the SMSP. When stable responding on the SMSP was observed for the first participant in each baseline group they began the intervention. When it was observed that baseline scores did not change for participants still in baseline, the next participant began the intervention. My recommended rate of progress through the programme was 2 weeks for Modules 1–4, and 4+ weeks for Modules 5–6, but this was not a rule and participants proceeded at their own pace.

I emailed participants once per week reminding them that if they had any questions or concerns regarding the project to contact me. During the VR exposure modules, I asked participants to answer an additional cybersickness question on the SMSP questionnaire to monitor their wellbeing.

Six weeks after the final administration of the SMSP questionnaire, participants were asked to complete a ‘follow-up’ SMSP.

Data Analysis

I used Microsoft Excel (Version 2310; https://www.microsoft.com/en-nz/microsoft-365/excel) to produce all figures. Behaviour analytic graphical analysis techniques were used to monitor participants' progress in real-time and make decisions about their progress, such as when to start the intervention or whether they needed an additional wellbeing check-in. Effect size for the intervention was calculated using the non-overlap of all pairs (NAP) method for analysis of graphical data (Parker & Vannest, 2009). The NAP method provides the probability that a random intervention data point will be lower than a random baseline data point. Parker and Vannest (2009) created NAP to overcome some of the shortcomings of other graphical analysis techniques such as percentage of non-overlapping data (PND), percentage exceeding the mean (PEM), and percentage of all non-overlapping data (PAND), while remaining relatively easy to calculate by hand. Parker and Vannest (2009) suggested NAP ranges of 0–.65 for a weak effect, .66–.92 for a medium effect, and .93–1.0 for a large or strong effect.

I used Jamovi open statistics software (Version 2.3; https://www.jamovi.org/) to perform a *t* test on participants' pre- and post-intervention SPOVI scores.

Results

Participant Results

Figure 1 illustrates the mean SMSP scores for Baseline Group 1 (P1–P3) over 11 weeks and at a 6-week follow-up.

P1

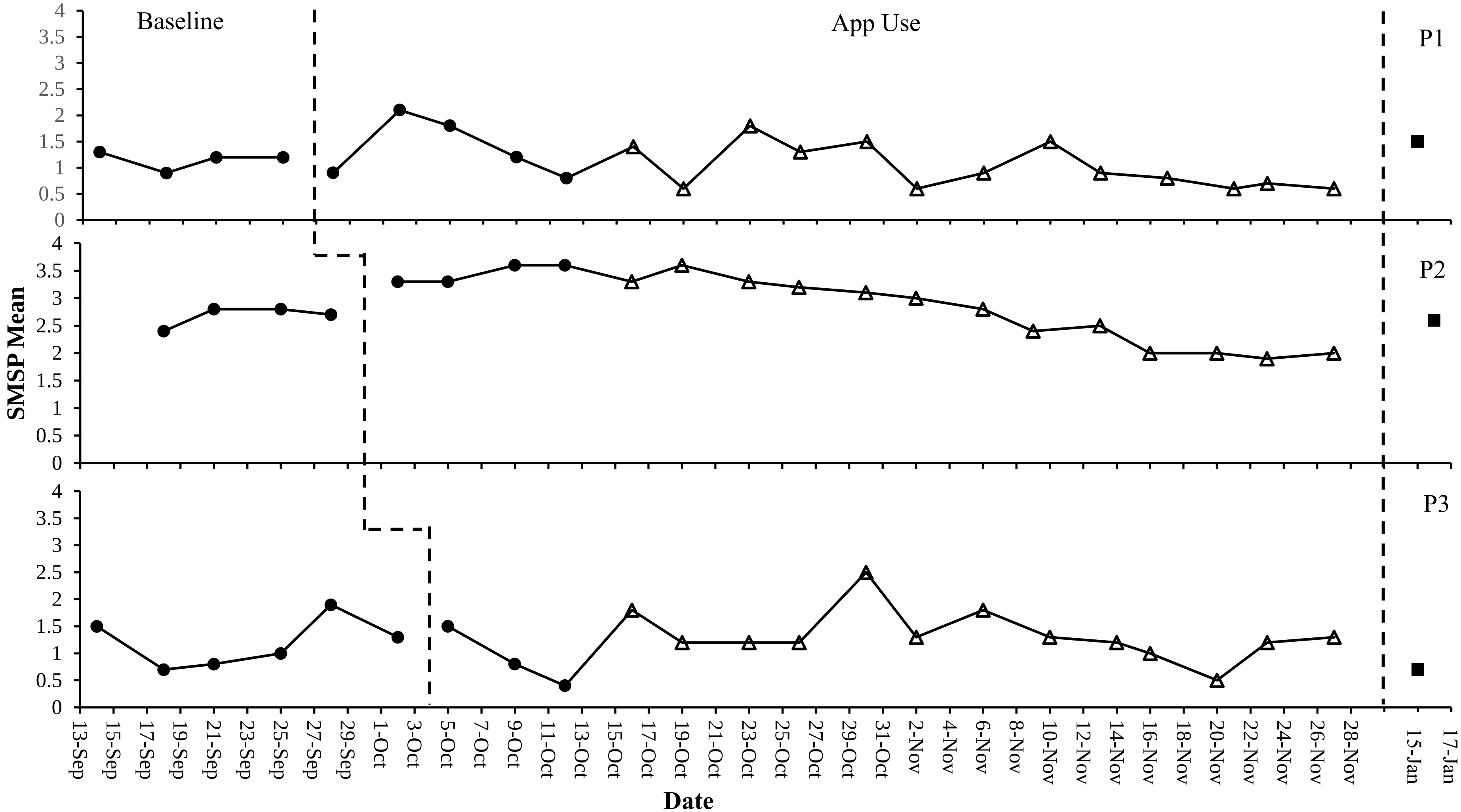
P1 demonstrated stable baseline SMSP scores first, so began the intervention phase first, with mean SMSP scores between 0.9–1.3, indicating mild-moderate phobia. The introduction of the app produced mixed results for P1. P1's mean SMSP scores briefly spiked within a week of starting the app before their scores trended downward for 2 weeks and returned to baseline scores. During P1's third week using the app, they began the VRET module. P1's phobia severity scores were variable (0.6–1.8), but they trended downward over their 6.5 weeks in the VRET module. Though there was an initial spike in phobia severity (2.1), across their time using the app, P1's mean SMSP scores trended downward, and had reached 0.6 by the end of data collection. At the 6-week follow up, P1's mean SMSP score had increased to 1.5, which was similar to their pre-app use scores. Using the NAP method, the calculated effect size of using the oVRcome app on mean SMSP score for P1was 56.9%, which is a weak effect (Parker & Vannest, 2009).

P1 responded '*yes, rarely*' to the cybersickness symptoms question on three occasions, 26-Oct, 30-Oct, and 6-Nov, but did not elaborate on them when I enquired.

On 6-Nov, P1 reported experiencing increased general anxiety and suggested this might be related to the VRET practice. This report by P1 corresponded with notable variability in their mean SMSP scores over the weeks prior (16-Oct–6-Nov). On 11-Nov, P1 reported experiencing a 'big reaction' to one of the final VRET scenarios, which corresponded with a spike in their mean SMSP score on 10-Nov. P1 reported they were taking a break for a few days and working back up to the scenario again over the following days.

Figure 1

Mean SMSP Scores of Baseline Group 1



Note. Open triangles (Δ) indicate when the participant reported beginning the VR module, filled squares (■) are 6-week follow-up data.

P2

P2 was a late addition to Baseline Group 1, hence the missing baseline data point. P2 began the intervention phase with fewer baseline data points than P3, as they had notably higher mean SMSP scores during baseline than the others in this group (2.4–2.8) and there was a slight upward trend. There was no change in baseline scores of P2 when P1 moved to the intervention phase, so P2 began using their intervention phase within a week of P1. For P2, beginning to use the oVRcome app resulted in mean SMSP scores increasing by as much as 1.2 points compared to baseline. Mean SMSP scores for P2 were trending upward when they began the VRET module at the start of their third week using the app. After starting the VRET module, there was a single elevated data point (19-Oct), before P2's phobia severity began trending downward for the remaining 5.5 weeks of the intervention phase and dropped below their lowest baseline score on 16-Nov. At the 6-week follow-up P2's mean SMSP score had increased to 2.6, but they reported a family member being sick at the time, which may have impacted their score. The effect size for using the oVRcome app on mean SMSP score for P2 was 34.6%, which is a weak effect (Parker & Vannest, 2009).

P2 experienced some cybersickness, responding to the cybersickness symptoms question '*yes, some of the time*' on 19-Oct and '*yes, rarely*' on 23-Oct. I followed up with them and they reported feeling dizzy after around 15mins in VR but were not distressed by this and had no other symptoms. P2 reported no more cybersickness symptom issues after 23-Oct.

On 10-Nov, P2 reported that VR may not be their "thing", and that although their phobia was apparently decreasing, it may be the result of external factors, rather than their app use.

P3

P3's mean baseline SMSP scores (0.7–1.9) were relatively low, indicating mild-moderate phobia. P3's scores were not stable before beginning the intervention phase, however, their mean SMSP scores were trending upward, so I decided they should begin the intervention phase without establishing a stable baseline. There was no apparent change in the baseline scores of P3 when P2 or P1 began the app, so after 3 weeks in the baseline condition, P3 began using the app. P3 progressed through Modules 1–4 in 1.5 weeks, slightly faster than the recommended 2 weeks. Prior to the VRET module, P3's mean SMSP scores had decreased below their baseline level. At the start of the VRET module, P3's mean SMSP score increased sharply to 1.8, which was just below their highest baseline score of 1.9, before decreasing to 1.2 for 1.5 weeks. At the end of the fourth week of app use, P3's SMSP score spiked to 2.5, before trending downward for the remaining 4 weeks of app use. Their final mean SMSP score was 1.3 and at the 6-week follow-up they scored 0.7, which indicates zero-to-mild phobia. The effect size for using the oVRcome app on mean SMSP scores for P3 was 47.9%, which is a weak effect (Parker & Vannest, 2009).

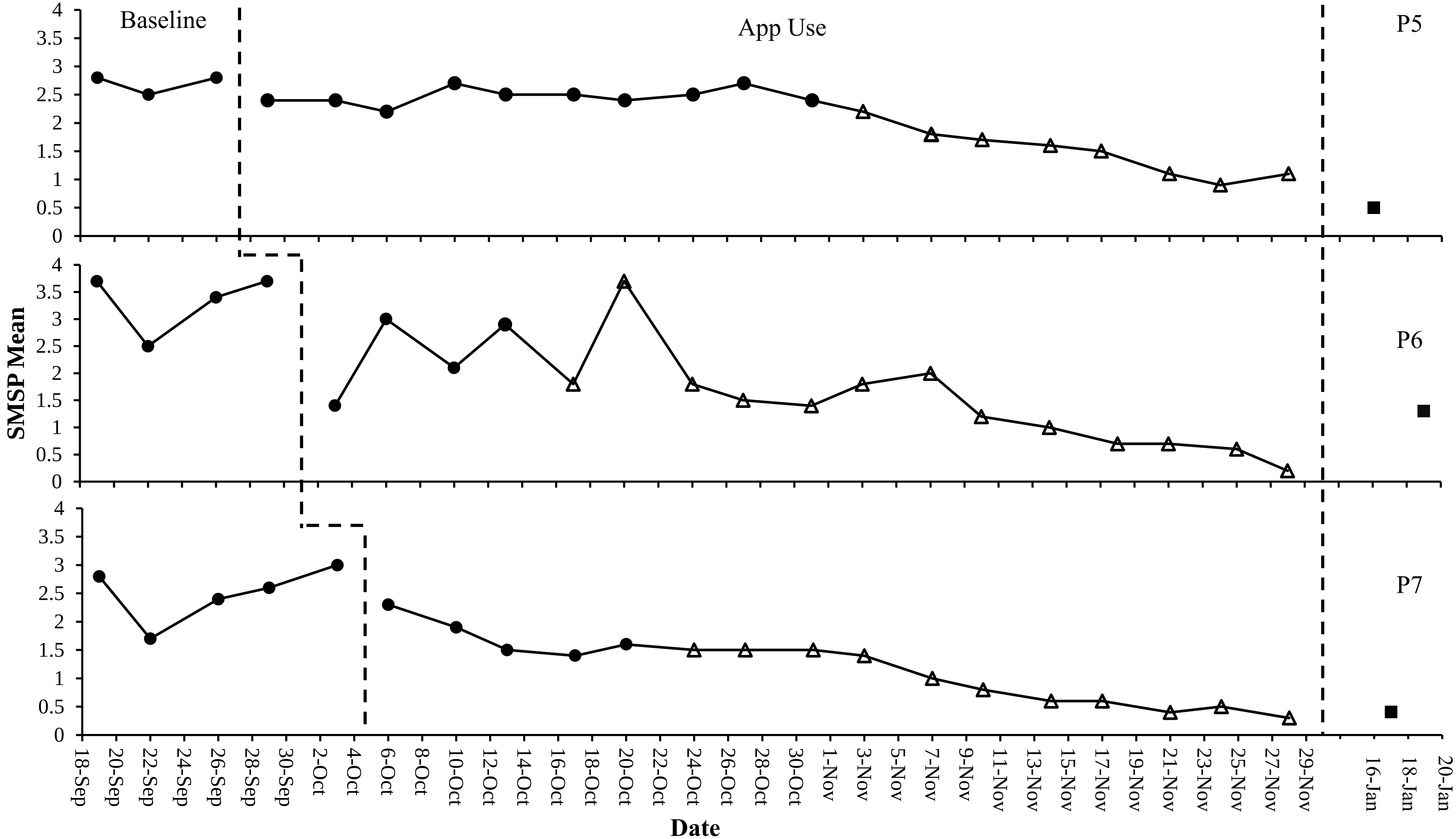
P3 reported no cybersickness symptoms throughout their time using the app.

P3 provided some verbal feedback on 19-Oct about a possible user-friendliness issue with the app, suggesting the volume of the narrator was much greater than the volume in the scenarios (which is hard to adjust with their phone in the HMD). This volume management issue reportedly made VR scenarios more difficult to complete as P3 reported audio exposure to vomiting, as part of the VRET, was important to them. It is unclear whether this user-friendliness issue affected P3's performance as their mean SMSP scores varied widely throughout the intervention phase.

Figure 2 illustrates the mean SMSP scores for Baseline Group 2 over 10.5 weeks and at 6-weeks post app use.

Figure 2

Mean SMSP Scores of Baseline Group 2



Note. Open triangles (Δ) indicate when the participant reported beginning the VR module, filled squares (■) are 6-week follow-up data.

P5

P5's baseline scores were stable after three administrations of the SMSP questionnaire, with their scores indicating moderate-severe phobia (2.5–2.8). P5 began the intervention phase first for Baseline Group 2. For P5, the introduction of the app resulted in an immediate drop of 0.4 of a point in their mean SMSP score. Across their 5 weeks in the first four modules of the app, P5's mean SMSP scores only exceeded their lowest mean SMSP score in baseline on two occasions (10-Oct and 27-Oct) but were not trending up or down. When P5 began the VRET module of the app, there was a steady downward trend in mean SMSP scores which continued for the remaining 4 weeks of data collection, reaching 1.1 on the last day of data recording. A score of 0.5 was reported by P5 at the 6-week follow-up. The effect size of using the oVRcome app on mean SMSP scores for P5 was 93.5%, which is a large or strong effect (Parker & Vannest, 2009).

P5 reported no cybersickness symptoms throughout their time using the app.

On 10-Oct P5 reported slow progression through Modules 1–4 due to external life factors which did not conclude until 29-Oct.

P6

P6's baseline scores were not stable but were trending upward and were often above 3, indicating severe-extreme phobia. P6's scores did not change when P5 moved into the intervention phase, so P6 started using the app shortly after P5. With the introduction of the app, there was a large drop in P6's mean SMSP scores (3.7–1.4). During the first four modules of the app, P6's mean SMSP scores remained notably lower than most of their baseline scores, though there was a wide range of scores (1.4–3), and they were trending upward. After the recommended 2 weeks for Modules 1–4, P6 started the VRET module. There was a brief spike in mean SMSP score to 3.7 (20-Oct), before P6's scores began to decrease steadily. Despite a moderate increase of scores for two data points (3-Nov and 7-Nov), the VRET module resulted in a downward trend for the remaining 5.5 weeks spent in the VRET module, reaching 0.2 (zero-mild phobia) at the end of data collection. P6 reported an SMSP score increase from 0.2 to 1.3 at the 6-week follow-up. The effect size for using the oVRcome app on mean SMSP score for P6 was calculated as 91.9%, which is a medium effect, and very close to the threshold for a strong effect (Parker & Vannest, 2009).

P6 responded '*yes, rarely*' to the cybersickness question on one occasion (7-Nov).

P6 reported heightened general anxiety on 12-Oct, 20-Oct, and 29-Oct. The 12-Oct and 20-Oct reports corresponded with spikes in mean SMSP scores and P6 suggested that their increase in general anxiety was to do with both external life factors and the exposure practice.

P7

P7's baseline mean SMSP scores were trending upward and approaching 3, which indicates severe phobia, so they began the intervention phase despite unstable baseline scores once it was observed that P7's scores did not change when P5 and P6 started using the app. With the introduction of the app, P7's mean SMSP score dropped by 0.7 points, and their scores continued to steadily decrease throughout the first four modules, only increasing slightly on one occasion (20-Oct). P7's mean SMSP scores plateaued at 1.5 for 1.5 weeks, during which time they began the VRET module. The start of the VRET module did not affect P7's mean SMSP scores for 1 week, after which their phobia severity began trending steadily downward again for the remaining 4 weeks of data collection. P7's final mean SMSP score was 0.3 when data collection was stopped, and they scored 0.4 at the 6-week follow-up. The effect size for using the oVRcome app on mean SMSP score was 97.5%, which is a large or strong effect (Parker & Vannest, 2009)

P7 reported ongoing cybersickness symptoms, initially responding '*yes, every time*' (24-Oct) to the cybersickness symptoms question. On the following questionnaire administration (31-Oct) they responded '*yes, often*' to experiencing cybersickness symptoms. I contacted P7 about this issue when it first occurred, and they reported dizziness, eye fatigue, and nausea within seconds of attempting the VRET. Every questionnaire administration after 31-Oct (3-Nov–28-Nov) they responded '*yes, some of the time*'. Though there was no resolution to P7's cybersickness, they continued to participate for the remainder of data collection.

Comparing SPOVIs

Pre- and post- app use SPOVI scores are reported in Table 3.

Table 3

SPOVI Scores for Participants Pre- and Post- oVRcome App Use

Participant	Pre-App SPOVI	Post-App SPOVI
P1	14	14
P2	36	16
P3	17	9
P5	29	16
P6	48	7
P7	46	15

I conducted a paired-samples *t* test to determine if there was a significant difference between the pre- and post-app SPOVI scores of all participants (excluding P4 and P8). Post-app SPOVI scores (M = 12.80, 95% CI[8.77, 16.90]) were significantly lower than pre-app SPOVI scores, $M = 31.70$, 95% CI[16.60, 46.70], $t(5) = 3.05$, $p = .01$. The effect size was large, with a Cohen's d of 1.24.

Anecdotal Data for Excluded Participants

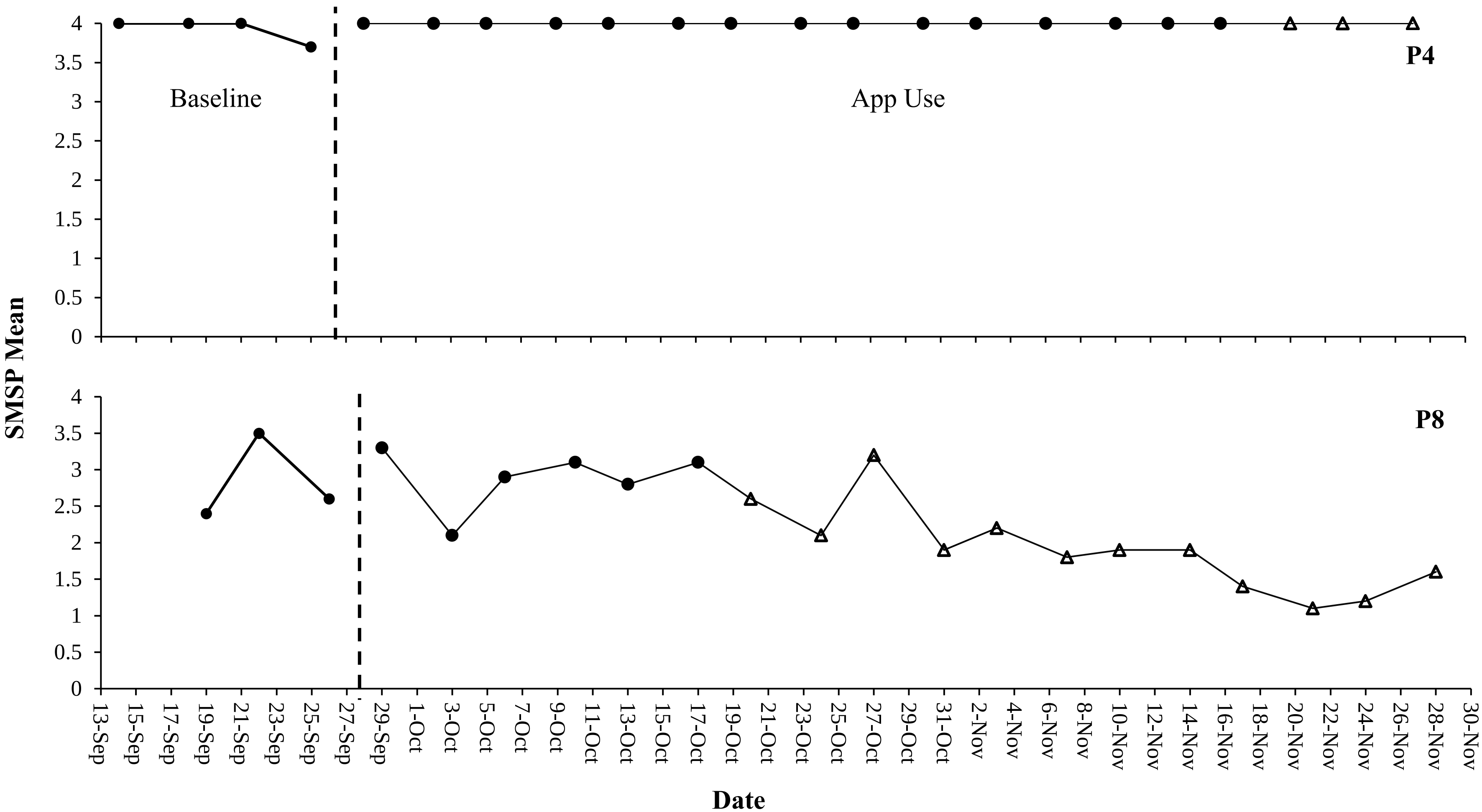
Figure 3 shows P4's mean SMSP scores were at the SMSP score ceiling of 4 on all but one occasion throughout data collection, indicating their emetophobia was extreme. P4 contacted me on 29-Sep, reporting having a 'bad few days' with their phobia. I offered to contact Dr Lacey (participant support, lead author on previous oVRcome RCT). Dr Lacey met with P4 on 5-Oct and P4 reported to me that they decided to progress through the app at a much slower pace due to their phobia severity and that they had support people in place to help them. P4 continued to fill out questionnaires and they reached the VRET module 1.5 weeks before data collection was stopped. P4 spent 5 hours and 43 minutes using the app across 11 sessions for a mean session length of 31 minutes. P4 did not watch any VR content.

As illustrated in Figure 3, the use of the oVRcome app appeared to have a similar effect for P8 as it did for most of the other participants. P8's mean SMSP scores in the intervention phase trended downward consistently but were visibly variable, like P1, P3, and P7. On 17-Oct, P8 reported the VRET module was impressive and extremely effective at getting their "anxiety going". P8 reported some technical issues with the app on 21-Oct and 6-Nov, where their progress in the VRET module was not being recorded correctly so they had to re-watch up to 15 mins of content before reaching the point they finished at. These technical issues reportedly made P8 frustrated and decreased the value they gained from the VRET. P8 spent 3 hours and 58 minutes using the app across five sessions for a mean session length of 48 minutes. P8 watched a total of 16 videos in 11 unique VR environments.

P8 responded to the cybersickness symptoms question with '*yes, some of the time*' on three occasions (10-Nov, 14-Nov, and 17-Nov). I attempted to contact P8 regarding their cybersickness symptoms but did not receive a response.

Figure 3

Mean SMSP Scores of Excluded Participants



Note. Open triangles (Δ) indicate when the participant reported beginning the VR module.

Discussion

I evaluated the emetophobia programme of the oVRcome (https://www.ovrcome.io/) VRET app for phobias. My hypothesis was that participants' use of the oVRcome VRET app would reduce their reported level of emetophobia symptoms and behaviours. My findings generally support my hypothesis as all participants reported some reduction in phobia severity, and for some (P5, P6, and P7) the reported decrease in phobia symptoms and behaviours were large. While I could not find any previous studies of VRET for emetophobia, my participants' reductions in emetophobia severity tend to align with the findings of other researchers who have used VRET for treating phobia (Garcia-Palacios et al., 2002; Miloff et al., 2019; Wiederhold et al., 2002), and importantly my findings align with those of Lacey et al. (2022), who examined VRET for different phobias but used the same app and the same primary measure.

Severity Measure for Specific Phobia

Visual analysis of Figures 1 and 2 suggest participants' app use resulted in reductions in emetophobia severity by the end of the graded VR exposure module for all participants, except P3, where the effect was more difficult to observe.

The mean SMSP scores of P1 and P2 increased when they started using the app and remained above their baseline scores for 2–6 weeks. Some short-term increase in phobia severity is not unusual (Botella et al., 2000; Botella et al., 2004; Wells & Papageorgiou, 2001; Yapan et al., 2023), as a participant may essentially 'trigger' their phobia by exposing themselves to their feared stimuli. The app itself may become associated with a participant's phobia symptoms and increase their anxiety responses when using the app, resulting in increased mean SMSP scores until they learn the app content is 'safe'. The mean SMSP scores of P1 and P2 trended downward for the remaining weeks of data collection suggesting that more time with the app can reduce emetophobia severity.

P3, P5, P6, and P7 reported reductions in mean SMSP scores within a week of starting to use the oVRcome app, which continued for the duration of data collection. P6's mean SMSP scores were variable for the first 3 weeks of app use, but their baseline scores indicated severe-extreme phobia, so it is understandable that there might be some variation in their phobia severity when the app confronts them with elements of their feared stimuli. Score variability can indicate the intervention (app) has poor control over the participant's responses (SMSP scores) (Virues-Ortega et al., 2023). However, my study was generally 'hands-off', and participants were largely self-directed in their engagement with the app, so it is possible that external factors could have influenced participants' scores at any time. Further, except for P3, by the end of data collection, the scores from all participants were stable, so it appears that the app did have some control over their scores.

The follow-up SMSP data collected 6 weeks after the app-use phase indicated that reported emetophobia severity continued to improve for two participants, did not change for one participant, and worsened for three, which also highlights the need for some amount of maintenance post-app to maintain phobia severity changes. There is evidence –in more closely controlled studies– that specific phobia improvements can be maintained for months or years after VR treatment (Botella et al., 2004; Botella et al., 1999; Lindner et al., 2019; Wiederhold & Wiederhold, 2003) and some evidence that improvements using non-VR exposure therapy for emetophobia can be maintained for 3 years (Maack et al., 2013). Given that my study was 'hands-off' and participant engagement with VR was not closely controlled, the fact that the outcomes for half the participants were maintained or improved is very promising. Furthermore, P2 reported that their phobia symptoms were heightened at follow-up because a member of their household was currently sick, and that prior to this their phobia symptoms were well under control, which suggests there could have been four of six participants with maintained or improved phobia symptom changes post app use. In future, to maintain the changes obtained from independent VRET practice, it may be beneficial to add some ‘refresher training’ or exercises to practice a few weeks after the initial VRET sessions have been completed.

Using the non-overlap of all pairs (NAP) effect-size calculation, it is possible to determine the likelihood that any intervention phase data point will be lower than any baseline data point (Parker & Vannest, 2009). Using the suggested effect size thresholds from Parker and Vannest (2009), effect sizes for P5 (93.5%), P6 (91.9%), and P7 (97.5%) were moderate-large or large, so it is very likely that any random intervention data point will be lower than any random baseline data point. These larger effect sizes tend to align with visual analysis of Figure 2, as all participants scored visibly lower during app use than they did during baseline. The effect of app use was weak for P1 (56.9%), and very weak for P2 (34.6%) and P3 (47.9%). The weak effect size for P1 and P3 may be somewhat misleading, as visual analysis of Figure 1 supports a minor-to-moderate improvement in mean SMSP scores for P1, and zero-to-minor improvement for P3. There may have been a ‘floor’ effect for P1 and P3, where the scoring range of the SMSP may have masked small changes in scores or the participants reached the lower limit of realistic scoring. P2, P5, P6, and P7 scored quite highly on the SMSP measure during baseline, so they had more scope to reduce their SMSP scores during app use than P1 and P3.

Specific Phobia of Vomiting Inventory

Participants’ scores on the pre- and post-app SPOVI support the findings from visual analysis and NAP effect size calculations of participants’ SMSP scores. There was a large, significant effect of app use on participants' SPOVI scores pre- and post-app use. Apart from P1, whose score of 14 did not change, all SPOVI scores improved after using the app, and all participants scored below 17, which was the second lowest of all pre-app SPOVI scores. Further, P3 and P6 scored below 10 on the post-app SPOVI, which is below the threshold for a likely emetophobia diagnosis (Veale et al., 2013).

App Engagement

There is evidence that more exposure practice sessions can lead to greater improvements in symptoms of anxiety, PTSD, and phobia (Deng et al., 2019; Opriş et al., 2012; Powers & Emmelkamp, 2008). P6 spent the most time using the app, followed by P1, P3, P2, P7, and P5. P6 recorded over 8 hrs of use and watched 29 VR scenarios, they also had the most severe phobia scores in baseline, and the least by the end of data collection. P1 recorded 6 hrs 25 mins of use, watching 27 VR scenarios, with their mean SMSP scores indicating mild-moderate phobia in baseline. By the end of data collection, P1 and P6 were scoring consistently lower on the SMSP than in baseline, which suggests that their phobia was reduced and the psychoeducation and exposure practice in the app was more beneficial than their avoidance or coping behaviours prior to app use.

Somewhat contrary to the evidence of more exposure leading to greater improvements in anxiety or phobia symptoms, P3 spent 3 hrs 18 mins with the app but did not score lower than their baseline for much of the intervention phase. It is also interesting that P2 used the app for 1 hr less than P3, but visual analysis suggests P2 improved more, and these improvements were more consistent than for P3. Even more interesting is that P5 and P7's scores improved compared to baseline, despite them using the app for only a fraction of the time that P6 and P1 did. P5 used the app for 1 hr 21 mins and P7 for 1 hr 48 mins. Neither P5 nor P7 completed any

VRET but both participants were scoring over two points lower than their baselines when data collection stopped.

It could be inferred from the results of P5 and P7 that VRET may not be necessary to improve emetophobia symptoms and behaviours, especially if the results of P5 and P7 are compared to P3's, who watched 17 VR scenarios, spent much longer using the app, and improved only a small amount. However, participants who did spend time in the VRET module would have been exposed to their feared stimuli, so their SMSP scores would reflect their responses when confronting their feared stimuli, while it is unclear how P5 and P7 will respond when faced with their feared stimuli. That is not to say that the results of P5 and P7 should be discounted - mindfulness, relaxation, and thought reframing are all part of cognitive-oriented interventions that have been effective for treating phobias (Clark et al., 2006).

Cybersickness

Cybersickness has been found to affect most VR users to some degree (Caserman et al., 2021; Garrido et al., 2022). The problem with VRET causing cybersickness is that symptoms such as dizziness and nausea can be similar to the physiological sensations experienced when a person encounters their phobic stimuli, making them more susceptible to cybersickness (Howard & Van Zandt, 2021). Cybersickness susceptibility could be particularly problematic for someone with emetophobia, as nausea can be a powerful fear response, and is often associated with emetophobia (Boschen, 2007; Keyes et al., 2018), which may deter them from future use of VRET. In this study, four of six participants (63%) reported experiencing cybersickness. P7's cybersickness was so severe they reported not being able to use the VRET module of the app at all. When P7 first indicated they were experiencing cybersickness, I contacted them to determine the severity of the symptoms. I then offered some cybersickness management strategies and attempted to arrange a meeting to further discuss a way to manage these symptoms and ensure the app and HMD were being used correctly. After several reschedules where P7 was too busy, we decided not to meet. In subsequent reports of cybersickness, P7 did not respond to my enquiries, and they did not participate in the VRET module, using the app for only 1 hr 48 mins across the study. P2 reported some mild-moderate cybersickness symptoms shortly after starting the VRET module, but none after 23-Oct. P2 used the app for only 2 hr 17 mins and watched 7 VR scenarios, so it is possible there were no subsequent cybersickness reports because of relatively little time spent in VR. Participants P1, P6, and P8 also reported cybersickness on 1–3 occasions, but did not elaborate on these symptoms when asked, which suggests they were minor and did not affect their participation in the VRET module.

It seems likely that P7's, and perhaps to a lesser extent P2's, participation in this study was limited by their experience of cybersickness. Some amount of cybersickness is unavoidable for most people, perhaps more so when using relatively low-cost, and therefore less capable, VR systems (Ramaseri Chandra et al., 2022). Cybersickness can be managed, and the emetophobia VRET programme of the oVRcome app does manage or limit cybersickness in some ways, such as having user's avatars remaining mostly stationary and upright in the virtual world, which can help reduce the likelihood and severity of cybersickness (Risi & Palmisano, 2019). Despite participants' varying experiences of cybersickness, the use of oVRcome's VRET app reduced phobia symptoms and behaviours for all participants, and further supports the efficacy of oVRcome's app and VRET as a treatment for specific phobias.

Strengths

One of the major strengths of this study was the small-N, within-subjects design, which is standard practice in applied behaviour analysis (Butler et al., 2011). Each participant's phobia severity was measured with the SMSP under baseline and treatment conditions twice a week for a total of 11 weeks, which allowed for a detailed picture of their progress (Figures 1 and 2), and more data available for each participant than would have been provided by using only pre- and post-intervention measures. Further, as each participant acts as their own control, inter-subject variability can be ignored, error variability is reduced, and all participants receive the treatment (Butler et al., 2011; Singh et al., 2017). Another benefit to a small-N, within-subjects design is that fewer participants are needed to demonstrate an effect (Butler et al., 2011), which is beneficial here as emetophobia is an uncommon phobia, so it would have been difficult to recruit enough participants for a between-subjects design. The small sample size also allowed me to closely monitor participants throughout the study and offer support where needed as soon as an issue became apparent.

A second strength of this study was that I included a secondary phobia measure, the SPOVI, pre- and post-intervention. An RCT would typically only measure participants' phobia severity scores before and after the intervention, which can become a problem if there are too few participants, as there is the possibility that any given score recorded could be impacted by external factors present when the participant completed the questionnaire, and as pre- and post-measures provide only two reference points, a single inflated score can affect what is inferred from the data. Using an applied behaviour analysis experimental design with a secondary pre-post-intervention measure meant I had a large amount of participants' data available from their SMSP scores and could use their SPOVI scores to support my findings. In this case, except for P1, all participants had improved SPOVI scores post-intervention. The triangulation effect of having 11 weeks' worth of phobia severity data, coupled with data from a secondary measure indicating the same phenomenon, constitutes a major strength of this study.

A third strength of this study was that I attempted to replicate the intended primary 'real world' use of the oVRcome app, that is, user-guided, independent use. I provided only general timeframe guidelines for the use of the app, and I did not specify an amount of time to spend using the app per day, or how long each module should take. By being 'hands off' and allowing flexibility in how participants used the app, such as when they started VR, I can be more confident that that is how they would have used the app in a naturalistic (non-study) context, and that similar improvements in emetophobia severity is possible for users without any direct support from a therapist. It is also noteworthy that despite overall improvements in phobia severity in this study, half of the participants experienced worsening phobia symptoms within a week of starting the app. This is a useful insight for oVRcome in the development of their app, and for users of the app, as knowing beforehand that their symptoms could worsen before improving, may improve overall treatment adherence. Another, related, strength is that remaining hands off while recording (relatively) more data from each participant than another design might, may lead to more understanding of the relationship between app use and phobia symptom improvement, which would not be possible using only a pre- and post-intervention measure.

Two final strengths of this study were the follow-up data I collected, which revealed the potential need for maintenance or practice to help maintain the changes obtained in the initial VRET treatment, and that this is the only study of VRET for emetophobia that I am aware of. VRET is still a relatively novel treatment modality, so it is understandable that VRET for emetophobia may not have been studied before, given emetophobia is an uncommon and generally understudied phobia (Becker et al., 2007; Keyes et al., 2018). Some of the elements of an exposure therapy plan for emetophobia may be easier to achieve with VR than in vivo or imaginal exposure. It may be difficult to recreate realistic depictions of vomiting using in vivo actors, which is more achievable using videoed instances in a VRET approach. With the reductions in phobia severity demonstrated by all participants in this study, it appears that VRET can be effective for treating emetophobia, and that more study is needed to determine how to best implement, or what constitutes, a good exposure programme.

Limitations

Although most participants' reported emetophobia symptoms improved while using the oVRcome VRET app, this study had several limitations. First was the self-report nature of the data, which could have been influenced by social desirability bias, where a participant's responses on a measure are distorted by their perception of what a socially desirable response would be (Nederhof, 1985), or their scores are lower at the end of the intervention, in response to a perceived expectation that the intervention worked (Singh et al., 2017). However, if social desirability was affecting responses, a participant's reported phobia would likely be uniformly lower across all their responses, which would not necessarily make changes in phobia symptoms easier to detect (Singh et al., 2017). Additionally, P3 improved only a small amount over the 11 weeks and their final two data points were slightly above their average baseline score, and P2, P3, and P5 recorded slight increases in SMSP scores on the final administration of the SMSP, despite knowing in advance that it was the final administration.

A second potential limitation was the SMSP itself. One participant (P1) reported finding the wording of the SMSP questionnaire confusing at times, which may have affected how they responded to the questionnaire. When P1 raised their issue with the SMSP (18-Sep), I attempted to clarify the SMSP wording, which appeared to be satisfactory to them, so consistency in responding to the questionnaire can be assumed, but not guaranteed. Using the SPOVI as the primary measure for this study, rather than the SMSP, may have produced more valid results. The SPOVI is a 14-item scale with possible scores ranging from 0-56 and was developed for emetophobia specifically, while the SMSP is 10-items, with a score range of 0-40 (before averaging) and is applicable to a wide range of specific phobias. It could be possible that the more 'generic' wording of the items in the SMSP caused some inconsistencies in responding or interpretation across participants and administrations. However, in this study participants were asked to complete a questionnaire two times per week, so using the shorter SMSP may have prevented some compliance problems during the later stages of data collection. Further, the SMSP has been demonstrated as an effective measure (Macleod et al., 2022) and I wanted measures from my study to align with the previous oVRcome RCT, so decided to use the same measure they did.

Another potential limitation was that I tried to mimic the intended 'self-guided' nature of the oVRcome app. With only general timeframe guidelines for the use of the app, it was possible for participants to not practice with the app and even delay their start with the VRET module. A possible effect of this self-guided approach was P5 starting the VRET module much later than everyone else, and quite close to when data collection was stopped. Further, P5 and P7 did not complete any VRET, which may have been less likely in a more controlled study where participants' activities and participation are closely monitored. However, it is likely to have been more beneficial to have attempted to mimic 'real world' use of the app, as that is closest to what a typical user would experience and is more reflective of people's 'natural' behaviour with the app.

Future Directions

Given that mine is the only study of VRET for emetophobia I am aware of, there are many possible directions for future research. My first suggestion would be replications of this study. The oVRcome app has previously been shown to be effective for treating a number of phobias (Lacey et al., 2022), but I examined oVRcome's first version of their emetophobia programme, and subsequent versions may improve the user experience and perhaps user outcomes. Second, whether specific to oVRcome's app or not, in future studies of VRET for emetophobia, it may be beneficial to try a more controlled approach, where time in app and the number and length of exposure sessions is prescribed. Having more control over participant's exposure practice could help to determine how to best implement app-based VRET for emetophobia, and what factors make up an effective programme. I suggest that further study retains a within-subjects design as it allows for a detailed account of participants' progress, and it may be difficult to find enough participants for a strong RCT. In this study, P5 and P7 did not complete any VR but reported significant changes in their emetophobia symptoms, so a third direction for future research may be to investigate the effectiveness of a VRET app if participants use the whole app, versus ones who only complete the pre-VRET modules (e.g., psychoeducation, relaxation, and mindfulness).

Conclusion

Exposure therapy has been the primary approach to treating phobias for a long time. After the creation of VR, VRET became an effective treatment modality that could overcome some of the limiting aspects of in vivo exposure. In this study – perhaps the first study of VRET for emetophobia – I examined the effectiveness of the emetophobia programme of the oVRcome VRET app, using a within-subjects, multiple-baseline-across-participants design. All participants improved from baseline or pre-app-use scores, some (P5, P6, and P7) substantially. The improvements made were maintained at a 6-week follow-up for some participants, while others worsened slightly, perhaps due to ‘hands off’ approach I took to mimic a real-world user experience. Overall, participants’ phobia severity improvements shown during app use support the use of the oVRcome app to treat emetophobia and my findings align with those in studies of VRET for the treatment of other phobias, including the previous RCT using the oVRcome app.

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Appendix A

Poster

Appendix B

oVRcome Email

Hello, my name is Rory Wallace (rww12@students.waikato.ac.nz), I am a psychology master's student at the University of Waikato. I want to investigate the effectiveness of the oVRcome app because it is a low-cost, local option to treat a range of potentially debilitating phobias. This is my thesis project that will contribute to completion of a Master of Applied Psychology.

I am contacting you because you have previously expressed interest in being part of an oVRcome study. Though this project is smaller and somewhat separate from oVRcome it will be using their equipment and app, and their research supervisor, Dr Cameron Lacey will be supporting and supervising the project.

We are currently looking for people based in Aotearoa New Zealand over 18 years old to participate. There is an information sheet attached describing the project and if you want to take part please email me for a link to the initial screening questionnaire, or if you have any questions feel free to email me and we can discuss it further.

Thank you for your time,

Rory Wallace

Appendix C

Information Sheet

Researchers: Rory Wallace, Dr. Rebecca Sargisson (Supervisor), Dr. Cameron Lacey (Consultant, oVRcome Research Supervisor)
Contact
Ph: 027 344 2798 (Rory), 022 070 2447 (Rebecca)
Email: rww12@students.waikato.ac.nz , rebecca.sargisson@waikato.ac.nz

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Evaluating oVRcome, a Virtual Reality Exposure Therapy app

Sponsored by oVRcome: https://www.ovrcome.io

My name is Rory Wallace, I am a psychology master's student at the University of Waikato. I want to investigate the effectiveness of the oVRcome app because it is a low-cost, local option to treat a range of potentially debilitating phobias. This is my thesis project that will contribute to completion of a Master of Applied Psychology.

The Project

To evaluate the effectiveness of the oVRcome virtual reality (VR) app we would like some participants to go through the app while we monitor the effects. Virtual reality is a computer (in this case mobile phone) simulated experience delivered through a head-mounted display that is intended to look and feel close to real life, but without the potential dangers of real life

Your Role

After determining your fit with the project with a screening questionnaire we will provide access to the oVRcome app and an oVRcome VR headset. All instructions about the use of the app and VR headset are provided in the app and we can help with downloading and starting it if needed.

Your role will be to progress through the stages of the app as the app recommends and also fill out a 10-question questionnaire twice a week (plus one additional questionnaire at the start and end of the study). The app can take as little as 10 minutes a day and the questionnaire should only take 5 minutes or less each time. Total participation time will vary by participant but should be 6 around weeks.

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Goals/Expected Outcomes

VR has a long history of being effective for exposure therapy, particularly around phobias so provides a good opportunity to overcome or reduce your own fear/phobia. We also aim to investigate the effectiveness of this NZ-based low-cost VR system and add to the published research base.

You/Your Privacy

As part of this project is attempting to mimic a typical user's experience of oVRcome, participants are asked to agree to oVRcome's terms of service and privacy policy. Participants will be asked to provide information to oVRcome such as your name, email address, and physical address (for mailing your VR headset). As the app is operated using oVRcome's secure servers, they will have access to information such as time spent in the app, progress though the programme, and self-ratings of your experience you may be prompted to provide in the app. Your information cannot be used by oVRcome beyond that which is specified in their privacy policy and oVRcome will not have access to the data we (the researchers) gather before it is anonymised. Participants will be identified only by initials prior to final publishing, at which point names will be completely anonymised.

oVRcome's terms of service and privacy policy can be found at https://www.ovrcome.io/terms-and-conditions and https://www.ovrcome.io/privacy-policy

Potential Risk

Some people experience symptoms such as headache or dizziness when using VR systems for extended periods. We will check in with participants weekly during the VR exposure modules and can provide support when needed.

Broadly speaking, exposure therapy works by gradually and safely exposing a person to their fear so they can learn not to fear it, this means that if you participate you will be exposed to some amount of a virtual representation of your fear. This can increase stress and anxiety to levels that are more than you are comfortable with. In most cases it will be manageable and the oVRcome app has built in safety features. If it becomes too overwhelming there is also the option to withdraw from the project.

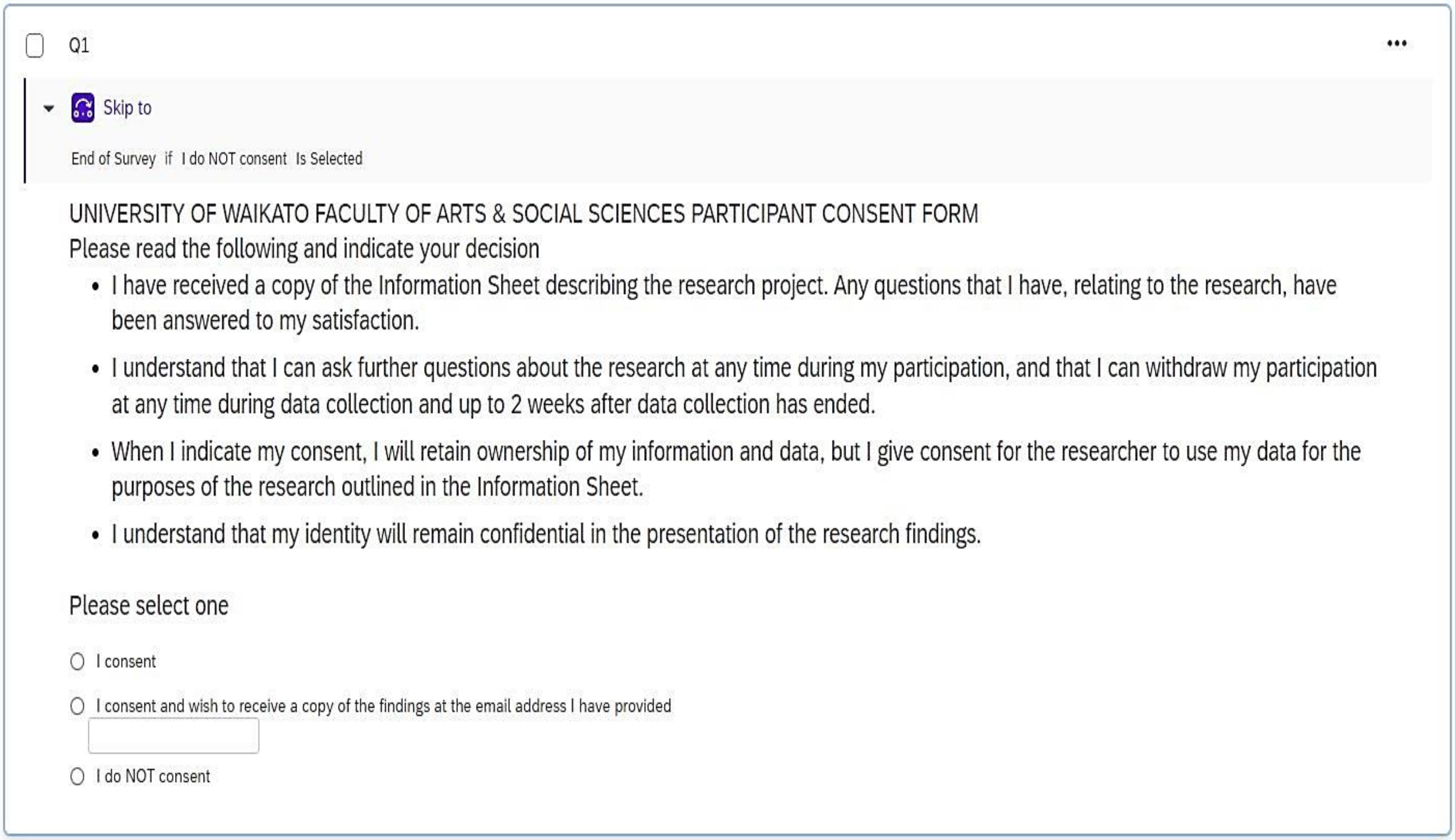
This research project has been approved by the Human Research Ethics Committee. Any questions about the ethical conduct of this research may be sent to the Secretary of the Committee

Email: humanethics@waikato.ac.nz

Postal address: Human Research Ethics Committee, University of Waikato, Te Whare Wananga o Waikato, Private Bag 3105, Gate 1 Knighton Road, Hamilton 3240, New Zealand

Appendix D

Participant Consent From (Hosted on Qualtrics (www.qualtrics.com/au/)



Q1

Skip to

End of Survey if I do NOT consent Is Selected

UNIVERSITY OF WAIKATO FACULTY OF ARTS & SOCIAL SCIENCES PARTICIPANT CONSENT FORM

Please read the following and indicate your decision

- I have received a copy of the Information Sheet describing the research project. Any questions that I have, relating to the research, have been answered to my satisfaction.
- I understand that I can ask further questions about the research at any time during my participation, and that I can withdraw my participation at any time during data collection and up to 2 weeks after data collection has ended.
- When I indicate my consent, I will retain ownership of my information and data, but I give consent for the researcher to use my data for the purposes of the research outlined in the Information Sheet.
- I understand that my identity will remain confidential in the presentation of the research findings.

Please select one

- I consent
- I consent and wish to receive a copy of the findings at the email address I have provided
- I do NOT consent

Appendix E

Patient Health Questionnaire – 9 (Hosted on Qualtrics (www.qualtrics.com/au/)

Over the last two weeks, how often have you been bothered by any of the following problems?

	Not at all	Several Days	More than half the days	Nearly every day
1. Little interest or pleasure in doing things	○	○	○	○
2. Feeling down, depressed, or hopeless	○	○	○	○
3. Trouble falling or staying asleep, or sleeping too much	○	○	○	○
4. Feeling tired or having little energy	○	○	○	○
5. Poor appetite or overeating	○	○	○	○
6. Feeling bad about yourself - or that you are a failure or have let yourself or your family down	○	○	○	○
7. Trouble concentrating on things, such as reading the newspaper or watching television	○	○	○	○
8. Moving or speaking so slowly that other people could have noticed, or the opposite, being so fidgety or restless that you have been moving around a lot more than usual	○	○	○	○
9. Thoughts that you would be better off dead or of hurting yourself in some way	○	○	○	○

Appendix F

Specific Phobia of Vomiting Inventory (Hosted on Qualtrics (www.qualtrics.com/au/)

SPOVI

Q1

Please tick the box that best describes how your fear of vomiting has affected you OVER THE PAST WEEK, INCLUDING TODAY.

	Not at all	A little	Often	A lot	All the time
1. I have been avoiding adults or children because of my fear of vomiting	○	○	○	○	○
2. I have been avoiding objects that other people have touched because of my fear of vomiting	○	○	○	○	○
3. I have been avoiding situations or activities because of my fear of vomiting	○	○	○	○	○
4. I have been looking at others to see if they may be ill and vomiting	○	○	○	○	○
5. I have escaped from situations because I am afraid I or others may vomit	○	○	○	○	○
6. I have been restricting the amount or type of food I eat or alcohol I drink because of my fear of vomiting	○	○	○	○	○
7. I have been trying to avoid or control any thoughts or images about about vomiting	○	○	○	○	○
8. I have been feeling nauseous	○	○	○	○	○
9. If I think I am going to vomit, I do something to try to stop myself from vomiting	○	○	○	○	○
10. I have been trying to find reasons to explain why I feel nauseous	○	○	○	○	○
11. I have been focused on whether I feel ill and may vomit, rather than on my surroundings	○	○	○	○	○
12. I have been worrying about myself or others vomiting	○	○	○	○	○
13. I have been thinking about how to stop myself or others from vomiting	○	○	○	○	○
14. I have been seeking reassurance that I or others will not be ill and vomit	○	○	○	○	○

Appendix G

Severity Measure for Specific Phobia (Hosted on Qualtrics (www.qualtrics.com/au/)

SMSP-A

Q1

The following questions ask about thoughts, feelings, and behaviours that you may have had in a variety of situations. Please choose **one item** and make your ratings based on the situations included in that item. (Note: please select vomiting or choking for this study)

- ○ Choking or Vomiting
- ○ Driving, Flying, Tunnels, Bridges, or Enclosed Spaces
- ○ Animals or insects
- ○ Blood, Needles, or Injections
- ○ Heights, Storms, or Water

Please respond to each item by marking one circle per row. Since the Last Time I answered this questionnaire I have...

	Never	Occasionally	Half of the Time	Most of the Time	All of the Time
1. felt moments of sudden terror, fear, or fright in these situations	○	○	○	○	○
2. felt anxious, worried, or nervous about these situations	○	○	○	○	○
3. had thoughts of being injured, overcome with fear, or other bad things happening in these situations	○	○	○	○	○
4. felt a racing heart, sweaty, trouble breathing, faint, or shaky in these situations	○	○	○	○	○
5. felt tense muscles, felt on edge or restless, or had trouble relaxing in these situations	○	○	○	○	○
6. avoided, or did not approach or enter, these situations	○	○	○	○	○
7. moved away from these situations or left them early	○	○	○	○	○
8. spent a lot of time preparing for, or procrastinating about (i.e., putting off), these situations	○	○	○	○	○
9. distracted myself to avoid thinking about these situations	○	○	○	○	○
10. needed help to cope with these situations (e.g., alcohol or medications, superstitious objects, other people)	○	○	○	○	○